Handling of alternative fuels

SfS Recommendation 055E/2025

SfS
Samarbeid for Sikkerhet

Prepared by Working Together for Safety Working Group: **March 2025**	Version: **Rev 00**	Working Together for Safety Project Manager: Hugo Halvorsen Hugo Halvorsen (signature on file)
Applies from date: **1 June 2025**		Approved by Working Together for Safety Board by Chairman: Atle Houg Ringheim Atle Houg Ringheim (signature on file)

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1 Introduction

In 2023, the International Maritime Organization (IMO) updated its Strategy on the Reduction of Greenhouse Gas (GHG) Emissions from Ships and introduced the target of net zero emissions of greenhouse gases from international shipping by 2050. This strategy is a central driving force for reducing emissions within the international shipping industry. Increasing expectations around the reporting of emissions within the value chain from various stakeholders, such as financial institutions and cargo owners, is also helping to accelerate the shipping industry's transition to net zero emission fuels.

The United Nations (UN) Sustainable Development Goals, political pressure and increasing demands from the value chain have contributed to the transportation industry, including the maritime sector, placing increased focus on alternative fuels in order to reduce harmful emissions. As a result, both the IMO and the European Union (EU) have committed to reducing greenhouse gas emissions to net zero by 2050, with incremental goals along the way.[1]

Alternative fuels and their associated new technologies involve additional safety challenges that must be managed; see the overview in Appendix A. During the initial stages of implementing new technologies in particular, experience from their practical use is often limited. It is therefore important to consider this aspect carefully and in detail.

The foundation of safe operations is effective technical solutions and barriers that must be implemented in the vessel's design and construction. The on-board crew and onshore personnel, in addition to how the organisation facilitates safe operations, are also important barriers in operational safety. Personnel must be aware of the hazards associated with fuels and new technologies, be able to manage systems and equipment safely, and ensure the necessary maintenance of technical equipment. Studies undertaken by the Maritime Technologies Forum (MTF), Maritime Just Transition Task Force (MJTTF) and Det Norske Veritas (DNV) among others, highlight the importance in this context of working with safety in a proactive way. It is important to have knowledge and working methods to detect deviations as early as possible to prevent more serious situations and accidents.

In terms of regulations, the IGF code[2] (International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels) currently applies to most alternative fuels. However, the present only contains prescriptive requirements for natural gas as a fuel, which means that detailed requirements for alternatives such as ammonia and hydrogen are lacking. The IMO has prepared interim (non-mandatory) guidelines for methanol[3] and ammonia[4], and is currently working to develop equivalent guidelines for hydrogen, which are expected to be published during 2025. The development of mandatory regulations is expected to take several more years to develop and be adopted. . In addition to preparing guidelines for technical barriers and safe design, work is also being undertaken to establish a foundation for competence requirements and necessary training.

Several alternative fuels are relevant to the maritime industry, and the International Transport Workers' Federation's Maritime Safety Committee (ITF MSC) has created an overview with relevant data for each of these. [5] See also Appendix A.

This document is based on relevant practice and regulations as at 01.03.2025.

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[1] DNV Energy Transition Outlook 2024, Maritime Forecast to 2050
[2] IGF code
[3] Interim Guidelines for the Safety of Ships Using Methyl/Ethyl Alcohol as Fuel (MSC.1/Circ.1621)
[4] Interim Guidelines for the Safety of Ships Using Ammonia as Fuel (MSC.1/Circ. 1687)
[5] Maritime Safety committee: Safety dynamics of ship's energy sources

2 Purpose

The purpose of this document is to offer a guide to organisations that are planning to use alternative fuels on board ships and mobile facilities. Specific recommendations are provided for how the organisation, and employees both on board and onshore, can be prepared in order to ensure safe and efficient operations.

This recommendation does not address technological solutions directly but instead focuses on means relating to human and organisational factors. The recommendation is based on selected existing studies, practice, standards and frameworks that are relevant to ships using alternative fuels.

3 Target group

The target group for this recommended practice is organisations considering or planning the use of alternative fuels on board vessels and mobile facilities. Other relevant parties, such as port authorities and bunkering and emergency personnel, should also be familiar with the contents of this document.

4 Recommended practice

This chapter describes recommended practice based on existing and recent publications within the industry, in order to ensure safe operations on board vessels using alternative fuels.

The recommended practice is divided into the following five main categories:

- Safety management system, safety philosophy, guidelines and principles
- Methods and practical frameworks for safety assessments within design and operations
- Emergency preparedness
- Training and competence
- Handling of the change process when introducing new fuel

4.1 *Safety management system, safety philosophy, guidelines and principles*

The introduction of alternative fuels and new technology will influence both the organisation and personnel-on board and onshore. When assessing safety, this is often referred to as safety from a system perspective; the individual interacts with technology within an organisational context. This means that all factors may impact one another, and a change in one of the areas may result in challenges in the others.

