Maritime Just Transition TASK FORCE

CONSIDERATIONS OF TRAINING ASPECTS FOR SEAFARERS ON SHIPS POWERED BY AMMONIA, METHANOL AND HYDROGEN

United Nations Global Compact

International Chamber of Shipping

INTERNATIONAL TRANSPORT WORKERS' FEDERATION

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With a special thanks to

Foundation

Executive Summary

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As the maritime industry moves towards reducing greenhouse gas emissions, there is a critical need to explore alternative fuels. The Maritime Just Transition Task Force (MJTTF), in collaboration with the International Maritime Organization (IMO) Secretariat with support from Lloyd's Register Foundation, has initiated a project to develop the training materials necessary for seafarers to safely use the new zero and near-zero GHG emission fuels and draft associated competency standards, as current competencies under the Seafarers' Training, Certification and Watchkeeping (STCW) Code do not yet cover these areas specifically. The project is titled **'Baseline Training Framework for Seafarers in Decarbonization'**.

To achieve this, a series of workshops were conducted focusing on the safe use of ammonia, methanol and hydrogen as marine fuels. These workshops aimed to gather industry perceptions on the necessary changes for seafarers transitioning from conventional fuels to alternative fuels, and to identify the possible new or modified competencies and training required to enable such a transition.

This consolidated report provides a distilled summary of the objectives, methodology, findings and conclusions acquired from 12 hybrid workshops that engaged 116 participants and produced substantial considerations for each fuel. Successful completion of the first part of the MJTTF training project marks the beginning of a new chapter in the upskilling and reskilling of seafarers to stand up to the decarbonization challenges of shipping. In essence, the output of the workshops will serve as the foundation for work in progress to be completed on proposing new training frameworks and competency standards for seafarers handling these three alternative fuels.

The workshops with experts underscored a broad consensus on the need for significant updates in training and competencies for seafarers as the industry transitions to alternative fuels. Each fuel – ammonia, methanol and hydrogen – presents unique challenges and hazards that require specialized knowledge and safety measures. The maritime industry, along with regulators like the IMO, will need to address these requirements thoroughly to ensure the safe and efficient adoption of these cleaner fuel technologies.

Continued collaboration between industry stakeholders is crucial as advances in ship design and fuel technologies evolve. Developing standardized training materials and certification programmes, reflecting the latest safety protocols and operational procedures, will be key to a successful transition.

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Introduction

Introduction

The Maritime Just Transition Task Force (MJTTF) is an initiative that was formed at the 26th Conference of Parties of the United Nations Framework Convention on Climate Change (COP26 in 2021) by the UN Global Compact (UNGC), International Chamber of Shipping (ICS), International Transport Workers' Federation (ITF), with the collaboration of the International Labour Organization (ILO) and the International Maritime Organization (IMO), supported by founding funder Lloyd's Register Foundation. The MJTTF aims to ensure that shipping's response to the climate emergency puts seafarers at the heart of the solution. The projects the MJTTF undertakes are supported by globally established Just Transition Principles.

The work of the MJTTF seeks to strengthen and coordinate collaboration between industry, workers, governments and academia toward a safe, equitable and human-centred approach to the transition towards a decarbonized shipping industry. There is work to be done by the shipping industry to reach the goals set up in the 2023 IMO GHG Strategy, in particular to reach net-zero emissions 'by or around' 2050.

The MJTTF secretariat commissioned a study supported by DNV to understand how best to support the maritime workforce as the industry decarbonizes. A key finding of the report was that 450,000 seafarers would require some additional training by 2030, while 800,000 seafarers would require some kind of additional training by the mid-2030s, with the scenario assuming an immediate ramp-up of alternative fuels in the 2030s.

These findings highlight a need for new competencies required for seafarers when new fuels such as ammonia, methanol and hydrogen are deployed. The Baseline Training Framework for Seafarers in Decarbonization Project is a joint project by the MJTTF, with collaboration of the IMO Secretariat and the support of Lloyd's Register Foundation, that addresses this gap. It sets out to develop a baseline training framework to support seafarers to equip necessary safety-related knowledge and skills as the industry decarbonizes. This project also facilitates the development of the required framework to secure seafarers' safety in future operations. The project is led by **Lloyd's Register's Maritime Decarbonization Hub**.

The Training Project has three key objectives:

1. Develop generic draft competencies and Knowledge, Understanding and Proficiencies (KUPs) for three alternative fuels (ammonia, methanol and hydrogen) where IMO interim safety guidelines are in place or currently being developed.
2. Develop a training framework and learning materials targeted at all seafarers and an instructor handbook for maritime education and training institutions.
3. Shape global future legislation and approaches to training through submissions at the IMO and contributions to the ongoing comprehensive review of the STCW Convention and Code, including the above-mentioned training framework.

