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North Sea Hydrogen Valley Ports

Creating the hydrogen corridor between North Sea ports

Deliverable D 3.2

Policy barriers to vessel design and policy changes needed to stimulate greater activity

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Contents

Abbreviations

AC	Alternating Current
BV	Bureau Veritas
CO_2	Carbon dioxide
DC	Direct Current
DSC	Design Safety Case
DNV (DNV GL)	Det Norske Veritas (formerly DNV GL)
EMC	Electromagnetic Compatibility
ETS	Emissions Trading System
FSA	Formal Safety Assessment
HAZID	Hazard Identification
H_2	Hydrogen
IEC	International Electrotechnical Commission
IACS	International Association of Classification Societies
IGF Code	International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels
IMO	International Maritime Organization
IMO CCC	IMO Sub-Committee on Carriage of Cargoes and Containers
IMO MSC	IMO Maritime Safety Committee
ISM	Industrial, Scientific and Medical (equipment)
kVA	Kilovolt-ampere
kW	Kilowatt
LR	Lloyd's Register
MARPOL	International Convention for the Prevention of Pollution from Ships
MW	Megawatt
NO_x	Nitrogen oxides
PEMFC	Proton Exchange Membrane Fuel Cell
QRA	Quantitative Risk Assessment
RCS	Rules, Codes and Standards
SOLAS	International Convention for the Safety of Life at Sea
UR	Unified Requirements

Executive summary

The North Sea region's ambition to decarbonize its maritime and port activities depends critically on overcoming regulatory hurdles for hydrogen-powered vessel design. Deliverable D3.2 examines the existing policy landscape, which currently presents significant barriers to the rapid deployment of these next-generation ships.

The central challenge is safety certification. Hydrogen's unique properties, particularly its high volatility and wide flammability range, necessitate stringent design requirements to mitigate fire and explosion risks. Current vessel approval processes rely heavily on the IMO IGF Code, which is prescriptive and often requires time-consuming, expensive, and specialized Formal Safety Assessments (FSA) and Quantitative Risk Assessments (QRA) for designs that deviate from existing standards. This rigid approach hinders innovation and delays market entry for new vessel types.

To stimulate greater activity, the report calls for essential policy changes. Recommendations focus on moving towards a risk-based regulatory framework that emphasizes design flexibility and accelerates the approval of new technologies. Key actions include harmonizing technical standards across classification societies and, crucially, aligning safety certification processes with broader EU decarbonization policies, such as the EU ETS and fuel mandates, to ensure regulatory incentives match design requirements. This shift is essential to move hydrogen shipping from early adoption to a mainstream solution.

Introduction

While considered new technologies a decade ago, vessels powered by alternative fuels are starting to find their place in the shipping sector.

As shown in deliverable D3.1, there are today about 13 hydrogen or methanol-powered coastal and inland shipping vessels in operation, with an average propulsion power of 800 kW. Confirmed orders and announced vessels for the 2025-2028 period indicate at least 20 additional vessels will hit the water, with an average propulsion power of 2.7 MW. This reveals a rapid shift from first-of-a-kind vessels and demonstrators to series of larger vessels.

While the sector is steadily maturing, the introduction of alternative fuels like hydrogen and its derivatives is still hampered by cost, limited fuel availability and uncertain regulatory frameworks for vessel design and safety.

This latter issue is key, as few vessels are built every year: decarbonizing the short-sea, coastal and inland vessels fleet will require a significant engineering and retroffiting effort. Major re-configuration of existing vessels will be necessary, which will not be possible without clear rules and regulations.

However, with the absence of rules and guidelines from the International Maritime Organization (IMO), new vessel design is based on the “Alternative Design Process” an approach that requires significant time and effort from project developers, who must actively demonstrate how the hazards and their impacts are managed by applying a risk-based design approach instead of demonstrating compliance with rules and regulations.

The purpose of this report is to present the current regulatory framework for vessel design and explore how it could evolve in the short term. A follow-up activity will make recommendations to improve this framework.

