Port Readiness Level assessment tool for Bunkering Clean Marine Fuels

PRL Bunkering



IAPH Port Readiness Level Working Group

Version 2.0

Assessment tool for bunkering

This tool is developed as best practice guidance to assess the port readiness for the bunkering of a clean marine fuel.

Developed by:

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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 the updated and simplified version 2.0 of the PRL Bunkering tool that was initially released back in 2023. For IAPH member ports, PRL Bunkering is also available as a digital tool via https://fuelreadyports.org/.



2. The PRL Bunkering Assessment and Guidance Framework

2.1 PRL Bunkering Overview / What is PRL Bunkering?

The Port Readiness Level Assessment tool for Bunkering Clean Marine Fuels (PRL Bunkering) is designed to help port communities evaluate and advance their readiness to bunker vessels using new clean marine fuels by identifying gaps, prioritizing actions, and monitoring progress towards operational readiness. Fuel-agnostic and applicable to any port configuration, the tool provides a structured pathway for port communities to assess their preparedness, coordinate actions across stakeholders, and support the development of clean marine fuel bunkering capabilities required to achieve their future ambitions.

PRL Bunkering is inspired by NASA's widely established Technology Readiness Level (TRL) methodology, which uses progressive maturity levels to guide the development and deployment of new technologies. While TRLs focus on technological maturity, PRL Bunkering assesses the readiness of governance, safety, infrastructure, and market conditions required to support bunkering of clean marine fuels through nine readiness levels grouped into three stages: Research, Development, and Deployment.

PRL Bunkering is also partly based on the Objectives and Goals elements of the OGSM methodology, complemented by practical actions and considerations that support implementation and progression through the readiness levels. These guide port communities from assessing potential demand and stakeholder interest, through developing policies, risk assessments, safety frameworks and pilot projects, to the commercial deployment and integration of bunkering services into regular port operations.

Developed by the PRL Working Group of the IAPH and designed by ports for port communities, PRL Bunkering is a collaborative framework that can be applied, supported, and referenced by a wide range of stakeholders, including port authorities, governments, financiers, bunker suppliers, terminal operators, vessel owner-operators, and first responders. It provides a common basis for dialogue, planning, coordination, and decision-making as port communities prepare for shipping's transition to clean marine fuels.

PRL Bunkering is intended as guidance for the port community: to start dialogue, establish ambitions, allocate resources, develop infrastructure, and put the right governance in place ahead of bunkering a new fuel. Two ports at the same PRL Bunkering level for the same fuel could demonstrate a broadly comparable level of readiness, even though the route to get there, and its exact shape, can differ between a large and a small port.

PRL Bunkering assesses readiness for one target fuel at a time and should be repeated for each additional fuel that a port considers bunkering. While each fuel presents its own specific technical, operational, safety, regulatory, and commercial considerations, the experience gained from previous PRL assessments, including knowledge of the readiness journey and the actions required at different stages, can be leveraged to support more efficient preparation for subsequent fuels.

PRL Bunkering provides guidance and is not a mandatory standard. Not every action will be relevant to every port. Ports select the actions that apply to them; an action considered not feasible or not relevant can be substituted or classified as optional.

2.2 Stakeholder participation in the PRL Bunkering process

Given the diversity of port configurations, governance structures, and stakeholder landscapes, the PRL Bunkering framework is designed to provide a common approach for assessing and advancing the readiness of the port community as a whole.

The effectiveness of the assessment depends on contributions from a broad range of stakeholders across the port community. Relevant stakeholders may include national maritime authorities, regulators, government bodies, vessel operators, bunker suppliers, terminal operators, safety organisations, emergency response services, consultancies, and advisory bodies.

These stakeholders may contribute information, expertise, validation, and resources to support the assessment process and the completion of readiness actions. Actions within a readiness level may be undertaken by one or multiple stakeholders. For example, a risk assessment may be performed by an external consultant, elements of a safety framework may be developed by a regulatory authority, and infrastructure investments may be delivered by a bunker operator. The allocation of responsibilities will vary according to the governance structure and operational characteristics of each port community.



2.3 PRL Bunkering structure and assessment process

The PRL framework consists of nine readiness levels. The first three levels concern the research phase (PRL Bunkering 1, 2 and 3), the next three levels the development phase (PRL Bunkering 4, 5 and 6), and the last three levels the deployment phase (PRL Bunkering 7, 8 and 9). An overview of nine readiness levels is shown in Table 1.

The goal of the research phase is to determine the relevance of the fuel for the port and its stakeholders. This phase will help to identify information gaps, determine pros and cons, and ascertain the interest of port stakeholders.

