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
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

Contents

1 Introduction

Green shipbuilding and ship repair are central to the decarbonization of the maritime sector, enabling emissions reduction across both new and existing fleets. As global regulatory requirements tighten and markets shift toward low-carbon transport, shipyards play a decisive role in embedding sustainability at the design, construction, and retrofit stages of vessels. Energy-efficient hull forms, optimized hydrodynamic designs, and advanced propulsion systems allow newbuild ships to achieve significant improvements in fuel efficiency while maintaining operational performance.

Beyond new construction, the transition to green shipping depends heavily on the large-scale retrofitting of existing vessels. Strategic upgrades such as hybrid propulsion systems, wind-assisted technologies, energy-saving devices, and digital energy management platforms enable legacy fleets to progressively align with evolving environmental standards. Digitalisation further strengthens this transition through real-time emissions monitoring, AI-driven route optimisation, and fuel analytics, supporting continuous improvements in vessel carbon performance and operational efficiency.

Ship repair yards therefore emerge as critical enablers of maritime decarbonization, extending asset life while supporting regulatory compliance and technology integration. To realise this transition at scale, a structured industrial approach is required, encompassing domestic manufacturing of green technologies, development of alternative-fuel-ready vessel designs, and workforce skilling in advanced marine engineering disciplines. Financial incentives, targeted policy support, and collaboration between shipyards, technology providers, and regulators will be essential to overcome cost, infrastructure, and capability barriers.

Collectively, green shipbuilding and retrofit-led ship repair form an integrated pathway for reducing lifecycle emissions in the maritime sector. By embedding low-carbon technologies into vessel design, construction, and maintenance, India can simultaneously lower emissions, enhance industrial competitiveness, and position its shipbuilding and repair ecosystem as a global hub for next-generation sustainable maritime solutions.

1.1 Green Shipbuilding and Ship Repair for Maritime Decarbonisation

Green shipbuilding and ship repair form the industrial backbone of maritime decarbonisation. As global regulatory frameworks tighten under the decarbonisation trajectory of the International Maritime Organization (IMO) and markets increasingly favour low-carbon transport solutions, shipyards assume a decisive role in embedding sustainability at the design, construction, upgrade, and maintenance stages of vessels. The transformation of the maritime sector therefore depends not only on fuel transition, but on how ships are designed, built, modernised, and serviced across their lifecycle.

To establish regulatory clarity and prevent ambiguity in implementation, this policy adopts performance-based definitions for **Green Ship**, **Green Retrofit**, and **Green Repair**, which together constitute the foundational framework for certification, incentives, compliance tracking, and lifecycle emissions reporting.

A **Green Ship** refers to a newly constructed vessel that demonstrably meets predefined lifecycle-based environmental performance thresholds at design approval and delivery. Qualification is not fuel-prescriptive; rather, it is performance-driven. A vessel shall be recognised as a Green Ship if it achieves measurable well-to-wake greenhouse gas (GHG) intensity reductions relative to an established baseline, complies with and exceeds applicable energy efficiency design requirements, incorporates low- or zero-carbon fuel capability or certified alternative-fuel readiness, and integrates digital emissions monitoring systems compatible with monitoring, reporting and verification (MRV) frameworks. Additionally, Green Ships must demonstrate design provisions for circularity, retrofit compatibility, and long-term technological adaptability.

A **Green Retrofit** refers to a structured technological upgrade applied to an existing vessel that results in quantifiable environmental performance improvement. Unlike routine maintenance, a Green Retrofit involves engineered modifications affecting propulsion systems, fuel systems, power generation, or energy optimisation architecture. Eligible interventions may include hybrid propulsion integration, alternative fuel conversion, wind-assisted technologies, energy-saving devices, air lubrication systems, shore power compatibility, or advanced digital energy management platforms. Qualification requires demonstrable emissions or efficiency gains supported by engineering validation and post-installation performance verification.

A **Green Repair**, by contrast, relates to the environmental performance of yard operations and maintenance practices. It encompasses ship repair and servicing conducted using low-emission dock operations, electrified or energy-efficient equipment, sustainable coatings and consumables, structured hazardous material management, waste recovery systems, marine pollution prevention controls, and digital work planning to reduce operational footprint. While Green Retrofit focuses on vessel-level technological enhancement, Green Repair addresses process-level environmental responsibility during maintenance and repair execution.

Collectively, these three pillars create an integrated industrial pathway for lifecycle emissions reduction. Green Ship standards ensure sustainability is embedded at the point of construction. Green Retrofit programmes enable legacy fleets to align progressively with evolving environmental benchmarks. Green Repair practices reduce environmental externalities within shipyard ecosystems and reinforce compliance across operational interfaces.

1.2 India's Approach to Green Shipping – Shipbuilding and Ship Repair for Maritime Decarbonisation

Evidence from global decarbonisation pathways and India's maritime profile indicates that shipbuilding and ship repair must function as **core lifecycle levers**—not adjacent enablers—of emissions reduction. The National Green Shipping Policy (NGSP) positions **Green Ships** as a central pillar, explicitly linking decarbonisation outcomes to (i) energy-efficient newbuild designs and (ii) retrofit-led upgrades for the in-service fleet. International experience reinforces this approach: while newbuilds can embed step-change efficiency through hull optimisation, propulsion integration and emissions-control architecture, **near-term compliance and emissions reduction are dominated by retrofit pathways**, because the existing fleet remains the primary emissions stock.

India's decarbonisation logic: segmentation + lifecycle prioritisation

India's fleet and operating context require differentiated levers across vessel segments:

- **Ocean-going fleet (high energy/emissions intensity):** a smaller subset of vessels typically accounts for a disproportionate share of fuel consumption and emissions; decarbonisation needs **efficiency upgrades now** and **alternative-fuel-ready newbuilds** over time.

- **Coastal, harbour and inland fleet (high population + older profiles):** decarbonisation gains are accelerated through **standardised retrofit packages**, electrification/hybridisation where feasible, and clean operational practices during repair and maintenance.

- The **Indian-flag fleet scale** underscores why retrofit is essential: DG Shipping's quarterly tonnage statement for **Jan–Mar 2025** reports that **as of 31 March 2025** India had **1,549 Indian-flag ships**, totalling **13,522,787 GT** and **20,724,521 DWT** (including Indian Controlled Tonnage).[1].

In parallel, domestic waterborne activity is expanding, strengthening the case for greening short-sea and inland ecosystems. Government releases report **cargo movement on national waterways of ~145.8 million tonnes in FY 2024–25**, alongside rapid growth in passenger movement (to **7.64 crore** in FY 2024–25)[2].

[1] https://www.dgshipping.gov.in/WriteReadData/userfiles/file/Jan-March%202025.pdf
[2] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2216510&reg=3&lang=1

What India has already done: concrete steps underway

India's approach is increasingly structured around a "**define, standardise, deploy, monitor**" transition model—anchored by policy instruments that directly touch shipbuilding and ship repair.

1) Policy architecture: NGSP explicitly anchors "Green Ships" and retrofit pathways

The NGSP (as circulated for consultation) frames decarbonisation as a **systems programme** integrating vessel technology, industrial capability, R&D and compliance—without mandating a single fuel or design pathway.

This gives India a workable basis to (i) define qualification criteria for green newbuilds/retrofits/repairs and (ii) link those criteria to incentives, approvals and MRV.

2) Standardised transition programme for harbour craft (shipbuilding demand signal + yard readiness)

India has moved beyond signalling into programmatic procurement under the **Green Tug Transition Programme (GTTP)**—a practical bridge between "policy intent" and "yard orderbooks":

- Target: **50 green tugs by 2030**
- Phase 1 deployment: **16 tugs between 2024–2027**
- Indicative investment: **~₹1,000 crore** for Phase 1 build-out
- Rollout structure: minimum procurement/charter requirements across Major Ports, supported by standardised specifications/SOPs[3]

This is a direct industrial step for Indian yards: it creates **repeatable designs**, a **volume pipeline**, and a credible basis to develop **battery-electric/hybrid integration, charging interfaces, safety protocols, and yard-level quality standards**.

3) Port-side Infrastructure as an Enabler for Retrofit Compatibility and Green Repair

While **Harit Sagar – Green Port Guidelines** are primarily a port decarbonisation framework, they function as a critical enabling condition for green retrofit and repair pathways.

By promoting port electrification, renewable energy integration, and energy-efficient operations, the framework creates the infrastructure necessary for vessels to adopt shore power systems, onboard electrical upgrades, and hybrid configurations. Without port-side electrical readiness and clean energy supply, retrofit investments in shore connection and emissions-reduction technologies would remain commercially and operationally constrained.

With Major Ports handling **853.57 million tonnes of cargo during Apr–Mar 2024–25**[4], the scale of port-linked maritime activity underscores the importance of electrified and low-emission port–yard ecosystems in supporting India's retrofit-led decarbonisation pathway.

4) Compliance alignment with IMO energy-efficiency rules (data capture → enforcement readiness)

India has operationalised MARPOL Annex VI implementation steps by issuing circulars/notices that extend beyond large ships and push system-wide data readiness. For example, DG Shipping Circular No. 4 of 2023 covers **data collection for implementation of EEXI/CII** (along with other compliance elements), strengthening India's ability to **measure and enforce efficiency transitions**[5].