The considerations in this report were generated from the risk assessment workshops carried out within the context of the 'Baseline Training for Seafarers in Decarbonization' training project. Leading industry experts were gathered to provide input to a predefined list of scenarios and share existing knowledge and experience regarding ammonia, methanol and hydrogen as marine fuels.

Safety is an area of cooperation, not competition. This form of collaboration can inspire other industries that seek to centre the betterment and safety of their workers as steps are taken to decarbonize and moves are made for a just transition.

Carrying more than 80% of international trade of goods, the world fleet of merchant vessels - operated by on-board crews, dockworkers and employees in all parts of the maritime supply chain - constitute the backbone of the global economy. While by far the most energy-efficient mode of long-haul transportation of large quantities of goods, the shipping industry today nevertheless accounts for some 3% of global greenhouse gas emissions. For the industry to decarbonize in accordance with the goals and trajectory of the Paris Agreement, zero-emission fuels will have to replace marine diesel and heavy fuel oil. For deep sea shipping, the most prominent candidates for this substitution are ammonia, methanol and hydrogen, all of which are addressed in this report.

In addition to technical, operational and commercial transitions, the decarbonization of shipping will happen and succeed only when workers in all parts of the maritime supply chain are newly-skilled, re-skilled and up-skilled. This will require new regulations, training standards and certifications, and new curriculums for maritime schools and training centres. It will also mean that the labour market for maritime workers will transit from one homogenous pool of workers all trained and certified on fossil fuels, to a diversified market of workers trained and certified for different zero-emission fuels.

Risk Assessment Workshops

Workshops were facilitated by Lloyd's Register's Maritime Decarbonisation Hub, the research and action unit of the organisation that focuses on the safe deployment and upscale of zero and near-zero fuels, involving various stakeholders representing different areas of the maritime supply chain, namely:

- Subject matter experts from LR and LR Maritime Decarbonization Hub.
- The Core Project team partners, comprising of organizations and associations who oversee the project (UNGC, ICS, ITF, IMO, WMU and LR).
- The MJTTF Action Group members who were invited to review the preliminary outcomes.
- Industry prominent figures invited as workshop participants for primary input.
- Industry subject matter experts with expertise in fuels, engineering, competencies and training.

The workshops were designed using the STCW Code tables as the main reference point. These tables specify the minimum standards of competence for basic and advanced training for ships propelled by fuels regulated under the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code). The workshops' objective was to establish a robust foundation for developing baseline competence standards and training materials for seafarers handling ammonia, methanol and hydrogen with some deep dives on the following areas:

- The common and unique aspects in the handling and management of each fuel.
- Identification of safety-critical tasks associated with maritime operations for each fuel.
- Identification of hazards, assessment and management of ALARP (As Low As Reasonably Practicable) risk mitigation measures.
- Development of a record of competency gaps and training considerations, including changes in existing frameworks.

The workshops operated on the assumption that seafarers on vessels using alternative fuels would have received relevant training and certification for conventional fuels. The goal was to identify the additional knowledge, understanding, proficiencies and skills required for working on ships powered by alternative fuels. Through systematically applying a central question to various scenarios based on current experiences and anticipated hazards for each fuel type, the workshops instigated discussions, identified critical areas of concern and conducted a deep dive to the actual gaps that training frameworks will need to address in future.

The project looked at the competencies for basic and advanced training and then created a list of scenarios that concern the planning and management of safe operations onboard ships. The table below is based on existing basic and advanced competencies specified within the STCW Code for training on ships subject to IGF Code. Overall, they represent all aspects of ship operations from supporting operations to planning and safe management. while also covering emergency response and knowledge of legislative requirements.

Competencies
Familiarity with physical and chemical properties, including hazards of fuels
Application of occupational health, safety precautions and measures, including prevention of hazards
Knowledge of the prevention, control, fire-fighting and extinguishing systems
Undertake precautions to prevent pollution of the environment from the release of fuels
Response to other emergencies
Operation of fuel controls related to propulsion plant
Operation of engineering systems, services and safety devices
Ability to safely perform and monitor all operations related to the fuels used
Safe management and planning of bunkering, stowage and securing of fuel
Compliance with legislative requirements

The starting premise for the workshops was to identify the modified or new competencies or training that would be needed to accommodate in the safe deployment of ammonia, methanol and hydrogen as marine fuels. In addition, the participants were also requested to estimate the scale of change needed to move seafarers training to the next level. The following Scale of Change descriptions were introduced:

Scale of change	Criteria Description
Low	Either no or small changes to seafarer competencies and training, including knowledge, understanding and proficiencies are required. This would include where vessel design or operational practices can follow existing regulations and / or industry practiced guidance. Task requirements, as well as seafarer competencies and training requirements, are similar to those that exist for conventional fuel oil.
Medium	Some changes to seafarer competencies and training are expected to add additional complexity, time requirements and an increased reliance on human knowledge, understanding and proficiencies above what is needed for operating with conventional fuel oil. New operational practices are required to accommodate the alternative fuel and modified vessel design.
High	Significant changes to seafarer competencies and training are expected to add additional complexity, time requirements and an increased reliance on human knowledge, understanding and proficiencies above what is needed for operating with conventional fuel oil. Operational practices are particularly reliant upon new or updated knowledge, human decision making and actions to accommodate modified vessel design. In addition, the consequences of wrong decisions or actions could be quite severe and could have adverse effects on those onboard or nearby including those ashore.

Consolidated Industry's views

The workshops resulted in a large number of considerations. Each specific or grouped consideration stands for a call for action among the stakeholders of the maritime industry to enhance the seafarers' competencies and develop new or advanced training programmes.

Notwithstanding the excessive number of considerations, several common themes emerged across all sessions:

Bunkering

Handling and transferring alternative fuels during bunkering operations will require specific competencies and safety communication protocols.

Process Safety Hazards

Proactively identifying and mitigating process-related hazards to ensure safe handling and usage of these fuels.

Occupational Health and Safety

This core training module will require a rewrite with additional pieces referencing the handling of hazardous materials whilst also addressing emergency response protocols.

New Operational Equipment and Systems

Adapting to and safely operating new technologies and systems that will come to the market as the technology readiness level of different solutions and fuel options will gradually mature and need significant uptake within the next decade.

Safety Devices

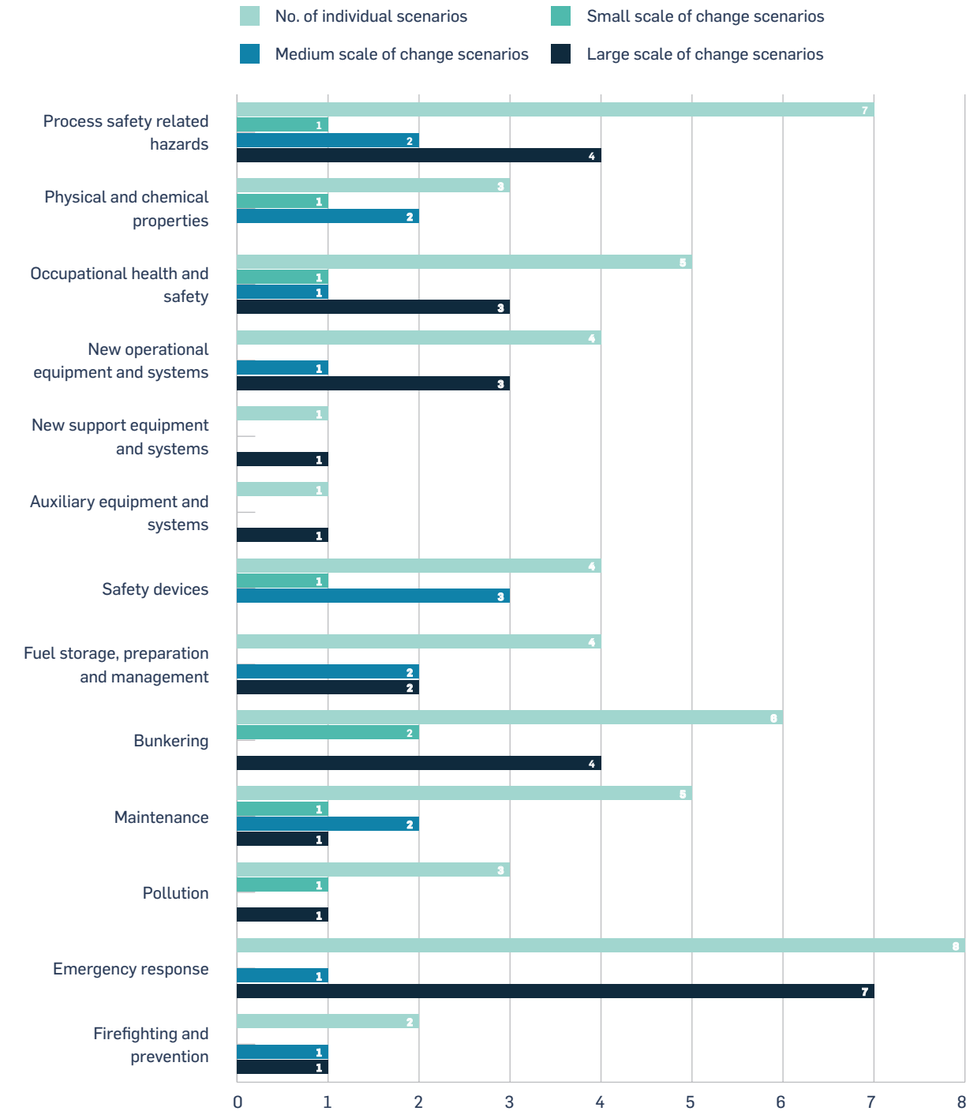
Knowledge and safe operation of safety devices, including their maintenance, are essential to preventing accidents and effectively managing risks.