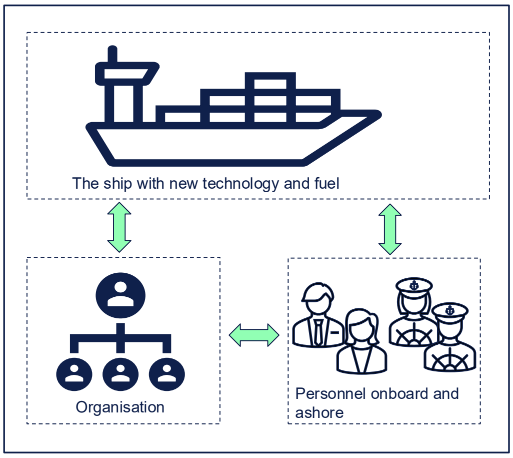

Figure 1 Both personnel and the organisation will be influenced by a change in technology

In accordance with the International Safety Management Code (ISM code)[6], companies shall develop, implement and maintain a safety management system (SMS). A well-designed and appropriately tailored SMS plays a crucial role in fostering the desired safety culture. The Lloyds List Intelligence Report[7] emphasises that organisations with mature and proactive safety cultures are better positioned to successfully implement new technologies, and to manage new and more complex risks. This includes maintaining a leaning oriented safety culture – one that continuously proactively evolves based on experience, situations and incidents. The SMS sets the standard for and expectations of the organisation and is therefore an important tool in developing the safety culture in the desired direction.

The safety philosophy, guidelines and principles within an organisation shall reflect the organisation's activities. When implementing and using new fuels, such as ammonia or hydrogen, the organisation's safety philosophy should be reviewed and adjusted to ensure an equally high or higher level of safety. This will provide a clear direction for the organisation's safety work and risk management.

When shipping companies and ships start using alternative fuels, this will result in a changed risk picture, especially in terms of the health and safety of involved personnel. It is essential that the SMS considers all aspects when using alternative fuels. Undesired incidents with low hazard potential for conventional fuels, such a minor leak, may have a higher hazard potential for ammonia or hydrogen.

There can often be more than one type of fuel on board to ensure propulsion, manoeuvring and emergency operations. An understanding of the risk elements and differences between the fuels being used at any given time is therefore important.

According to the ISM code, the organisation's safety and environment guidelines shall be an expression of the organisation's overall purpose and shall reflect the organisation's top-down approach to safety.

The MTF has developed a guideline[8] for the development and implementation of a safety management system for alternative fuels on board vessels. This guideline states that the organisation's framework and procedures should include aspects and impacts of using alternative fuels in order to ensure continued operational safety. In addition to the MTF guideline, DNV[9] also highlights that the use of new fuels requires a proactive safety culture. The organisation's safety culture remains important with regard to the safe implementation of alternative fuels.

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[6] International Safety Management Code (ISM code)
[7] DNV and Lloyds List Intelligence Report
[8] MTF: Guideline to develop and implement a safety management system for alternative fuels
[9] Maritime Safety trends 2012-2022: Advancing a culture of safety in a changing industry landscape

The MTF guide, along with ISO 31000[10], offers good foundational principles when taking steps towards establishing a proactive and appropriate safety culture. Both provide concrete examples that should be used as the basis for the organisation's safety management system, and mention that risk management should:

- Create value
- Be an integrated part of the organisation's processes
- Be included in decision-making processes
- Be a systematic, structured and timely process
- Build upon the best available information
- Consider human and cultural factors
- Be open and inclusive
- Be dynamic and iterative
- Be continually improved

Table 1 Recommendations for safety management system, etc. for alternative fuels

RECOMMENDATIONS	
1	Update the organisation's **policy** on safety, the working environment and environment to cover relevant alternative fuels, ref. MTF.[7]
2	Update basic **principles for managing risk** by using ISO 31000[9] or an equivalent standard.
3	The organisation should develop safety **frameworks and processes** that form the basis for a proactive safety culture, ref. LLI/DNV[6], MTF.[7]
4	Perform an **assessment of the current situation** against the organisation's new policy and applicable regulations and recommendations with regard to the existing SMS, safety culture, cyber security and emergency preparedness.
5	Ensure that updated **methods** and frameworks for assessing safety are included in the organisation's processes and procedures (see also Chapter 4.2).
6	Develop specific **procedures and operating manuals for the individual vessel** for the handling of alternative fuels in accordance with relevant regulations (ISM).
7	Update the SMS in accordance with the need for develop and maintaining competence and training; further information is provided in Chapter 4.4.
8	Updating of SMS o Governing documentation and procedures with associated tools and equipment for execution. o Establish and implement appropriate operating manuals for alternative fuels for: bunkering, use, maintenance and emergency preparedness. o Update the reporting system for learning from undesired incidents and near misses, in addition to the identification and reporting of hazardous conditions. Good incentives and systems that support policy/safety philosophy described above in order to reinforce a more appropriate safety culture.