1 The hydrogen safety challenge

1.1 Hydrogen properties

As further described in deliverable D3.1 Hydrogen is the most abundant element in the universe and forms the basis of many chemicals and molecules. Hydrogen in normal atmospheric temperature and pressure is diatomic molecule with the symbol H_2. Given its use in industrial application for more than a century, its main characheristics are well known:

- Gaseous at normal atmospheric pressure and temperature.
- Nontoxic – Note that it can be an asphyxiant if there is not enough air present.
- Colourless.
- Odourless.
- Flammable.
- Burns with a clear - almost invisible to the human eye - flame.
- Autoignition temperature of 500ºC.
- Has a low radiated temperature.
- Has a wide flammable range – 4% - 74% in air.
- The stoichiometric ratio of hydrogen in air is 30%.
- Has a very low density and disperses readily[1].

1.2 Mitigating the fire and explosion risk

The main safety implication of using hydrogen in the marine environment, which are defined from its characteristics above, is the risk of fire and potentially of explosion.

To create a fire there are three ingredients, oxygen, fuel, and heat forming the fire triangle. If any of these constituents is missing then a flammable atmosphere cannot exist. It is not possible to remove oxygen in normal environments as it is present in air, and therefore the fuel cell module must be designed to mitigate the risk of hydrogen leak (i.e. the fuel), and remove any potential ignition sources (i.e. the heat).

[1] European Industrial Gases Association (EIGA), *DOC 15/21 "Properties of hydrogen"*, available at https://www.eiga.eu/uploads/documents/DOC015.pdf

1.3 Impact on vessel design

Mitigating the risk associated with use of hydrogen and derivatives on board requires specific adptation to vessel design, both in the case of newbuild and retrofit. Of particular importance are:

- tank storage space and location, which are likely to be placed above deck for safety reason
- venting mast, to mitigate fire and explosion risks in case of fuel leakage
- engine space must be reconsidered, given the size, shape and volume of fuel cell modules that may differ from conventinal engines
- piping and piping materials must be thouroughly selected considering the higher risk of embrittlement and corosion with hydrogen and ammonia
- anchorage and mooring equipment, due to the different weight distribution in hydrogen-powered vessel.

However, designing a vessel with these considerations in mind is not sufficient. To re-assure the prospective ship owner and operator of the vessel safety, and to make it insureable, individual components must be type approved and the design itself must be conducted in accordance with IMO guidelines.

2 Approval Process Today

Bringing innovative fuel and propulsion systems into the shipping industry demands substantial work from project developers. Since globally accepted rules and standards for hydrogen-powered vessels are not yet in place, project owners must proactively show how potential risks and safety concerns are addressed through risk-based design approaches, rather than simply adhering to existing regulations. This section outlines the approval challenges currently encountered by vessel designers and component suppliers.

2.1 Type approval process for individual components

With conventional technologies such as combustion engines burning marine oil or diesel, risk is mitigated by subjecting all equipment to type approval, i.e. a certification process guaranteeing that equipment have been designed based on well-know standards, proven to mitigate these risks. Type approval is granted by classification societies acting as neutral assessors and technical experts.

In the case of hydrogen, reaching type approval remains a complex process given the relative novelty of hydrogen technologies in a marine environment. It is therefore up to clean shipping frontrunners to identify the relevant standards that wil reduce the risk, or develop new standards if necessary, leveraging existing regulations, codes and standards (RCS) in place for similar technologies or for the same hydrogen technology used in a different sector.

Using the similar of analogous technologies and existing RCS as a basis, a set of criteria can be set out for innovative technology, by following these steps:

1. Application: the manufacturer submits an application with the necessary technical documentation to the certification body.
2. Evaluation: the certification body reviews the documentation and performs tests, inspections, audits, or simulations to verify the compliance of the product or system with the applicable standards and requirements.
3. Decision: the certification body issues a Type Approval certificate if the product or system meets the criteria for approval. The certificate is valid for a specified period and may include conditions or limitations.
4. Monitor: the certification monitors the production and quality control of the approved product or system to ensure its continued conformity with the Type Approval certificate. Further tests and validation are undertaken if the core function or specification of the product is changed or updated.

As an example, the table represents that classification standards that a marine hydrogen fuel cell must below must be comply with or pass to receive type approval.