For ship repair and retrofit yards, this effectively increases demand for **EEXI/CII-linked retrofit solutions**

[3] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2045946&reg=3&lang=2
[4] https://shipmin.gov.in/sites/default/files/Report%20Monthly%20Major%20Port%20March%202025.pdf
[5] https://www.dgshipping.gov.in/writereaddata/ShippingNotices/202301200616440801897DGSCircular04of2023.pdf

(propulsion efficiency upgrades, ESDs, digital monitoring, performance verification during dry-docking).

5) Industrial lifecycle integration via national tonnage monitoring (shipbuilding + retrofit planning base)

DG Shipping's quarterly tonnage statement provides an institutional mechanism to track the Indian-flag fleet and its evolution; as of **31 March 2025**, it reports **1,549 ships** and **13.52 million GT**[6], offering a quantified planning base for staged retrofit and green newbuild programmes.

Key Considerations in NGSP under the Green Ships (Shipbuilding and Ship Repair) Pillar:

A. The Green Ships pillar is guided by the need to enable India's maritime sector to progressively comply with evolving international greenhouse gas and energy efficiency regulations, particularly those emerging under the IMO framework, while preserving operational continuity and the competitiveness of Indian shipping and shipbuilding industries.

B. The policy recognises that decarbonisation through shipbuilding and ship repair is inherently a lifecycle challenge, extending beyond new vessel construction to include retrofit pathways, operational optimisation, and maintenance regimes across existing fleets.

C. Given uncertainties in future propulsion technologies, cost trajectories, and regulatory evolution, the Green Ships pillar avoids prescribing a single technological pathway and instead promotes technology neutrality and design flexibility, allowing multiple low-emission solutions to evolve in parallel.

D. The framework supports phased and risk-managed adoption of green ship technologies, recognising that different vessel segments will transition at different speeds and that premature technological lock-in could expose shipowners and yards to stranded asset risks.

E. Early adoption is expected to be driven by energy-efficiency improvements and retrofit measures that minimise disruption to existing vessels and shipyard operations, while longer-term decarbonisation will require deeper integration of low-emission technologies and alternative-fuel-ready vessel designs.

F. The policy places strong emphasis on shipyard-led enablement, recognising shipyards as critical nodes for innovation, workforce development, and industrial scaling of green ship technologies.

G. Successful implementation depends on alignment between maritime decarbonisation objectives and national industrial and technology strategies, including domestic manufacturing of green maritime technologies and R&D ecosystems.

H. The pillar underscores the importance of pilot projects, demonstration vessels, and stakeholder collaboration to generate operational evidence, refine standards, and reduce uncertainty before large-scale replication.

[6] https://www.dgshipping.gov.in/WriteReadData/userfiles/file/Jan-March%202025.pdf

1.3 Green Shipping Across the Maritime Value Chain

1.4 Shipbuilding and Ship Repair for India's Green Shipping Transition

Shipbuilding and ship repair are positioned in the NGSP as structural enablers of maritime decarbonisation under the **Green Ships pillar**, reflecting a lifecycle-based approach rather than fuel-only transition logic. The framework aligns with evolving IMO instruments (EEDI, EEXI, CII and MRV systems), where compliance increasingly depends on inherent vessel efficiency, retrofit performance, and verified operational outcomes. Accordingly, green construction and retrofit capability are treated as long-term industrial assets, not peripheral activities.

International experience demonstrates a dual pathway:

- **Energy-efficient newbuilds** drive structural fleet transformation;
- **Systematic retrofit programmes** deliver near-term compliance across legacy fleets.

The NGSP mirrors this model, recognising India's gradual fleet turnover and the continued dominance of existing tonnage over the next two decades.

Vessel segmentation further shapes policy direction. Coastal and inland vessels - older and route-bound - are better suited to efficiency retrofits, hybridisation, and digital optimisation. Ocean-going vessels, with higher energy intensity, represent the principal platform for alternative-fuel-ready designs and advanced propulsion integration at the newbuild stage. Accordingly, new construction supports long-term decarbonisation, while repair and retrofit anchor near-term transition.

Green ships are defined not by a single technology pathway but by **performance-based integration** of hull optimisation, propulsion efficiency, alternative-fuel readiness, and digital monitoring. Shipyards are repositioned as industrial platforms for technology integration, compliance execution, and capability development, linking vessel decarbonisation with yard-level modernisation.

The NGSP adopts a systems-based framework integrating design standards, retrofit pathways, digital optimisation, certification mechanisms, and industrial capability—while preserving technology neutrality to avoid premature lock-in amid evolving fuel and regulatory trajectories.

Key Policy Signals on Shipbuilding and Ship Repairs from NGSP:

- Shipbuilding and repair are treated as primary decarbonisation levers, reflecting lifecycle emissions management.
- Newbuilds are prioritised for structural efficiency integration and future fuel readiness.
- Retrofit is positioned as the dominant near-term compliance pathway.
- Shipyards function as strategic execution platforms linking technology, certification, and industrial transformation.
- Digitalisation is embedded as both a performance and regulatory instrument.
- The framework emphasises performance-based outcomes and technology neutrality.

1.4.1 Energy-Efficient Ship Design (Green Newbuilds)

The NGSP frames energy-efficient ship design as a foundational decarbonisation measure aligned with IMO design-based instruments such as EEDI and successor regimes. Design-stage efficiency—through hull optimisation, propulsion refinement, and integrated energy systems—reduces baseline energy demand independent of fuel choice, generating cumulative lifecycle emissions benefits.

Given long vessel lifespans and the strategic role of domestic shipbuilding, newbuild efficiency is treated as a structural determinant of long-term regulatory viability rather than an optional enhancement.

Key Policy Signals on Energy-Efficient Ship Design from NGSP:

- Design efficiency is a core pillar of lifecycle decarbonisation.
- Alignment with IMO design-based frameworks signals tightening regulatory dependence on inherent vessel performance.
- Newbuilds are prioritised for efficiency integration and fuel-readiness.
- Performance-based standards are favoured over prescriptive technology mandates.
- Shipyards are central to translating regulatory benchmarks into physical vessel characteristics.

1.4.2 Ship Retrofit and Efficiency Upgrades

Retrofit is identified as the principal near-term decarbonisation pathway for India’s legacy fleet. Recognising economic and industrial constraints on rapid fleet replacement, the NGSP emphasises hydrodynamic improvements, energy-saving devices, propulsion optimisation, and digital performance tools to meet efficiency and carbon intensity thresholds.

Repair yards are repositioned from maintenance facilities to emissions-reduction execution nodes, supporting transitional compliance while extending asset life and mitigating stranded asset risks.

Key Policy Signals on Ship Retrofit from NGSP:

- Retrofit anchors near-term emissions reduction.
- Compliance is achieved primarily through modification, not replacement.
- Repair activity is repositioned as a decarbonisation function.
- Retrofit supports transition without premature scrapping.
- Lifecycle framing integrates retrofit and newbuild strategies.

1.4.3 Hybrid and Low-Emission Propulsion Integration

Hybrid systems are treated as transitional technologies enabling incremental emissions reduction while preserving compatibility with existing vessel architectures. Particularly suited to harbour, coastal, and inland fleets, hybrid propulsion supports load optimisation and partial electrification.

The NGSP frames hybridisation as a risk-managed bridge rather than a long-term end-state, consistent with technology-neutral transition logic.

Key NGSP Signals on Hybrid Propulsion Integration:

- Hybrid propulsion is an intermediate pathway.
- Deployment is segment-specific.
- The framework avoids long-term lock-in.
- Transition is progressive and adaptive.
- Policy reflects phased decarbonisation logic.

1.4.4 Digital and Operational Optimisation Systems

Digital systems—energy management platforms, emissions monitoring, and route optimisation—are embedded as cross-cutting enablers of efficiency and regulatory transparency. While not altering fuel characteristics, digitalisation reduces overall energy demand and strengthens MRV-based compliance.

For India, digital adoption offers a scalable, lower-disruption pathway for early emissions improvement, particularly where physical retrofits are constrained.

Key NGSP Signals on Digital Systems:

- Digitalisation supports monitoring, optimisation, and reporting.
- MRV alignment strengthens transparency and accountability.
- Digital systems amplify both design and retrofit measures.
- Real-time data replaces static compliance logic.
- Early gains are achievable with limited capital disruption.

1.4.5 Green Shipyards and Industrial Enablement

The NGSP extends decarbonisation beyond vessels to shipyard operations, recognising that green ships require green industrial ecosystems. Green shipyards are characterised by low-carbon production processes, electrified equipment, renewable energy integration, and structured certification compliance.

Shipyards are framed as industrial anchors for technology integration, workforce development, and regulatory execution-linking maritime decarbonisation with national manufacturing and competitiveness objectives.

Key Policy Signals on Green Shipyards:

- Vessel decarbonisation is linked to yard-level capability.
- Shipyards serve as implementation and compliance platforms.
- Yard modernisation supports industrial competitiveness.
- Workforce capability is integral to green deployment.
- Shipyard operations fall within the decarbonisation system boundary.

1.5 Possible Solutions and Key Opportunities

The table below outlines key solutions and opportunities for green shipping – shipbuilding and ship repair.

Solutions	Key Opportunities (India-focused action pathways)
A. Green Ship Certification & Compliance Standards (Newbuild + Major Retrofit "certification-ready")	Establish a **Green Ship Certification framework** covering both newbuilds and major retrofits, based on **design performance, operational efficiency and lifecycle emissions**.