[10] Standard Norge: ISO 31000

4.2 *Methods and practical frameworks for risk assessments during design and operation*

When introducing a new technology, there is limited experience in establishing effective routines and solutions for its use. Past experience shows that the implementation of new technologies can introduce unforeseen risks, uncertainties, and operational challenges that may not be anticipated before the technology is in use. To reduce or remove uncertainties and prevent accidents during operations, it is therefore important to ensure good solutions are included in the design. Risk assessments during the design phase should also form the basis for operating procedures, as well as technical solutions.

For vessels that shall use hydrogen or ammonia as a fuel, it is currently mandatory to follow IMO MSC.1/Circ.1455,[11] which concerns alternative designs. The alternative design process facilitates the risk-based approval of solutions with the overall principle that an alternative solution shall have an equivalent or better level of safety when compared with conventional solutions. This process is also described in open DNV publications.[12]

New vessels require two approvals from the Norwegian Maritime Authority[13] before they can be built and put into service. First, the vessels' design must be approved, followed by a final approval when the vessel is fully built and tested. To obtain approval, the shipowner must conduct thorough risk assessments. These analyses must include both technical risks and risks/hazards to persons (such as injuries, diseases), including third party risks. It is therefore important that relevant experts in i.e safety risks, working environment and human factors are involved in the design phase. It is also important that both a ship classification society and the authorities are involved in this work.

Operational risks shall also be assessed in detail, typically. through methods such as HAZOP or HAZID. These evaluations will vary, depending on type of fuel selected and the specific measures and procedures/routines required to reduce the risk to an acceptable level. It is essential that all crew members are familiar with the risk landscape and associated controls, routines and procedures. Extra emphasis must be placed on areas in which the use of the alternative fuel involves entirely different routines and procedures than those used for conventional fuels. Bunkering, and operations and maintenance, in addition to emergency preparedness, must be included.

The purpose of the methods and frameworks for risk assessments in the design and operation phases is to: 1) ensure effective design solutions to prevent incorrect use or inappropriate work situations with regard to safety, 2) incorporate methods and frameworks in operating procedures and manuals (so they become part of the SMS).

For operational procedures, it is important to emphasize working methods that enable the early detection and correction of deviations, minor faults and deficiencies in safety-critical equipment. This helps prevent such issues from escalating into more serious situations. In addition, it is essential to identify appropriate methods for risk assessment during special operations and integrate these into operational procedures

[11] Guidelines for the approval of alternatives and equivalents
[12] Interim guidelines for ammonia and hydrogen as fuel
[13] Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments

For all safety-critical operations, including bunkering, detailed checklists and routines shall be prepared to ensure that a single error cannot lead to a major accident. Over time, it will be natural to update the original risk analyses, the procedures and checklist, with experience from the vessel's operation or simulator training on board.

Risk associated with daily activities and related changes shall be managed through a work permit (WP) system and management of change (MoC) procedures. The use of risk analyses from the design process provides an important basis for operations, and operations must also be considered when completing risk assessments during the design phase.

Methods and practical frameworks will also form part of the organisation's updated safety management system.

Recommendations regarding the above are summarised in Table 2.

Table 2 Recommendations for methods and practical frameworks for risk assessments

RECOMMENDATIONS	
1	Maintain a close dialogue with relevant flag state and classification society regarding risk assessments for approval of design and of constructed and tested vessel.
2	Ensure that performance of risk assessments through Alternative Design and Approval Process (AD&A)[12,14] includes **competence** within 1) technical safety, 2) safety with regard to human-machine (human factors (HF) in design) to prevent incorrect handling and use in operation, 3) safety with regard to impacts and hazards related to exposure and injuries to persons including third parties, 4) safety in relation to environmental impact.
3	Perform **risk assessments** (e.g. HAZOP) for ship operations such as ordinary operations, bunkering and maintenance, during the design phase (newbuild or reconditioning).
4	Plan and perform risk assessments during the **design phase**, so that these can be **reused** during operations. This applies to e.g. 1) basis for preparation of operating procedures, 2) relevant leak and fire scenarios as basis for emergency preparedness plan and exercises. Ref. MTF guideline[15]
5	Develop **methods** and **practical tools** (e.g. checklists, safety reviews) and procedures for the assessment of safety risks before the completion of various operations, ensuring a proactive approach. Examples include 1) bunkering, 2) maintenance, 3) inspection. This will make it possible to detect minor faults and nonconformities through work methods/procedures, and to correct these before they develop into something more serious, in addition to performing simple risk assessments before activities are started.

