



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping



Ammonia as Fuel **Competencies** **and Training**

Project summary report

Executive summary

The decarbonisation of global shipping requires alternative fuels, with ammonia emerging as a promising contender for low-emissions ocean transport. However, ammonia is associated with specific hazards – primarily toxicity, but also material incompatibilities and flammability and explosion hazards in enclosed spaces where appropriate conditions exist. Managing such hazards demands specialised crew training and competencies. While current frameworks for seafarer training provide a foundation, they are insufficient to meet ammonia's unique challenges.

The *Ammonia as Fuel – Competencies and Training* project addresses these gaps. This project was undertaken by Lloyd's Register Maritime Decarbonisation Hub, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping and their partners. The project outlines the minimal requirements that should be built into regulations, advanced requirements that seafarers should be capable of, and role-based requirements that apply to specific onboard and shore-based roles. To make these requirements a reality, many stakeholders across the industry have a role to play.

Ultimately, seafarers need to acquire knowledge of ammonia's properties, such as its toxicity and material incompatibility, alongside operational, maintenance, and emergency response skills. In this project, we propose expanded training frameworks to meet this need.

Regulators need to update regulations (including the IMO STCW Convention and Code) and seafarer certification standards. Flag states and national safety authorities need to collaborate to ensure consistent safety regulations across the vessel and shoreside interface.

Ship owners and operators need to carry out a gap analysis across the organisation to scope the extent of change and build change programs to close the gaps. They also need to revise corporate policies, protocols and procedures. Finally, these stakeholders must introduce new training at all levels of the operation, including the training needed to allow corporate shoreside personnel to support those serving on ammonia-fuelled ships.

Training providers need to develop a transition journey for the various categories of seafarer and shore-based staff to take them from current levels of knowledge, understanding and proficiency to a point where they can safely interface with ammonia as a marine fuel. This process will likely involve new training facilities and methods.

Finally, seafarers need to be aware of the changing competency and training requirements that the introduction of ammonia fuel will bring to their roles. They should understand how ammonia fuel will impact their work and responsibilities, as well as the support from onshore personnel.

All stakeholders, including vessel operators, port authorities, training providers, maritime academies and regulatory bodies, must act collaboratively to implement these measures. In this way, the industry can ensure safe integration of ammonia as a marine fuel.



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Acknowledgements

The findings of this report are built on extensive cross-sector collaboration between organisations in the maritime industry and beyond. The project team consisted of the Lloyd's Register Maritime Decarbonisation Hub, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Anglo-Eastern Ship Management, the Ammonia Safety & Training Institute (ASTI), BP, Cargill, CF Industries, Hapag-Lloyd, A. P. Moller-Maersk, Maersk Training, MAN Energy Solutions, NYK Line, Seaspn, Stolt Tankers, TotalEnergies and V.Group.



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Introduction

Implementing alternatives to conventional fossil fuels is key to decarbonising the global shipping industry. Ammonia is currently one of the frontrunners among alternative marine fuels, as it can be combusted with much lower greenhouse gas (GHG) emissions than fossil fuels. However, using ammonia as a marine fuel involves safety hazards: primarily toxicity, but also corrosivity, onboard fires and explosions. Seafarers on ammonia-fuelled vessels risk harm to themselves, their colleagues, the vessel and its environment, which may include impacts on ports, other vessels and coastal communities.

The Lloyd's Register Maritime Decarbonisation Hub (the Decarb Hub), the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) and partners have collaborated on a work programme to address these risks from ammonia as a marine fuel. The programme has identified risks to seafarers and developed mitigations, resulting in recommendations for design and operation of ammonia-fuelled vessels published in 2023.¹ This work identified a range of critical human factors considerations that must be addressed for safe operation, including seafarer competencies and training. Specific training and upskilling will be needed to prepare crew for operation, maintenance and emergency response tasks on ammonia-fuelled vessels.

