Interreg North-West Europe H2SHIPS

System-Based Solutions for H2-Fuelled Water Transport in North-West Europe

Final report & policy paper on upgraded regulatory framework for H2 propulsion & bunkering in North-West Europe

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List of Abbreviations

ADN Convention	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
ADR Convention	Agreement Concerning the International Carriage of Dangerous Goods by Road
BCN	Belgian Code of Navigation
Brzo 2015	Major Accidents Risks Decree 2015 (Besluit risico's zware ongevallen 2015
CCNR	Central Commission for the Navigation of the Rhine
CESNI	Committee for Drawing up Standards in the field of Inland Navigation
DGPR	General Directorate of Risk Prevention
ES-TRIN	Technical Requirements for Inland Navigation vessels
EU	European Union
EU ETS	EU Emission Trading Scheme
GHG	Greenhouse gas
HFC	Hydrogen Fuel Cells
IAPH	International Association of Ports and Harbors
IGF Code	International Code of Safety for Ships using Gases or other Low-Flashpoint Fuel
IMO	International Maritime Organisation
ISO	International Organization for Standardization
LNG	liquified natural gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MSC	Maritime Safety Committee of the International Maritime Organisation
MTE	Ministry of Ecological Transition
NWE	North West Europe
PGS	Hazardous Substances Publication Series (Publicatiereeks gevaarlijke stoffen)
SOLAS	International Convention for the Safety of Life at Sea
UN	United Nations
UNECE	United Nations Economic Commission for Europe

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1 Introduction

Considering the unprecedented effects across the climate system, there is an urgent need to limit human-induced greenhouse gas emissions (hereinafter GHG).[1] The shipping sector accounted for 1,076 million tonnes of GHG or 2.89% of the global anthropogenic GHG emissions in 2018.[2] For context, in the same year the total GHG emissions from Germany amounted to 886.1 million tonnes.[3] Thus, the pressure to decarbonize the sector, is increasing.

In the context of the European Union (hereinafter EU), the European Climate Law sets a binding target to achieve climate neutrality by 2050 and a commitment to cut emissions by at least 55% by 2030.[4] For the shipping sector, this is reflected in the Fit for 55 package, which includes proposals for the inclusion of the maritime sector in the EU Emission Trading System (hereinafter EU ETS),[5] and for a Fuel EU Maritime Regulation on the use of renewable and low-carbon fuels in maritime transport.[6]

Furthermore, the various regional and local governments, where members of the consortium are located have also made climate commitments. The City of Paris has set the objective of phasing out diesel mobility by 2024 and gasoline by 2030 for land vehicles, Antwerp committed to reducing its GHG emissions by at least 40% by 2030;[7] while the Flemish region, to which Oostende belongs, is aiming to reduce its GHG emissions from sectors not covered by the EU ETS by 85% by 2050 compared to 2005 (see section 4.1).

In light of these commitments, the need to change the motorization of both maritime and inland shipping, towards a sustainable solution is crucial. Hydrogen (H_2) represents an important tool for decarbonization, since it is a carbon-free carrier, which can be produced from low-carbon or renewable sources.[8] In this context, the H2Ships project intends to demonstrate the added value of hydrogen for water transport in the context of North-West Europe (hereinafter NWE). The partnership intends to lay the ground for the development of a dedicated H_2 value-chain. The consortium of partners includes 13 partners from 5 different countries with the aim to develop the use of hydrogen for the propulsion of vessels.

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[1] IPCC (2021), Climate Change 2021: The Physical Science Basis: Summary for Policymakers

[2] International Maritime Organization (2021), Fourth IMO GHG Study 2020: Executive Summary, 2021p. 1

[3] European Commission (2021), EU Energy in figures: Statistical Pocketbook 2021, Luxembourg: Publications Office of the European Union, p. 191

[4] Art. 2(1) and 4(1) of Regulation 2021/1119 of the European Parliament and of the Council ('European Climate Law')

[5] European Commission (2021), Proposal Directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757, COM(2021) 551 final

[6] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC, COM(2021) 562 final (Fuel EU Maritime Proposal).

