Port Readiness Level assessment tool for Clean Fuel Cargo

PRL Cargo



IAPH Port Readiness Level Working Group

Version 1.0

Developed by:

IAPH Port Readiness Level Working Group

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1. The Port Readiness Level Framework and Toolkit

Providing practical tools for ports to assess their readiness against new low- and zero- carbon fuels is a key aspiration for IAPH and its Port Readiness Level (PRL) working group. Bringing together experts from IAPH member ports, the PRL working group has developed a suite of tools addressing the different roles, responsibilities and ambitions of ports in enabling and promoting low- and zero-carbon fuels. The PRL toolkit includes the three following assessment tools.

- Port Readiness Level assessment tool for Bunkering Clean Marine Fuels – in short, **PRL Bunkering**
- Port Readiness Level assessment tool for Clean Fuel Cargo – in short, **PRL Cargo**
- Port Readiness Level assessment tool for Vessel Calls by Clean Marine Fuel-powered vessels – in short, **PRL Vessel Calls**

This document presents version 1.0 of the PRL Cargo tool.



2. Introduction

The maritime sector plays a crucial role in the global energy fuel system, with 36% of the world's energy transported by ship. As the global economy transitions towards both electrification and lower-carbon fuels, the energy-maritime value chain will need to be transformed accordingly. Ports will need to become part of the ecosystem that facilitates the transportation, storage and handling of low-carbon fuels at scale worldwide.

Although the alternative fuel market is still emerging, it is expected that up to 50% of the global trade of low-carbon fuels will need to be transported by ship. Ports therefore need to strengthen their readiness to support this transition, helping to unlock global trade in clean fuel cargoes more efficiently and within a shorter timeframe.

The storage, loading, transportation and discharge of seaborne clean energy cargoes is a complex undertaking that requires significant investment and long lead times. However, if this transformation is managed effectively by regulators, investors and industry stakeholders, with ports acting as clean energy marine hubs, it has the potential to deliver substantial economic and environmental benefits.

Currently, the main barrier for investment into storage and seaborne transportation of clean fuel cargo is the need for long-term offtake contract commitments. At present, these low-carbon fuels have higher production and distribution costs than conventional options and market confidence in long-term demand remains limited. Clean fuel cargoes have yet to become established as conventional, regulated, standardised downstream energy commodities. For the maritime and port sectors, access to these new fuels will be critical in their enabling role, particularly as shipping will only account for approximately 5–10% of overall global demand by 2050 (according to the International Renewable Energy Agency – IRENA).

For some ports, the availability of space and resources is likely to present a significant challenge. This encompasses renewable energy requirements, industrial feedstocks, access to carbon dioxide and availability of clean water. Above all, port space will be a critical factor when considering production, storage and transport of new liquid bulk clean fuel cargoes to and from ports.

By 2050 fuel trade dynamics are expected to change as the global economy reduces its dependence on fossil fuels. The supply of diverse new clean fuels is expected to grow and become part of the global fuel mix. The shipping sector is expected to play a significant role in transporting low-carbon fuels between different regions, helping to connect supply and demand, and supporting the decarbonisation of sectors that cannot be easily electrified. IRENA estimates that up to 50% of these low- and zero-carbon fuels will need to be transported by sea from supply regions to demand centres, with the remaining 50% transported by pipeline. This presents the port industry with an opportunity to strengthen its role as enabler of new seaborne clean energy corridors, with ports acting as the primary physical and economic nexus for future fuel production, storage, transshipment and seaborne transportation. This clean fuel cargo readiness tool supports that opportunity.



3. Overview

What is the Port Readiness Level for Clean Fuel Cargo (PRL Cargo)?

The Port Readiness Level for Clean Fuel Cargo assessment tool (PRL Cargo) has been designed by the International Association of Ports and Harbors (IAPH) Port Readiness Level Working Group, in conjunction with the International Chamber of Shipping (ICS) and the supporting organizations of Clean Energy Ministerial CEM-HUBS initiative. PRL Cargo is an assessment framework and set of best practice guidance that can support ports, and their public and private stakeholders, as they prepare for the energy transition. PRL Cargo identifies areas requiring further development for ports to facilitate their role as storage, loading, discharging and transshipment enablers of low-carbon fuels.

PRL Cargo can be used by ports to assess their readiness to become a hub for storage and for new clean fuel cargo operations. It encompasses four key domains: governance, safety, infrastructure and market; the four domains should be treated as interdependent if a port is seriously considering becoming a trading or transshipment hub for these new fuels.

PRL Cargo is designed to be used as guidance by ports and their private and public stakeholders, enabling them to ask the right questions and thereby fostering informed, timely decision-making. It clarifies what needs to be achieved, or what consensus needs to be reached, to progress from one stage to the next in the transformation process, whether this involves remodelling existing infrastructure or developing new infrastructure from the ground up.

The tool is completely fuel agnostic and does not prescribe one fuel type over another. It makes no assumptions about whether the port has owner-stakeholder status regarding the production, storage and operation of clean cargoes. The principal use of the tool is for ports to assess their own capability to act as a clean fuel cargo hub by following clear, regulatory-driven governance, clearly defined safety protocols, and a clearly structured operational path for engineering, procurement and construction of infrastructure – all within the solid boundaries of a market for demand and supply that satisfies the long-term goals of investors, public entities and financiers.

While the purpose of the tool is to allow ports to be compared using a common framework, ports may achieve their objectives through different pathways depending on their size, structure, and context. The levels should therefore be seen as a progression framework rather than mandatory steps to the same end goal. Not all ports are expected to reach the same final level; Level 7 may represent a suitable end state for a smaller port, while larger ports may need to progress further to achieve their strategic objectives.