¹ [Recommendations for Design and Operation of Ammonia-Fuelled Vessels Based on Multi-disciplinary Risk Analysis](#), Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2023.



Understanding of these safety issues is also growing among the wider maritime community. A 2024 survey² by the MMMCZCS investigated maritime community perceptions of ammonia as a marine fuel. This survey found that although a majority of respondents from across the maritime community were willing to sail on or work with ammonia-fuelled vessels, this willingness was conditional on a comprehensive level of training that addresses their safety concerns. Further, whilst respondents had a good understanding of the basic risks (primarily ammonia's toxicity), they lacked knowledge regarding technical aspects of ammonia handling and operations.

At the end of 2023, the MMMCZCS and the Decarb Hub initiated Phase 3 of their collaborative work programme: the *Ammonia as Fuel – Competencies and Training* project. This project aimed to answer the following specific questions:

- How will seafarers' roles change with the introduction of ammonia as a fuel?
- What are the minimum standards of competency required across the seafarer community?
- What specific additional competencies will be required for specialist roles at sea?
- In what areas will additional training need to be developed and introduced?

The *Ammonia as Fuel – Competencies and Training* project continued through 2024. This project has brought together a wide group of stakeholders from across the maritime industry – including participants with relevant ammonia experience. The project was enhanced by input from contributors with previous experience in adjacent areas, including:

- Conventional fuel oil
- The transition to liquefied petroleum gas (LPG) and liquefied natural gas (LNG)
- LNG/LPG operations, maintenance, emergency response and the structure and content of the training associated with this transition
- Manufacture of ammonia for industrial use
- Ammonia transfer to seagoing vessels
- Carriage of ammonia as a cargo
- Onshore ammonia emergency response

Concurrently, members of our project team have participated in other related initiatives. These include the investigation into training considerations for future shipping fuels by the Maritime Just Transition Task Force (MJTTF)³ and the work of the Society for Gas as a Marine Fuel (SGMF) relating to ammonia bunkering guidelines.⁴

² [Investigating Maritime Community Perceptions of Ammonia as a Marine Fuel](#), Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

³ [Considerations of Training Aspects for Seafarers on Ships Powered by Ammonia, Methanol and Hydrogen](#), Maritime Just Transition Task Force, 2024.

⁴ These included: Ammonia – Safety and Operational Guidelines – Bunkering and An Introduction to Ammonia: Accidental Release Preparedness and Response. See <https://sgmf.info/resources/>.

This project summary report summarises two technical reports from the *Ammonia as Fuel – Competencies and Training* project. Each technical report describes the outcomes of a specific stage within the project:

- 1. Proposed overall framework for competency and training standards:**⁵ Provides minimum competency and training standards for all seafarers. This framework is modelled on the International Maritime Organization's (IMO) International Convention on Standards of Training, Competency and Watchkeeping for Seafarers (STCW) Code relating to the specifications for minimum standards of competence for training for ships subject to the International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels (IGF Code). The proposal addresses both basic and advanced training. The primary audience for this 'proposed overall framework' report is technical teams within regulatory bodies.
- 2. Operations, maintenance and emergency response tasks:**⁶ Detailed competency requirements and training standards for specific operations, maintenance and emergency response tasks beyond those outlined in a typical STCW framework. The primary audiences for this 'operations, maintenance and emergency response tasks' report are ship operators/managers and training organisations.

⁵ Ammonia Phase 3 – Competencies and Training – Proposed Overall Framework, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

⁶ Ammonia Phase 3 – Detailed Competency & Training Operational, Maintenance and Emergency Response Scenario Evaluations, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.



The collective findings of the entire *Ammonia as Fuel – Competencies and Training* project, as captured in these three reports, will be of interest to a broad range of stakeholders. To conclude this introduction, here we summarise some key benefits that this body of work can bring to different stakeholder groups.



Regulators*

can gain ...