[7] DNV (2018), DNV GL outlines Antwerp's 'low carbon 2030' roadmap, < https://www.dnv.com/news/dnv-gl-outlines-antwerp-s-low-carbon-2030-roadmap-130820 > (last accessed 10.03.2022)

[8] Ad van Wijk and Hydrogen Europe (2021), Hydrogen – a carbon-free energy carrier and commodity, p. 3

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This report is part of WP2 of the project: "Defining requirements for uptake of H_2 propulsion in water transport in NWE" and it intends to provide an understanding of the regulatory framework of Belgium, France and Netherlands. The focus is on questions related to hydrogen deployment in waterborne transportation such as certification of vessels, bunkering, bunkering infrastructure and others.

The report is structured in two main chapters. In the first chapter an analysis of the international and European norms is presented. The second chapter focuses on the national rules and regulations. The aim is to identify the applicable legal regime to hydrogen powered vessels, including hydrogen bunkering, hydrogen storage and production for maritime and inland water transport. The final part of this report are the conclusions and recommendations, where the main conclusions of the analysis carried out, are presented, and the main identified recommendations are summarized.

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2 Applicable rules on international and European levels

To begin understanding the regulatory framework applicable to hydrogen propulsion in waterborne transportation, this chapter will look at the international and European regulations and recommendations applicable to both the maritime and inland waterways sectors. In relation to the maritime sector, the regulatory framework originates mostly at the international level, through different types of legal instruments in the framework of the International Maritime Organization (hereinafter IMO). The European regulations and directives have a complementary role, to supplement and further elaborate on the international rules.

In the inland waterway transportation sector, the situation is very different. Despite ongoing harmonization efforts, the regulatory regime of the sector is complex,[9] with regulation originating from different entities at the various levels: international, European and national. The reason behind this is the historical evolution of the regulatory bodies. In essence, at the international level, the regulatory entities are the United Nations Economic Commission for Europe (hereinafter UNECE) and the international commissions, of which there are several for the major navigable rivers in Europe. Those with relevance for NWE are the Central Commission for the Navigation of the Rhine (hereinafter CCNR) and the Moselle Commission.[10] In relation to the EU, it has had a limited regulatory role in the inland waterway sector until the 1990's, but with the successive expansions from 15 to 27 Member States and the concurrent efforts to liberalize and decarbonize different sector the economy, the situation has changed.[11]

Before moving to the regulatory regimes, in order to understand the context in which they are developing, the analysis will begin with the relevant policies. Subsequently, it will move to the specific questions of vessel approval, bunkering and hydrogen storage.

It is important to note that due to the global decarbonization efforts and the burgeoning interest in hydrogen technologies, this is a very dynamic field of law. At the time of writing, there are multiple regulatory developments taking place, which although mentioned in the analysis, fall outside its scope. The reason for this is that they are subject to change until their final adoption and an evaluation of their impact would be void of much meaning until legislative bodies have settled on the final wording of the text.

[9] Biljana Činčurak Erceg (2019), Inland waterways transport in the European Union - flowing or still standing?, presented at the 6th International Scientific Conference: Social Changes In The Global World, Shtip, 05-06 September 2019, p. 129

[10] Central Commission for the Navigation of the Rhine (2022), CCNR Website, < https://www.ccr-zkr.org/> (last accessed on 11.03.2022) and Moselle Commission (2021), Moselle Commission's website, < https://www.moselkommission.org/ >, last accessed at (11.03.2022)

[11] Tilman Erich Platz and Kees Ruijgrok (2013), Inland Waterways in Matthias Finger and Torben Holvad (eds.) (2013) Regulating Transport in Europe, Edward Elgar

2.1 Policies

2.1.1 Maritime transport

For maritime shipping at the international level, the key actor is the IMO. The IMO is a specialized agency of the United Nations (hereinafter UN). Its purpose is to facilitate the cooperation among governments in the field of governmental regulation and practices relating to shipping in international trade and to encourage the adoption of the highest practical standards in maritime safety and efficiency of navigation.[12] The key instruments in international maritime law and policy are developed under its framework. A notable example is the International Convention for the Prevention of Pollution from Ships (hereinafter MARPOL), among other conventions, regulations, codes and guidelines for shipping.