Fuel Storage, Preparation and Management

Specialized knowledge during storage, preparation and management of alternative fuels to prevent accidents and ensure operational efficiency.

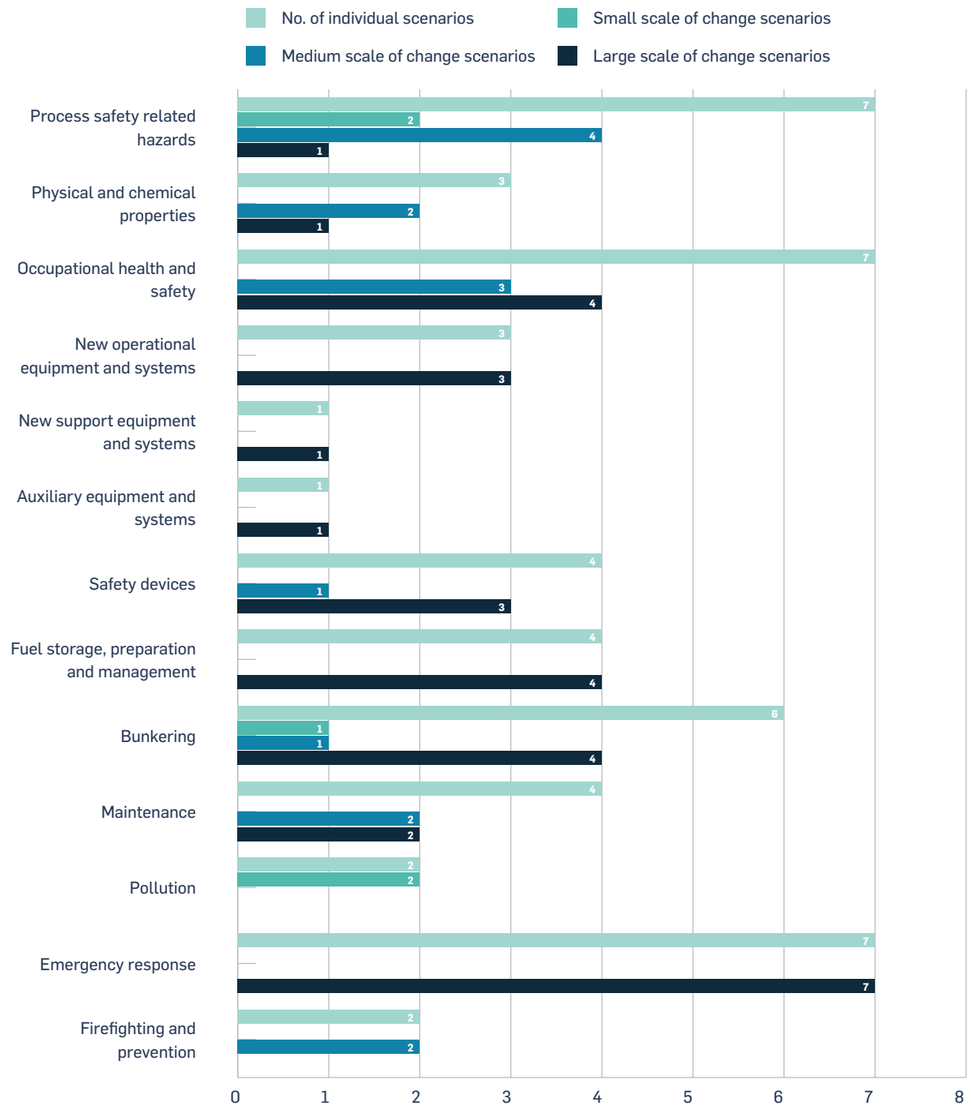
The tables below offer the consolidated output regarding the perceived scale of change across ammonia, methanol and hydrogen as well as the scale of change by theme.