	Use certification as the gateway for incentives (Shipbuilding Financial Assistance, port tariff rebates, green finance eligibility).
	Introduce an Indian "Green Ship Label" to ensure vessels built or retrofitted in India meet tightening international efficiency and carbon-intensity rules, improving export competitiveness of Indian yards.
	Develop certification pathways for retrofit packages (e.g., "CII-improvement retrofit", "alternative-fuel-ready retrofit") so yards can offer standardised upgrade bundles instead of one-off engineering solutions.
B. Monitoring, Reporting & Verification (MRV) and "Green Compliance Status" for shipyards and repair ecosystems	Establish a **national MRV system for ship energy use and emissions** and extend it to shipyards through a **Green Compliance Status** applicable to shipyards, ports and shipping companies.
	Make MRV yard-actionable by requiring repair yards to report at minimum: energy consumption, fabrication and welding loads, coating and paint controls, waste and hazardous material handling, and project-level carbon footprints for major refits.
C. Efficient Newbuild Ships (design + hull + propulsion efficiency as the first decarbonisation lever)	Prioritise **efficient newbuild ships** as the first structural decarbonisation step, focusing on **design optimisation and energy efficiency before fuel switching**.
	Create an Indian standard "efficiency kit" for newbuilds: energy-efficient hull forms, low-friction coatings, propulsor upgrades, waste-heat-recovery-ready layouts and digital optimisation packages.
	Reward ships that exceed baseline efficiency standards through higher incentives, lower port dues and preferential access to green finance.
D. Hybrid / Electric Newbuilds and Retrofit-ready Ships (coastal, inland and harbour craft focus)	Scale **hybrid newbuilds** and **retrofit-ready specifications** for vessels with predictable routes and frequent port calls (ferries, tugs, pilot boats, inland vessels).
	Combine this with Zero-Emission Zones (ZEZs) on priority coastal routes and inland waterways to create guaranteed demand for electric and hybrid fleets.
	Use public procurement and concession design (ferries, port craft, patrol boats) to rapidly expand battery-electric and hybrid vessels where operating profiles allow.
E. Retrofit Manufacturing Hub for Indian Shipyards (repair-led decarbonisation at scale)	Position India as a **retrofit manufacturing hub**, centred on ship-repair clusters capable of delivering **efficiency-improvement packages, propulsion upgrades, and fuel-ready conversions**.

	Implement financial risk-sharing mechanisms for retrofits (loan guarantees, insurance support, blended finance) to de-risk owner decisions and stabilise yard workloads.
	Standardise retrofit designs and class approval pathways to reduce engineering lead time, increase throughput and lower unit costs.
F. Shipbuilding Financial Assistance redesigned for decarbonisation outcomes	Use the Shipbuilding Financial Assistance framework as the **primary lever for green ships**, prioritising projects integrating **alternative fuels, hybrid systems and high-efficiency designs**.
	Expand eligibility beyond propulsion to include advanced hull designs, automation, digital energy management and efficiency technologies.
	Introduce tiered assistance levels specifically for green ships and retrofit projects, linked to certified environmental performance rather than only capital cost.
G. Global Ship Design Hub and R&D, testing and demonstration ecosystem	Build a **Global Ship Design Hub** anchored in Indian design capability and supported by validation and testing infrastructure.
	Establish a Green Innovation Fund for R&D, pilots and technology development, prioritising demonstration vessels and large-scale retrofit trials.
	Support staged testing and real-ship demonstrations of emerging propulsion and efficiency technologies before large-scale commercial deployment.
H. Workforce development, certification and industrial coordination	Strengthen **skill-development and knowledge-sharing programmes** to train naval architects, yard engineers and technicians in green ship technologies.
	Create a Green Talent Fund to support specialised training, scholarships and shipyard upskilling linked to certification and compliance levels.
	Use industry association platforms to aggregate demand, standardise retrofit kits and coordinate technology adoption across the shipbuilding and repair supply chain.
I. Electric boats and ferries (rapid wins for domestic decarbonisation)	Promote **electric boats and ferries** as the fastest-scaling segment for coastal and inland networks.
	Design route-based programmes combining fleet renewal, charging infrastructure and operational incentives.
	Use early deployments to build domestic capability in battery integration, shore-interface systems and specialised maintenance services.

2 Indicative Action Pathway

The NGSP sets out a phased, implementation-led pathway to decarbonise shipbuilding and ship repair by (i) accelerating green newbuilds (efficiency-first, alternative-fuel capable) and (ii) scaling retrofit and repair ecosystems that can deliver emissions-reduction outcomes quickly at fleet level, while building India's long-term industrial competitiveness. This approach is anchored in (a) financial and industrial levers already available to India (e.g., Shipbuilding Financial Assistance Policy), (b) standards/certification and MRV mechanisms, and (c) targeted capability development across shipyards, suppliers, and workforce.

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

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

A. Establish Green Shipbuilding & Repair Classification Frameworks

In the short term, the foundational requirement for greening shipbuilding and ship repair is the establishment of a nationally harmonised **green classification and compliance framework** applicable to Indian yards. This involves defining what constitutes a "green newbuild" and a "green retrofit" in the Indian regulatory context, aligned with IMO decarbonisation trajectories and lifecycle-based emissions accounting. The absence of standard definitions currently creates ambiguity for shipowners and shipyards regarding acceptable technologies, fuels, and performance thresholds. A short-term focus must therefore be on codifying performance-based criteria covering energy efficiency, propulsion readiness for alternative fuels, digital emissions monitoring, and retrofit compatibility. This framework should act as the entry gate for future incentives, certification, and financial support mechanisms, ensuring early alignment between regulatory intent and industrial practice.

Implementation Approach (0–6 Months):

The short-term objective under this action is to operationalise a nationally harmonised Green Shipbuilding and Green Ship Repair Classification Framework that clearly defines what qualifies as a "green" newbuild and a "green" retrofit in the Indian context. This framework must be performance-based, lifecycle-oriented, and aligned with IMO decarbonisation trajectories, while remaining technology-neutral to avoid premature lock-in to specific fuel pathways.

- **Constitute a Green Ship & Retrofit Standards Taskforce** through formal notification, comprising classification societies, major shipyards, repair clusters, naval architects, propulsion OEMs, and MRV specialists, with a mandate to deliver Version 1.0 of the Indian Green Shipbuilding and Repair Classification Framework.

- **Define a Tiered Green Yard Output Standard** covering Green Newbuild, Green Retrofit/Conversion, and Green Repair activities, structured across 2–3 progressive tiers (e.g., Baseline Green, Advanced Green, Zero-Emission Ready) with clearly defined requirements across design intent, build/repair execution, and verification protocols.

- **Embed "MRV-Ready by Design" Requirements**, specifying minimum onboard monitoring systems, data capture parameters, and handover documentation standards to ensure certified vessels generate credible emissions and performance data aligned with national reporting expectations.

- **Introduce Lifecycle and Retrofit-Readiness Provisions**, including design adaptability (space/weight allowances, modularity), material documentation standards, and basic design-for-recycling intent to prevent asset lock-in and future compliance bottlenecks.

- **Pilot the Framework on 2–3 Live Projects** (newbuild and retrofit cases), assess cost, documentation burden, and verification practicality, and issue Green Ship/Retrofit Classification Framework v1.0 as a national guideline circular linked to future incentive eligibility and early-adopter recognition (soft launch).

B. Initiate Retrofit-Readiness and Energy Efficiency Upgrade Programmes

Given the dominance of existing fleets and repair yards in India's maritime ecosystem, immediate decarbonisation impact can be achieved through structured retrofit-readiness programmes. In the short term, the emphasis must be on identifying repair and drydock facilities capable of undertaking energy efficiency upgrades such as hull optimisation, propeller upgrades, waste heat recovery systems, and digital fuel monitoring installations. This phase does not require full alternative fuel conversion but focuses on building technical confidence in modular retrofitting approaches. Establishing retrofit-ready standards for ship repair yards also reduces long-term lock-in risk by ensuring that vessels undergoing maintenance today remain adaptable for future fuel transitions. Early-stage retrofitting thus serves as both an emissions reduction measure and a workforce capability-building exercise for Indian yards.

Implementation Approach (0–6 Months):

- **Launch a National Green Retrofit Readiness Programme (GRRP)** defining eligible retrofit interventions that deliver immediate efficiency gains (e.g., hull and propeller optimisation, waste heat recovery, auxiliary load optimisation, energy management systems) while distinguishing these from structural "retrofit-ready" provisions (space, cabling, piping, control margins) for future hybrid or alternative fuel systems.
- **Standardise Retrofit Packages** (e.g., Energy Efficiency Package, Digital & MRV Package, Hybrid/Fuel-Ready Package) to reduce engineering uncertainty, shorten repair cycles, and align directly with the Green Ship/Retrofit Classification tiers under Action A, enabling automatic tier progression upon completion.
- **Designate Selected Repair Yards as Green Retrofit Pilot Yards**, supporting process adaptation, supervisor and fitter training, integration of energy upgrades into work-pack planning, and quality control protocols to shift yards from "maintenance only" to "maintenance + decarbonisation enablement."
- **Mandate Post-Retrofit Performance Documentation**, including fuel consumption baselines, efficiency gains, MRV system validation, and documentation of future-fuel adaptability (space, electrical margins, control readiness), feeding into a national retrofit performance registry.
- **Pilot the Programme on Selected Vessels and Yards** and issue a public GRRP guideline circular, positioning participation as linked to future green incentives and recognition under the national Green Classification Framework (soft launch, voluntary phase).