The framework is not meant to be mandatory, because not all strategies and tasks will be applicable for every port. Organizations can use this tool as best practice guidance and take only those steps that are considered appropriate and relevant. If an action is deemed unfeasible or irrelevant for a specific port's needs, this can be well-substantiated and recorded as moved into the optional category.

Who can use this tool?

This is a tool for all ports, irrespective of location, size and governance model; it is designed to raise awareness about what 'port readiness' really means. Despite the differences in the configuration of various ports and their stakeholder networks, it is vital to create a universal framework that allows all relevant parties to prepare themselves, manage expectations, and meet their strategic, environmental, and social commitments.

The tool has been designed to support port authorities in acting as an enabler to transport low-carbon fuels and may serve as key guidance for relevant national or regional ministries or relevant municipal bodies, national maritime authorities, terminal operators, ship-operating customers, regulators, safety agencies, offtake candidates, traders and financiers.

4. PRL Cargo Nine-Level Framework

The PRL Cargo framework consists of nine readiness levels – largely following the schematic of the NASA Technology Readiness Level (TRL) – and these are divided into the following phases:

Phase	RESEARCH OPPORTUNITY & FEASIBILITY			COMMERCIAL DEVELOPMENT		CARGO OPERATIONS & SCALE-UP		MATURITY & LEADERSHIP	
Level	1	2	3	4	5	6	7	8	9
	Assessment opportunity for Clean Cargo Fuel handling	**Validation of stakeholder interest and feasibility**	**Detailed Assessment, Gap Analysis and Conclusions**	**Port position and project plan**	**Establish groundwork**	**Initial cargo operation**	**Established cargo operation**	**Standardised cargo operations**	**Advanced cargo operations**
Objective	A clear understanding of the opportunity and its strategic value has been established.	Key port stakeholders are informed, engaged, and committed to exploring the opportunity.	A comprehensive gap analysis has been completed, enabling an informed go/no-go decision.	A resourced implementation roadmap is approved and activated.	The port is operationally ready for first cargo handling.	Safe and successful first cargo operations demonstrate technical and operational feasibility.	The port is ready to conduct recurring cargo transfer operations in a safe and controlled manner.	Cargo-handling operations are standardised, governed, and controlled through a fully implemented Integrated Management System.	Cargo handling is fully integrated into regular port operations and continuously optimised.

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	Assessment opportunity for Clean Cargo Fuel handling	Validation of stakeholder interest and feasibility	Detailed Assessment, Gap Analysis and Conclusions	Port position and project plan	Establish groundwork	Initial cargo operation	Established cargo operation	Standardised cargo operations	Advanced cargo operations
Objective	A clear understanding of the opportunity and its strategic value has been established.	Key port stakeholders are informed, engaged, and committed to exploring the opportunity.	A comprehensive gap analysis has been completed, enabling an informed go/no-go decision.	A resourced implementation roadmap is approved and activated.	The port is operationally ready for first cargo handling	Safe and successful first cargo operations demonstrate technical and operational feasibility	The port is ready to conduct recurring cargo transfer operations in a safe and controlled manner.	Cargo-handling operations are standardised, governed, and controlled through a fully implemented Integrated Management System.	Cargo handling is fully integrated into regular port operations and continuously optimised
Domains									
Governance	The port has clear visibility of which body has authority over each aspect of clean fuel cargo operations and where coordination gaps exist.	The port has clear insight into what approvals are required for commercial actors and domains, and the order in which they must be obtained.	A prioritised governance gap analysis has been completed covering cross-border trade barriers and market-enabling governance requirements, enabling an informed go/no-go decision on proceeding to development.	Formal accountability for governance decisions required for clean fuel cargo operations has been documented, with carbon registry alignment and corridor compatibility confirmed.	Approval sequences have been validated in practice, fuel origin tracking methodology is operational, and coordination mechanisms have been established between authorities that have been demonstrated to function under real clean fuel cargo operation conditions.	Roles, approval pathways, and fuel certification processes function reliably without case-by-case redesign, demonstrated through consistent performance across pilot activities and documented corrective actions for identified gaps.	Repeatable approval pathways have been established across at least two clean fuel cargo projects involving different fuel types or counterparties, without the need for case-by-case redesign.	Clean fuel cargo operations governance is fully embedded in port-wide management systems, with routine trades requiring no special coordination or authority escalation.	Governance remains fit for purpose through documented improvement cycles and institutional knowledge resilient to personnel change, demonstrated through the effective review and update of governance arrangements following material changes in regulatory, market, or fuel conditions.
Safety	Safety implications, major hazards, and applicable regulatory and operational requirements associated with the clean fuel cargo operation have been identified and understood.	Relevant stakeholders have been identified and their safety requirements, concerns, interests, and regulatory expectations and influence have been captured and consolidated.	A comprehensive gap analysis has been completed against applicable safety, regulatory, permitting, and approval requirements, enabling an informed go/no-go decision on progressing to safety strategy and roadmap development.	A safety roadmap and implementation plan have been defined, setting out the governance, responsibilities, studies, risk controls, and safety measures required to support safe initial clean fuel cargo operations and future scale-up.	The operational readiness has been demonstrated and all prerequisites required to safely conduct clean fuel cargo operations are in place.	The safe execution of an initial cargo operation has been successfully demonstrated under controlled conditions.	Recurring cargo operations are safely and consistently executed within an established operational, safety, and regulatory framework.	Safety requirements are fully embedded into the port's safety management systems and operational governance framework.	A mature, resilient, and continuously improving safety management system supports safe and reliable cargo operations.
Infrastructure	The port's existing infrastructure, preliminary constraints, and key interfaces for the safe handling and transfer of low-emission commodities have been identified.	Relevant infrastructure stakeholders, their needs, constraints, and dependencies have been identified and documented.	The existing port infrastructure has been assessed, and gaps in space, equipment, services, and enabling infrastructure required for the first transfer, have been identified.	An infrastructure roadmap and delivery plan have been defined, setting out the port's position, governance, responsibilities, studies, upgrades, and controls needed for safe initial operations and scale-up.	The minimum viable infrastructure and operating conditions required to safely conduct an initial low-emission commodity transfer have been established and confirmed, with provision for compliance with international standards and future scalability.	The port infrastructure and associated systems have been validated under real operating conditions, demonstrating that a low-emission commodity transfer can be completed safely, compliantly, and in a controlled manner, with requirements for repeatability identified.	Approved infrastructure configurations, operational protocols, and project-specific requirements for product transfer have been formally defined, registered, and implemented.	Infrastructure standards, controls, and asset-integrity processes have been embedded within the port's management systems, enabling the safe and compliant handling of low-emission commodities as part of day-to-day operations.	A mature, continuously improving infrastructure management system has been established, enabling low-emission commodities to be handled as a routine port activity.
Market	The port has identified and wants to confirm there is a credible opportunity and potential commercial rationale for clean fuel cargo operations with the relevant actors.	The port can confirm a valid commercial interest with a credible business case with one or more actors with sufficient volumes in clean fuel cargo operations.	The clean fuel cargo opportunity at feasibility level has been validated, enabling an informed next level go/no-go decision.	A roadmap and preliminary commercial framework between the port and the relevant stakeholder(s) for clean fuel cargo operations is defined, with prioritised actions to address the key gaps identified in levels 1-3.	The key commercial, financial, contractual, and service delivery requirements for the operator(s) have been secured, providing a solid foundation for the first clean fuel cargo operations.	The clean fuel cargo proposition is operational and validated in the market, confirming that commercial assumptions, pricing, partnerships, contractual arrangements, and service delivery processes are effective and scalable.	The clean fuel cargo business is scaled (one or more) beyond initial operations, with a growing portfolio of commercial projects, expanding market participation, and demonstrated revenue generation.	Clean fuel cargo day-to-day operations are established as a mature and reliable commercial capability for the port, with standardised pricing, service delivery, customer relationships, and sustained market participation.	The Port is an established and reliable clean fuel cargo hub (CEM-HUB), continuously optimising its commercial proposition and innovating services.