Specifically for the topic of this report, one policy document stands out. This is the Initial Strategy on Reduction of GHG Emissions from Ships. The strategy defines the IMO level of ambition for GHG emissions reduction until 2050. This level is set at a reduction of total annual GHG emissions by at least 50%, when compared to 2008.[13]

Outside of maritime law, additional guidance for hydrogen deployment in shipping can come from the International Organization for Standardization (hereinafter ISO). Although technical standards are voluntary, they contribute significantly to the removal of trade barriers, market access and sustainability.[14] While at the moment, there are no specific standards for hydrogen vessels, there are several standards which can be relevant. Some have as their subject matter hydrogen use and applications in general, while others are related to different gases, but can serve as guidance for the shipping industry.

While the implementation of the IMO's Initial Strategy on Reduction of GHG Emissions from Ships has been rather slow,[15] the same cannot be said about the developments at the European level. The main policy developments at the European level begin with the European Green Deal, which sets the goal for a carbon neutral society by 2050.[16] The goal is made into a binding target through the already mentioned European Climate Law. The law sets a climate neutrality objective by 2050 and an intermediate target of 55% GHG emissions reduction by 2030, when compared to 1990 levels.[17]

The follow-up of the European Climate Law comes in the form of the Fit-for-55 package. The package represents a revision of the climate, energy and transport legislation at the EU level. More broadly, together with the abovementioned

[12] The Convention on the International Maritime Organization, Geneva, 6 March 1948

[13] International Maritime Organization (2018), Initial IMO Strategy on Reduction of GHG Emissions from Ships, Res. MEPC.304(72), 13 April 2018

[14] European Commission (2022), Benefits of standards, < https://ec.europa.eu/growth/single-market/european-standards/standardisation-policy/benefits-standards_en> (last accessed: 11/02/2022)

[15] Psaraftis, Harilaos N., and Christos A. Kontovas. 2021. "Decarbonization of Maritime Transport: Is There Light at the End of the Tunnel?" Sustainability 13, no. 1: 237

[16] European Commission (2019), The European Green Deal, COM(2021)640 final

[17] *Supra* note 4, European Climate Law.

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proposed revisions of the EU ETS and a new Fuel EU Maritime Regulation,[18] the package also includes a revision of the Effort Sharing Regulation;[19] a revision of the LULUCF Regulation;[20] a revision of the Renewable Energy Directive;[21] a revision of Energy Efficiency Directive;[22] proposal for a Regulation on Alternative Fuels Infrastructure;[23] amendment of the Regulation for CO_2 emissions of cars and vans;[24] revision of the Energy Taxation Directive;[25] proposal for a Regulation on Carbon Border Adjustment Mechanism and a proposal for a ReFuelEU Aviation Regulation.[26]

This extensive revision of EU legal acts serves to highlight the dynamic situation in which all economic sectors are, in light of the European decarbonization efforts. Specifically, for the context of hydrogen deployment in maritime transportation, several EU legal acts are of relevance:

- Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants;
- Directive 2014/94 on the deployment of alternative fuels infrastructure, and the European Commission delegated act:
    - Commission Delegated Regulation 2019/1745 as regards recharging points for L-category motor vehicles, shore-side electricity supply for inland waterway vessels, hydrogen supply for road transport and natural gas supply for road and waterborne transport;
- Directive 2014/68 on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment (recast);

[18] *Supra* note 4 European Climate law and note 6 Fuel EU Maritime Proposal.

[19] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, COM(2021) 555 final.