C. Launch Green Technology Compliance and Reporting for Shipyards

A critical short-term enabler is the introduction of structured **green technology reporting and compliance requirements** for shipyards and repair facilities. This involves mandating baseline data collection on energy use, emissions intensity, waste handling, and adoption of low-carbon equipment within yard operations. The objective is not punitive enforcement but the creation of a national performance baseline against which progress can be tracked. By institutionalising technology reporting at the yard level, policymakers gain visibility into gaps in electrification, digitalisation, and process efficiency. For shipbuilders and repairers, this introduces early exposure to environmental performance metrics that will increasingly shape market access and financing conditions in the medium term.

Implementation Approach (0–6 Months)

MoPSW and DG Shipping (DGS) will operationalise a structured Green Technology Compliance and Reporting Framework applicable to newbuild and major repair yards participating in NGSP-linked schemes.

- **Notify a Mandatory Green Technology & Emissions Inventory (GTEI)** requirement for participating shipyards, documenting installed production technologies, energy sources and consumption patterns, emissions-relevant processes (e.g., engine testing, coating, trials), and waste/hazardous material handling systems, using a standardised national inventory template.

- **Publish a Green Technology Compliance Matrix** mapping key yard processes (fabrication, outfitting, repair, testing) against NGSP-aligned objectives such as energy efficiency, electrification potential, emissions reduction, digital monitoring, and circularity, including baseline practices, preferred upgrade pathways, and indicative performance indicators.
- **Introduce a Standardised Yard-Level Digital Reporting Protocol**, defining common units, quarterly submission cycles, and compatibility with national MRV systems, covering energy consumption by production area, emissions-related activities, and green technology adoption metrics.
- **Link Compliance and Reporting to Classification and Incentive Eligibility**, explicitly tying participation in the reporting framework to qualification under the Green Ship/Retrofit Classification Framework (Action A), future financial incentives, and potential procurement preference mechanisms.
- **Pilot the Reporting System Across Representative Yard Categories** (large integrated yard, medium repair yard, regional/specialised yard), assess data burden and indicator practicality, refine compliance matrices, and issue a finalised national rollout circular.

D. Enable Early Adoption of Transitional and Drop-in Green Fuels for Repair & Trials

Short-term fuel transition in shipbuilding and repair should prioritise fuels that can be deployed without structural redesign of vessels. Drop-in biofuels, bio-LNG blends, and pilot methanol-compatible systems provide immediate learning platforms for Indian yards. In the repair context, this enables controlled trials of fuel systems, storage safety protocols, and bunkering interfaces. These early deployments reduce uncertainty around handling practices and technical integration while generating operational data. Importantly, this phase supports the NGSP principle of technology neutrality by avoiding premature lock-in to a single fuel pathway, while still building readiness for future hydrogen and ammonia systems.

Implementation Approach (0–6 Months):

- **Notify a Green Fuel Trial & Readiness Window**, permitting controlled use of certified drop-in fuels (e.g., biofuels, bio-LNG blends, methanol-compatible systems) during newbuild sea trials, post-repair trials, and limited operational demonstrations, with defined safety and reporting conditions.
- **Issue a Yard-Specific Green Fuel Safety & Handling Manual**, standardising temporary storage, system compatibility checks, fire safety, ventilation protocols, bunkering interfaces, and spill response measures tailored to shipyard and repair environments.
- **Mandate Fuel-Readiness Documentation** for participating projects, requiring declaration of drop-in compatibility, space and piping allowances for future alternative fuels, electrical capacity margins, and control system adaptability — aligned with Green Classification and retrofit frameworks.
- **Establish a Green Fuel Trial Reporting Protocol**, requiring post-trial performance, safety, and operational reports to be submitted into a centralised national repository managed by DGS for policy learning and infrastructure planning.
- **Link Participation to Classification and Incentive Eligibility**, formally recognising fuel trial engagement as a positive factor under the Green Ship/Retrofit Classification Framework, retrofit readiness programmes, and future green finance mechanisms.

E. Initiate Green Skills and Certification Pathways for Yard Workforce

Shipbuilding and repair decarbonisation cannot progress without parallel workforce transition. In the short term, the priority is to define skill standards and certification pathways for green ship design, alternative fuel handling, emissions monitoring systems, and energy efficiency retrofits. This phase focuses on curriculum development, institutional partnerships, and pilot training programmes rather than mass deployment. The objective is to prepare engineers, supervisors, and technicians for emerging roles linked to fuel systems integration, digital ship performance tools, and environmental compliance. By anchoring green transition within skill ecosystems early, resistance to technology change is reduced and domestic capability is strengthened.

Implementation Approach (0–6 Months)

- **Publish a Green Maritime Skills Framework for Shipyards and Repair Facilities**, mapping NGSP objectives into role-specific competency requirements for design engineers, production supervisors, welders, electricians, pipefitters, QA/QC personnel, dock managers, and retrofit specialists, covering energy efficiency, hybrid systems, alternative fuel awareness, MRV systems, and lifecycle-conscious construction practices.

- **Develop Modular, Short-Duration Green Certification Modules** (2–6 weeks) aligned to yard realities, covering energy-efficiency retrofits, emissions monitoring systems installation, hybrid and electric propulsion basics, alternative/blended fuel safety, and environmental compliance in repair operations — structured as green endorsements layered onto existing technical certifications.

- **Designate Selected Shipyards and Repair Clusters as Green Yard Training Hubs**, integrating classroom instruction with live project demonstrations and digital simulation tools, ensuring operational relevance and faster workforce absorption.

- **Embed Mandatory Safety and Environmental Compliance Components** into all green skill pathways, covering fire and explosion risks, fuel storage and handling protocols, coating and waste management controls, and emergency response procedures specific to yard environments.

- **Link Green Certification to Classification and Incentive Eligibility**, formally recognising certified workforce presence as a qualifying or positive criterion under the Green Ship/Retrofit Classification Framework (Action A), Retrofit Readiness Programme (Action B), and future financial or demonstration schemes.

F. Strengthen Green Recycling Linkages with Ship Repair and End-of-Life Planning

Short-term action must also integrate ship repair and ship recycling under a circular economy logic. Repair yards act as transitional nodes between operational vessels and end-of-life dismantling. Introducing documentation requirements on material composition, hazardous substances, and recyclability at the repair stage creates traceability across the vessel lifecycle. This supports compliance with Hong Kong Convention standards and EU Ship Recycling Regulation equivalence while laying the groundwork for green ship design-for-recycling principles. Early integration of recycling logic into repair processes prevents future compliance shocks and aligns India's shipbreaking ecosystem with green shipping objectives.

Implementation Approach (0–6 Months):

- **Notify a Repair-to-Recycling Traceability Pack (RRTP)** requirement for vessels undergoing major repair, life extension, or conversion at participating yards, consolidating updated equipment lists, hazardous material handling records, waste disposal documentation, and structural modification logs into a standardised lifecycle-ready template.

- **Issue a Green Repair Environmental & Safety SOP Addendum** aligned with Hong Kong Convention principles, covering hazardous waste segregation, spill prevention, controlled disposal, and documentation protocols adapted specifically to repair yard environments.

- **Introduce a Design-for-Recycling Checklist for Repairs and Conversions**, guiding material selection, coating choices, modular layouts, and documentation practices that improve future dismantling safety and recyclability without requiring full redesign of vessels.
- **Establish a Repair Yard Recycling Transparency Reporting Template**, requiring structured reporting of hazardous waste volumes, disposal pathways, and authorised facility usage, forming the foundation for integration into national recycling monitoring systems.
- **Pilot Lifecycle Documentation Flow Between a Repair Yard and an HKC-Aligned Recycling Yard**, testing whether repair-stage traceability improves end-of-life preparedness, and refine documentation templates and SOPs based on recycler validation feedback.

G. Establish Institutional Coordination and Financial Signalling for Green Yards

The final short-term pillar is institutional rather than technological. Immediate action is required to clarify the governance architecture linking shipyards, regulators, classification societies, and financial institutions under the NGSP framework. This includes signalling preferential treatment for green-certified yards through existing shipbuilding assistance schemes and green finance instruments. While large-scale funding mobilisation is a medium-term objective, short-term emphasis lies in establishing eligibility rules, risk-sharing logic for retrofits, and alignment between environmental performance and fiscal incentives. This ensures that early movers in green shipbuilding and repair are rewarded rather than penalised during the transition phase.

Implementation Approach (0–6 Months):

- **Constitute a Green Shipyard Coordination Mechanism (GSCM)** under NGSP to align regulators, classification societies, shipyards, repair clusters, and public financial institutions. The platform will synchronise technical standards (Actions A–F), reporting requirements, and financial eligibility rules, meeting on a defined review cycle.
- **Insert Green Eligibility Clauses into Existing Maritime Support Schemes**, linking access or prioritisation to participation in green classification (A), retrofit readiness (B), yard reporting (C), fuel trials (D), and skills certification (E), with a defined transition window for non-compliant yards.
- **Recognise "Green-Compliant Yards" for Lending and Insurance Purposes**, through a joint advisory with public sector banks and development finance institutions, enabling preferential treatment, transition-risk recognition, and access to green finance instruments.
- **Integrate Green Compliance into Public Procurement and Chartering Criteria**, introducing preferential scoring or eligibility for vessels and yards meeting NGSP-aligned standards in government-linked newbuild, repair, and demonstration projects.
- **Launch a National Registry of NGSP-Aligned Green Shipyards and Repair Yards**, providing public visibility of verified early movers and creating reputational and commercial incentives for compliance.