- A framework for determining which minimum requirements should be formalised and how to establish a level playing field across the industry (*proposed overall framework for competencies and training standards* report)
- Perspective on safety management needs when using ammonia as a fuel (*operations, maintenance and emergency response tasks* report)



Ship owners and operators

can gain ...

- Help in determining the knowledge and understanding that shipboard personnel need
- Help in determining how the shoreside organisation may need to support the vessel



Crew/ship management companies

can gain ...

- Information about basic expectations for what officers and crew should know to work with ammonia as a fuel (*proposed overall framework for competencies and training standards* report)
- Information about additional training the company may wish to provide to prepare seafarers for ammonia fuel use (*operations, maintenance and emergency response tasks* report)



Training providers

can gain ...

- Comprehensive content and new approaches on which to base their training programmes



Charterers

can gain ...

- Information about potential regulatory obligations
- Help with decisions regarding vessel and fuel selection
- An overview of potential safety concerns
- Potential assistance with language needed in contracting for ammonia-fuelled vessels



Shoreside entities**

can gain ...

- Information on shoreside competency and training needs regarding ammonia as a marine fuel
- Perspective on how to work together with ammonia-fuelled vessels in a safe and environmentally sensitive manner

*Including the IMO, flag states and classification societies

**e.g., port authorities, terminal management operators, support organisations

Competencies and training requirements for ammonia as fuel

Seafarers and shore-based staff will require new skills and training

This is not the first time that the shipping community has had to navigate introduction of new fuels and resulting changes to competency and training requirements. For example, the expertise required of seafarers has already undergone a step change for those vessels that have moved from conventional fuels to LNG propulsion. Operating vessels on conventional fuel primarily required proficiency in managing internal combustion engines, diverse fuel properties and fuel treatment systems. The shift to LNG, a cryogenic gaseous fuel, introduced new demands, including knowledge of specialised storage and systems, handling gas as fuel, cryogenic safety protocols and advanced engine technologies like dual-fuel engines.

The STCW Tables A-V/3-1 and A-V/3-2 relating to the IGF Code establish mandatory competencies and training requirements for seafarers working on ships using low-flashpoint fuels, including LNG. These tables emphasise safety in handling and in operating with gas or low-flashpoint fuel. The existing training is structured into two levels.

Namely, this basic course is aimed at Officers and Ratings assigned to specific duties and responsibilities related to cargo or cargo equipment on a Liquefied Natural Gas Tanker and is a mandatory requirement under STCW Regulation V/1-2. The advanced course is aimed at Senior Officers (Deck and Engineering) and personnel with immediate responsibility for the loading, discharging, care in transit, handling of cargo, tank cleaning and cargo-related operations. The course is a mandatory requirement under STCW Regulation V/1-2.

The IGF Code does not currently address the competencies required for alternative fuels like ammonia, hydrogen or methanol. As ammonia is introduced, seafarers will need to master its specific properties, such as its toxicity, corrosiveness, and the risk of nitrogen-based emissions. This will necessitate training in advanced safety measures, specialized containment systems and new engine designs. Therefore, updates to the IGF Code are required to accommodate the introduction of ammonia as a marine fuel.

Safe operating principles are the foundation

The general principles for safe ship operation are common to all marine fuels. Whichever fuel is used, a seafarer should be able to:

- Contribute to the safe operation of a ship
- Ensure a safe working environment
- Take precautions to prevent hazards on a ship
- Apply occupational health and safety precautions and measures
- Carry out firefighting operations on a ship
- Respond to emergencies
- Take precautions to prevent environmental pollution from the release of fuels

When applied to ammonia, these principles remain the same as those embodied in the IGF Code. However, the application of the principles can differ for each fuel, both for essential basic training for all seafarers and for advanced training in the management of fuel-related operations. Some seafarers may have already met some expected training requirements by virtue of having worked on ships using gas as fuels or having served on ships carrying ammonia as a cargo.