RESEARCH OPPORTUNITY & FEASIBILITY

LEVEL 1

Assessment opportunity for Clean Fuel Cargo handling

A clear understanding of the opportunity and its strategic value has been established.

Actions

Governance

The port has clear visibility of which body has authority over each aspect of clean fuel cargo operations and where coordination gaps exist.

1. Confirm whether clean fuel trading falls within the port authority's legal mandate and identify any mandate gaps requiring regulatory clarification or government authorization.
2. Assign a lead to coordinate the governance mapping exercise.
3. List key public authorities and entities with decision-making roles affecting clean fuel trading, including relevant external partners where coordination is required.
4. Identify authority boundaries across port, national regulator, maritime authority, and energy regulator.
5. Identify existing regulations, policies, and mandates applicable to clean fuel trading.
6. Identify governance decisions requiring coordination across Safety, Infrastructure, and Market.
7. Document where responsibilities overlap between departments or authorities.
8. Identify potential trading actors and confirm which regulatory bodies oversee each.
9. Map energy market regulators and system operators relevant to the port.
10. Identify interactions between port governance and national energy market governance.
11. Coordinate an initial assessment of governance arrangements required to enable clean fuel cargo operations.

Safety

Safety implications, major hazards, and applicable regulatory and operational requirements associated with the clean fuel cargo operation have been identified and understood.

1. Identify the physical, chemical, environmental, and operational hazards associated with the clean fuel cargo.
2. Identify potential impacts on port operations, infrastructure, stakeholders, and adjacent activities.
3. Establish an understanding of applicable safety frameworks, regulations, standards, and best practices.
4. Develop an initial understanding of vessel, terminal, transport, and emergency response requirements.
5. Capture lessons learned from other ports handling similar cargoes.
6. Identify major uncertainties, knowledge gaps, and potential safety showstoppers.
7. Identify key safety framework elements likely to be required for safe handling of the clean fuel cargo.
8. Assess key interfaces and dependencies between Safety, Governance, Infrastructure, and Market domains.
9. Coordinate a preliminary assessment of safety risks, opportunities, constraints, and mitigation requirements.

Infrastructure

The port's existing infrastructure, preliminary constraints, and key interfaces for the safe handling and transfer of low-emission commodities have been identified.

1. Research the infrastructure requirements necessary to serve as a port to trade the target commodities.
2. Identify the most likely cargo transfer scenarios within the port context, including mapping of port transfer locations for operations.
3. Define the preliminary infrastructure boundaries and key interfaces for the assessment
4. Review applicable port regulations to identify existing standards that could enable or constrain the opportunity.
5. Identify initial space and infrastructure needs and constraints
6. Coordinate a preliminary assessment of infrastructure requirements and constraints across Safety, Governance and Market domains.

Market

The port has identified and wants to confirm there is a credible opportunity and potential commercial rationale for clean fuel cargo operations with the relevant actors.

1. Identify key clean fuel cargo actors and major cargo flows relevant to the port, including producers, traders, shipping lines, cargo owners, and end users.
2. Assess current and future clean fuel cargo supply and demand signals, cargo volumes, and the decarbonisation potential of relevant trade flows.
3. Identify trade routes and cargo segments that may be suitable for early adoption of clean fuel cargo seaborne transportation, considering fuel characteristics, operational requirements, and market conditions.
4. Map the port's potential role within relevant clean fuel cargo supply chains and corridors, including potential archetypes such as export gateway, import hub, or transshipment node.
5. Assess competing ports and alternative locations that may influence clean fuel cargo trade flows and market development.
6. Identify potential commercial opportunities, constraints, and market drivers relevant to clean fuel cargo within the port strategy.
7. Develop an initial understanding of how regulation may influence demand, pricing, competitiveness, and trade flows for clean fuel cargo.
8. Coordinate a preliminary assessment of market opportunities, constraints, and commercial dependencies across Safety, Governance, and Infrastructure domains.