Classification Standard and Test	Requirement
Requirement Validation - IACS UR E1 01	Specifies the requirements for the design, construction, and testing of electrical installations on board ships. It covers topics such as power generation, distribution, protection, grounding, lighting, and communication systems. The document aims to ensure the safety, reliability, and efficiency of electrical installations on ships.
Visual Inspection - IIEC 62282-3-100	The standard that specifies the requirements for the performance of stationary fuel cell power systems. It covers the electrical, thermal, environmental, and safety aspects of the systems, as well as the test methods and procedures. The standard applies to systems that use hydrogen, natural gas, or other fuels, and that operate in grid-connected, grid-support, or stand-alone modes.
Fuel Cell Safety - IACS UR E10 02	The standard for the design and construction of marine diesel engines. It specifies the requirements for the materials, dimensions, tolerances, testing and inspection of the engine components. The standard also provides guidance on the installation, operation, and maintenance of the engines. The purpose of ICAS UR E10 02 is to ensure the safety, reliability, and performance of marine diesel engines in various operating conditions.
Fuel Cell Safety - IEC 62282-3-100	The international standard that specifies the safety requirements for stationary fuel cell power systems that generate electricity through electrochemical reactions. It applies to self-contained or factory-matched systems that can be connected to the grid or an island network, and that can deliver AC or DC power, with or without heat recovery. The standard covers various aspects of the system design, installation, operation, maintenance, and testing, as well as protection against fire and explosion hazards.
Performance - IACS UR E1 02 62282-3-200	The standard for the design and installation of fuel cell systems on board ships. It covers the requirements for safety, performance, environmental protection, and electrical compatibility of fuel cell systems. The standard is based on the International Electrotechnical Commission (IEC) standard 62282-3-200, which applies to stationary fuel cell power systems.
Inclination - IACS UR E10 8	The ICAS UR E10 8 inclination test is a method to evaluate the performance of electrical equipment installed on ships. The test simulates the conditions of a ship's movement in rough seas, such as rolling and pitching. The test involves tilting the equipment at various angles and measuring its electrical parameters,

	such as voltage, current, power, and frequency. The test aims to ensure that the equipment can operate safely and reliably under different inclinations. The test is designed to meet IEC 60092-504 , the international standard that specifies the requirements for electrical installations on board ships. It covers aspects such as design, selection, installation, inspection, and testing of electrical equipment.
Environmental - IACS UR E10 5/6/11	The procedure to evaluate the performance and reliability of integrated circuits under various stress conditions. The test involves exposing the circuits to high and low temperatures, humidity, vibration, shock, and electrostatic discharge. The test aims to simulate the real-world environments that the circuits may encounter during their operation and lifetime. The test results can help identify potential defects, failures, or degradation of the circuits.
External Power - IACS UR E10 3/4	This standard sets the external power marine requirements that can be used to supply electricity to ships or other vessels. It is designed to meet the International Convention for the Safety of Life at Sea (SOLAS) standards and the Unified Requirements (UR) of the International Association of Classification Societies (IACS). The system needs to have a power rating of 10 kVA and a voltage of 400 V.
EMC - IACS UR E10 13	The standard for electromagnetic compatibility (EMC) testing of electrical and electronic equipment. EMC testing ensures that the equipment does not interfere with other devices or systems in its intended environment, and that it can operate normally under various electromagnetic conditions. ICAS UR E10 13 specifies the general requirements, test methods, and limits for EMC testing of equipment used in industrial, scientific, and medical (ISM) applications.

With hydrogen technologies, type approval is pivotal to show the technology is safe, and accelerate technology adoption. It provides certainty and validation for a ship owner or operators, therefore derisking at the adoption of the technology.

2.2 Vessel approval through the alternative design process

Similary to individual component type approval, vessel design using the IMO Alternative Design process is a risk-based exercise. Instead of following only prescriptive rules (e.g., “the bulkhead must be X meters high”), a ship designer can propose an alternative design that meets or exceeds the required safety level through a risk-based engineering analysis.

The process to be followed is described in the IMO Guidelines for the Approval of Alternatives and Equivalents (MSC.1/Circ. 1455[2]).

Preliminary Proposal & Approval in Principle

- Shipowner/designer informs the Flag Administration that an alternative design is being pursued.
- The Administration evaluates whether the proposal is acceptable in principle.

Hazard Identification (HAZID)

- Systematic identification of hazards related to the alternative design.
- Workshops and expert input are used to map out credible risks.

Risk Assessment

- Formal safety assessment (FSA) methods such as Quantitative Risk Assessment (QRA), fault tree analysis, event tree analysis, or fire simulation.
- Compare risk levels between the proposed design and the conventional prescriptive design.