[20] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council amending Regulations (EU) 2018/841 as regards the scope, simplifying the compliance rules, setting out the targets of the Member States for 2030 and committing to the collective achievement of climate neutrality by 2035 in the land use, forestry and agriculture sector, and (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review, COM (2021) 554 final.

[21] European Commission (2021), Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, COM(2021) 557 final.

[22] European Commission (2021), Proposal for a Directive of the European Parliament and of the Council on energy efficiency (recast), COM(558) final/2

[23] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council, COM (2021) 559 final.

[24] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2019/631 as regards strengthening the CO2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union’s increased climate ambition, COM(2021)556 final.

[25] European Commission (2021), Proposal for a Council Directive restructuring the Union framework for the taxation of energy products and electricity (recast), COM(2021) 563 final.

[26] European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism, COM(2021) 564 final and European Commission (2021), Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport, COM(2021) 564 final.

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- Directive 2012/18 on the control of major-accident hazards involving dangerous substances (Seveso Directive);
- Directive 2014/34 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (ATEX Directive);
- Directive 2001/42 on the assessment of the effects of certain plans and programmes on the environment (SEA Directive);
- Directive 2011/92 on the assessment of the effects of certain public and private projects on the environment (EIA Directive);
- Regulation 2016/1628 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery;
- Directive 2016/1629 on laying down technical requirements for inland waterway vessels

The significance of these acts will be discussed in the appropriate sections below. As for the directives however, it is important to note that the specific obligations derived from them, are to be found in the national laws of member-states. The reason for this is that it is up to the member-states to choose the forms and methods on how to achieve the objectives set out in the directives in their national legal regimes, when transposing them.[27]

2.1.2 Inland navigation

Moving to the policies applicable to the inland waterways, as mentioned above, the sector is covered by policy documents at the three levels of governance. In order to better understand the impact of the commitments pertaining to inland navigation it is worthwhile to briefly highlight the complex governance regime applicable to the sector in Europe. A detailed overview of the regulatory regime can be found in the White paper Efficient and Sustainable Inland Water Transport in Europe.[28] While an historical evolution of the regulatory regime is described in Tilman Erich Platz and Kees Ruijgrok.[29] The White Paper on the Progress, Accomplishments and Future of Sustainable Inland Water Transport describes the developments that have taken place in the 2011-2020 period.[30]

The governance structures for European inland navigation are complex and multi-layered. They include a variety of intergovernmental institutions and bodies such as the EU, UNECE, river-specific navigation commissions and pan-European ministerial conferences. Starting with the UNECE, it addresses inland navigation through its Inland Transport Committee, which is the highest UNECE policy-making body in the sector, providing an intergovernmental forum for cooperation and

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[27] Bradley Kieran (2020), Legislating in the European Union *in* Barnard, Catherin and Steeve Peers (2020), European Union Law, Oxford University Press, p. 104.

[28] UNECE (2011), White paper on Efficient and Sustainable Inland Water Transport in Europe, < https://unece.org/fileadmin/DAM/trans/main/sc3/publications/WhitePaper_Inland_Water_Transport_2011e.pdf > (last accessed 11.03.2022), pp. 37-39.

[29] *Supra* note 11, Platz and Ruijgrok

[30] UNECE (2020), White Paper on the Progress, Accomplishments and Future of Sustainable Inland Water Transport, < https://unece.org/DAM/trans/main/sc3/publications/IWW_WhitePaper_ECE_TRANS_279.pdf > (last accessed 11.03.2022).

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adoption of legal instruments regulating the sector.[31] It addresses the latter both at the technical and policy levels and maintains several international conventions such as the European Agreement on Main Inland Waterways of International Importance, the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (hereinafter ADN Convention) and several technical and safety standards.

At the same level, but with a limited membership are the international commissions. The CCNR is an international organisation with Belgium, France, Germany, Netherlands and Switzerland as members. Its aim is to promote the development of navigation on the Rhine and to guarantee a high level of safety for navigation and environment. The decisions of the CCNR are legally binding for its Member States. The Mosel Commission is another international organisation with France, Germany and Luxembourg as members and it regulates navigation on Mosel River. Its decisions are also binding on its Member States.