The goal of the development phase is to make strategic decisions about implementation, create a guiding framework based on assessments and testing, and run a pilot test for the target fuel.

Finally, the deployment stage includes scaling-up operations, beginning with a project-based approach and growing into a systems approach that will create a regular port operation.

For each readiness level, actions and considerations are identified across the domains of governance, safety, infrastructure, and market development. Port communities progress through the nine readiness levels for each target fuel, using the framework to assess readiness, identify gaps, and support decision-making. The resulting readiness level, together with any associated roadmap and timeline, may be shared with relevant stakeholders where appropriate to support informed investment and planning decisions.

3. PRL Bunkering Nine-Level Framework

Phase	RESEARCH			DEVELOPMENT			DEPLOYMENT		
Level	1	2	3	4	5	6	7	8	9
	Foundational background information	Stakeholder interest and feasibility assessment	Detailed research, analysis, and conclusions	Roadmap to proceed; framework and timeline developed	Roadmap implementation	Pilot-scale demonstration	Project-based approach	A system-based approach, embedding bunkering into day-to-day port processes	Market penetration and growth
Objective	The properties, opportunities, risks and regulatory aspects of the target fuel are documented and available to support research and decision-making.	The feasibility of target fuel bunkering, and stakeholder willingness to support its implementation, are understood and documented to support decision-making.	The information required to support a go/no-go decision on progression to the development phase is available and documented.	A clear roadmap defining the actions, stakeholders and requirements for developing target fuel bunkering is established.	The roadmap has been executed and the required conditions for implementation and validation of target fuel bunkering have been established.	The key governance, market, safety and infrastructure aspects required for a first pilot bunkering operation of the target fuel have been implemented, tested and validated through a controlled pilot, providing the basis for deployment decisions and further scale-up.	The governance, market, safety and infrastructure arrangements enable repeatable project-based target fuel bunkering in the port.	The governance, market, safety and infrastructure arrangements required for system-based target fuel bunkering have been established in the port.	A fully integrated target fuel bunkering system continuously improves and scales in line with market demand.

Table 1. PRL Bunkering Nine-level Framework

4. Objectives, goals, actions and considerations

The PRL assessment process is intended to be led by the port authority or another organization responsible for coordinating readiness within the port community. This entity is responsible for assessing, monitoring, and demonstrating readiness progression, while ensuring that the actions required to achieve each readiness level are appropriately addressed. Although individual actions may be assigned to, and executed by, different stakeholders, responsibility for the overall readiness assessment and progression remains with the entity leading the PRL process.

Each PRL level has a defined objective supported by domain-specific goals. The four PRL domains are governance, safety, infrastructure, and market development. These domain goals are achieved through a set of identified actions, to be led by the stakeholder or entity with the appropriate responsibility and expertise within the respective domain.

While actions from multiple readiness levels may be addressed/undertaken simultaneously, each readiness level is designed to culminate in a key decision point or deliverable that guides progression through the framework. Therefore, it is recommended that the actions associated with a given level are sufficiently addressed before outcomes from subsequent levels are considered final. This does not preclude stakeholders from initiating actions associated with higher readiness levels where there is sufficient confidence that these activities will remain relevant and contribute to the overall readiness pathway.

Port communities are expected to identify and work towards completing all actions that are applicable to their specific circumstances. In exceptional cases, where an action is demonstrably not relevant or not applicable to a particular port context, it may be designated as optional.

In addition to actions, each readiness level may include considerations. These are supplementary activities, initiatives, or areas of attention that port communities may wish to consider in support of the level objective and goals. Unlike actions, considerations are not required to achieve a readiness level and may not be applicable in every port context. Ports are encouraged to evaluate these considerations and, where appropriate, identify additional activities that reflect their specific circumstances, ambitions, and operational environment.

This structure enables port communities to assess readiness in a consistent and transparent manner while maintaining the flexibility required to accommodate different port configurations, stakeholder landscapes, and clean marine fuel pathways.



5. PRL Bunkering

PRL Bunkering assesses readiness for one target fuel at a time and should be repeated for each additional fuel that a port considers bunkering.

PORT:		
TARGET FUEL:		
☐	Bunkering from trucks (TTS)	
☐	Bunkering from a bunker vessel (STS)	
☐	Swapping of Modular Energy Containment Systems (MECS)	
☐	Bunkering from a shore-based bunker facility (LTS)	
☐	Other:	

RESEARCH

LEVEL 1

Foundational background information

The properties, opportunities, risks and regulatory aspects of the target fuel are documented and available to support research and decision-making.

GOVERNANCE

Relevant policies, regulations, and stakeholders impacting the target fuel have been identified.