Equivalence Demonstration

- Show that the alternative design provides a safety level at least equivalent to that required by the SOLAS regulations.

Documentation

- A Design Safety Case (DSC) is prepared, including:
    - Hazard and risk assessments
    - Risk control measures
    - Design features and operational limitations
    - Compliance demonstration

Flag Administration Review

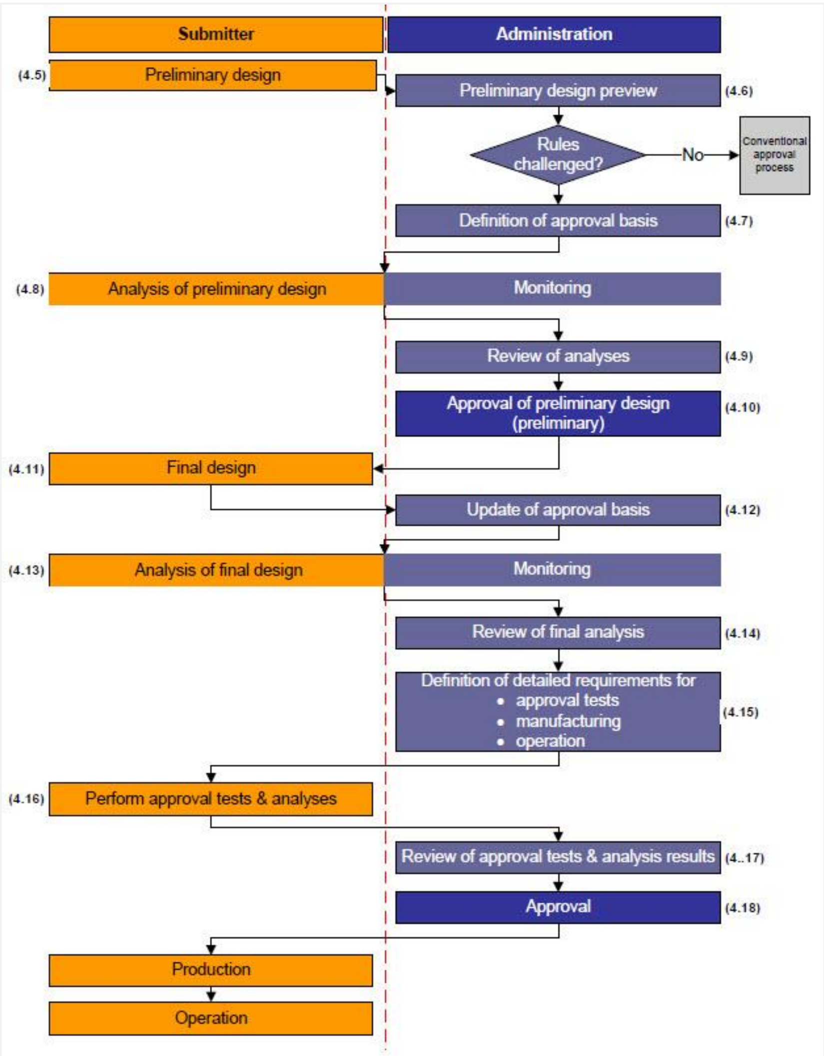
- The documentation is submitted to the Flag State Administration (and often reviewed by its Recognized Organization, e.g., classification society).
- If satisfied, the Administration approves the design.

[2] https://puc.overheid.nl/nsi/doc/PUC_2017_14/

IMO Notification

- The Flag State must notify the IMO of the approved alternative design, including a summary of the risk assessment and justification of equivalence.
- This ensures transparency and sharing of lessons learned.

Figure 1: Overview of the alternative design approval process



Source: https://puc.overheid.nl/nsi/doc/PUC_2017_14/

3 Regulatory Developments

With negotiations on greenhouse gas reduction in the shipping sector steadily progressing at international level with the IMO, and with the adoption of more stringent regulatory framework at European level (EU ETS, Refuel Maritime), classifications socieites are providing guidelines for ship design. The section below provides an overview of the current state of play, with a focus on guidelines issued by European organizations.