As for the EU, it is a *sui generis* organization and its legislative acts in the form of regulations, directives and decisions are also binding on its 27 Member States or addressees. Over the years, the EU legislative action aimed at the inland waterway sector has been increasing.[32]

Some efforts to simplify the regime are being undertaken, such as the establishment of the European Committee for Drawing up Standards in the field of Inland Navigation (hereinafter CESNI), in cooperation between the EU and the CCNR, however the regulatory framework is still fragmented.

Having this in mind, it is possible to move to the different policy goals. Starting with the UNECE, in its white paper from 2020, it identifies as one of the main challenges facing the sector, the need to modernize and green the European inland waterway fleet, since most of the vessels operating in Europe were built more than 30 years ago and still use their original propulsion systems. However, it notes the low investment readiness in the sector, which is composed mostly from small and medium-sized enterprises and which were significantly affected by the COVID-19 crisis.[33]

Despite this, alternative propulsion systems such as hydrogen are being discussed as possible ways to green the fleet. In this context, the abovementioned paper proposes six actions at the UNECE level to tackle the problem, under Policy Recommendation No. 4: Encouraging the modernization and greening of the fleet and infrastructure to better tackle environmental challenges. Four of these actions are directly related to the topic of this report. Firstly, support for programmes and pilot projects aimed at modernizing and greening the fleet with low- and zero-emission propulsion systems. Secondly, support for research in environmental performance, including research on measures to reduce emissions by inland vessels and on alternative fuels for inland vessels. Thirdly, support the Mannheim declaration objectives (signed under the framework of the CCNR), which sets the

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[31] UNECE (2022), ITC 75th Anniversary 2022, < https://itc-75th-anniversary.unece.org/ > (last accessed 05/04/2022)

[32] *Supra* note 28, UNECE 2011, pp. 37-39.

[33] European Commissions (2021), NAIADES III: Boosting future-proof European inland waterway transport, COM(2021) 324 final, < https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:324:FIN >

initiative to reduce GHG emissions and pollutant emissions by 35% compared with 2015 by 2035, and to largely eliminate greenhouse gases and other pollutants by 2050.[34] Lastly, promote the role of water transport using alternative fuels in urban environments and support the development of clean and sustainable, enhanced or alternative propulsions systems for inland navigation vessels.[35] Furthermore, the issue has become a regular topic in the agenda of the UNECE Working Party on Inland Water Transport (SC.3).[36]

At the European level, the decarbonization commitments explained in the previous section apply to the inland waterways transportation sector, as well. However, two additional documents address the sector specifically: the Sustainable and Smart Mobility Strategy and the NAIADES III Action Plan.

Starting with the Sustainable and Smart Mobility Strategy, published by the European Commission on 9th December 2020, it has as main message the ambition of making mobility 'more sustainable, smarter and more resilient' by 2030. For inland waterway transport, it sets the ambition to have zero-emission vessels ready for market by 2030. Under Flagship 4 – Greening Freight Transport, the strategy calls for the shift of road freight transport to rail and inland waterways and it will propose the NAIADES III programme to explore the untapped potential for inland waterways transport in a sustainable way. Moreover, it foresees inland ports as new clean energy hubs. Additionally, the EC will work to internalize the environmental costs. Furthermore, it considers that investment must finance the modernisation of all fleets in all modes to ensure the deployment of zero- and low-emission technologies.[37]

Moving to the Commission's communication "Boosting future-proof European inland waterway transport" (hereinafter NAIADES III), its goal is to present the Inland Waterway Transport Action Plan for 2021-2027 in order to detail the actions to be taken to achieve the EU Green Deal target of shift of 75% of inland road freight transport to inland waterways and rail. For the purposes of this report section 2.2 on Transitioning to zero-emissions inland waterway transport, envisages that the sector embarks towards zero GHG emissions by 2050. The section is separated in two parts which set out the initiatives of the Commission in relation to a zero-emission fleet and for greening inland waterway infrastructure and ports.