[14] Alternative design and arrangements for Solas chapter II-1 (contains description of design team)
[15] MTF: Guideline to develop and implement a Safety Management system for alternative fuels

4.3 Emergency preparedness

Emergency preparedness is addressed in Chapter 8 of the ISM code.[6] Additional requirements may also apply dependent on the vessel type or segment, including national regulations, flag state requirements and classification society requirements.

Emergency preparedness is the ability to manage and mitigate the consequences of unwanted incidents that may cause harm to people, the external environment or result in material losses. This may involve technical, operational and organisational measures. The use of new fuels with different characteristics, as well as new equipment and onboard designs, will lead to new emergency scenarios and require revised procedures and personal protective measures. Developing various scenarios related to the specific vessel and its alternative fuels is therefore essential, and will form the basis for emergency plans, drills and training, as well as the emergency response organization.

Different phases of an emergency situation that should be addressed includes:

- Alarm & alert phase (e.g. detection, alarm, mobilisation of personnel)
- Response (eliminate ignition sources, shut-off, depressurisation, firefighting, etc.)
- Rescue (missing personnel, first aid, move to safe area)
- Evacuation
- Normalisation

All vessels with an ISM certification[6] must have an emergency preparedness plan linked to a manning certificate. The preparedness plan must reflect the chosen fuel type, and the following elements should be covered:

- Ship-specific assessments – which scenarios must the organisation be prepared for?
- Manning plans for relevant scenarios – including search and rescue
- Emergency preparedness plan to prevent and handle incidents such as sabotage and cyber attacks
- Overview of other resources available in an emergency situation
- Onshore emergency preparedness (port authority must have competence)
- Emergency preparedness at quays, platforms, etc. that may be affected
- Personal protective equipment and resources for first aid and medical treatment
- Equipment for handling acute emissions and spills.

Organisations should complete a systematic assessment of onboard emergency preparedness, including the identification and dimensioning of scenarios and corresponding emergency preparedness measures. This shall be reflected in an integrated emergency preparedness plan. The assessment should also cover available external emergency preparedness resources, with particular focus on knowledge and response capabilities related to emissions, fire and explosions, as well as the dispersion of toxic gas clouds (e.g. ammonia), depending on the fuel in use.

Table 3 Recommendations relating to emergency preparedness

RECOMMENDATIONS	
1	Use of dispersion analyses from risk assessments in ref. AD&A[12] as the basis for establishing which emergency preparedness scenarios shall be included in preparedness analyses, plans and exercises.

2	Update emergency preparedness analyses and emergency preparedness plan to include relevant scenarios that shall be covered in preparedness exercises depending on the fuel in use.
3	Update or establish emergency preparedness plan to include external emergency preparedness resources relevant to the fuel in use.

4.4 Competence and training when implementing new fuels

The introduction of new fuels on board requires updated and expanded competence. The specific competencies that each company needs to update may vary. The ISM Code sets requirements for both the vessel and the shore-based office regarding competence (ISM 2.2 and 3). The shipping company must be able to document that relevant crew members possess the necessary competence to ensure the safe operation of the vessel at all times. It is also important that the shore-based organization has the knowledge needed to support and facilitate safe operations for personnel on board
Competence requirements for the use of alternative fuels are currently being developed by the IMO for inclusion in the Standards of Training, Certification, and Watchkeeping (STCW). In 2024, the IMO and the IMO and Maritime Just Transition Task Force (MJTTF) published a report[16] outlining high-level competence needs that must be addressed going forward. The IMO expects to release interim guidelines on competence requirements for new fuels by 2025.

In 2024, DNV published standards and recommended practice for the use of methanol[17] and ammonia[18] as fuels. Both documents focus on specific competence requirements for engine room personnel, deck/bridge crew, and general crew members. Both documents have been developed with input from the industry and reflect competence requirements relating to activities on board and specific equipment related to the specific fuel. These documents are publicly available and can be used to develop tailored training courses, as well as to establish an overview of competence requirements for individual shipping companies and as a foundation for onboard manuals. DNV has also published a corresponding standard for LNG. Figure 4-2 shows relevant areas of competence for vessels with ammonia as a fuel and is taken from DNV-RP-0699[15].