New or modified knowledge, understanding and proficiencies (KUPs) will be required on board

A key aspect of our collaborative programme was to identify the additional training and competencies needed for personnel assigned on dual-fuelled vessels with ammonia as one fuel. Our proposed framework⁷ is consistent with STCW specifications for basic and advanced standards. Required standards, expressed as competency statements, are broken down into three areas: knowledge, understanding and proficiencies (KUPs).

Seafarers need **knowledge** of:

- the key characteristics of ammonia, such as toxicity, flammability, explosivity, corrosion and material incompatibility
- a ship's ammonia-related systems and equipment, including storage
- ammonia's physical and chemical properties
- hazards and hazard controls of ammonia
- occupational health and safety precautions and measures
- how to respond to emergencies, such as leaks, spills, fires and explosions
- pollution prevention mechanisms

Seafarers will need **understanding** of:

- the specific operational and maintenance regimes required by ammonia
- fuel changeover procedures
- how approaches to emergency response differ on board ammonia-fuelled vessels
- how processes change with increased automation
- the legislative requirements with which they must comply

Seafarers will need new skills and **proficiencies** in:

- operation and maintenance of ammonia-related equipment, including increased use of automation to enable remote operations
- handling of ammonia storage, transfer and handling systems applicable to pressurized and refrigerated ammonia or a combination of both.
- use of new materials
- use of new types of instrumentation and control systems
- use of new types of detection and monitoring equipment
- use of different personal protective equipment (PPE)

Under the current framework, basic training provides foundational knowledge and skills. This training focuses on general awareness of the risks, properties and safety measures associated with low-flashpoint fuels such as LNG. The training is intended for all seafarers prior to being assigned duties on board a ship using fuels governed by the IGF Code. Any seafarer responsible for designated safety duties associated with the care, use or emergency response to the fuel on board ships subject to the IGF Code should receive basic training.

To upskill seafarers for ammonia fuel use, basic training will need to address the KUPs listed above. The basic training table in our **proposed overall framework report**⁸ details the required KUPs for each element of this basic training. The table also covers the methods for demonstrating competence and the criteria for evaluation.

⁷ Ammonia Phase 3 – Competencies and Training – Proposed Overall Framework, Lloyd's Register Maritime Decarbonisation Hub and the Maersk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.
⁸ Ibid

Additional skills and competencies are role-dependent

The IGF Code also outlines advanced training requirements for seafarers operating on vessels powered by gases or other low-flashpoint fuels. Advanced training is for Masters, engineers and all personnel with immediate responsibility for the care and use of fuels and fuel systems on ships subject to the IGF Code. This level of training includes in-depth education on fuel system design, hazard control, fuel-handling procedures and advanced emergency management.

Advanced training will be required in each of the following competency areas to upskill for ammonia:

- Familiarity with physical and chemical properties of ammonia fuel
- Operation of fuel system controls related to propulsion plant and engineering systems and to services and safety devices
- Ability to safely perform and monitor all operations related to ammonia fuel

- Ability to plan and monitor safe bunkering, stowage and securing of the ammonia fuel on board
- Precautions to prevent environmental pollution from the release of ammonia fuel from ships
- Monitoring and control of compliance with legislative requirements
- Precautions to prevent hazards
- Application of occupational health and safety precautions and measures on board
- Knowledge of the prevention, control and firefighting and extinguishing systems

The advanced training table in our **proposed overall framework report**⁹ details the required KUPs for each element of advanced training. The table also covers the methods for demonstrating competence and the criteria for evaluation.

⁹ Ammonia Phase 3 – Competencies and Training – Proposed Overall Framework, Lloyd's Register Maritime Decarbonisation Hub and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.