To stimulate the move towards alternative fuels in vessels the action plan envisages a series of actions, the most important of which include: research and development under the Zero Emission Waterborne Partnership;[38] full

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[34] Congress of CCNR (2018), Mannheim Declaration: "150 years of the Mannheim Act – the driving force behind dynamic Rhine and inland navigation", < https://www.ccr-zkr.org/files/documents/dmannheim/Mannheimer_Erklaerung_en.pdf > (last accessed 11.03.2022).

[35] *Supra* note 27, pp. 39, 63-64

[36] Economic Commission for Europe Inland Transport Committee Working Party on Inland Water Transport (2021), Introducing the circular economy principles in inland water transport, ECE/TRANS/SC.3/2021/8, < https://unece.org/sites/default/files/2021-12/ECE-TRANS-SC.3-2021-08e.pdf > (last accessed 11.03.2022)

[37] European Commission (2020), Sustainable and Smart Mobility Strategy – putting European transport on track for the future, COM(2020)789 final, pp. 6, 10-12

[38] WATERBORNE (2022), Zero Emission Waterborne Transport, < https://www.waterborne.eu/partnership/partnership > (last accessed 11.03.2022)

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implementation of the abovementioned Regulation 2016/1628; facilitation of certification procedures for innovative and low-emission vessels when reviewing Directive 2016/1629 on technical requirements for inland waterway vessels; facilitation of access to financial instruments under regional, national and European funding mechanisms, especially for alternative fuels technologies; encouragement of uptake of renewable low-carbon fuels under the revisions of the Energy Taxation Directive and lastly, under the revisions of the State aid guidelines, enlargement of their scope to include the inland waterways transport sector.

As to the greening of infrastructure and ports, the EC proposes the adoption of technical guidelines, so that climate and environmental objectives are included when investments are made in transport infrastructure, and to develop inland ports as multimodal alternative fuels infrastructure hubs under the review of Directive 2014/94 and Regulation 1315/2013 - TEN-T Regulation.

To achieve these and the other measures in the action plan, the Commission envisages financing for the sector under the Connecting Europe Facility, Recovery and Resilience Facility, InvestEU, Innovation Fund, LIFE programme, Horizon Europe, while public and private efforts are to be facilitated, through different mechanisms, among which the EU taxonomy.

Lastly, the communication also calls for the simplification of the above-described governance regime, with the Commission's intent to work closely with the different institutions to further harmonize rules, standards, and policies to reduce the administrative burden.[39]

Having identified the policy-setting and some of the relevant legal acts, it is possible to move to the analysis of the applicable legal norms in the rest of the chapter. After the analysis relating to vessel approval, bunkering and storage, a brief conclusion of the chapter will be presented, before moving to the analysis of national law.

[39] *Supra* note 33, NAIADES III

2.2Regulations

Moving to the regulations, the same structure of the previous section, will be followed, by firstly looking at the maritime sector and subsequently, moving to the inland waterway transportation sector.

Before starting, with the analysis proper, a brief explanation is necessary. In general regulations and codes are imposed by legislative bodies and are mandatory. They can be distinguished from standards, recommendations, guidelines and codes of practice which are voluntary, unless the regulations or codes mandate their application. Furthermore, in addition to the rules at the international level there might be additional rules and regulations that are mandatory, depending on how the international agreements are implemented in national law. Examples of these are class rules.[40]

2.2.1 Ship Approval

2.2.1.1 International regulations

Starting with approval of ships or class of ships using hydrogen propulsion systems, at the international level the issue is regulated within the IMO framework.