RESEARCH OPPORTUNITY & FEASIBILITY

LEVEL 2

Validation of stakeholder interest and feasibility

Key port stakeholders are informed, engaged, and committed to exploring the opportunity.

Actions

Governance

The port has clear insight into what approvals are required for commercial actors and domains, and the order in which they must be obtained.

1. Confirm which authority approves clean fuel cargo operations activities.
2. Identify required permits, licences, and regulatory approvals.
3. Document the approval sequence, including required coordination between authorities.
4. Confirm which approvals require coordination with Safety, Infrastructure, or Market.
5. Identify existing governance or coordination platforms such as inter-agency forums or decision-making bodies.
6. Define whether the port acts as infrastructure provider, market facilitator, or operator.
7. Validate governance alignment with energy market structures
8. Assess authority and organisational capability to support future governance arrangements.

Safety

Relevant stakeholders have been identified and their safety requirements, concerns, interests, and regulatory expectations and influence have been captured and consolidated.

1. Identify safety-related port and other competent authorities involved in cargo transfer, transport, and related operations within the port.
2. Identify relevant stakeholders with safety responsibilities and/or interests.
3. Establish a stakeholder engagement network and conduct workshops and consultations to secure participation in the development of the safety framework.
4. Gather and consolidate stakeholder safety requirements, performance expectations, and concerns related to navigation, storage, transfer, and emergency response
5. Validate stakeholder alignment on key safety requirements, responsibilities, and framework objectives.
6. Assess the implications of applicable safety regulations, permitting requirements, and approval processes for the clean fuel cargo and its transfer and transport activities.
7. Assess stakeholder capabilities, competencies, resources and readiness to contribute to the port-specific safety framework.

Infrastructure

Relevant infrastructure stakeholders, their needs, constraints, and dependencies have been identified and documented.

1. Identify and engage relevant infrastructure stakeholders.
2. Collect stakeholder views on infrastructure feasibility and constraints.
3. Port-infrastructure boundary alignment: confirm the port-infrastructure boundary and key dependencies.
4. Screen candidate areas or berths for potential operations.
5. Document stakeholder positions, constraints, and responsibilities.
6. Evaluate the suitability of vessels, berths, and terminals for anticipated operations.
7. Assess infrastructure owner capability and readiness to support future operations.

Market

The port can confirm a valid commercial interest with a credible business case with one or more actors with sufficient volumes in clean fuel cargo operations

1. Engage potential trading partners – shipping lines, fuel producers, traders, cargo owners who fit the port's commercial proposition.
2. Assess the capability and financial capacity of interested parties to support clean fuel cargo storage and seaborne transportation volumes.
3. Assess competitive positioning and opportunity costs relative to alternative port use cases and competing locations
4. Confirm alignment between commercial actor timelines and port master planning.
5. Document expressions of interest and assess their credibility as commercial signals.
6. Assess commercial stakeholder capability and commitment to participate in future trading activities
7. Validate stakeholder alignment on the commercial opportunity, development timeline, and anticipated market demand.

RESEARCH OPPORTUNITY & FEASIBILITY

LEVEL 3

Detailed assessment, gap analysis and conclusions

A comprehensive gap analysis has been completed, enabling an informed go/no-go decision.

Actions

Governance

A prioritised governance gap analysis has been completed covering cross-border trade barriers and market-enabling governance requirements, enabling an informed go/no-go decision on proceeding to development.

1. Identify gaps in policies, approvals, decision authority, and jurisdictional clarity that could delay or block clean fuel trading.
2. Identify regulatory or governance barriers affecting cross-border or multi-jurisdictional trade.
3. Confirm that regulatory boundaries and oversight responsibilities are clear enough for commercial actors to design trading activities.
4. Conduct a governance review using a realistic clean fuel trading scenario that includes a cross-border or multi-jurisdictional element, to test approval pathways, certification recognition, customs clearance, and inter-agency coordination across jurisdictions.
5. Assess and prioritise governance risks based on likelihood and potential impact on trading implementation.
6. Identify gaps in market-enabling governance mechanics that could prevent clean fuels from being recognised as compliant in trade.
7. Evaluate governance frameworks for shared infrastructure such as pipelines, grids, and storage facilities.
8. Assess governance readiness and remaining actions required to enable the first clean fuel cargo operations.

Safety

A comprehensive gap analysis has been completed against applicable safety, regulatory, permitting, and approval requirements, enabling an informed go/no-go decision on progressing to safety strategy and roadmap development.

1. Assess the safety risks associated with the commodity and their implications for port operations
2. Assess impact on existing port operations, infrastructure and potential conflict areas.
3. Assess compatibility with adjacent activities and future developments.
4. Assess compliance gaps against applicable regulations, permitting requirements, approval processes, and standards.
5. Review emergency response capability and resource requirements.
6. Assess and coordinate risk acceptance criteria and the safety barriers and controls required for safe handling of the commodity.
7. Validate emergency response capabilities.
8. Assess the organizational capabilities, competencies, and resources required for safe handling of the clean fuel cargo.
9. Assess the budget, resources, and implementation effort required to establish the port-specific safety framework.
10. Assess safety readiness and identify remaining actions required to support a decision on the first clean fuel cargo operation.

Infrastructure

The existing port infrastructure has been assessed, and gaps in space, equipment, services, and enabling infrastructure required for the first transfer, have been identified.