Going beyond the standard framework

Seafarers will require additional knowledge, skills and proficiencies over and above the minimum requirements specified by current frameworks, such as the IGF Code, to carry out their roles.¹⁰ The Ammonia as Fuel – Competencies and Training project identified a wide range of operational scenarios (both routine tasks and infrequent or specialised tasks) relating to onboard activities:

- Hazards, characteristics and hazard awareness
- Overall safety and environmental/risk awareness
- Occupational health and safety
- Operational and process safety
- Regulations, local requirements and industry guidelines
- Storage, management and transfers
- Gas purging and venting from compartments
- Leak detection, management, isolation and repair
- Simultaneous operations (SIMOPs)
- Maintenance
- Emergency response

¹⁰ Ammonia Phase 3 – Detailed Competency & Training Operational, Maintenance and Emergency Response Scenario Evaluations, Lloyd's Register Maritime Decarbonisation Hub and the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

The level of KUPs required of individuals depends on their role on board. Similar KUPs will apply to shoreside workers based on their roles. Accordingly, we further examined these KUPs in the context of different professional groupings. We divided seafarers into three distinct groups: management, operations and support. Shoreside personnel were represented by four groups: company corporate, port authority, terminal management and shore support personnel.

Shipboard management

The senior officers on board – Master, Chief Officer, Chief Engineer and First Engineer – hold critical roles in ensuring the safe and efficient operation of the vessel. These officers lead and manage operations on board as well as joint operations with shoreside entities, including cargo management and handling, machinery, and systems operations and maintenance.

The introduction of ammonia as a marine fuel will bring changes to roles and responsibilities. Senior officers will require knowledge of the physics and chemistry of ammonia and its interactions with other materials, as well as how it is impacted by weather and environmental factors. They will oversee strict compliance with new regulations, as well as IMO guidelines, industrial guidelines and best practices, and environmental standards. They will also lead emergency response strategies tailored to ammonia-related incidents.

Further, these senior officers will supervise the maintenance and operation of ammonia storage tanks, fuel transfer systems, fuel systems and dual-fuel engines. It will be critical to monitor ammonia's effect on machinery components, particularly its corrosivity. Ensuring proper ventilation, spill prevention and containment measures will be essential. This group will also oversee safety drills and emergency preparedness focused on ammonia-specific risks, such as toxicity and flammability under certain conditions.

Shipboard operations

Junior officers will conduct navigation, safety, watchkeeping, maintenance and cargo operations under the responsibility of a Master or senior officer such as Chief Officer. Similarly, Junior Engineers will conduct engine room operations and maintenance of equipment under the responsibility of the Chief Engineer. These operations will take place within the broader context of potential ammonia risks. To give an example, the likely consequences of a collision are more severe with ammonia-fuelled vessels than when using conventional fuel.

As a result, these junior roles will shift towards more safety-critical, environmentally conscious and technically advanced operations. Their responsibilities will expand, requiring close collaboration across departments as well as greater technical and safety skills. For instance, the role of the Electro-Technical Officer (ETO) could broaden with increased automation.

Shipboard support personnel

This group includes ratings (Bosun/Boatswain), Able Seaman, Ordinary Seaman, Motorman, Oiler, and others. Currently, there is no existing training framework for this category under the IGF Code if the seafarer does not have safety-critical duties. These seafarers will require an overall knowledge of ammonia and its hazards to assist with operations and maintenance.

Furthermore, seafarers in these roles must be able to recognise ammonia hazards and know what to do to protect themselves and others. They will need to support and follow plans and instructions provided by officers and have the relevant knowledge to fulfil their roles while reducing the potential for ammonia exposure. They will be tasked with ensuring necessary resources are provided, including PPE.

Other seafarers such as cooks, galley personnel and stewards, who would also fall under this category, will need a dedicated training framework. Training, including shipboard familiarisation, should allow these seafarers to recognize safety hazards relative to ammonia and participate in emergency response according to their role as specified in each company's safety management system.

Company corporate personnel

Company corporate personnel can include shore-based personnel in departments managing the ships. These include operational; technical; safety, security, health and environment; and supply chain or procurement departments.