Within this framework, the most important convention in relation to safety of vessels at sea is the International Convention for the Safety of Life at Sea (hereinafter SOLAS). The convention sets minimum safety standards for the construction, equipment and operation of ships. Once a state becomes a party to the convention, it is enforced by the national agencies and authorized recognized organizations (e.g. classification societies). It does not apply to war ships, cargo ships of less than 500 gross tonnage, ships not propelled by mechanical means, wooden ships, pleasure yachts not engaged in trade and fishing vessels.[41] Considering, that it has 167 contracting states, the convention covers approximately 99.89% of the gross tonnage of the world's merchant fleet. With the current version of SOLAS, which was adopted in 1974, the IMO has followed a path of continuous development and improvement, to enable the regulatory regime to follow the technological developments, thereby mitigating existing or new risks. This continuous development has resulted in 181 amendments of the Convention.[42] The Maritime Safety Committee (hereinafter MSC), which deals with all matters related to maritime safety and security within the IMO, has implemented a four-year cycle for the entry into force of amendments and revisions of SOLAS, in line with the proactive approach to regulation making.[43]

The convention does not operate in vacuum, but in combination with Codes, which prescribe rules to mitigate risks identified in the Convention, while keeping the text

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[40] DNV (2021), Handbook for Hydrogen-Fuelled Vessels, p. 31

[41] Henryk Pepliński, Application of maritime legislation, guidance and standards on automation systems, in Henryk Pepliński, Ship and Mobile Offshore Unit Automation, Gulf Professional Publishing, 2019, Pages 45-47

[42] IMO (2022), Status of Treaties: Comprehensive information on the status of multilateral Conventions and instruments in respect of which the International Maritime Organization or its Secretary-General performs depositary or other functions, < https://wwwcdn.imo.org/localresources/en/About/Conventions/StatusOfConventions/Status%20-%202022.pdf >

[43] D. Guevara and D. Dalaklis (2021), Understanding the Interrelation between the Safety of Life at Sea Convention and Certain IMO's Codes, TransNav - The International Journal on Marine Navigation and Safety of Sea Transportation, vol 15 (2), p. 382-383

of the latter, generic and compact (allowing for wider acceptance and adoption).[44] The most relevant code for hydrogen propulsion is the International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels (hereinafter IGF Code).

The code is applicable by virtue of Regulations 56-57 SOLAS. The regulations state that any ship covered by the SOLAS Convention, that uses low-flashpoint fuels, that is ordered or which has its keel laid on or after 1st January 2017 or any ship which is converted to such fuels after 1st January 2021 must comply with the IGF Code.[45] In this context by low-flashpoint it is meant any gaseous or liquid fuel having a flashpoint lower than 60ºC.[46] Consequently, since hydrogen's flashpoint is -253ºC, the IGF Code is applicable to cargo ships with a gross tonnage of 500 or more, and passenger ships on international voyages.[47]

As it stands in its current version from 2016, the code contains detailed prescriptive requirements only for ships using liquified natural gas (hereinafter LNG) as fuel. For other types of low-flashpoint fuels, the Code refers back to the SOLAS Convention. The approval of vessels using such fuels is to be made under the Alternative Design process.[48] In essence, this means that fuels other than LNG can be used, as long as it is proven that the level of safety is maintained in comparison with a ship running on conventional fuel. It is important to note that national implementations of the code can vary, thus the Flag State and its national regulations and the relevant certification and classification societies, are fundamental for consideration when starting the process.[49]

The Alternative Design assessment process is set out in SOLAS Chapter II, Part F, Regulations 55, 56, 57. Of those, Regulation 55 prescribes the use of the Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO

[44] Anish Joseph and Dimitrios Dalaklis (2021) The international convention for the safety of life at sea: highlighting interrelations of measures towards effective risk mitigation, Journal of International Maritime Safety, Environmental Affairs, and Shipping, 5:1, p. 3

[45] International Maritime Organization (1974), International Convention for the Safety of Life at Sea, 1184 UNTS 3, Chapter I, Part G, Regulations 56 and 57

[46] *Id.* Chapter II-2, Part B, Regulation 4.2.1.1

[47] *Supra* note 40, DNV, p.32

[48] International Maritime Organization (2015), International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels, Resolution MSC.391(95), Art. A.2.3