1. Assess the existing port and boundary infrastructure required for the first transfer.
2. Identify and quantify gaps between existing capability, required performance, and operating conditions.
3. Compare feasible transfer locations and configurations, including key interfaces and dependencies.
4. Define the preliminary scope, responsibilities, priorities, and preliminary CAPEX required to close the identified gaps.
5. Assess infrastructure readiness, implementation effort, and remaining actions required to support first cargo operations.

Market

The clean fuel cargo opportunity at feasibility level has been validated, enabling an informed next level go/no-go decision.

1. Establish a pre-contractual arrangement between market partner and the port.
2. Validate the volume forecasts for target clean fuel cargo based on identified supply and demand information, pricing trends and corridor development trajectories.
3. Conduct an initial cost benefit assessment.
4. Assess the port's competitive market position and commercial proposition.
5. Identify financial incentives, public funding mechanisms, or corridor partnership opportunities that could improve commercial viability.
6. Assess market readiness and likelihood of achieving sufficient commercial commitment to support initial trading operations.

COMMERCIAL DEVELOPMENT

LEVEL 4

Port position and project plan

A resourced implementation roadmap is approved and activated.

Actions

Governance

Formal accountability for governance decisions required for clean fuel cargo operations has been documented, with carbon registry alignment and corridor compatibility confirmed.

1. Establish and document a formal governance structure with defined roles and responsibilities, including a responsibility matrix specifying which authority approves, oversees, coordinates, and escalates decisions.
2. Formalise approval pathways and inter-agency coordination procedures.
3. Document escalation and dispute resolution mechanisms between authorities.
4. Link governance responsibilities to defined deliverables and implementation milestones.
5. Confirm which national carbon registry applies to trading activities; document the port's role in the chain of custody and how clean fuel attributes will be verified and transferred between counterparties.
6. Confirm compatibility of the port's governance framework with partner port frameworks on shared trading corridors and document alignment gaps requiring resolution.
7. Define the port’s role within the broader energy hub ecosystem.

Safety

A safety roadmap and implementation plan have been defined, setting out the governance, responsibilities, studies, risk controls, and safety measures required to support safe initial clean fuel cargo operations and future scale-up.

1. Translate identified risks and compliance gaps into mitigation and improvement initiatives.
2. Translate identified safety gaps into roadmap actions and ownership assignments across the port ecosystem
3. Translate identified gaps into roadmap actions for establishing the required governance, ownership, assurance, and approval arrangements.
4. Translate identified gaps into roadmap actions for competency development, training, and organizational preparedness.
5. Prioritise identified initiatives, gaps, risks, and regulatory requirements based on impact, urgency, dependencies, and implementation complexity.
6. Structure roadmap actions into implementation phases, milestones, dependencies, and decision gates.
7. Facilitate agreement on responsibilities and identify resource and budget requirements for roadmap actions
8. Coordinate the development of the safety implementation roadmap.

Infrastructure

An infrastructure roadmap and delivery plan have been defined, setting out the port’s position, governance, responsibilities, studies, upgrades, and controls needed for safe initial operations and scale-up.

1. Identify the necessary steps and studies to fill the gaps from the level 3 gap analyses.
2. Translate level 3 findings into a plan and roadmap that states the port’s position on infrastructure, identifies governance and responsibilities regarding infrastructure, and sequences the studies, upgrades, and controls required to enable first safe operations and scale-up.
3. Define the roadmap for port rules, operational procedures, and IMS integration.
4. Establish an infrastructure engagement and change-management plan.
5. Confirm ownership, responsibilities, and decision-making arrangements for required infrastructure developments.
6. Prioritise the minimum infrastructure, services, and controls required for the first safe operation, while defining a structured pathway for future scale-up.

Market

A roadmap and preliminary commercial framework between the port and the relevant stakeholder(s) for clean fuel cargo operations is defined, with prioritised actions to address the key gaps identified in levels 1-3

1. Define the port's business model: direct fuel supply, third-party trading facilitation, or energy hub anchor tenant model.
2. Agree port terms and contract(s) by archetype (including fees with customer segments): shipping lines, traders, cargo owners, and fuel producers.
3. Secure expressions of interest from potential offtakers and assess their commitment level.
4. Sign a space reservation agreement supporting future clean fuel cargo operations and aligned with the agreed development roadmap.

COMMERCIAL DEVELOPMENT

LEVEL 5

Establish groundwork

The port is operationally ready for first cargo handling

Actions

Governance

Approval sequences have been validated in practice, fuel origin tracking methodology is operational, and coordination mechanisms have been established between authorities that have been demonstrated to function under real clean fuel cargo operation conditions.

1. Implement documented governance procedures in a pilot or controlled trading activity.
2. Run at least one complete approval sequence end-to-end including all required authority sign-offs; document time taken, bottlenecks, governance issues, delays, and authority conflicts encountered.
3. Implement governance procedures for real-time coordination of energy systems.
4. Confirm which fuel origin tracking methodology applies (mass balance, book-and-claim, or physical chain of custody); document data-handling responsibilities, verification authority, and interface with the carbon accounting framework established at level 4.
5. Apply governance procedures consistently across recurring clean fuel cargo operations
6. Confirm that customs clearance procedures for clean fuel cargo storage and seaborne transportation function as designed and that sustainability attributes are preserved through the clearance process; document any gaps.
7. Resolve identified governance bottlenecks, authority conflicts, and coordination gaps before advancing to level 6; document corrective actions taken and confirm resolution with relevant authorities.

Safety

The operational readiness has been demonstrated and all prerequisites required to safely conduct clean fuel cargo operations are in place.