The information in this project's two technical reports outlines certain KUPs that corporate personnel would need to support seafarers on board and, where appropriate, to interface with others on behalf on the vessel. Examples of the latter include interfacing with shoreside organisations such as port authorities and terminal managers, and with other entities such as support vessels, contractors and vendors.

The information in the two technical reports¹¹¹² can also assist with the modification of planning processes and management systems. This includes procedures and work processes used by or to support seafarers and other workers interfacing with ammonia.

11 Ammonia Phase 3 – Competencies and Training – Proposed Overall Framework, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

12 Ammonia Phase 3 – Detailed Competency & Training Operational, Maintenance and Emergency Response Scenario Evaluations, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

Port authorities

A port authority is typically a government entity that governs port entries and operations. Key staff will need knowledge of ammonia to support vessels with planning for port entries and visits. They will also require an understanding of how to provide support in the case of a combined emergency response.

Terminal management teams

This group represents port or terminal managers, supervisors and other terminal personnel. It also includes any emergency responders, such as local/shoreside fire teams.

These teams will require new knowledge to work with ammonia-fuelled vessels. They need to be able to protect workers both ashore and on the vessel as support for combined operations like bunkering, and to assist if necessary with emergency response. They will need to understand the impact of ammonia on human health and on equipment, and have some knowledge about ammonia dispersion.

Shore support personnel

This group represents bunker barges, waste reception barges and tugs, and emergency response entities such as salvors. As with terminal operators, these teams will need the knowledge to work with ammonia-fuelled vessels on combined operations, protect their workers and understand their role if they need to assist with emergency response.



Recommendations

Collaboration is critical to the decarbonisation of shipping. Vessels and onboard technologies are evolving rapidly, meaning that seafarer competencies (and their training requirements) must do the same. Constant dialogue between the many stakeholders involved in the marine fuel supply chain is paramount.

The information in this project summary report, and the two technical reports from the same project, is provided to support the reader in moving forward with training frameworks for ammonia as fuel. We ask that you review the content, identify how it applies to your circumstances, determine what is relevant to you and your organisation, and take the necessary actions.

In this section, we highlight some specific recommendations for some of the stakeholder groups we believe need to act quickly. However, these recommendations are by no means exhaustive. Every reader must come to their own conclusion on what they need to do.

Recommendations for regulators

Regulations need to be updated and finalised to cover the required seafarer competencies for use of ammonia as a fuel. As a first step we would need interim training guidelines to account for ammonia as fuel. Over time these will become prescriptive and incorporated into relevant codes as STCW Convention and IGF.

Standardised seafarer certification programmes supported by training materials are required in all flag administrations. Each administration will need to determine the specific requirements pertinent to its situation.

Flag administrations should consider alternatives to actual experience for seafarer certification, given the lack of ammonia-fuelled vessels on the water at this point.

Flag administrations should work with national safety authorities to build a roadmap for future safety regulation where the vessel and shoreside entities interface to ensure a consistent health and safety regime.

Recommendations for vessel operators and ship owners

The first step for these stakeholders is to understand the scope of the required change. This understanding will begin with a gap analysis across the organisation, identifying the upskilling needed to move from conventional fuel oil operations to ammonia fuel operations.

Subsequently, vessel operators and ship owners need to create change programs to close the identified gaps. Change programs will include revisions to corporate policies, protocols and procedures, including those governed by departments for health, safety and environment; security; marine operations and training. Roles and responsibilities will likely be updated across the organisation. Safety management systems and emergency response methods will also need to be updated.

Further, these stakeholders need to reappraise the shoreside interface and determine what knowledge and understanding the shoreside organisation may need to support the vessel. Changes will be needed to accommodate ammonia as a fuel, with adjustments for new or modified tasks related to ammonia fuel management. Vessel operators and ship owners, along with ship managers and others, will need to update operational and maintenance regimes around fuel bunkering, storage, transfer and management. They should also upgrade their corporate ship-to-shore and shore-to-ship communications.