Figure 1: Methanol Perceived scale of change by theme, level and number of related scenarios



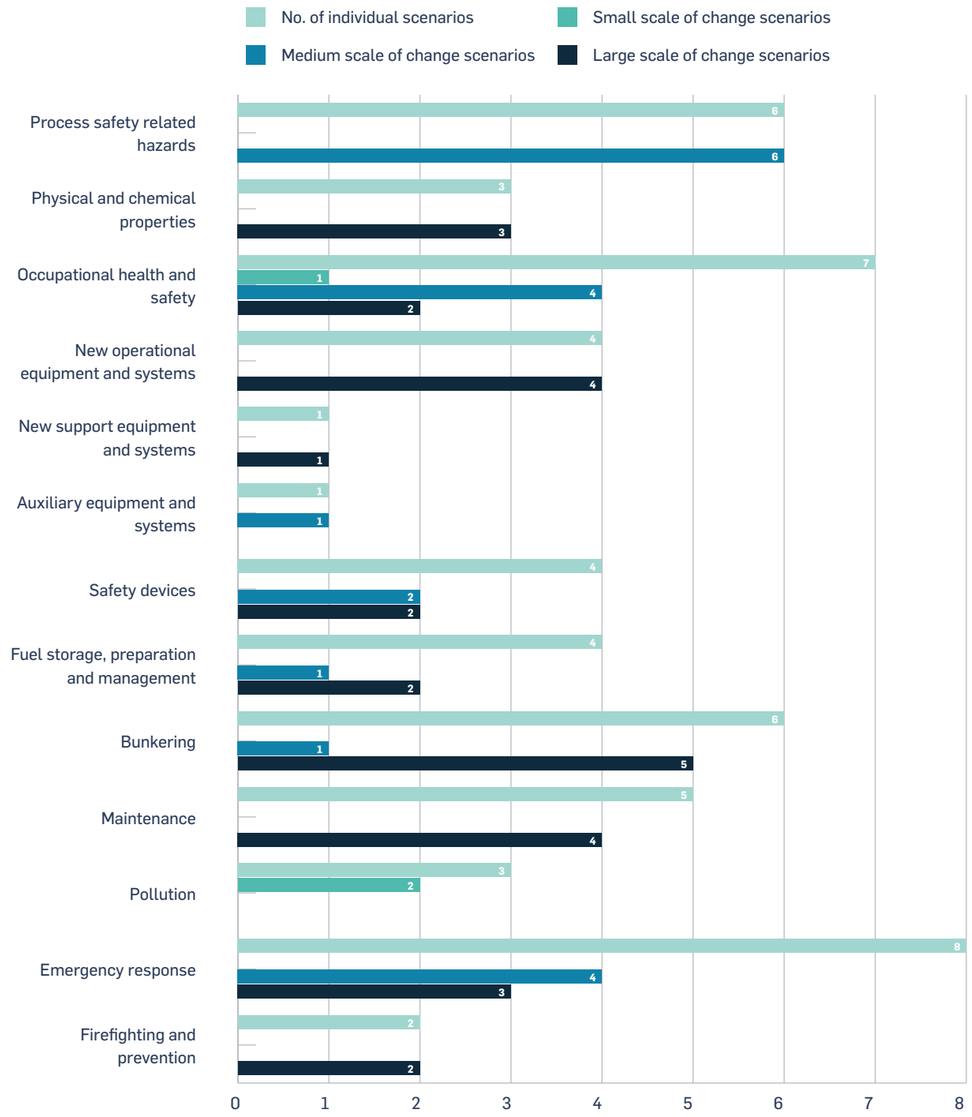
Totals				
	53	8	15	28
	No. of individual scenarios	Small scale of change scenarios	Medium scale of change scenarios	Large scale of change scenarios

Figure 2: Ammonia Perceived scale of change by theme, level and number of related scenarios



Totals				
	51	5	15	31
	No. of individual scenarios	Small scale of change scenarios	Medium scale of change scenarios	Large scale of change scenarios

Figure 3: Hydrogen Perceived scale of change by theme, level and number of related scenarios



Totals				
	54	3	13	34
	No. of individual scenarios	Small scale of change scenarios	Medium scale of change scenarios	Large scale of change scenarios

The workshops demonstrate their impact by raising differentiated safety considerations specifically for each fuel option.

Some of the key considerations associated with the use of ammonia as a marine fuel focused on safety devices, process safety and occupational health and safety training are:

- Ammonia's toxicity poses new challenges, requiring knowledge of its physical and chemical properties, hazardous profile and human exposure threshold limits.
- New knowledge of ammonia fuel supply system design.
- New knowledge on ammonia fuel supply system operation.
- New maintenance and inspection regimes.
- Additional working practices for ammonia handling onboard the ship, including work permits, toxic space entry, management of change.
- Definition of hazardous and toxic zones onboard the ships and Personal Protective Equipment (PPE) requirements for entry and operation within these zones.
- Enhanced PPE requirements and ammonia-specific emergency response strategies.
- Training on the use of new equipment and safety systems, in addition to training on the use of PPE and emergency response to ammonia incidents onboard the ship.