2.2 Medium-term Action Plan (Upto 2 Years)

The medium-term focus is to move from definition to operational execution at scale, by (i) locking down standards, certification and reporting, (ii) scaling retrofit throughput, and (iii) industrialising green shipbuilding competitiveness (design, OEM tie-ups, workforce, and supply chain).

A. Scaling Green Ship Design, Newbuild Standards & Retrofit Programs

In the medium term, India's shipbuilding and ship repair ecosystem should transition from demonstration projects to mainstream integration of green design principles across newbuilds and repair/refit activity. This phase focuses on embedding energy-efficient hull forms, hybrid propulsion readiness, and low-emission equipment as default technical standards rather than niche options. Shipyards are expected to build institutional design capability for alternative fuel readiness (methanol-ready, ammonia-ready, hybrid-ready), while repair yards expand capacity for energy-efficiency retrofits such as air-lubrication systems, waste heat recovery, wind-assisted propulsion devices, and digital energy management systems. The medium term is critical for converting regulatory intent into repeatable industrial practices, ensuring that green ships are no longer treated as special projects but as commercially viable products supported by domestic design and engineering competence.

Implementation Approach (6–24 Months):

- **Notify Green Newbuild Technical Design Standards** by upgrading the short-term Green Classification Framework into vessel-category standards (coastal/inland/ferries/OSVs and selected ocean-going classes), covering minimum energy-efficiency thresholds, mandatory fuel-readiness design provisions, and MRV/digital energy management integration at design stage.

- **Institutionalise National Retrofit Programmes** by converting retrofit readiness into structured schemes with standard retrofit packages, segment-specific eligibility criteria, approved equipment lists, and class-verified installation practices, delivered through certified Green Retrofit Execution Yards across major repair clusters.

- **Build Indigenous Alternative-Fuel and Hybrid Design Capability** through structured capability programmes linking shipyards, OEMs, classification societies, and Indian R&D institutions to enable dual-fuel/hybrid system integration, alternative-fuel safety architecture, and risk-based design processes (HAZID/HAZOP), supported by targeted demonstrations.

- **Embed International Alignment into Standards Updates**, ensuring Indian newbuild and retrofit requirements stay consistent with evolving IMO lifecycle accounting and major export-market regulations, through periodic technical circular updates rather than one-time standards.

- **Establish Performance Feedback Loops Using MRV Data**, capturing operational performance from green newbuilds and retrofits and feeding insights into revised design guidelines, retrofit packages, and equipment qualification lists.

B. Deployment of Green Shipyard Infrastructure & Low-Carbon Manufacturing

During this phase, shipyards and repair facilities must move from energy audits and pilot installations to systematic conversion of yard infrastructure toward low-carbon operations. This includes electrification of yard equipment, integration of rooftop and captive renewable power, replacement of fossil-fuel-based material handling with electric alternatives, and improved energy management systems across dry docks and workshops. The medium term also enables adoption of green construction practices such as modular fabrication (reducing rework and material waste), digital twins for production planning, and cleaner coating and surface treatment technologies. This transforms shipyards themselves into demonstration sites of industrial decarbonisation, strengthening their credibility as builders and maintainers of green vessels while reducing embedded emissions in ship construction and repair activities.

Implementation Approach (6–24 Months):

- **Scale Low-Carbon Yard Energy Systems** by enabling large-scale rooftop/captive renewable installations, electrification of auxiliary systems, hybridisation of captive power with storage, and deployment of energy management systems to actively reduce energy intensity per CGT or dock cycle.

- **Electrify and Modernise Yard Equipment** through phased replacement of diesel-based cranes, forklifts, generators, and blasting systems with electric or high-efficiency alternatives, alongside expansion of CNC cutting, robotic welding, and modular block fabrication to reduce material waste and rework.

- **Institutionalise Green Construction Protocols** by embedding modular fabrication, advanced low-emission coating systems, solvent recovery, waste segregation, and water recycling into standard operating procedures, with environmental KPIs integrated into QA/QC and production planning systems.

- **Deploy Digital Twin & Smart Manufacturing Tools** that integrate energy use, emissions, and material flows into production sequencing decisions, allowing yards to optimise both cost and carbon through data-driven scheduling and resource allocation.

- **Link Infrastructure Upgrades to Certification & Finance**, formally recognising low-carbon yard infrastructure within green shipyard certification frameworks and aligning eligibility with concessional finance, blended finance instruments, and preferential procurement pathways.

C. Integration of Alternative Fuels into Shipbuilding & Repair Ecosystems

The medium term is when alternative fuels shift from conceptual readiness to operational integration within shipyards and repair facilities. This includes development of technical capability for installing and maintaining dual-fuel engines, fuel storage systems, safety systems, and bunkering interfaces for methanol, LNG, biofuels, and early hydrogen/ammonia applications. Ship repair yards become key actors in converting existing fleets for compliance with evolving fuel standards. At this stage, India begins building domestic technical competence in fuel-system engineering, reducing dependence on imported turnkey solutions and ensuring Indian yards can serve both domestic and export markets. This phase also establishes feedback loops between fuel producers, classification societies, and shipyards, aligning vessel design, fuel availability, and safety regulation into a coordinated transition architecture.

Implementation Approach (6–24 Months):

- **Build Full Alternative-Fuel Construction & Conversion Capability** by enabling shipyards to integrate dual-fuel engines, fuel storage tanks, safety systems, and control architecture into standard workflows, supported by formal HAZID/HAZOP studies and class-approved safety cases.

- **Develop Yard-Level Fuel Handling & Bunkering Interfaces** through installation of compliant transfer systems, gas detection, fire suppression, and emergency response arrangements in selected shipbuilding and repair hubs, coordinated with port authorities and fuel suppliers.

- **Standardise Alternative-Fuel Design & Conversion Guidelines** by issuing nationally notified technical rules covering tank design, safety zoning, redundancy, fail-safe logic, and dual-fuel integration—aligned with IMO and class frameworks but adapted to Indian vessel segments.

- **Integrate Fuel Transition with MRV & Lifecycle Accounting** by mandating onboard emissions monitoring, digital reporting compatibility, and documentation of well-to-wake performance for all alternative-fuel projects to inform national fuel pathway decisions.

- **Link Fuel Integration to Market & Finance Mechanisms** by recognising alternative-fuel vessels under national green certification, prioritising them for green finance and demonstration support, and positioning them as export-ready low-emission vessels.

D. Institutionalisation of Green Certification, MRV & Digital Compliance Systems

Medium-term action shifts from voluntary reporting to formalised green compliance mechanisms for ships and shipyards. This includes operationalising national green ship certification frameworks, lifecycle carbon performance benchmarks, and digital Monitoring-Reporting-Verification (MRV) systems linked to yard operations and vessel performance. Shipyards and repair facilities begin reporting energy use, emissions, and material efficiency metrics, enabling benchmarking and continuous improvement. This phase embeds transparency into industrial practice and links compliance with financial incentives, insurance conditions, and export competitiveness. Over time, this creates a data-driven governance ecosystem where green performance becomes measurable, auditable, and commercially meaningful for shipbuilders and repair operators.

Implementation Approach (6–24 Months):

- **Notify Formal Green Ship & Shipyard Certification Regimes** with defined applicability thresholds, audit requirements, validity cycles, and re-certification rules covering newbuilds, retrofits, and repair activities.
- **Operationalise a National Digital Maritime MRV Platform** capturing ship-level fuel/emissions data, yard-level energy and material efficiency metrics, and retrofit/alternative fuel performance outcomes through standardised reporting templates and digital interfaces.
- **Embed Lifecycle & Material Efficiency Metrics** within certification logic, incorporating well-to-wake emissions (where applicable), embedded construction emissions, waste management indicators, and recyclability documentation into compliance assessments.
- **Link Certification & MRV Outcomes to Finance and Oversight Functions** by integrating compliance status into green finance eligibility, insurance risk assessment, and Port State Control prioritisation through formal data-sharing arrangements.
- **Establish Continuous Review & International Alignment Mechanisms** through a standing technical committee responsible for periodic updates to certification criteria and MRV indicators aligned with IMO developments and export market standards.

E. Development of Green Ship Recycling Linkages with Shipbuilding & Repair

The medium term enables structural integration between shipbuilding, ship repair, and ship recycling under circular-economy principles. This includes designing vessels with end-of-life dismantling considerations, improving hazardous material inventories, and upgrading recycling yards to meet Hong Kong Convention and EU Ship Recycling Regulation standards. Repair yards begin functioning as intermediaries for life-extension and safe decommissioning planning, while shipbuilders incorporate recyclable materials and modular design. This stage transforms recycling from a downstream activity into an integrated industrial function, reinforcing India's competitiveness in sustainable maritime manufacturing and ensuring environmental safeguards are aligned across the vessel lifecycle.