Actions

1. Research current, present and upcoming international, national, regional, and local regulations related to shipping decarbonization in general and specifically in the use of clean marine fuels.
2. Consult research reports and scientific papers on the target fuel.
3. Assess the decarbonization level of the target fuel.
4. Identify relevant stakeholders and establish dialogue to understand their positions, interests, and expectations regarding the target fuel.

Considerations

1. Assess potential contribution of the target fuel to achieving port emission-reduction targets.

SAFETY

Initial risks have been assessed and required components for the safety framework have been identified

Actions

1. Gather available background information on the specific safety aspects of the target fuel.
2. Research current international and national safety regulations, standards, and best practices related to the target fuel.
3. Assess the safety risks associated with the target fuel.
4. Determine the safety components to be included in the safety framework, including risk mitigation measures, operational procedures, training requirements, and incident-response preparedness.
5. Identify the safety-related authorities and emergency services involved in bunkering operations at the port.
6. Inform relevant safety and environmental authorities about potential developments in alternative fuel markets to create awareness.

Considerations

1. Participate in relevant working groups (e.g. IAPH PRL, IAPH CMF, SGMF).

INFRASTRUCTURE

Infrastructure requirements for bunkering the target fuel have been identified

Actions

1. Research the infrastructural requirements to bunker the target fuel.
2. Assess the availability of suitable space in the port for bunkering the target fuel.
3. Assess whether the target fuel would require new or modified infrastructure within the port.

Considerations

1. Assess infrastructural requirements for accommodating bunker vessels, including berth availability and operational constraints.

MARKET

Initial market potential and relevant incentives for bunkering the target fuel have been identified

Actions

1. Research fuel trends within the shipping industry.
2. Research current and upcoming incentives that support shipping decarbonization and alternative fuel adoption including:
   - International incentives,
   - National incentives, and
   - Regional and local incentives.
3. Assess the market maturity and adoption level of the target fuel within the shipping industry
4. Identify current and future commercial interest for the target fuel among shipping companies, fuel suppliers, and cargo owners.
5. Acquaint relevant port stakeholders with the value chain of the target fuel from well to wake.

Considerations

1. Engage with bunker and industry associations (IBIA) to gather market and industry perspectives.

LEVEL 2

Stakeholder interest and feasibility assessment

The feasibility of target fuel bunkering, and stakeholder willingness to support its implementation, are understood and documented to support decision-making.

GOVERNANCE

Sufficient understanding into the bunker value chain and stakeholder positions for the target fuel have been established.

Actions

1. Provide stakeholders with the background information gathered in Level 1 and assess their interest to support/invest in the target fuel.
2. Assess public perception and acceptance of facilitating the target fuel within the port area.
3. Assess stakeholder support, concerns, and perceived barriers regarding the bunkering of the target fuel.
4. Assess the impact of existing and upcoming regulations on the potential bunkering of the target fuel.

Considerations

1. Encourage relevant stakeholders to participate in research projects, consortiums, and partnerships to strengthen knowledge development and collaboration.
2. Include green corridor partners in discussions and feasibility assessments.

SAFETY

Stakeholder willingness and the resources available for a port-specific safety framework have been assessed, supported by an initial view of relevant safety regulations and gaps.

Actions

1. Assess the willingness of relevant authorities to participate in the development and implementation of a safety framework.
2. Assess interest of stakeholders to create a port-specific safety framework for bunkering the target fuel.
3. Establish a network involving relevant authorities and key players to support the development of the port-specific safety framework.
4. Assess capabilities, knowledge or other resources of stakeholders to contribute to the port-specific framework.
5. Assess the budget and resources available for establishing a port-specific safety framework for calling or bunkering the target fuel.
6. Assess whether existing safety regulations adequately support bunkering of the target fuel and identify regulatory gaps.
7. Conduct a preliminary gap analysis between current port safety procedures and the requirements identified for the target fuel.

INFRASTRUCTURE

Current and future infrastructure gaps for bunkering the target fuel have been identified and assessed.

Actions

1. Assess the extent to which new infrastructure, modifications, or upgrades would be required.
2. Assess the suitability of existing port infrastructure for bunkering the target fuel.
3. Assess the physical feasibility of creating or utilizing a specific port area for bunkering of the target fuel
4. Assess the physical feasibility for establishing enough distance between bunkering of the target fuel and vulnerable areas.
5. Assess infrastructure investment requirements, implementation timelines, and potential spatial constraints.

MARKET

Market opportunities, including demand, supply, and entry potential for port stakeholders, have been identified

Actions

1. Assess current and future supply availability, supply-chain reliability, and accessibility of the target fuel within the port region.
2. Assess current and future demand for the target fuel from vessel operators and cargo-related stakeholders.
3. Assess stakeholders' willingness and perceived feasibility to enter the target fuel market, including their potential roles and positions within the target fuel value chain.