Some of the key considerations associated with the use of methanol as a marine fuel focused on bunkering, process safety hazards and occupational health and safety are:

- Methanol's greater flammability compared to conventional fuels requires new fire detection methods and safety protocols.
- Detailed training on methanol's properties, including its toxic effects, corrosivity and chemical compatibility, is necessary.
- PPE protocols and process safety measures need updating to account for methanol's unique hazards.

Some of the key considerations associated with the use of hydrogen as a marine fuel focused on bunkering, process safety hazards and new operational equipment are:

- Hydrogen's high flammability necessitates new flame detection methods and enhanced fire safety measures.
- Theoretical knowledge of hydrogen's properties, such as high leak propensity and potential for corrosion, is crucial.
- New PPE protocols and occupational health and safety training are required due to hydrogen's unique hazards.
- Special attention to fuel storage, particularly with liquid and compressed hydrogen, to prevent flammable atmosphere formation.

Competencies and KUPs

The tables below show the high-level Knowledge, Understanding and Proficiency's that need to be addressed relating to the development of training frameworks for seafarers working on ships subject to propulsion with ammonia, methanol and hydrogen as fuels.

Figure 4: Knowledge, Understanding and Proficiencies required for the three fuels:

Ammonia

Competency	Knowledge Understanding and Proficiency
Familiarity with physical and chemical properties, including hazards of fuels	Thermodynamics of a liquefied gas, liquid-to-gas expansion ratio, cooling properties and release characteristics. Ammonia toxic thresholds limits to humans and exposure routes. Flammability profile. Hygroscopic, corrosive and caustic properties of ammonia. Exothermic reaction with water.
Application of occupational health, safety precautions and measures, including prevention of hazards	Safety risk analysis and hierarchy of controls. Preventive and mitigating safety measures. Safe job analysis and safety protocols.
Knowledge of the prevention, control, fire-fighting and extinguishing systems	Preventive and mitigating safety barriers to control ammonia vapour ignition in the confined space. Response to ammonia fire, including use of fire-fighting equipment and PPE.
Undertake precautions to prevent pollution of the environment from the release of fuels	NOx/N2O emission control in exhaust fumes. ARMS, treatment of operational emissions and waste. Handling of emergencies and venting to air. Ammonia spill to sea and leak collection management.
Response to other emergencies	Definition of toxic zone/area on the ship and bunkering safety zone, including associated requirements to access, entry and work on ammonia systems. Selection and use of PPE. Pre-defined emergency response strategies/ plan to ammonia leaks. First aid provision and appliances for ammonia leak exposure. Use of escape routes and safe haven in the event of emergency.
Operation of fuel controls related to the propulsion plant	Layout, design specifications and functional requirements for ammonia storage system, boil-off management system, fuel preparation system and bunkering system, including associated auxiliary systems.
Operation of engineering systems, services and safety devices	ARMS, pressure relief system, venting system, ventilation system, ESD system, gas detection system, fire safety system, water spray system (ammonia vapor dispersion mitigation), remote process parameter monitoring, management of trips and alarms, in addition to the management of foreseeable process deviations.
Ability to safely perform and monitor all operations related to the fuels used	Standard Operating Procedures covering normal and expected deviance from normal operating conditions, in addition to temporary operation, emergency shutdown operation, hot-standby mode. AFSS maintenance, inspection programmes and preparations for maintenance. Clear distinction between maintenance activities to be conducted by the crew and by external service providers. Management of change.
Safe management and planning of bunkering, stowage and securing of fuel	Safety risk analysis, safety zone definition, compatibility of transfer equipment, material requirements, bunkering procedure and checklist, safety checklist, emergency response and ship contingency plan.
Compliance with legislative requirements	Relevant IMO instruments including non-mandatory guidelines and industry guidance.