1. Verify completion and acceptance of required safety and risk assessments, including SIMOPS, HAZID, HAZOP, spatial analyses, and supporting studies
2. Establish and validate zoning requirements for target fuel activities, including safety distances to vulnerable areas, populated areas, and passing vessels.
3. Verify that operational procedures, work instructions, and operating limits have been developed and agreed by relevant parties.
4. Coordinate the development and validation of an operational execution plan covering port, terminal, vessel, emergency response, and stakeholder interfaces.
5. Verify availability and readiness of required infrastructure, equipment, and supporting services.
6. Verify readiness of participating terminals, vessels, service providers, and other relevant stakeholders.
7. Confirm completion of required training and competency programmes by relevant organizations and personnel.
8. Verify emergency preparedness, response arrangements, and supporting resources across participating organizations.
9. Facilitate and evaluate tabletop exercises and operational readiness drills.
10. Validate communication, coordination, and decision-making arrangements between stakeholders.
11. Verify closure of identified safety-critical gaps.
12. Verify that required approvals, permits, authorizations, and operational clearances have been obtained.

Infrastructure

The minimum viable infrastructure and operating conditions required to safely conduct an initial low-emission commodity transfer have been established and confirmed, with provision for compliance with international standards and future scalability.

1. Choose the ideal location for pilot to take place and pilot boundaries.
2. Implement or facilitate the implementation of prioritised port infrastructure adaptations required for the first transfer.
3. Confirm minimum viable port-infrastructure readiness for the first cargo operation, including infrastructure, operational interfaces, supporting services, and required controls.
4. Validate that required infrastructure adaptations, operational interfaces, and supporting services perform as intended for the first clean fuel cargo operation.

Market

The key commercial, financial, contractual, and service delivery requirements for the operator(s) have been secured, providing a solid foundation for the first clean fuel cargo operations.

1. At least one commercial (lease) agreement is in place covering at least the storage and terminal operations.
2. Establish commercial actor coordination mechanisms: how buyers, sellers, traders, and the port communicate and coordinate in real time.
3. Establish commercial contingency arrangements – namely what happens if volumes, prices, or partners change.
4. Confirm commercial actor readiness to participate and document their role in the first cargo operation.
5. Assure confirmation that FEED or pre-FEED is concluded and FID taken.

CARGO OPERATIONS & SCALE-UP

LEVEL 6

Initial cargo operation

Safe and successful first cargo operations demonstrate technical and operational feasibility

Governance	Safety	Infrastructure	Market
Roles, approval pathways, and fuel certification processes function reliably without case-by-case redesign, demonstrated through consistent performance across pilot activities and documented corrective actions for identified gaps.	The safe execution of an initial cargo operation has been successfully demonstrated under controlled conditions.	The port infrastructure and associated systems have been validated under real operating conditions, demonstrating that a low-emission commodity transfer can be completed safely, compliantly, and in a controlled manner, with requirements for repeatability identified.	The clean fuel cargo proposition is operational and validated in the market, confirming that commercial assumptions, pricing, partnerships, contractual arrangements, and service delivery processes are effective and scalable.
Actions			
1. Monitor inter-agency coordination during pilot trading activity and identify recurring friction points across regulatory, safety, and commercial actors. 2. Confirm that roles, responsibilities, and approval pathways are repeatable and predictable across clean fuel cargo operations and seaborne transportation activities without case-by-case authority clarification. 3. Confirm that fuel certification and chain of custody processes are functioning as designed and producing verifiable, transferable clean fuel attribute claims. 4. Establish formal monitoring of initial clean fuel cargo operations specific governance performance indicators including issue resolution time, decision turnaround, coordination effectiveness, regulatory compliance rate, and fuel certification verification success rate. 5. Confirm that clean fuel cargo attribute certifications generated during the pilot are recognised by partner port authorities, corridor regulators, and relevant national authorities; document any recognition gaps requiring resolution. 6. Apply corrective actions to address identified governance weaknesses and document lessons learned. 7. Confirm that Safety and Infrastructure domains are performing consistently at an equivalent maturity level before declaring level 6 governance achieved.	1. Observe, coordinate and facilitate execution of the initial cargo operation in accordance with the approved operational plan and safety arrangements. 2. Ensure the initial cargo operation is conducted under enhanced supervision and monitoring arrangements. 3. Monitor performance of the effectiveness of critical safety barriers. 4. Confirm that relevant organizations demonstrate required operational and safety performance. 5. Validate the effectiveness of training and competency arrangements across participating organizations during operations. 6. Validate communication and coordination between stakeholders. 7. Validate emergency response arrangements during operations. 8. Record and evaluate operational observations, experience, deviations, incidents, and near misses. 9. Capture lessons learned, improvement actions, and recommendations for recurring operations. 10. Confirm readiness for safe and repeatable cargo operations.	1. Validate port-infrastructure assumptions during the pilot. 2. Interface integration proof: Prove ship/shore interface elements used for safety behave reliably (ESD/communications, monitoring, berth-integrated systems). 3. Record infrastructure performance and deviations. 4. Convert pilot findings into explicit requirements/controls for repeated project operations. 5. Confirm infrastructure readiness and suitability for safe and repeatable cargo operations.	1. Execute the first operation with committed commercial partners under agreed commercial terms. 2. Monitor commercial performance against targets – volumes, pricing, turnaround, certification compliance. 3. Gather structured feedback from commercial partners on service quality, process efficiency, and commercial terms. 4. Identify commercial gaps – where did the commercial model not perform as expected? 5. Assess lessons learned and determine adjustments needed to the commercial model before scaling. 6. Confirm commercial partner commitment to proceed to recurring cargo operations. 7. Assure compliance with clean fuel cargo registration, certification, and applicable regulatory requirements. 8. Support the assessment of implications for GHG emissions accounting, reporting, and regulatory compliance arising from clean fuel cargo use and certification. 9. Monitor market competitiveness, potential customer portfolio and supply chain efficiency, and flexibility of the port.