Considerations

1. Create a coalition of stakeholders to establish the value chain for bunkering of the target fuel.
2. Ensure stakeholders in the bunker market are equipped to stay informed on the future market conditions of the target fuel and will have the information necessary to balance demand and supply.
3. Identify potential commercial partnerships to attract shipping lines that make use of the target fuel.
4. Consider initial options for attracting vessels/operators on the target fuel (e.g., reduced port fee, priority berthing, incentive programs, etc.).
5. Consider becoming part of a green corridor.

RESEARCH

LEVEL 3

Detailed research, analysis, and conclusions

The information required to support a go/no-go decision on progression to the development phase is available and documented.

GOVERNANCE

Governance gaps and requirements for bunkering the target fuel have been identified and analysed, providing the strategic arguments needed for a governance go/no-go decision.

Actions

1. Conduct a gap analysis for facilitating the target fuel.
2. Identify domain interdependencies for the governance roadmap.
3. Document, based on the SWOT analyses, the opportunities, risks, and strategic arguments for supporting or discouraging facilitation of the target fuel.

Considerations

1. Draft a publicly available position paper explaining the port's decision to proceed or halt with the target fuel.

SAFETY

Safety and regulatory gaps and requirements for bunkering the target fuel have been identified and assessed, and a safety policy and roadmap can be established.

Actions

1. Conduct a detailed analysis of the safety issues and risks associated with the target fuel.
2. Conduct a gap analysis on the existing safety standards, regulations, and industry best practices.
3. Conduct a gap analysis of your existing safety framework to match the required safety framework for bunkering the target fuel.
4. Assess the budget and resources needed for establishing a port-specific safety framework for calling or bunkering the target fuel.

INFRASTRUCTURE

The port has sufficient information to develop an infrastructure policy and roadmap for bunkering the target fuel.

Actions

1. Research the infrastructure demand and the scale required for bunkering the target fuel at a commercial level.
2. Identify future operational and support services required for commercial bunkering of the target fuel, such as reservation systems, logistics management, and operational support services.
3. Conduct a gap analysis on the port-specific aspects for bunkering of the target fuel.

Considerations

1. Identify future infrastructural, operational, and support services required for commercial bunkering of the target fuel, such as gas-freeing services, maintenance support, and supply of auxiliary products.

MARKET

Market availability, supply and demand dynamics, and cost structures for bunkering the target fuel have been analysed, and a market development roadmap can be established.

Actions

1. Assess the long-term availability, reliability, and scalability of the target fuel supply chain.
2. Assess costs including capital expenses (CAPEX) and operating expenses (OPEX) for bunkering operations of the target fuel.

Considerations

1. Perform a SWOT analysis on possible pattern changes in the port's bunker market.
2. Provide an update to relevant existing green corridor initiatives on the port's readiness status for the target fuel.

DEVELOPMENT

LEVEL 4

Roadmap to proceed; framework and timeline developed

A clear roadmap defining the actions, stakeholders and requirements for developing target fuel bunkering is established.

GOVERNANCE

A governance policy and roadmap for bunkering the target fuel have been established, including clearly defined roles and responsibilities

Actions

1. Create a governance roadmap including the port's position and ambitions, actions, roles and responsibilities and regulatory impact.
2. Identify, secure and allocate resources and budget for implementation of the roadmaps across all domains
3. Draft a communication and strategic stakeholder management plan for stakeholders, regulatory authorities, the press, and the public.

Considerations

1. Include a strategy for monitoring the environmental impact of the target fuel use.
2. Draft a strategy to set up a new green corridor or another coalition that include the port value chain.
3. Establish a market licensing scheme by the competent authority with permits for working in assigned areas to regulate the market (if allowed).

SAFETY

A safety policy, roadmap, and supporting framework for bunkering the target fuel have been established.

Actions

1. Identify the necessary steps – e.g. actions and studies – to address the gaps from the Level 3 gap analysis.
2. Define the port's position, ambitions, and responsibilities on safety, and the regulatory impact.
3. Draft a safety roadmap/timeline and initiate the required safety framework actions and studies etc.

INFRASTRUCTURE

An infrastructure policy and a development roadmap for bunkering the target fuel have been established.

Actions

1. Identify the necessary steps, e.g. actions and studies, to address the gaps from the Level 3 gap analysis.
2. Define the port's position, ambitions, and responsibilities on infrastructure, and the regulatory impact.
3. Draft a roadmap to timeline and initiate the required infrastructural actions and studies, etc.