Methanol

Competency	Knowledge Understanding and Proficiency
Familiarity with physical and chemical properties, including hazards of fuels	Chemical composition, boiling and flash point, vapour density, toxicity and other hazards.
Application of occupational health, safety precautions and measures, including prevention of hazards	Risk assessment and hierarchy of controls, knowledge of safe working practices and good housekeeping.
Knowledge of the prevention, control, fire-fighting and extinguishing systems	Flammability including that of methanol-water mixtures, fire-fighting equipment and emergency shutoff procedures.
Undertake precautions to prevent pollution of the environment from the release of fuels	Spill response and containment measures, action in the event of marine pollution.
Response to other emergencies	Ship-specific response to emergencies that may impact methanol systems.
Operation of fuel controls related to the propulsion plant	Layout and design of propulsion plant, fuels system components and Standard Operating Procedures related to transfer.
Operation of engineering systems, services and safety devices	Pressure relief systems, leak detection systems and Emergency Shutdown (ESD) procedures.
Ability to safely perform and monitor all operations related to the fuels used	Standard Operating Procedures related to bunkering, internal transfer, associated alarms and response procedures.
Safe management and planning of bunkering, stowage and securing of fuel	Planning and safe management of operations, safe transfer procedures for connection and disconnection.
Compliance with legislative requirements	Relevant IMO instruments including non-mandatory guidelines and industry guidance.

Hydrogen

Competency	Knowledge Understanding and Proficiency
Familiarity with physical and chemical properties, including hazards of fuels	Physical, chemical and hazardous properties of compressed (CH_2) and liquid hydrogen (LH_2) properties.
Application of occupational health, safety precautions and measures, including prevention of hazards	Function and calibration of gas measuring instruments, leak and flame detection devices.
Knowledge of the prevention, control, fire-fighting and extinguishing systems	Fire organization, the unique hazards of hydrogen fuel systems, fuel handling, ventilation and vapour ignition.
Undertake precautions to prevent pollution of the environment from the release of fuels	Shipboard spill/leakage/venting response procedures, PPE to use when dealing with CH_2 and LH_2 incidents.
Response to other emergencies	Ship-specific response to emergencies that may impact CH_2 and LH_2 systems.
Operation of fuel controls related to the propulsion plant	Operating principles of main and auxiliary machinery.
Operation of engineering systems, services and safety devices	Automation for cryogenic fuel systems, fuel preparation rooms, ventilation systems.
Ability to safely perform and monitor all operations related to the fuels used	Fuel handling systems, materials of construction and insulation and difference between CH_2 and LH_2 systems.
Safe management and planning of bunkering, stowage and securing of fuel	Fuel storage systems, Quick Connect Disconnect Couplings and Vessel Separation Devices, Emergency Shutdown (ESD) procedures.
Compliance with legislative requirements	Relevant IMO instruments including non-mandatory guidelines and industry guidance.

Concluding Remarks

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The transition to alternative fuels and technologies as a vehicle to decarbonize the maritime industry will demand a comprehensive overhaul of seafarer training and competencies. The workshops on ammonia, methanol and hydrogen as alternative fuels made evident that there is a need to collectively emphasize the following overarching themes:

Regulatory frameworks update

The introduction of ammonia, methanol and hydrogen as marine fuels requires significant updates to the training and competencies of seafarers. Existing frameworks must incorporate specialized knowledge about the unique characteristics and hazards that accompany these fuels. Understanding their specific chemical and physical properties, handling requirements, safety protocols and emergency response strategies are a few indicative areas for intervention. Regulatory bodies like the IMO or industry associations are expected to update their instruments, in particular the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 and the Code (STCW Convention and Code) and relevant guidelines, such as the Medical First Aid Guide (MFAG), to reflect these changes.

Provision of targeted education on fuel-specific properties and risk profiles

For the safe handling of alternative fuels, the experience of seafarers on the type of ships, type of fuel and type of cargo, will play a key role, thus largely defining the scale of change required for their safe deployment. Those with backgrounds in handling gases such as LNG/LPG or ammonia may require less upskilling. However, even experienced seafarers will need to deepen their understanding of fuel-specific hazards and new equipment. Training will need to address the transition from conventional fuels to low and zero carbon alternatives, focusing particularly on safety concerns related to toxicity, flammability and potential material incompatibilities.

Moreover, it should be noted when compared with the future fuels of ammonia and methanol, hydrogen may be the most challenging for marine use as there is less overall knowledge and experience. Unlike ammonia or methanol, for example, compressed or liquid hydrogen is not known to be widely carried as a bulk cargo. For this reason, it will be important that the maritime industry highlights the unique aspects regarding the use of hydrogen as an alternative fuel, whether in compressed or liquid form and set requirements, beyond interim guidelines to ensure its safe use. As requirements are set, the competency and training recommendations in this report would need to be reviewed and amended considering the new information.

Enhanced safety measures and equipment

The use of alternative fuels will necessitate new or additional safety systems, personal protective equipment (PPE) and devices. On several occasions, specific breathing apparatus, protective suits and gas detectors will be required. Seafarers will need to be subject to additional training in the operation and maintenance of the fuel supply systems and associated safety and auxiliary systems, as well as in managing potential risks such as flammable vapours, toxic exposures and corrosion. The complexity of onboard systems will also increase, calling for a greater emphasis to be placed on process control and automation to minimize human error and enhance safety.