DNV-RP-0699:

Competence for onboard use of ammonia as fuel

1. General knowledge and understanding
2. The ammonia bunkering – and fuel containment system
3. The Fuel Supply System
4. Venting and Ventilation
5. Technical Safety Barriers
6. Auxiliary Systems
7. Bunkering procedure
8. Tank Preparing for Internal Maintenance
9. Maintenance
10. Emergencies / Contingencies

Figure 2 Contents of DNV's recommended guidelines for competence on board vessels using ammonia as a fuel (DNV-RP-0699)

At the end of 2024, the European Maritime Safety Agency (EMSA) published a report,[19] prepared by DNV, which also addresses competence relating to alternative fuels. The report

[16] MJTTF (Nov 2024) Considerations of training aspects for seafarers on ships powered by ammonia, methanol and hydrogen
[17] DNV-ST-0687 "Competence related to the use of methanol as fuel"
[18] DNV-RP-0699 "Competence related to the use of ammonia as fuel"
[19] TRAINALTER - Study on the identification of specific competences for seafarers on ships using alternative fuels and energy systems

refers to competence needs for several fuel types and provides guidance on competence and training. It also includes insights from other industries and explores ways to demonstrate competence through the use of new technologies, such as virtual reality (VR). Experience from other industries regarding the development of competence and competence management is also discussed. This is shown in Figure 3.

Figure 3 Experience from other industries regarding competence management, ref. EMSA(2024)

The process of identifying competence needs—both on board and within the shore-based organization—should begin early, once a decision has been made to acquire or convert a vessel. The assessment of training and competence requirements should include both onboard personnel and shore staff. Available guidelines, standards, and recommended practices, as described above, can be used to support this assessment.
The figure below has been developed by DNV in connection with DNV-RP-0699,[17] and outlines the main steps that should be taken with regard to competence before the vessel enters into operation.

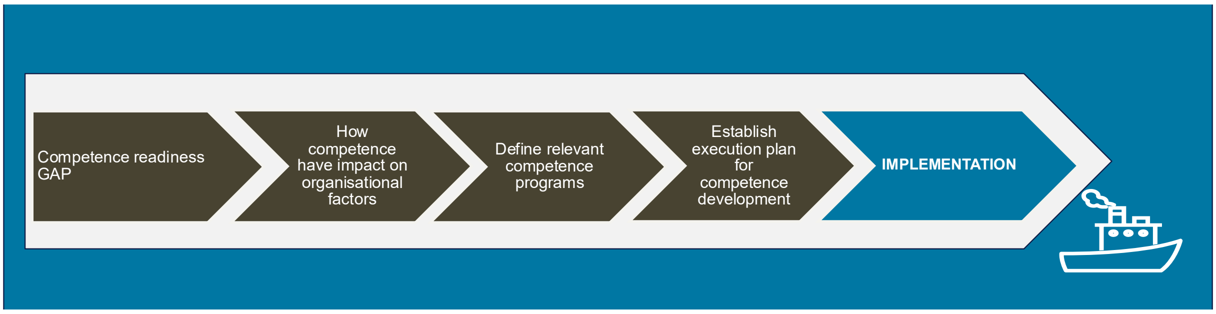

Figure 4 Systematic approach to competence in order to ensure the organisation facilitates putting vessels using alternative fuels into service (from DNV).

As a starting point for fuels with a low flash point such as hydrogen, ammonia and natural gas, it must be ensured that the crew's competence satisfies the minimum regulatory requirements (ref. the IGF/IGC code). Ammonia has been transported by sea for many decades, and the

IGC code[20] sets requirements related to such transport. While there is a significant difference between transporting ammonia as cargo and using it as fuel, operational experience—such as loading and unloading—can still be relevant for the use of ammonia as marine fuel.
There are already some standards and recommended practices outlining the topics that should be covered in training related to the introduction of new fuels.Examples of topics that should be covered in the training are:

- **Fuel characteristics**, including hazards such as toxicity, corrosiveness, fire and explosion risk, risk of major accidents and third-party risk
- **Safety competence** including methods and frameworks for assessing risk and implementation of safety measures
- **Handling and use of systems and equipment**, including bunkering, inspection and maintenance
- Design and construction knowledge
- First aid/medical treatment knowledge
- Knowledge of personal protective equipment used in various situations, both planned situations and emergencies
- Risk and hazard analysis, operation and emergency situations
- Technica and operational (organisational and human) barriers competencies.

Other important elements that must be included:
- Plan for familiarizing personnel with the vessel-specific systems and procedures for commissioning and operation of the vessel
- Assessment of needs for qualification regime (checksouts and clearances) for safety-critical activities or roles
- Resources to maintain and update training plans as new knowledge becomes available
- Frequency of training and drills.