Considerations

1. Assess how the target fuel impacts Vessel Traffic Management.
2. Incorporate a plan to provide a proper level of service in the roadmap, e.g., maintenance, cleaning, gas freeing facilities, etc.

MARKET

A commercial policy, including a market uptake and incentive strategy, and a supporting roadmap for bunkering the target fuel, have been established

Actions

1. Draft a market uptake plan to support and guide bunkering of the target fuel. This may include:
   - Policies and pricing incentives.
   - Funding for support of demonstration projects or short-term and long-term funding for CAPEX and OPEX.
   - A strategy to form a coalition of stakeholders involved in the bunkering supply and value chain.

Considerations

1. Develop a way to measure the socio-economic impacts of bunkering the target fuel at the port.
2. A strategy to support innovators and start-ups related to the target fuel.

DEVELOPMENT

LEVEL 5

Roadmap implementation

The roadmap has been executed and the required conditions for implementation and validation of target fuel bunkering have been established.

GOVERNANCE

Initial implementation of governance structures and processes for bunkering the target fuel has been initiated, supported by approval and communication of the framework among key stakeholders.

Actions

1. Obtain approval of the governance framework from all required entities.
2. Implement the strategic stakeholder management plan with stakeholders, regulatory authorities, the press, and the public. Share relevant pieces of the framework with each entity and request feedback where necessary.
3. Create a submission system for fuel providers to request licensing / audit of their anticipated target fuel operations.
4. Update external communication channels based on the framework(s) established for bunkering the target fuel.

Considerations

1. Establish a change-management program to address and manage required changes based on the guiding framework for use of the target fuel at the port.
2. Disperse public guidance covering the new reporting protocol and changing procedures for bunkering in the port.

SAFETY

The safety and regulatory framework has been put in place and initial implementation has started.

Actions

1. Conduct a port-specific risk assessment and spatial analysis, maintaining a safe distance between target fuel activities and vulnerable or populated areas, as well as a minimum distance required for passing vessels.
2. Conduct credible spill scenarios and gas dispersion studies. From the results, incorporate defined control, safety, and exclusion zones into the safety framework.
3. Based on at least on the outcomes of at least one external safety / nautical high-risk study, establish a ‘bunker map’ identifying approved locations and operational conditions for bunkering of the target fuel.
4. Conduct studies on incident response and required security measures.
5. Conduct HAZID and HAZOP studies.

Considerations

1. Simulate, in a test environment, all relevant planning and procedures of the safety framework using computational fluid dynamics (CFD).

INFRASTRUCTURE

Minimum viable infrastructure and operational conditions for bunkering the target fuel have begun to be implemented

Actions

1. Establish the minimum viable infrastructure required for pilot-scale bunkering of the target fuel.
2. Establish the operational procedures and supporting services required for pilot-scale bunkering.

Considerations

1. Simulate processes with IT-supported digital twinning.

MARKET

Market support mechanisms for bunkering the target fuel have been activated, and pilot projects have been initiated.

Actions

1. Release an (open) call for applications from fuel providers and vessel operators to deploy the first pilot projects for bunkering of the target fuel.
2. Establish criteria for the selection and support of pilot projects.

DEVELOPMENT

LEVEL 6

Pilot-scale demonstration

The key governance, market, safety and infrastructure aspects required for a first pilot bunkering operation of the target fuel have been implemented, tested and validated through a controlled pilot, providing the basis for deployment decisions and further scale-up.

GOVERNANCE

Governance arrangements required for a first pilot bunkering operation, as identified and developed in previous levels, have been applied, tested and validated through a pilot operation, providing confidence that they are suitable for future bunkering operations and further operational scale-up.

Actions

1. Select an appropriate small-scale pilot for bunkering the target fuel and identify a suitable location for its execution.
2. Assemble a single project team to lead and coordinate the pilot operation, with members covering governance, safety, infrastructure, market and communication.
3. Have the project team review the studies, simulations and frameworks developed in previous levels and determine which arrangements, requirements and framework elements are applicable to the pilot operation.
4. Develop and maintain an integrated pilot implementation plan covering governance, safety, infrastructure and market requirements and activities, and secure the required approvals from competent authorities prior to execution.
5. Communicate the pilot scope, objectives, governance arrangements and timeline through established governance and stakeholder engagement channels.
6. Coordinate alignment between port authorities, competent authorities, operators and other relevant stakeholders during the pilot operation.
7. Monitor and evaluate the effectiveness of the governance arrangements during the pilot, assessing their suitability for future and repeatable bunkering operations.
8. Consolidate lessons learned from the pilot across all domains and update governance frameworks, procedures and roadmaps, while ensuring relevant findings are reflected in the respective domain frameworks and roadmaps.
9. Disseminate pilot findings, lessons learned and recommended framework updates with relevant stakeholders.
10. Share the successful completion of the pilot operation with relevant stakeholders.