Implementation Approach (6–24 Months):

- **Notify a Lifecycle Compliance Framework** linking ship design, repair documentation, and recycling requirements through mandatory hazardous material inventories (IHM), material traceability, and end-of-life compatibility provisions.
- **Designate and Upgrade Green Recycling Anchor Yards** aligned with Hong Kong Convention and international-equivalent standards, formally integrating them with shipbuilding and repair clusters to create documentation feedback loops.
- **Establish a National Hazardous Material & Waste Traceability System** digitally linking shipyards, repair yards, and recycling yards to ensure lifecycle documentation is continuously updated and verifiable.
- **Embed Design-for-Recycling Requirements** into green ship and retrofit technical standards, covering modular design, material selection, dismantling compatibility, and recyclability criteria.

- **Link Recycling Compliance to Certification & Finance** by integrating traceability and IHM maintenance into green certification renewals, retrofit eligibility, and green finance access mechanisms.

F. Mobilisation of Green Finance for Shipbuilding & Retrofit Markets

In the medium term, financial mechanisms move from pilot incentives to structured market instruments supporting green shipbuilding and retrofit programs. This includes operationalisation of enhanced Shipbuilding Financial Assistance (SBFA) schemes for green vessels, risk-sharing mechanisms for retrofits, blended finance for yard upgrades, and eligibility of shipyards for green bonds and sustainability-linked loans. Financial institutions begin using certified green performance as underwriting criteria, shifting investment logic from asset value alone to lifecycle emissions performance. This embeds decarbonisation within industrial finance, enabling shipbuilders and repair yards to plan capital investments with reduced risk and longer-term visibility.

Implementation Approach (6–24 Months):

- **Operationalise Dedicated Green Finance Windows** within existing maritime schemes (including SBFA enhancements) for green-certified newbuilds, retrofit projects, and yard infrastructure upgrades, offering differentiated terms (longer tenors, reduced margins, structured repayment).

- **Embed Green Performance into Lending Frameworks** by integrating certification status, MRV performance data, lifecycle emissions metrics, and recycling compliance into maritime credit appraisal and risk assessment guidelines.

- **Introduce Blended Finance & Risk-Sharing Instruments** (partial guarantees, co-financing, interest subvention) to de-risk first-mover retrofits, alternative-fuel vessels, and capital-intensive yard decarbonisation investments.

- **Enable Access to Capital Markets** through green bonds, sustainability-linked loans, and transition finance instruments for shipyards and shipowners, supported by clear eligibility and reporting standards to ensure credibility.

- **Link Financial Access to Certification & MRV Compliance**, ensuring that green finance eligibility is contingent on verified performance under national green ship, yard certification, and recycling traceability frameworks.

G. Workforce Transformation & Technology Absorption in Shipyards

The medium term is when skill development transitions from awareness to specialised workforce transformation. This includes structured certification programs for alternative fuel systems, green coatings, digital energy management, and environmental compliance. Engineering curricula, vocational programs, and shipyard apprenticeships are aligned with green shipbuilding needs, creating a domestic talent pipeline capable of sustaining technological change. At this stage, the workforce becomes a strategic enabler rather than a constraint, ensuring that green ship design, construction, and repair are supported by trained technicians, engineers, inspectors, and safety professionals. This anchors the transition in human capital rather than only hardware investment.

Implementation Approach (6–24 Months):

- **Operationalise Dedicated Green Finance Windows** within existing maritime schemes (including SBFA enhancements) for green-certified newbuilds, retrofit projects, and yard infrastructure upgrades, offering differentiated terms (longer tenors, reduced margins, structured repayment).

- **Embed Green Performance into Lending Frameworks** by integrating certification status, MRV performance data, lifecycle emissions metrics, and recycling compliance into maritime credit appraisal and risk assessment guidelines.

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- **Enable Access to Capital Markets** through green bonds, sustainability-linked loans, and transition finance instruments for shipyards and shipowners, supported by clear eligibility and reporting standards to ensure credibility.

- **Link Financial Access to Certification & MRV Compliance**, ensuring that green finance eligibility is contingent on verified performance under national green ship, yard certification, and recycling traceability frameworks.

2.3 Long-term Action Plan (Upto 5 Years)

A. Full Transition to Net-Zero–Aligned Green Ship Design and Construction

In the long term, India's shipbuilding industry is expected to complete its shift from transitional green vessels toward net-zero-aligned ship design and construction as the industrial norm. This phase focuses on embedding zero- and near-zero-emission propulsion technologies, advanced hull optimisation, lightweight materials, and digital performance management into mainstream ship production. Shipyards evolve from compliance-driven builders into centres of excellence for low- and zero-carbon ship design, capable of producing vessels optimised for hydrogen, ammonia, methanol, and future fuels. Green ship design becomes export-oriented and globally competitive, aligned with IMO decarbonisation trajectories and international carbon intensity standards. This stage represents a structural repositioning of India's shipbuilding sector from cost-based competition to technology-led, sustainability-driven market leadership.

Implementation Approach (5+ Years):

- **Notify a Net-Zero Ship Design Code for India**, replacing transitional green standards and making net-zero alignment mandatory for newbuild approvals, including fuel compatibility, lifecycle carbon thresholds, and digital MRV integration at design stage.

- **Institutionalise Zero- and Near-Zero-Emission Propulsion Capability** across major shipyards, ensuring permanent engineering competence, secured supply chains, and routine production of hydrogen-, ammonia-, methanol-, and advanced hybrid-ready vessels.

- **Mandate Lifecycle & Design-for-Recycling Standards**, embedding circularity, embedded carbon reduction, modular upgrade pathways, and recyclability requirements into naval architecture rules and class approvals.

- **Align Indian Design Rules with Global Carbon Regimes**, harmonising national standards with IMO lifecycle frameworks and major export market requirements to ensure global trading eligibility and export competitiveness.

- **Establish a Continuous Design–Operation–Innovation Feedback Loop**, integrating MRV performance data from operating vessels into periodic updates of ship design codes to ensure adaptive, evidence-based standard evolution.

B. Transformation of Shipyards into Low-Carbon and Circular Manufacturing Hubs

Over the long term, shipyards and ship repair facilities transition into low-carbon industrial ecosystems, rather than merely energy-efficient production sites. Yard operations are powered predominantly by renewable energy, supported by electrified equipment, automated fabrication systems, and smart energy management platforms. Material flows within yards are optimised through circular manufacturing principles, enabling reuse, recycling, and minimal waste generation. Ship repair yards become integral nodes in lifecycle emissions reduction, serving as hubs for upgrades, retrofits, and life-extension strategies. This transformation ensures that both vessels and the facilities that build and maintain them are aligned with national net-zero objectives, strengthening India's credibility in sustainable industrial manufacturing.

Implementation Approach (5+ Years):

- **Notify a Low-Carbon Shipyard Operating Code**, introducing mandatory yard-level emissions intensity benchmarks (e.g., per CGT or per dock cycle), verified through integrated MRV and energy management systems.
- **Institutionalise Renewable Energy, Electrification & Automation as the Dominant Operating Model**, requiring large yards to transition to renewable-dominated energy mixes, electrified material handling and fabrication systems, and digitally optimised production planning.
- **Embed Circular Manufacturing Principles into Yard Operations**, including recycled material integration, structured waste recovery, solvent and water recycling systems, and closed-loop steel flows linked with certified recycling yards.
- **Integrate Yard Performance into Carbon Markets & Sustainability Frameworks**, linking emissions performance to national carbon accounting, green finance eligibility, export competitiveness, and insurance risk assessment.
- **Establish Permanent Green Industrial Innovation Pathways**, mandating ongoing modernisation, energy optimisation, and advanced manufacturing upgrades (robotics, modularisation, additive manufacturing) supported by targeted R&D and innovation frameworks.

C. Maturity of Alternative Fuel Integration and National Fuel Ecosystems

By the long-term horizon, alternative fuels move from early deployment into systemic integration across shipbuilding and ship repair ecosystems. Indian yards routinely construct and retrofit vessels for hydrogen, ammonia, methanol, biofuels, and emerging e-fuels, supported by stable domestic fuel supply chains and standardised safety frameworks. Fuel storage, handling, and bunkering systems are fully harmonised with vessel design, port infrastructure, and regulatory controls. This phase also enables India to link vessel manufacturing with green fuel production zones and maritime corridors, positioning shipyards as enablers of national fuel transition strategies. Alternative fuel capability becomes a permanent industrial competency rather than a niche technical function.

Implementation Approach (5+ Years):

- **Mandate Zero- and Near-Zero-Emission Fuels as the Default Design Basis** for defined vessel segments, progressively restricting fossil-only propulsion and phasing out transitional dual-fuel configurations.
- **Integrate Shipyards with National Green Fuel Production & Corridor Strategies**, linking vessel design portfolios with hydrogen, ammonia, green methanol hubs, and designated low-carbon shipping corridors to ensure fuel–vessel–infrastructure alignment.
- **Standardise Alternative-Fuel Safety & Lifecycle Operational Codes**, harmonising construction, repair, bunkering, storage, crew certification, and emergency response requirements across the vessel lifecycle.
- **Embed Mandatory Lifecycle (Well-to-Wake) Fuel Accounting** within certification and MRV regimes, ensuring fuel eligibility for green status, finance, and market access is based on verified upstream and downstream emissions performance.

- **Position India as a Regional Supplier of Alternative-Fuel Vessel Solutions**, promoting export-ready green vessel classes, retrofit services, and participation in international green corridor projects.