Table 4 Recommendations for competence/training when implementing new fuels

RECOMMENDATIONS:	
1	The design team[13] shall ensure that sufficient training of personnel is identified and made available.
2	Undertake an assessment of the shipping company's competence needs relating to the introduction of new fuels. This can be done by using existing regulations, recommended guidelines, the IGF Code, DNV-RP-0699 (ammonia), DNV-ST- 0687 (methanol), EMSA (Dec. 2024) and recommendations from system suppliers, in addition to via dialogue with the relevant flag state.
3	Review the impact of competence needs on the organisation and working methods and specify the competence each resource shall possess.
4	Identify appropriate qualification regimes and checks for safety-critical activities and/or roles.
5	Plan internal competence programs (e.g. risk assessments, ship-specific courses and competence on Standard Operating Procedures (SOP))

[20] IMO International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

6	Plan and vetting of competence programs from external training institutions and suppliers.
7	Establish training implementation plan.
8	Conduct and complete training before the vessel is put into operation and maintain competence and training of personnel.

4.5 Handling of the change processes

The introduction of new fuels entails changes for the organisation. This should be addressed through the organisation’s management of change process (MoC), which is part of the SMS. Typical steps in this process include preparing the organisation for changes, planning how the changes will be implemented, implementing the changes, integrating changes so that they become part of daily operations (and long term), as well as evaluating and adjusting, if necessary, see Table 5.

Table 5 Recommendations regarding handling of the change processes

RECOMMENDATION	
1	Ensure ownership and engagement from the highest level of the organization regarding the introduction of new fuel
2	Establish initiative for systematic “Management of Change” (MoC) to assess the impact of the introduction of alternative fuels with associated technologies on the organisation, along with the identification of necessary measures. Ref. MTF/ISM guidelines.
3	Assess organisational changes in roles and responsibilities among the crew and for the onshore organisation, as well as ensure sufficient robustness (number and competence).
4	Evaluate overarching changes and provide input to strategies (e.g. shipping routes, ports, bunkering, etc.), in addition to involvement of external stakeholders that impact upon the organisation.

5 References

Relevant guidelines and information about ammonia, hydrogen and methanol:

DNV. (2023). Ammonia as a Marine Fuel Safety Handbook. DNV on behalf of the Green Shipping Programme. Version 02. DNV, Green shipping programme and Norwegian Maritime Authority 02.
DNV. (2021). Ammonia Bunkering of Passenger Vessel - Concept Quantitative Risk Assessment. Green Shipping Programme. DNV report no. 2021-0205, Version 0.
GCMD (2024), Safety and Operational Guidelines for Piloting Ammonia Bunkering in Singapore Global Centre for Maritime Decarbonisation, Singapore Maritime Academy, Surbna Jurong, DNV
MarHySafe. (2021). Handbook for hydrogen-fuelled vessels. MarHySafe JDP Phase 1. DNV, 1st edition.
DNV (2024) DNV-ST-0687 Competence related to methanol as fuel
DNV (2024) DNV-RP-0699 Competence related to ammonia as fuel
DNV (2022) DNV-ST-0026 Competence related to onboard use of LNG as fuel

Other references:

UNCLOS ARTICLE 94 Duties of the flag state
Maritime Labour Convention 2006 (MLC 2006) *a) MLC Standard A2.7 – Manning levels* *b) MLC Standard A2.8 - Career and skill development and opportunities for seafarers' employment*
MARPOL, International Convention for the Prevention of Pollution from Ships
Norwegian Maritime Authority/SOLAS: Alternative design and arrangements for SOLAS chapter II-1
LCA Guidelines on life cycle GHG intensity of marine fuels
DNV. (2022). Insights Into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry. DNV Report no. 2022-0814, version 0.
DNV. (2022e). Fuel properties and their consequence for safety and operability. DNV report no. 2022-1163, Nordic Roadmap publication no.1-B/2/2022.
Menon. (2022). Infrastructure and bunkering challenges for zero-carbon fuels. Menon publication no.172/2022. Nordic Roadmap publication no.2-B/1/2022.
MTF. (2023). Operational Management to Accelerate Safe Maritime Decarbonisation. Maritime Technologies Forum (MTF) April 2023.
DNV. (2024). Fuel Transition Roadmap for Nordic Shipping. Nordic Roadmap publication Dec. 2024.

6 Abbreviations

AD&A	Alternative Design and Approval Process
GCMD	Global Centre for Maritime Decarbonisation
GHG	Greenhouse gases
EMSA	European Maritime Safety Agency
EU	The European Union
HAZID	Hazard Identification
HAZOP	Hazard and Operability Analysis
IAPH	International Association of Ports and Harbours
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (gas code).
IGF	International Code of Safety for Ships Using Gases or other Low-Flashpoint fuels
ILO	International Labour Organization
IMO	International Maritime Organization
ISM	International standard for the safe management and operation of ships, and for managing pollution prevention
ITF MSC	International Transport Workers' Federation – Maritime Safety Committee
LCA	Life cycle assessment
LLI	Lloyds List Intelligence
LNG	Liquefied Natural Gas
MARPOL	The International Convention for the Prevention of Pollution from Ships
MLC	Maritime Labour Convention
MTF	Maritime Technology Forum
SEP	Safety and Environmental Protection
SMS	Safety management system
SOLAS	Safety of Life at Sea (IMO convention)
STCW	Standards of Training, Certification, and Watchkeeping
UN	The United Nations
UNCLOS	United Nations Convention on the Law of the Sea

Appendix A: Alternative fuels

This list contains both alternative fuels and other measures that can reduce fuel consumption and thereby reduce greenhouse gas emissions. For more information about each fuel, use this link: ITF MSC Safety dynamics of ship's energy sources.