SAFETY

Safety arrangements, procedures and regulatory requirements required for a first pilot bunkering operation, as identified and developed in previous levels, have been applied, tested and validated under operational conditions to confirm their effectiveness and suitability for future, repeatable bunkering operations and further scale-up.

Actions

1. Define the operational safety requirements and arrangements for inclusion in the integrated pilot implementation plan, including:
   - compliance with the developed JPBO,
   - spatial planning arrangements,
   - control zones,
   - use of applicable operational bunker checklists.
2. Define the pilot oversight and preparedness arrangements for inclusion in the integrated pilot implementation plan, including:
   - supervision by relevant authorities,
   - enforcement by safety specialists,
   - incident response arrangements,
   - training requirements.
3. Confirm the operational readiness of participating organizations, vessels, terminals, bunker operators and relevant emergency response capabilities for the pilot operation.
4. Conduct any additional simulations, testing, exercises, training or validation activities required to confirm readiness for safe execution of the pilot operation.
5. Execute and monitor the pilot operation under the agreed safety framework and assess the effectiveness of the implemented safety arrangements and authority oversight.
6. Evaluate the preparation and execution of the pilot operation, identify lessons learned and determine improvements required to support future and repeatable bunkering operations.
7. Update and communicate the safety framework, procedures and roadmap based on validated pilot outcomes.

INFRASTRUCTURE

The minimum viable infrastructure, operational processes and supporting systems required for a first pilot bunkering operation, as identified and developed in previous levels, have been applied, tested and validated under operational conditions to confirm their suitability for future, repeatable bunkering operations and further scale-up.

Actions

1. Define the infrastructure, operational process and supporting system requirements for inclusion in the integrated pilot implementation plan.
2. Confirm the suitability of the selected pilot location and associated infrastructure for the intended bunkering operation.
3. Implement any temporary or permanent infrastructure modifications required for safe pilot execution.
4. Execute the bunkering pilot and validate infrastructure performance under operational conditions.
5. Validate pilot outcomes and incorporate lessons learned into future infrastructure development and scale-up plans.

Considerations

Governance

1. Assess pilot findings with the broader port community and relevant stakeholders.
2. Share insights and lessons learned with other ports and, where relevant, green corridor partners.

MARKET

Commercial arrangements, stakeholder participation and value-chain readiness required for a first pilot bunkering operation, as identified and developed in previous levels, have been applied, tested and validated through a pilot operation to confirm their suitability for future, repeatable bunkering operations and further scale-up.

Actions

1. Define the commercial, contractual and stakeholder participation requirements for inclusion in the integrated pilot implementation plan.
2. Identify, engage and confirm the participation of the required commercial stakeholders for the pilot operation.
3. Establish the contractual, liability and commercial arrangements required to execute the pilot operation.
4. Use pilot outcomes to demonstrate commercial viability, build market confidence and attract additional market participants.
5. Capture market feedback and incorporate lessons learned into future deployment and scale-up strategies.
6. Share pilot outcomes and lessons learned with relevant market stakeholders and, where applicable, green corridor initiatives.

Considerations

Market

1. Establish pilot partnership agreements between participating organisations.
2. Involve green corridor partners, cargo owners and other relevant market participants where feasible to strengthen market relevance and future demand.

DEPLOYMENT

LEVEL 7

Project-based approach

The governance, market, safety and infrastructure arrangements enable repeatable project-based target fuel bunkering in the port.

GOVERNANCE

Governance structures and processes for bunkering the target fuel have been formalised, endorsed by relevant stakeholders, and are capable of supporting project-based bunker operations.

Actions

1. Encourage operators and fuel providers to continue to submit requests to bunker the target fuel.
2. Vet proposals and projects as they are received.
3. Assemble project team(s) to lead and/or support each project, as in Level 6.
4. Apply the bunkering framework to multiple project scenarios as listed above and incorporate review and learnings from each project.
5. Support schooling and training institutes to prepare port staff and operators for more regular, larger scale bunkering of the target fuel.
6. Update the external communication channels.
7. Engage in communication to share knowledge and experience with other ports.
8. Provide public communications announcing initiation of more regular bunkering of the target fuel at the port.
9. Project-based operations are monitored and evaluated, and lessons learned are used to further refine the governance, safety, infrastructure, and market frameworks.
10. Establish clear roles and responsibilities for recurring project-based bunkering operations involving the target fuel.

Considerations

1. Monitor the effect of the use of the target fuel in the port on GHG emissions and air quality.
2. Monitor and publish the quantities bunkered of the target fuel.