CARGO OPERATIONS & SCALE-UP

LEVEL 7

Established cargo operation

The port is ready to conduct recurring cargo transfer operations in a safe and controlled manner.

Actions

Governance

Repeatable approval pathways have been established across at least two clean fuel cargo projects involving different fuel types or counterparties, without the need for case-by-case redesign.

1. Apply governance framework consistently across multiple clean fuel trading projects, including varied fuel types, trade structures, and counterparties; confirm approval pathways are repeatable without case-by-case redesign.
2. Assess incoming trade proposals against established governance criteria – regulatory compliance, approval sequence completeness, fuel certification validity, carbon accounting methodology alignment, and corridor governance compatibility – and document decisions.
3. Identify and assess governance risks arising across multiple concurrent projects, including authority conflicts, cross-border coordination gaps, and certification recognition failures.
4. Incorporate lessons learned from each project into updated governance procedures through a structured review cycle.
5. Initiate embedding of governance procedures into port-wide management systems and standard operating documentation in preparation for full system integration at level 8.
6. Support training and capability development across relevant port departments and regulatory authorities on governance procedures for clean fuel trading.

Safety

Recurring cargo operations are safely and consistently executed within an established operational, safety, and regulatory framework.

1. Promote and coordinate updates of procedures, guidance, and controls based on lessons learned from initial operations
2. Facilitate alignment on standard operating practices, training requirements, and safety controls for recurring operations across relevant stakeholders
3. Establish and maintain repeatable risk assessment and operational review methodologies.
4. Formalise approval and authorization processes.
5. Maintain effective coordination mechanisms among collaboration partners.
6. Ensure structured incident reporting and investigation processes are implemented across participating organizations
7. Monitor performance against agreed safety criteria.
8. Conduct periodic reviews of operational experience.
9. Ensure consistent application of operational, safety, and regulatory requirements across recurring operations.

Infrastructure

Approved infrastructure configurations, operational protocols, and project-specific requirements for product transfer have been formally defined, registered, and implemented.

1. Establish approved infrastructure configurations for scenario or project-based operations.
2. Implement a pre-operation infrastructure sign-off process.
3. Define change-control requirements for infrastructure configurations.
4. Ensure all relevant infrastructure stakeholders understand and fulfil their roles and responsibilities for recurring cargo operations.
5. Ensure applicable nautical and operational requirements, including safety distances, mooring arrangements, signalling, and traffic management measures, are consistently applied during recurring cargo operations.

Market

The clean fuel cargo business is scaled (one or more) beyond initial operations, with a growing portfolio of commercial projects, expanding market participation, and demonstrated revenue generation.

1. Consider promoting clean fuel cargo storage and transportation services to target market segments – shipping lines, traders, fuel producers, cargo owners, industries.
2. Improving added value to established port portfolio for additional fuels and counterparties.
3. Monitor commercial plans on hinterland integration – identify and advance prospective trading relationships toward contract.
4. Implement commercial account management – track partner performance, manage relationships, address commercial issues.
5. Identify opportunities to add value – bundled services, trade corridor partnerships by fuel type, alternative parties – to differentiate the port's commercial offering.

MATURITY & LEADERSHIP

LEVEL 8

Standardised cargo operations

Cargo-handling operations are standardised, governed, and controlled through a fully implemented Integrated Management System.

Actions

Governance

clean fuel cargo operations governance is fully embedded in port-wide management systems, with routine trades requiring no special coordination or authority escalation.

1. Integrate clean fuel cargo operations governance fully into port-wide management systems, digital workflows, and standard operating procedures so that this is administered as routine port business.
2. Establish and maintain a governance KPI dashboard linking to Safety, Infrastructure, and Market performance indicators; use integrated outputs to identify cross-domain performance gaps and drive systematic improvement.
3. Implement formal governance review cycles; update procedures, authority boundaries, and coordination mechanisms in response to regulatory developments, market evolution, and cross-domain performance findings.
4. Establish a regular structured engagement mechanism with key regulators, corridor partners, and certification bodies to maintain alignment with evolving clean fuel governance requirements including carbon accounting, sustainability certification, and customs frameworks.
5. Embed data governance requirements into port-wide management systems, including digital traceability for fuel attributes, cybersecurity protocols for trading and reporting systems, and regulatory reporting obligations under applicable national and international frameworks.
6. Establish transparency and accountability mechanisms for clean fuel trading governance performance, including public- or stakeholder-facing reporting on compliance rates and governance outcomes where required.
7. Establish formal governance incident response protocols for clean fuel cargo operations disruptions caused by regulatory authority action, certification failure, or cross-border clearance issues – including escalation pathways, communication requirements, and resolution procedures.

Safety

Safety requirements are fully embedded into the port's safety management systems and operational governance framework

1. Embed cargo-specific requirements into the port management system.
2. Incorporate governance responsibilities, reporting lines, and decision-making processes into standard port management practices.
3. Establish and coordinate assurance and audit arrangements across relevant stakeholders
4. Implement and monitor key safety performance indicators.
5. Ensure management of change procedures are embedded within relevant organizations and interfaces
6. Verify that participating organizations maintain appropriate competency management and refresher training programmes are embedded within relevant organization
7. Implement systematic risk monitoring and reporting processes.
8. Establish document control and governance processes.
9. Embed stakeholder communication and coordination into routine operational processes.
10. Embed coordinated emergency preparedness and response arrangements into routine operations and exercises.

Infrastructure

Infrastructure standards, controls, and asset-integrity processes have been embedded within the port’s management systems, enabling the safe and compliant handling of low-emission commodities as part of day-to-day operations.