Overall, the conclusions from the workshops shed light on emerging areas of future standards with the use of alternative fuels to ensure safety in maritime operations. Training programmes for seafarers and those involved in supporting clean energy transitions in maritime decarbonization will need appropriate skills and training. To facilitate the process of human-centred clean energy transition through thorough training, further work will be carried out by incorporating relevant risk profiles of the alternative fuels concerned into seafarer training and train-the-trainer frameworks. The next steps of the project led by the MJTTF include:

- The development of detailed training frameworks and draft competency standards for ammonia, methanol and hydrogen.
- The creation of an instructor handbook for maritime training institutions to further refine the training material and training programmes required to achieve the necessary standards of competence and the desired levels of reskilling and upskilling of the workforce.
- The convergence of industry experts and stakeholders to harmoniously collaborate and provide feedback towards the continuous improvement of the training programmes initially developed based on the frameworks of the project.
- The delivery of train-the-trainer programme for maritime instructors with regard to the above-mentioned three alternative fuels as a trial to collect feedback for further improvement and policymaking.

Appendix: Feeding into the IMO regulatory path

There are three forums within the IMO that are relevant to this project and its impact. These are listed here below:

Sub-Committee on Human Element, Training and Watchkeeping (HTW)

- Dealing with the comprehensive review of STCW Convention and Code
- Expected to revise the training for crew on ships using alternative fuels and technologies

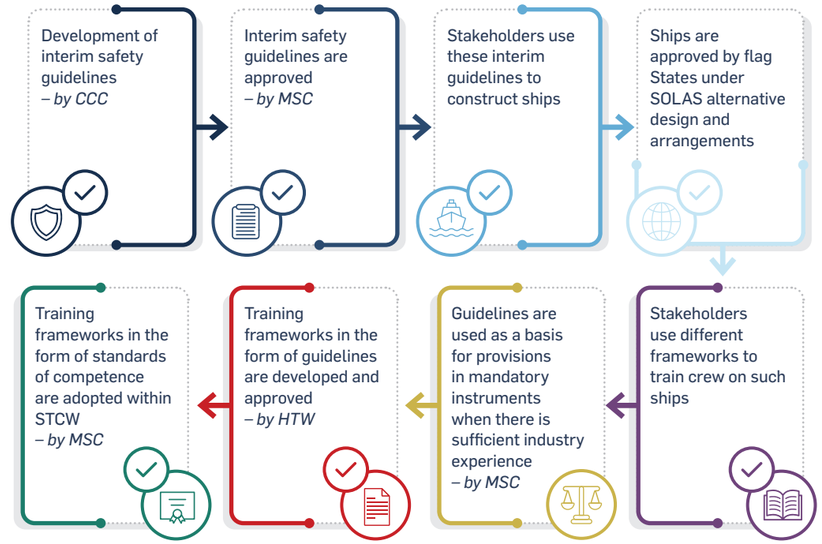
Sub-Committee on Cargo Carriage and Containers (CCC)

- Developing the interim safety guidelines for various alternative fuels
- Developing future safety provisions in relation to alternative fuels as part of a mandatory instrument

Maritime Safety Committee (MSC)

- Approving the interim guidelines with a view to developing provisions in a mandatory instrument
- Expected to be approving and adopting standards of competence in chapter V of the STCW Code

Stages for how guidelines develop into mandatory instruments by IMO:



This is the current status of the safety guidelines in relation to ammonia, methanol and hydrogen:

MSC 102 (4 to 11 November 2020), approved MSC.1/Circ.1621 i.e. *Interim guidelines for safety of ships using methyl/ethyl alcohol as fuel.* (MSC 102/24 para 15.2).

CCC 10 (16 to 20 September 2024), as per the "UPDATED WORK PLAN FOR THE DEVELOPMENT OF NEW ALTERNATIVE FUELS UNDER THE IGF CODE" (CCC 10/WP.6 Annex 3), agreed to:

- finalize the revision of the MSC.1/Circ.1621 i.e. *Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel*, with a view to developing mandatory instruments in 2027;
- invite MSC 109 (2 to 6 December 2024), to approve the *Interim guidelines for the safety of ships using ammonia as fuel*, with a view to further consider revisions to the guidelines in the future; and
- further develop/finalise I*nterim guidelines for safety of ships using hydrogen as fuel* at CCC 11 (8 to 12 September 2025), with a view to approval by the MSC 111 (2026).

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Project team and collaborators

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Yara Clean Ammonia

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