SAFETY

The safety and regulatory framework for bunkering the target fuel has been formalised and can support project-based bunker operations.

Actions

1. Project teams should plan and execute each new bunkering with the target fuel as was done in Level 6, including receiving approval from relevant competent authorities and ensuring safety protocols for every project.
2. Develop and implement a training and competency programme to ensure that all personnel involved in project-based bunkering operations possess the knowledge and skills required for the target fuel.
3. Standardize operational procedures, training requirements, and safety practices to support consistent execution of project-based bunkering operations.
4. Expand organisational preparedness by ensuring that sufficient personnel, contractors, service providers, and authorities are trained and capable of supporting recurring project-based bunkering operations.
5. Ensure a competent authority is granting project-based licences or exemptions for operations.
6. Implement training of auditors or establish a conformity assessment system on which audits can be done by external conformity assessment bodies, to audit fuel providers for compliance with established protocol.

Considerations

1. Initiate training programs by third-party institutes to establish industry training standards.

INFRASTRUCTURE

The infrastructure required for the target fuel has been upgraded and is capable of supporting project-based bunker operations.

Actions

1. Ensure necessary infrastructure with relevant protocols and supervision exists or is developed for (if applicable) STS, TTS, or LTS bunkering (e.g. gas freeing).
2. Ensure the nautical restrictions – such as safety distances, additional mooring requirements, additional signalling – are followed
3. Ensure the nautical service providers (pilots, VTS, Traffic Management, etc.) are informed about and prepared for, the bunkering fuel on board of the vessel.
4. Ensure that operational support services, nautical service providers, and infrastructure operators are equipped and prepared to support recurring project-based bunkering operations.

Considerations

1. Develop procedures, or integrate procedures, for Traffic Management.
2. Aid port operations with strong IT support that is adapted to the target fuel
3. Ensure necessary “spin-off ” infrastructure, such as gas-freeing services or delivery of auxiliary products.

MARKET

A viable initial market for project-based bunkering of the target fuel has been established through committed customers and commercial arrangements, creating the basis for scale-up of bunkering operations.

Actions

1. Support stakeholders to make final investment decisions (FID) on new target fuel projects.
2. Implement a market strategy that identifies new opportunities and supports the uptake of the target fuel and technologies, including:
   - Short-term or long-term funding of CAPEX or OPEX,
   - A pricing incentive for bunkering the target fuel vs vessels operating on conventional fuels.
3. Secure funding and support for early movers and monitor funding and pricing opportunities.
4. Connect stakeholders within the supply chain with potential customers.

Considerations

1. Explore niches in the bunker market and market opportunities.
2. Release an open call for more projects utilizing the target fuel.

DEPLOYMENT

LEVEL 8

A system-based approach, embedding bunkering into day-to-day port processes

The governance, market, safety and infrastructure arrangements required for system-based target fuel bunkering have been established in the port.

GOVERNANCE

Governance structures and processes have been fully integrated into day-to-day operations, enabling routine bunkering of the target fuel.

Actions

1. Ensure that all elements of a port –regulation, operations, procedures, infrastructure and stakeholders – are in place to ensure activities are integrated, consistent, and scalable.
2. Ensure the bunkering-request process is well organised, established, and effective, including clear responsibilities and sufficient operational information for all stakeholders.
3. Ensure that the bunkering request reaches all involved or impacted parties, triggering the designated relevant procedures for the vessel, terminal, incident response organisation, port authorities and other relevant port stakeholders.
4. Integrate governance responsibilities, reporting lines, and decision-making processes related to the target fuel into standard port management systems.
5. Establish routine engagement mechanisms with stakeholders, authorities, and service providers to support day-to-day bunkering operations and continuous improvement.
6. Initiate a system of auditing, licensing or permitting for relevant related bunkering stakeholders.

Considerations

1. Measure and report the effect of the target fuel use on GHG emissions and air quality.
2. Report and publish the quantity of target fuel bunkered.
3. Continue to share experiences and lessons learned with other ports. Join the IAPH working groups, share your insights and learn from the lessons of other ports.

SAFETY

The safety and regulatory framework has been fully embedded, enabling safe day-to-day bunkering operations.