D. Institutionalisation of Lifecycle Regulation, MRV, and Global Compliance Alignment

In the long term, green certification and MRV systems evolve into a comprehensive lifecycle regulatory regime covering ship design, construction, operation, repair, and recycling. Compliance is no longer limited to operational emissions but incorporates embedded carbon, material efficiency, recyclability, and fuel lifecycle performance. Digital MRV platforms enable real-time integration of yard-level, vessel-level, and recycling-stage data, supporting both domestic regulation and international reporting obligations. This phase embeds India's maritime sector into global carbon accounting and compliance architectures, ensuring that Indian-built and Indian-serviced vessels meet future international environmental market access requirements.

Implementation Approach (5+ Years):

- **Mandate Zero- and Near-Zero-Emission Fuels as the Default Design Basis** for defined vessel segments, progressively restricting fossil-only propulsion and phasing out transitional dual-fuel configurations.
- **Integrate Shipyards with National Green Fuel Production & Corridor Strategies**, linking vessel design portfolios with hydrogen, ammonia, green methanol hubs, and designated low-carbon shipping corridors to ensure fuel–vessel–infrastructure alignment.
- **Standardise Alternative-Fuel Safety & Lifecycle Operational Codes**, harmonising construction, repair, bunkering, storage, crew certification, and emergency response requirements across the vessel lifecycle.
- **Embed Mandatory Lifecycle (Well-to-Wake) Fuel Accounting** within certification and MRV regimes, ensuring fuel eligibility for green status, finance, and market access is based on verified upstream and downstream emissions performance.
- **Position India as a Regional Supplier of Alternative-Fuel Vessel Solutions**, promoting export-ready green vessel classes, retrofit services, and participation in international green corridor projects.

E. Integration of Ship Recycling into a National Circular Maritime Economy

By the five-year horizon, ship recycling is fully integrated with shipbuilding and repair under a national circular maritime economy model. Vessels are designed for dismantling from the outset, repair yards maintain continuous hazardous material inventories, and certified recycling yards operate with mechanised, low-emission, and safe dismantling systems. Recycling shifts from being an end-of-life disposal activity to a strategic industrial function linked to material recovery, secondary steel supply, and sustainable manufacturing chains. This integration ensures that environmental responsibility is embedded across the entire vessel lifecycle and that India's recycling sector becomes globally recognised for compliant, transparent, and sustainable practices.

Implementation Approach (5+ Years):

- **Make Green Certification the Default National Compliance Regime**, transitioning from parallel conventional and green pathways to a unified certification architecture where lifecycle carbon performance, recyclability compliance, and digital reporting are mandatory across defined vessel classes and shipyard categories.
- **Operationalise a Fully Integrated Maritime Digital MRV Ecosystem**, enabling real-time or near-real-time data integration from ships, shipyards, repair facilities, and recycling yards into a central compliance and benchmarking platform aligned with national and international carbon accounting standards.

- **Embed Lifecycle Carbon Accounting into Regulatory and Market Access Systems**, incorporating well-to-wake fuel performance, embedded construction emissions, and end-of-life compliance into certification renewal, port state control prioritisation, and export eligibility frameworks.

- **Integrate Certification Data with Financial, Insurance, and Carbon Market Mechanisms**, ensuring that verified green performance directly influences lending rates, insurance risk profiles, carbon pricing exposure, and sustainability-linked finance instruments.

- **Establish a Permanent Technical Review & International Alignment Mechanism**, maintaining continuous updates to certification criteria and MRV indicators in response to IMO developments, evolving fuel pathways, and global market requirements.

F. Establishment of a Mature Green Maritime Finance and Investment Market

In the long term, green finance transitions from targeted incentives into a self-sustaining maritime investment ecosystem. Shipyards and shipowners access capital markets through green bonds, sustainability-linked instruments, and transition finance mechanisms aligned with verified emissions performance. Financial institutions routinely integrate lifecycle carbon risk into lending decisions, and public funds shift toward strategic innovation and technology leadership rather than risk mitigation. This stage ensures that green shipbuilding and repair are no longer dependent on subsidies but supported by market-based finance structures that reward long-term environmental performance and industrial resilience.

Implementation Approach (5+ Years):

- **Mandate Design-for-Recycling Requirements** within national ship design and certification rules, requiring all newbuilds and major conversions to demonstrate modularity, material traceability, and dismantling compatibility at design approval stage.

- **Institutionalise Continuous Hazardous Material Traceability**, transforming the Inventory of Hazardous Materials (IHM) into a digitally maintained lifecycle system integrated with MRV and certification platforms.

- **Develop a Certified Network of High-Compliance Recycling Yards**, operating at Hong Kong Convention–aligned standards with mechanised dismantling, environmental controls, worker safety systems, and transparent reporting.

- **Position Repair Yards as Lifecycle Transition Nodes**, embedding decommissioning planning, reusable component recovery, and circular material routing into major repair and life-extension processes.

- **Link Recycling Compliance to Certification, Finance & Market Access**, ensuring that end-of-life alignment influences green certification renewal, access to finance, insurance terms, and international trading credibility.

G. Emergence of a Globally Competitive Green Maritime Workforce and Innovation System

By the long-term stage, India develops a globally competitive green maritime workforce, supported by advanced education, research, and innovation ecosystems. Shipyard workers, engineers, and inspectors operate within specialised green skill frameworks covering alternative fuels, digital compliance systems, and sustainable manufacturing. Continuous innovation in ship design, fuel systems, and lifecycle optimisation is driven by partnerships between shipyards, research institutions, and international collaborators. This phase ensures that technological leadership and human capital evolve together, anchoring India's position as a hub for green shipbuilding, green repair, and sustainable maritime services.

Implementation Approach (5+ Years):

- **Establish Green Maritime Professional Specialisations**, embedding zero-emission propulsion, lifecycle design, digital MRV, circular manufacturing, and alternative fuel safety tracks within national qualification, licensing, and continuous professional development systems.

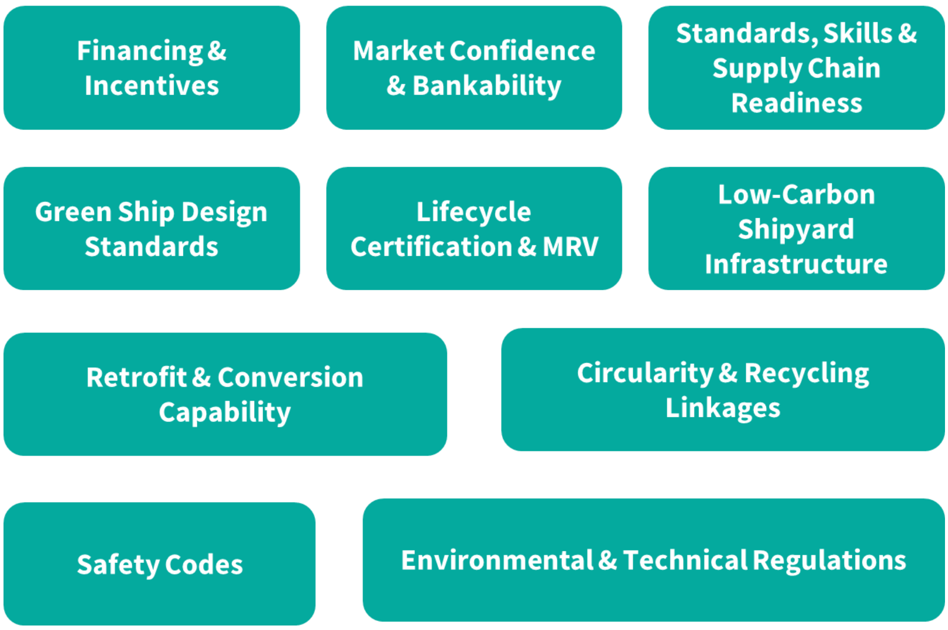
- **Create a Permanent Green Maritime Innovation Network**, linking shipyards, universities, classification societies, and fuel technology developers to sustain R&D in next-generation vessels, advanced materials, propulsion systems, and lifecycle optimisation technologies.

- **Institutionalise Continuous Workforce Upgrading & Re-Certification**, ensuring structured curriculum updates and mandatory re-certification aligned with evolving fuel technologies, safety regimes, and international regulatory developments.

- **Position Indian Shipyards as Global Green Skill & Service Hubs**, promoting training exports, alternative-fuel vessel expertise, retrofit services, and recycling-linked lifecycle solutions through international partnerships and corridor participation.

- **Embed Skills & Innovation into Finance and Regulatory Incentives**, linking workforce capability and innovation performance to certification, green finance access, export eligibility, and participation in advanced vessel programmes.

To summarize, the building blocks for the Green Shipping (Shipbuilding & Ship Repair) pillar implementation are as indicated in the diagram below:



3 Responsibility Mapping

The implementation of the Green Shipping pillar for Shipbuilding and Ship Repair under the NGSP requires coordinated action across industrial, regulatory, financial, and knowledge institutions. Unlike fuels, this pillar spans the entire vessel lifecycle, from design and construction to repair, retrofit, and end-of-life recycling. Clear allocation of responsibilities is therefore essential to ensure alignment between policy intent, industrial execution, safety regulation, and market uptake.

This responsibility mapping framework identifies the key stakeholders involved in green shipbuilding and ship repair and clarifies their respective roles across policy formulation, standard-setting, infrastructure development, certification, workforce enablement, and lifecycle compliance. The framework is intended to support effective coordination, accountability, and phased execution of green shipping initiatives under the NGSP.