	Alternative fuels/new technologies	**Toxicity**	**Corrosiveness**	**Explosion**
Liquid fuels /Biodiesel	Fatty-acid methyl ester (FAME)	No	Yes	No
	Hydrothermal liquefaction (HTL) fuel			
	Pyrolysis fuel			
	Fischer-Tropsch (FT) diesel			
	Hydrotreated vegetable oil (HVO)			
	Fischer-Tropsch (FT) diesel			
	Methyl/Ethyl alcohol fuels	Yes	Yes	Yes
Liquefied & Compressed Gaseous Fuels	Ammonia (liquid/gas)	Yes (high)	Yes (high)	Yes
	Dimethyl Ether (DME)	Yes	Yes	No
	Ethane	No	No	Yes
	Hydrogen	No	No	Yes
	Methane/Natural Gas	No	No	Yes
	Propane/Butane (LPG)	Yes	Yes	Yes
	Fuel Blends/Mixtures (e.g. hydrogen - natural gas)	Depends on the fuel used		
Power Conversion Systems	Fuel Cell Power Installations	Depends on the fuel used		
	Fuel Reforming	Depends on the fuel used		
	Nuclear Power	No	No	Yes
	Solar Power	No	No	No
	Wind Propulsion	No	No	No
Energy Storage (Storage also addressed within fuel categories)	Lithium-Ion Batteries	Yes	No	Yes
	Supercapacitor energy storage technology	Yes	Yes	Yes
	High-Pressure Composite Cylinders	No	No	Yes
	Metal Hydrides	No	No	Yes
	Liquid Organic Hydrogen Carrier (LOHC)	Depends on the organic compound that is used		
Improved Efficiency	Wind Assisted Power	No	No	No
	Air Lubrication	No	No	No
	Foils / Hydrodynamic Energy Saving Devices	No	No	No
	Low-Friction Antifouling Paints	Yes	No	No
	Hull Form Optimization	No	No	No
	Optimal Routing	No	No	No
	Propeller Optimization and Propulsion Improving Devices	No	No	No
	Advanced Waste Heat Recovery	No	No	Yes

	Alternative fuels/new technologies	Toxicity	Corrosiveness	Explosion
Liquid fuels /Biodiesel	Fatty-acid methyl ester (FAME)	No	Yes	No
	Hydrothermal liquefaction (HTL) fuel			
	Pyrolysis fuel			
	Fischer-Tropsch (FT) diesel			
	Hydrotreated vegetable oil (HVO)			
	Fischer-Tropsch (FT) diesel			
	Methyl/Ethyl alcohol fuels	Yes	Yes	Yes
Liquefied & Compressed Gaseous Fuels	Ammonia (liquid/gas)	Yes (high)	Yes (high)	Yes
	Dimethyl Ether (DME)	Yes	Yes	No
	Ethane	No	No	Yes
	Hydrogen	No	No	Yes
	Methane/Natural Gas	No	No	Yes
	Propane/Butane (LPG)	Yes	Yes	Yes
	Fuel Blends/Mixtures (e.g. hydrogen - natural gas)	Depends on the fuel used		
Power Conversion Systems	Fuel Cell Power Installations	Depends on the fuel used		
	Fuel Reforming	Depends on the fuel used		
	Nuclear Power	No	No	Yes
	Solar Power	No	No	No
	Wind Propulsion	No	No	No
Energy Storage (Storage also addressed within fuel categories)	Lithium-Ion Batteries	Yes	No	Yes
	Supercapacitor energy storage technology	Yes	Yes	Yes
	High-Pressure Composite Cylinders	No	No	Yes
	Metal Hydrides	No	No	Yes
	Liquid Organic Hydrogen Carrier (LOHC)	Depends on the organic compound that is used		
Improved Efficiency	Wind Assisted Power	No	No	No
	Air Lubrication	No	No	No
	Foils / Hydrodynamic Energy Saving Devices	No	No	No
	Low-Friction Antifouling Paints	Yes	No	No
	Hull Form Optimization	No	No	No
	Optimal Routing	No	No	No
	Propeller Optimization and Propulsion Improving Devices	No	No	No
	Advanced Waste Heat Recovery	No	No	Yes

Appendix B: Regulations

UNCLOS provides the foundation for the four safety pillars at sea, SOLAS, MARPOL, MLC and STCW, where the international standard for the safe management and operation of ships, and for managing pollution prevention (the ISM code) is the management tool. This UN/ILO/IMO regulation with additional EU directives has been entered into Norwegian law.