Finally, these stakeholders will need to introduce new and modified training requirements. This should happen both at the regulatory level and in the form of company-desired training for operations, maintenance and emergency response.

Recommendations for training providers

Training providers need to understand flag states' expectations and requirements regarding seafarer competencies and training.

A key early step for training providers is to address the planning challenge. They should consider how to meet the anticipated needs – potentially re-training 800,000 seafarers in a relatively short period.¹³ New training will need to include operation and maintenance of fuel systems, use of new safety and monitoring systems and equipment, and management of risks such as toxic exposure and corrosion.

Based on this knowledge, training providers need to build a transition journey. The transition journey needs to account for the varying levels of prior training and competency across the maritime industry. For example, there may be one route forward for those who only have experience of conventional fuel oil, and another for those with prior experience of dangerous liquid cargo in bulk – for instance, experience involving the carriage of ammonia as a cargo or with LNG/LPG as a fuel.

Training providers must determine the training methods needed to ensure competency. Training facilities may need to be upgraded to, for example, support a practical interface with ammonia. The trainers themselves will also need to be trained before any training can be delivered to the rest of the industry.

Taking all of the above into consideration, training providers should develop training programmes for each of the onboard and shoreside roles identified in this project. Commonalities across these groups mean that modularity is possible, but there will be some role-related differences.

Recommendations for seafarers

Considering the concerns and requests for training expressed by seafarers in a recent survey,¹⁴ the outputs of the *Ammonia as Fuel – Competencies and Training* project will bring some clarity and transparency. These outputs explain how existing competency and training frameworks can be modified to address the current gaps.

Seafarers should be aware of the contents of this summary report and the other publications from the *Ammonia as Fuel – Competencies and Training* project. They should understand the competencies they will need to meet the new requirements and the upcoming changes in their training that ammonia will create. They will also learn how the shoreside organisation can support them as they serve on board an ammonia-fuelled vessel.

The training frameworks proposed in our project^{15,16} will allow seafarers to gain some insight into the potential impacts of ammonia on factors such as:

- ammonia hazards
- human health, including how to avoid or treat exposures
- environmental aspects
- new requirements for working knowledge and skills
- modifications to risk assessment and safe working practices
- updated approaches to operational tasks such as bunkering, fuel management and handling
- emergency response for leaks, spills, fires or explosions

¹³ Kaspersen, Karlsen, Helgesen, Giskegjerde, Krugerud & Hoffmann, *Insights into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry*, DNV, 2022.

¹⁴ *Investigating Maritime Community Perceptions of Ammonia as a Marine Fuel*, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

¹⁵ Ammonia Phase 3 – Competencies and Training – Proposed Overall Framework, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.

¹⁶ Ammonia Phase 3 – Detailed Competency & Training Operational, Maintenance and Emergency Response Scenario Evaluations, Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, 2024.



Additional considerations: human factors and ship design

While this project and report have focused on competency and training frameworks, we acknowledge that much can be done to shape new ammonia-related systems, equipment, components, and spaces before a vessel is even built. Vessel designers and original equipment manufacturers have a key role in applying user-centred design criteria and principles for new systems, equipment and interfaces. The application of human factors design criteria and principles will reduce risks to seafarers and the impact of any ammonia-related incident.

Closing remarks

The industry should continue to address seafarers' and workers' concerns related to the introduction of ammonia as a fuel. We should encourage active participation in the safety and training dialogue by seafarers or their representatives such as labour organizations, the International Labour Organization and flag states.

When the detailed requirements are assessed in each area, it is likely that additional consideration may be needed for specific items. For example, practical exercises will be vital for some high-risk operations such as firefighting.

We encourage the marine industry and seafarers in particular to continue to raise awareness about their safety and environmental needs as the technology related to ammonia fuel evolves. In doing so, the industry can help ensure that this alternative fuel can effectively reduce future GHG emissions from ships.