Actions

1. Align operations according to the safety and regulatory framework to perform bunkering of the target fuel as a day-to-day port operation.
2. Ensure the port's emergency response organization is sufficiently trained, staffed and equipped.
3. Ensure port authority personnel are sufficiently staffed, trained, informed, and equipped with the necessary competence to support safe, consistent, and wellcoordinated alternative fuel bunkering as part of daytoday port operations.
4. Assess bunker requests to be compliant with the safety and regulatory framework.
5. Monitor bunker operations and operators to ensure compliance with the safety and regulatory framework.
6. Ensure the competent authorities grant system-based licences, permits, or exemptions for routine operations where required.
7. Establish and maintain a competency management system to ensure that all personnel involved in bunkering operations remain qualified, trained, and up to date on procedures related to the target fuel.
8. Ensure sufficient staffing, expertise, and operational coverage are available to support routine bunkering operations involving the target fuel.
9. Establish processes for capturing, sharing, and maintaining operational knowledge and lessons learned related to bunkering of the target fuel.
10. Implement periodic refresher training, exercises, and emergency response drills for personnel involved in bunkering operations and incident response

Considerations

1. Perform and manage audits and assessments to support the licensing and compliance of bunkering stakeholders.

INFRASTRUCTURE

Infrastructure has been upgraded and is fully operational, supporting day-to-day bunkering of the target fuel.

Actions

1. Ensure dedicated infrastructure is in place for the target fuel, including tanks or land-based infrastructure, bunker vessels, and sufficient services.
2. Ensure the admission policy and procedures are well known and that bunker stakeholders are compliant with the admission policy
3. Ensure all applicable nautical requirements and operational restrictions are incorporated into bunkering operations.
4. Implement maintenance, inspection and, if relevant, asset-management programmes for infrastructure supporting bunkering of the target fuel.
5. Ensure service providers and supporting infrastructure operators can reliably support routine bunkering activities.

MARKET

A stable and functioning bunkering market for the target fuel has been established, supporting day-to-day operations and continued demand growth.

Actions

1. Monitor and stimulate (market) traction in target fuel bunkering to further build on the foundation for an established and scalable market.

Considerations

1. Monitor customer ambitions, including their timelines for decarbonization.

DEPLOYMENT

LEVEL 9

Market penetration and growth

A fully integrated target fuel bunkering system continuously improves and scales in line with market demand.

GOVERNANCE

Continuous governance improvement mechanisms have been implemented, ensuring alignment with increasing demand for the target fuel.

Actions

1. Implement and maintain a Plan-Do-Check-Act (PDCA) cycle to continuously improve governance arrangements for the target fuel.
2. Remain up to date with the market, innovations and new trends on infrastructure and technical improvements for the target fuel.
3. Ensure that information flows and response procedures scale with growing bunkering activity, keeping all relevant parties – terminals, vessels, port authorities, and emergency responders – consistently informed and prepared

Considerations

1. Establish key performance indicators (KPIs) and performance-monitoring processes across governance, safety, infrastructure, and market domains to support continuous improvement and strategic decision-making.
2. Develop and implement a system to track all fuel sales at the port to aid in monitoring GHG impacts of the target fuel and new low- or zero-carbon marine fuels that are introduced.

SAFETY

Continuous improvement mechanisms for safety management (e.g. PDCA cycle) have been implemented, ensuring safe and scalable bunkering operations for the target fuel.

Actions

1. Incorporate a plan, do, check, act (PDCA) cycle to check and continuously improve the target fuel's safety framework.
2. Periodically evaluate and update competency requirements and training programmes based on operational experience, incidents, audits, and technological developments.
3. Periodically review incidents, near misses, audits, inspections, exercises, and operational performance to identify opportunities for improvement of the safety framework.

INFRASTRUCTURE

Infrastructure improvement and scaling mechanisms have been implemented, ensuring alignment with the growing demand for bunkering the target fuel.

Actions

1. Improve the ports capabilities and infrastructure to align with rising demand of the target fuel.
2. Continuously evaluate and expand dedicated bunkering infrastructure – including storage, bunker vessels, and associated services – to keep pace with growing demand for the target fuel.
3. Incorporate a plan, do, check, act (PDCA) cycle to check and continuously improve the infrastructure.
4. Periodically reassess infrastructure capacity, utilization, and operational performance to anticipate future growth and investment needs.

MARKET

A mature, competitive, and balanced bunkering market for the target fuel has been established and is actively monitored and supported.

Actions

1. Assess the quality and effectiveness of the market arrangements for the target fuel, including the market strategy and supply chain arrangements, port incentives for supporting the target fuel, the port pricing strategy, and market communication. The market should support:
   - Multiple suppliers supplying the target fuel,
   - multiple bunker operators providing the target fuel to vessels,
   - A balanced supply and demand, and
   - fuel contracts or agreements between suppliers and vessel operators

Considerations

1. Develop a strategy to phase out or reduce the market for conventional fuels and replace them with the target fuel or other low- or zero-carbon marine fuels.
2. Provide an update to relevant green corridor projects or proposals on the new status of the port as a port of bunker for the target fuel.

6. 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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