The Ship Safety and Security Act[21] aims to protect life and health, the environment and material assets at sea. The act applies to all Norwegian and foreign ships with some exceptions, including ships that are not used for commercial purposes. The act applies to Norwegian ships irrespective of their position. For foreign ships, the act applies in Norwegian territorial waters, including waters near Svalbard and Jan Mayen, as well as in the Norwegian economic zone and on the Norwegian Continental Shelf.

The act has around 100 regulations founded upon it, all of which have the purpose of facilitating a high level of ship safety and safety management, including to ensure a fully satisfactory working environment and safe working conditions on board. Regarding training of the crew, section 22 of the Ship Safety and Security Act states that "*The work on board shall be arranged and carried out so as to safeguard life, health and the working environment. In the arrangement of work, due regard shall be paid to the individual person's qualifications to undertake the work on a safe and sound basis*." This presumes that crew members have sufficient knowledge and a good understanding of the conditions on board. This requires the correct competence and education.

The regulations regarding the working environment, health and safety of persons working on board ship[22] is one of the regulations founded on the Ship Safety and Security Act in order to ensure the aforementioned section 22. Section 2-6 of the Regulations regarding the working environment, health and safety of persons working on board ship requires that every individual working on board shall receive the necessary training to be able to carry out their work in a safe and proper manner. Training shall be provided before anyone is given access to areas involving a serious or special risk, and when new technology is introduced, including alternative types of fuel.

The Regulations on qualifications and certificates for seafarers (Qualifications regulations)[23] are also founded on the Ship Safety and Security Act. Sections 69 and 69a set requirements regarding certificates of proficiency for crew members that shall undertake specific duties on board ships using fuel with a flashpoint of less than 60°C (IGF Basic), and for crew members directly responsible for the handling and use of this type of fuel (IGF Advanced). The minimum competence that satisfies the requirements of these certificates can be found in Annex IX and in Chapter 5 rule V/3 of the STCW convention[24] and STCW code rule A-V/3.

Both ammonia and methanol are covered by these requirements, but there is currently no IMO mandatory competence requirements relating specifically to ammonia or methanol. The current mandatory competence requirements are general for fuels with a flash point below 60°C, and are to a great extent adapted to LNG, since this is the only fuel which has historically required these certificates of proficiency.

The IMO has published interim guidelines regarding the use of methanol as a fuel ((MSC.1/Circ.1621)[25], and the qualification requirements are covered in section 16. The IGF courses mentioned above are used as a basis for the training, but the guidelines also specify

21 Ship Safety and Security Act
22 Regulations regarding the working environment, health and safety of persons working on board ship
23 Qualifications regulations
24 STCW convention
25 MSC circular 1621

that all crew members shall be familiarised with methanol specifically and possess all appropriate knowledge in order to ensure safe operations. The Norwegian Maritime Authority uses these guidelines in the certification and supervision of methanol-operated ships and their crews.

The IMO has also approved temporary guidelines for the use of ammonia as a fuel, and the qualification requirements are covered in section 19. The guidelines do not refer to the IGF courses specifically, but the STCW applies through Part D section 19 of the IGF Code, and crew members who shall handle ammonia shall therefore complete appropriate IGF courses and also possess the necessary additional competence required to manage the extra hazards associated with ammonia. It is the shipping company's responsibility to ensure that the necessary training is provided, cf. sections 5 and 6 of the Qualifications regulations.

The IMO is also working to develop model courses for hydrogen and ammonia where characteristics such as toxicity, explosion risk and the use of personal protective equipment, etc. are emphasised in relation to personnel both on board and onshore. The Norwegian Maritime Authority has also begun developing circulars that will specify interim competence targets and minimum competence, pending the development and completion of the model courses.

So as not to impede technological progress, SOLAS permits new maritime technologies to be adopted even if there are no existing regulations that cover the technology in question. This is currently the case for most alternative fuels, and pending the mandatory competence requirements coming into effect, a risk-based certification process must be used. This certification process is called the alternative design process and is specified in SOLAS II-I/55. In turn, SOLAS II-I/55 refers to MSC.1/Circ.1455, which contains a description of the elements that shall be included in the alternative design process. The certification process mainly focuses on the technical aspects and only briefly touches on the training of crew members, but part 3.2 of the circular mentions that the design team is responsible for ensuring that sufficient training of personnel is identified and made available. Detailed training procedures shall be available before a final operating permit is given.

Figure 1: ISM Code stakeholder system