3.1 Preliminary design guidelines for hydrogen-powered vessels

In 2021, the IMO issued interim guidelines on the safety of ships using fuel cell power systems[3], the first global framework addressing hydrogen-fuelled vessels. The guidelines specify technical requirements for design, layout, materials, storage, bunkering, electrical systems, and emergency response. Key priorities include leak prevention, inerting measures, and system compatibility. Their objective is to provide lifecycle safety management for hydrogen vessels, reducing fire and explosion risks and laying the groundwork for future mandatory regulation.

Also in 2021, DNV GL, in cooperation with 26 stakeholders, released a handbook for hydrogen-fuelled ships[4]. Centered on PEMFC technology, it addresses design, construction, and risk assessment, with guidance on storage, bunkering, and leak prevention in offshore contexts. A second edition will expand to experimental research and standards for cryogenic liquid hydrogen.

Bureau Veritas (BV) has issued guidelines for fuel cell integration in commercial ships, establishing technical and safety requirements[5]. These stress incorporation into the vessel's energy system and support biodiesel and biogas as auxiliary fuels to ensure return-to-port capability.

Lloyd's Register (LR) published its hydrogen vessel design code (Appendix LR3) in 2023[6], specifying safety measures such as leak analysis and bunkering station design. The framework has been applied to Norway's MS Hydra ferry, launched in 2024.

In the rest of the world, classification societies are also looking at hydrogen vessels and released their own recommendations. This was the case of the Amercian Bureau of Shipping (ABS), the

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[3] International Maritime Organization (IMO). *Interim Guidelines for the Safety of Ships Using Fuel Cell Power Installations* (MSC.1/Circ. 1647). Available at: https://greenvoyage2050.imo.org/wp-content/uploads/2023/02/MSC.1-Circ.-1647-Interim-Guidelines-for-the-Safety-of-Ships-Using-Fuel-Cell-Power-Installations-Secretariat.pdf

[4] Handbook for Hydrogen-fuelled Vessels (DNV): https://www.dnv.com/maritime/publications/handbook-for-hydrogen-fuelled-vessels-download/

[5] Bureau Veritas, *Rule Note NR 547 – Ships Using Fuel Cells*, January 2022, https://marine-offshore.bureauveritas.com/nr547-ships-using-fuel-cells

[6] Lloyd's Register, *Appendix LR3 – Rules and Regulations for the Classification of Ships using Gases or other Low-Flashpoint Fuels: Requirements for Ships Using Hydrogen as Fuel*, Notice No. 3, July 3, 2023, https://www.lr.org/en/knowledge/horizons/june-2023/lr-issues-worlds-first-rules-for-hydrogen-fuel/

Japanese Nippon Kaiji Kyokai (NK), the Korean Register (KR) and the China Classification Society (CCS) in collaboration with the China Maritime Safety Administration (CMSA).

A summary of these regulatory frameworks is presented in Table 2. Collectively, classification societies and international bodies have established a robust foundation for hydrogen vessel safety and reliability, supporting maritime decarbonization. With technological progress, cost reductions, and growing environmental pressures, hydrogen-fuelled vessels are expected to play an expanding role in the sector’s green transition.

Table 2: Overview of hydrogen vessel design guidelines by classification societies