Category	Stakeholder	Primary Role
Policy & Governance	**Ministry of Ports, Shipping and Waterways (MoPSW)**	Apex policy owner for the Green Shipping pillar; strategic direction for green shipbuilding and ship repair; coordination across ports, yards, and maritime agencies
	Directorate General of Shipping (DG Shipping)	Regulatory authority for ship design approval, construction oversight, retrofit certification, lifecycle compliance, and safety regulation for green ships
	Department for Promotion of Industry and Internal Trade (DPIIT)	Industrial policy alignment, manufacturing ecosystem development, localisation of green shipbuilding technologies and equipment
	Ministry of Environment, Forest and Climate Change (MoEFCC)	Environmental regulation, lifecycle emissions alignment, circular economy and ship recycling policy coherence
Shipyards & Industrial Infrastructure	**Public and Private Shipyards**	Implementation of green ship design standards, low-carbon construction practices, retrofit and conversion execution, yard-level decarbonisation
	Ship Repair Yards	Energy-efficiency retrofits, alternative fuel conversions, lifecycle documentation updates, decommissioning and recycling readiness
	Port Authorities (as Yard Hosts)	Provision of enabling infrastructure, utilities, safety coordination, and integration of green yard operations within port ecosystems
Design, Standards & Certification	**Classification Societies**	Approval of green ship designs, certification of alternative technologies, verification of retrofit and lifecycle compliance

	Bureau of Indian Standards (BIS)	Development of technical standards for materials, equipment, construction practices, and environmental performance
	Technical Committees / Expert Panels	Advisory support for evolving green ship design rules, recyclability standards, and technology adoption
Safety & Environmental Compliance	**DG Shipping (Safety Wing)**	Enforcement of construction, repair, and conversion safety requirements, including emerging technologies
	Emergency & Disaster Management Authorities	Yard-level and port-level emergency preparedness for new technologies, materials, and fuels
	Pollution Control Boards	Oversight of yard emissions, waste handling, hazardous materials, and environmental compliance
Finance & Market Enablement	**Shipping Ministry Financing Bodies / PSU Lenders**	Targeted financing for green shipbuilding, retrofits, and yard upgrades; alignment of incentives with certification outcomes
	Multilateral & Development Finance Institutions	Concessional finance, risk-sharing instruments, and technical assistance for first-of-kind projects
	Insurance Providers	Risk assessment and premium differentiation based on green compliance and lifecycle performance
Shipowners & Operators	**Indian Shipowners' Association**	Demand aggregation, fleet transition planning, feedback on operational performance of green vessels
	Public Sector Vessel Operators	Early adoption of green ships and retrofits; demonstration and market creation
Recycling & Circularity	**Certified Ship Recycling Yards**	Environmentally sound dismantling, material recovery, compliance with international recycling standards
	Repair Yards (Lifecycle Interface Role)	Identification of end-of-life readiness, material recovery pathways, and documentation continuity
Knowledge & Capacity Building	**Indian Maritime University (IMU)**	Curriculum development, professional training, and green skill certification
	Technical Institutes & Skill Councils	Workforce upskilling for green shipbuilding, repair, safety, and digital compliance
	Research Institutions & Think Tanks	Applied research, benchmarking, lifecycle studies, and policy support

4 Critical Barriers

The transition to green shipbuilding and ship repair in India is constrained by a combination of **industrial readiness gaps, regulatory uncertainty, high capital intensity, and limited lifecycle integration**. As highlighted in the NGSP baseline study, many of these barriers are structural in nature and arise from fragmented supply chains, uneven technology access, and weak alignment between design, construction, repair, and recycling stages. Without targeted intervention, these barriers will slow the scale-up of green ships and undermine the credibility of lifecycle-based compliance frameworks.

To enable effective implementation of the Green Shipping pillar for shipbuilding and ship repair, the following critical barriers must be addressed:

4.1 Uneven shipyard capability for green construction and complex retrofits

The NGSP identifies significant variation in technological maturity and infrastructure across Indian shipyards. While a few large yards can adopt energy-efficient designs and advanced production methods, many small and medium yards rely on conventional construction practices, limited automation, and legacy equipment. This constrains their ability to build hybrid or alternative-technology vessels and to execute sophisticated retrofit projects involving new propulsion systems, energy-saving devices, or digital monitoring platforms. Space constraints, unreliable power supply, and limited digitalisation further restrict readiness for low-carbon yard operations.

4.2 Lack of institutionalised green ship and green yard certification frameworks

The policy notes that green ship certification, lifecycle compliance, and technology reporting systems are still evolving. There is no fully embedded national framework that clearly defines what constitutes a "green ship" or a "green shipyard" in terms of design, construction, repair, and recyclability. This creates uncertainty over approval timelines, compliance pathways, and eligibility for financial support. In the absence of stable certification regimes, shipowners and yards face difficulty in planning long-term investments and in demonstrating environmental performance to financiers and international markets.

4.3 High upfront costs and weak commercial viability of green construction and yard upgrades

The NGSP highlights that green propulsion systems, energy-efficient equipment, and digital compliance tools remain expensive and are often imported. For shipyards, additional costs arise from electrification of operations, waste handling systems, and redesign of production processes. For shipowners, the cost differential between conventional and green newbuilds or retrofits remains high, especially for coastal and inland vessels with limited revenue margins. Without performance-linked incentives, risk-sharing mechanisms, and predictable demand, the business case for green shipbuilding and repair remains fragile.

4.4 Fragmentation between design, construction, repair, and recycling stages

The NGSP's lifecycle analysis shows that green ships, green technologies, and green recycling are often treated as separate policy domains. In practice, ship design rarely incorporates end-of-life recyclability requirements, and repair yards operate largely outside recycling and circular economy strategies. This weak integration undermines extended producer responsibility principles and disrupts continuity of hazardous material inventories and environmental documentation. As a result, environmental performance achieved during construction or operation can be offset by poor practices at repair or dismantling stages.

4.5 Limited domestic experience with green ship technologies and lifecycle compliance

The document notes that India lacks large-scale operational experience with advanced green ship designs, hybrid propulsion systems, and digital emissions monitoring under Indian climatic and operating conditions. Most benchmarks are drawn from international fleets and yards operating under different cost structures and regulatory regimes. This absence of India-specific data on performance, reliability, and lifecycle cost creates hesitation among shipowners, yards, and financiers, leading to cautious investment behaviour and slow replication of pilot projects.

4.6 Weak integration of ship repair and recycling into green transition strategies

Green recycling is recognised in the NGSP as a critical but underdeveloped pillar. Many Indian recycling yards still rely on unmechanised processes, inconsistent hazardous waste reporting, and partial compliance with international conventions. Repair yards are not yet systematically linked to recycling through design-for-recycling principles or lifecycle documentation. This disconnect limits the ability to enforce circular economy practices and weakens India's positioning as a globally credible green ship lifecycle ecosystem.

4.7 Skills and workforce gaps in advanced green shipbuilding and compliance functions

The transition requires specialised skills in energy-efficient design, alternative propulsion integration, lifecycle assessment, and digital MRV systems. The NGSP identifies shortages of trained personnel in these areas and limited availability of structured green maritime training programmes. Most of the existing workforce is oriented toward conventional shipbuilding and repair, slowing absorption of new technologies and increasing dependence on external expertise.

5 Conclusion

The Green Shipping pillar of the National Green Shipping Policy establishes a structured and phased pathway for transforming India's shipbuilding and ship repair ecosystem in line with national decarbonisation commitments and long-term industrial competitiveness objectives. Consistent with the NGSP's overarching vision of integrating **green finance, green regulations, green collaboration, and green reporting**, this pillar adopts a lifecycle-based and systems-oriented approach that spans vessel design, construction, retrofit, operation, and end-of-life recycling. It recognises that the transition of shipyards and repair facilities involves differing levels of technological maturity, capital intensity, and institutional readiness, and therefore requires differentiated and sequenced policy action.

The phased short-, medium-, and long-term action plans translate strategic intent into implementable measures across green ship design standards, low-carbon shipyard infrastructure, workforce development, certification and MRV systems, and circular economy integration through green recycling. These measures are reinforced through a clearly defined responsibility mapping across ministries, regulators, shipyards, classification societies, financial institutions, and knowledge bodies, alongside explicit identification of critical barriers related to industrial readiness, regulatory clarity, financial viability, and lifecycle integration.

Successful implementation of the Green Shipping pillar will depend on sustained coordination between maritime regulation, industrial policy, environmental governance, and financial frameworks, as well as continued alignment with evolving international norms on ship design, lifecycle emissions, and ship recycling compliance. In line with the NGSP's emphasis on technology neutrality, innovation, and global competitiveness, this pillar positions green shipbuilding and repair not only as an environmental obligation but also as a strategic opportunity to strengthen domestic manufacturing capability, promote green technology adoption, and integrate India more deeply into global low-carbon maritime value chains.

Taken together, the Green Shipping pillar provides a coherent and practical foundation for enabling India's shipbuilding and ship repair sector to progressively transition toward low- and zero-carbon practices while maintaining operational continuity and economic viability. By embedding lifecycle sustainability into industrial and regulatory systems, it supports India's broader maritime decarbonisation pathway and reinforces the country's ambition to emerge as a globally competitive hub for sustainable ship construction, repair, and recycling within a low-carbon maritime economy.