1. Confirm that the approved infrastructure configuration is in place and signed off, including port assets within the agreed battery limit.
2. Embed infrastructure requirements, operating controls, and responsibilities in the port’s integrated management system.
3. Implement a lifecycle asset-integrity and maintenance programme for safety-critical infrastructure.
4. Monitor performance through defined KPIs, internal assurance, and periodic audits.
5. Apply management-of-change and continuous-improvement processes as operations, volumes, or infrastructure change.

Market

Clean fuel cargo day-to-day operations are established as a mature and reliable commercial capability for the port, with standardised pricing, service delivery, customer relationships, and sustained market participation.

1. Integrate clean fuel cargo operations into standard port commercial systems – pricing, contract management, customer relationship management, service levels.
2. Establish long-term commercial relationships with key trading partners – framework agreements, preferred supplier arrangements, corridor partnerships.
3. Implement systematic commercial monitoring – track volumes, revenues, customer satisfaction, and market share.
4. Develop commercial reporting – regular market intelligence updates on clean fuel cargo price trends, regulatory developments, and competitor positioning.
5. Monitor regulatory developments that directly affect demand, pricing and trade flows, and identify actions that enhance the product’s premium.
6. Implement periodic commercial performance reviews and continuous improvement processes to maintain competitiveness and support long-term growth.

MATURITY & LEADERSHIP

LEVEL 9

Advanced cargo operations

Cargo handling is fully integrated into regular port operations and continuously optimised

Actions

Governance

Governance remains fit for purpose through documented improvement cycles and institutional knowledge resilient to personnel change, demonstrated through the effective review and update of governance arrangements following material changes in regulatory, market, or fuel conditions.

1. Maintain a continuous governance risk management cycle – identify, analyse, evaluate, treat, monitor, and communicate – covering emerging regulatory, market, and geopolitical risks including evolving clean fuel governance frameworks, IMO developments, and corridor governance changes.
2. Demonstrate governance resilience during material change events – regulatory shifts, scale expansion, or new fuel types – absorbing change without disrupting routine trading operations or requiring governance redesign.
3. Review governance structure, authority boundaries, and coordination mechanisms periodically for effectiveness and fitness for evolving trade volumes, fuel mix, and counterparty complexity; update procedures accordingly.
4. Incorporate stakeholder feedback and lessons learned into documented governance improvement cycles; ensure cross-domain readiness is verified before new fuel types or trading scenarios are introduced.
5. Ensure governance, institutional knowledge and capability are documented and transferable through backup and succession management – governance maturity must be resilient to personnel changes at both port and regulatory authority level.
6. Actively contribute to the development of international clean fuel cargo operations governance guidance, certification frameworks, and trade-facilitation protocols; demonstrate through published practice what effective port governance for clean fuel trading looks like.
7. Interface with international clean fuel relevant bodies e.g. IMO, EU, IAPH, SGMF, OCIMF, Intertanko, Hydrogen Council

Safety

A mature, resilient, and continuously improving safety management system supports safe and reliable cargo operations.

1. Apply data-driven performance monitoring and trend analysis.
2. Benchmark safety performance and operational maturity against comparable ports handling similar commodities.
3. Periodically reassess risks, safeguards, and emerging operational challenges.
4. Conduct independent reviews and assurance assessments.
5. Promote and facilitate continuous improvement initiatives based on operational experience and performance insights.
6. Support the adoption and sharing of innovations that improve safety performance and operational reliability.
7. Strengthen resilience to emerging threats and disruptions.
8. Share lessons learned throughout the port ecosystem.
9. Promote a proactive safety culture across all stakeholders.
10. Support the continuous optimization of safety performance and operational reliability across the port ecosystem.
11. Ensure critical safety knowledge, competencies, and lessons learned are documented and transferable across the port ecosystem.

Infrastructure

A mature, continuously improving infrastructure management system has been established, enabling low-emission commodities to be handled as a routine port activity.

1. Improve the ports capabilities and infrastructure to align with rising demand of the target commodity.
2. Monitor infrastructure performance against demand growth.
3. Define triggers for infrastructure upgrades.
4. Implement continuous infrastructure optimisation based on operational performance, utilization, reliability, and demand growth.
5. Assess and adopt innovative infrastructure solutions that improve operational efficiency, flexibility, safety, or scalability.
6. Strengthen infrastructure resilience against future growth, technology shifts, climate impacts, and evolving fuel requirements.
7. Ensure critical infrastructure knowledge, operating constraints, maintenance requirements, and lessons learned are documented and transferable across relevant organizations.

Market

The Port is an established and reliable clean fuel cargo hub (CEM-HUB), continuously optimising its commercial proposition and innovating services.

1. Continuously improve clean fuel cargo services – new fuel types, bundled certification services, corridor integration, digital trading platforms.
2. Monitor and respond to international market developments – new regulations, emerging fuel types, corridor developments, competitor innovations.
3. Position the port as a preferred hub for clean fuel cargo operations on key international corridors – actively shape corridor commercial frameworks.
4. Continuously improve market competitiveness, service offerings, service levels, supply chain efficiency customer satisfaction and flexibility of the port.
5. Ensure critical commercial knowledge, customer relationships, and market insights are captured and transferable to support long-term market development and operational continuity.

5. About IAPH

Founded in 1955, the International Association of Ports and Harbors (IAPH) is a global alliance of port authorities and port-related businesses. Comprising over 100 different nationalities across the world's continents, member ports handle over one third of the world's sea-borne trade and well over 60% of the world container traffic. IAPH leads global port industry initiatives on decarbonisation and energy transition, risk and resilience management, and accelerating digitalisation in the maritime transport chain. The IAPH's **World Ports Sustainability Program** has grown into the reference database of best practices of ports applying the UN Sustainable Development Goals and integrating them into their businesses - **iaphworldports.org.**



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