Issuing Authority	Field	Release Date	Main Contents	Technical Highlights
IMO	Interim Guidelines for the Safety of Ships Using Fuel Cells	2021	First global framework addressing hydrogen fuel cell safety, covering design, arrangement, material selection, hydrogen storage/loading, electrical systems, and emergency management. PROVIDED a basis for future mandatory regulations.	Emphasized hydrogen leakage control, inert atmosphere requirements, and integration with shipboard power systems.
DNV	Handbook for Hydrogen-Fuelled Vessels	2021	Systematic guidelines for hydrogen-fuelled ship design, construction, and risk assessment, focusing on PEMFC technology and marine environmental adaptability.	Addressed hydrogen's physical properties (lightweight, high diffusibility) and introduced risk-based safety assessments.
ABS	Guide for Fuel Cell Power Systems in Marine and Offshore Applications	2021	Defined hydrogen fuel cell advantages (40%-60% energy efficiency, zero emissions) and proposed SOFC-gas turbine hybrid systems for decarbonization.	Highlighted three-stage decarbonization strategy: energy efficiency (short-term), transitional fuels (medium-term), and hydrogen-carbon cycle (long-term). Predicted hydrogen to account for 30% of marine energy by 2050.
ABS	SETTING THE COURSE TO LOW CARBON SHIPPING: 2030 Outlook 2050 Vision	2021	Outlined hydrogen as a transitional fuel alongside green hydrogen for zero-carbon shipping.	Emphasized hydrogen storage, bunkering infrastructure, and certification standards.
BV	Guidelines for Fuel Cell Systems Onboard Commercial Ships	2021	Required deep integration of fuel cell systems with ship energy architectures, supporting dual-fuel compatibility (e.g., biodiesel, biogas).	Mandated hydrogen storage safety standards, heat recovery systems, and compliance with SOLAS/MARPOL conventions.
LR	Hydrogen Fuelled Ships Design Code (Appendix LR3)	2023	Established safety requirements for hydrogen fuel cell systems, including leak scenarios, bunker station layouts, and lifecycle management.	Validated for Norwegian hydrogen-powered ferry projects (2025 launch).
JMSA	Guidelines for Alternative Fuel Ships (2024 Update)	2024	Added hydrogen-specific requirements, emphasizing leak prevention and safe return-to-port (SRtP) capabilities. Granted AiP to the world's first liquid hydrogen tanker.	Proposed hybrid systems (fuel cells + Wärtsilä engines) and ammonia transition strategies.
KR	Hydrogen Fuel Safety Bunkering Operations Guidelines	2024	Standardized gaseous, liquid, and solid hydrogen bunkering procedures, aligning with international standards.	Focused on standardized operations and safety protocols for global hydrogen supply chains.
CCS	Guidelines for Alternative Fuel Ships	2017	First Chinese framework incorporating hydrogen fuel cells, outlining basic safety requirements.	Laid foundational standards for China's hydrogen ship sector.
CCS	Guidelines for Fuel Cell Power Generation Systems on Board Ships	2021	Detailed technical specifications for hydrogen fuel cell ships, including design, layout, storage, and electrical systems. Introduced optional certification marks.	Specified hydrogen storage, bunkering, and system integration standards.
CCS	Interim Rules for Hydrogen Fuel Cell-Powered Ships (2022)	2022	Formalized hydrogen fuel cells as primary propulsion systems, clarifying technical validation and environmental compliance.	Established mandatory inspection procedures for hydrogen fuel cell systems.
CCS	Product Inspection Guidelines for Hydrogen Fuel Cells, Hydrogen Tanks, and Reformers (2022)	2022	Set validation criteria for key components (e.g., PEMFC durability [-20°C to 60°C], hydrogen tank safety valves, reformer efficiency).	Fulfilled technical gaps in domestic hydrogen ship standards; ensured compliance with international norms (SOLAS/MARPOL).

Source: Zhou Z and Tao J (2025) Hydrogen-powered vessels in green maritime decarbonization: policy drivers, technological frontiers and challenges. Front. Mar. Sci. 12:1601617. doi: 10.3389/fmars.2025.1601617

3.2 Standardization gaps

While classification societies are taking steps to derisk vessel design, standardization work is also underway to bridge gaps prevent a broader adoption of hydrogen technologies. As identified by the IMO and shown in the table below, standardization is still lacking for hydrogen fuel quality. International safety guidelines do exist for the transport of hydrogen as a commodity, but not for its transport and use as a fuel.

Table 2 Regulatory and Standardisation Map for Alternative Fuels

Fuel	External standards	IMO SAFETY - SOLAS	IMO ENVIRONMENT - MARPOL
Methyl Alcohol (Methanol)	**Marine standards in progress** Marine standards in progress **ISO/AWI 6583** "Specification of methanol as a fuel for marine applications" is under development. Currently, IMPCA[1] Methanol reference specification and ASTM[2] D1152 standard are used when specifying methanol quality.	**High regulatory readiness level** SOLAS Chapter II regulates low-flashpoint fuels (< 60°C) through • SOLAS Ch II-1 Part G (low-flashpoint liquid fuel or gas) and IGF Code; alternatively • SOLAS Ch II-1 Part F (Alternative design and arrangement) –**MSC.1/Circ.1212/Rev.1** and **MSC.1/Circ.1455** The IGF Code does not cover methanol as fuel but **MSC.1/Circ.1621** *Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel* has been developed.	**Low regulatory readiness level** Methanol is assigned category Y as per the IBC Code, meaning it presents a hazard to either marine resources or human health. MARPOL Annex II requirements do not apply for spill and discharges of methanol as fuel. **High regulatory readiness level** MARPOL Annex VI regulates emissions of CO_2 and NO_x
Ammonia	**No marine standards available** No marine standards available	**Medium regulatory readiness level** SOLAS Chapter II regulates low-flashpoint fuels (< 60°C) through • SOLAS Ch II-1 Part G (low-flashpoint liquid fuel or gas) and IGF Code; alternatively • SOLAS Ch II-1 Part F (Alternative design and arrangement) –**MSC.1/Circ.1212/Rev.1** and **MSC.1/Circ.1455** IGC Code identifies ammonia as a toxic product and prohibits toxic cargo to be used as a fuel. The IGF Code does not cover ammonia as fuel. Draft interim guidelines for the safety of ships using ammonia as fuel are currently under development.	**Low regulatory readiness level** "Ammonia aqueous" is assigned category Y as per the IBC Code, meaning it presents a hazard to either marine resources or human health. MARPOL Annex II requirements do not apply for spill and discharges of ammonia as fuel. **High regulatory readiness level** MARPOL Annex VI regulates emissions of NO_x **Low regulatory readiness level** Other combustion products e.g., N_2O are not currently regulated under MARPOL Annex VI.
Hydrogen	**No marine standards available** **ISO 14687:2019** "Hydrogen fuel quality – Product specification"	**Medium regulatory readiness level** SOLAS Chapter II regulates low-flashpoint fuels (< 60°C) through • SOLAS Ch II-1 Part G (low-flashpoint liquid fuel or gas) and IGF Code; alternatively • SOLAS Ch II-1 Part F (Alternative design and arrangement) –**MSC.1/Circ.1212/Rev.1** and **MSC.1/Circ.1455** The IGF Code does not cover hydrogen as fuel. Resolution MSC.420(97) provides interim recommendations for carriage of liquid hydrogen in bulk. Draft interim guidelines for the safety of ships using hydrogen as fuel are currently under development.	**High regulatory readiness level** MARPOL Annex VI regulates emissions of NO_x

Source: https://greenvoyage2050.imo.org/alternative-marine-fuels-regulatory-mapping/

3.3 Expected regulatory developments

The IMO Sub-Committee on Carriage of Cargoes and Containers (IMO CCC) presented interim guidelines for the safety of ships using hydrogen as fuel in 2024, agreeing on functional requirements for all sections of the guidelines, and on certain fundamental design principles. Work on the interim guidelines will continue in a Correspondence Group aiming for finalization in 2025 and approval by the Maritime Safety Committee (IMO MSC) in 2026.

4 Conclusions

The maritime sector is entering a decisive phase in the transition toward zero-emission propulsion. While the number of hydrogen and methanol-powered vessels remains limited today, the pipeline of announced projects indicates strong momentum and a shift from pilot projects to commercial deployment. This transition, however, is constrained by the absence of clear and harmonized rules for vessel design, type approval, and certification.

The current reliance on the IMO Alternative Design process, combined with fragmented guidelines from classification societies, places a heavy burden on technology developers and shipowners, often slowing down innovation. At the same time, ongoing international and European regulatory developments – such as the IMO's work on interim guidelines for hydrogen vessels and the EU's introduction of instruments like the ETS and Refuel Maritime – highlight that the regulatory framework is evolving quickly.

To accelerate the uptake of hydrogen-fuelled vessels, three areas stand out as priorities:

1. **Clearer global standards** – Internationally recognized rules for hydrogen storage, fuel cell systems, and safety management must be finalized and adopted to reduce uncertainty and facilitate type approval.
2. **Consistency across classification societies** – While frontrunners such as DNV, Bureau Veritas, and Lloyd's Register have issued useful guidance, harmonization will be key to avoiding duplication and enabling scale-up.
3. **Integration with wider decarbonization policy** – Alignment of vessel certification with climate policy tools (EU ETS, fuel mandates) will ensure that regulatory incentives match safety and design requirements.

Overall, the successful deployment of hydrogen-powered ships will depend not only on technological progress but also on the ability of regulators, classification societies, and industry stakeholders to work together on pragmatic, risk-based, and forward-looking frameworks. If these challenges are addressed, hydrogen vessels can move from early adoption to becoming a mainstream solution in the decarbonization of short sea, inland, and eventually deep-sea shipping.