[49] *Supra* note 40, DNV, p. 32

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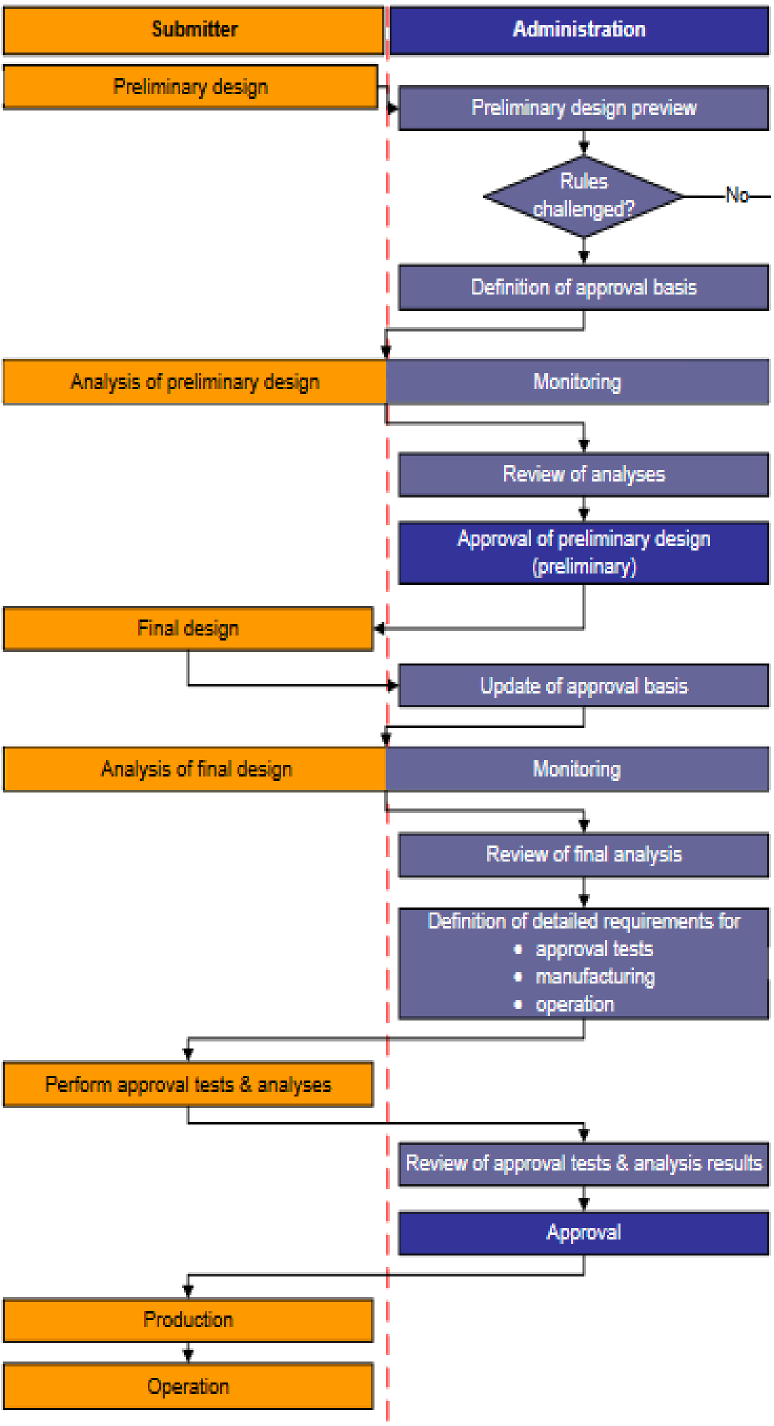

Figure 1 - Design and Approval Process Source: International Maritime Organization (2013), Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments, MSC.1/Circ.1455, p. 7

Instruments,[50] which prescribe the proper procedure for approval. The approval itself is based on a risk-assessment approach, instead of the traditional prescriptive and regulations-based approach. The goal of this approach is to demonstrate that the vessel, or class of vessels using hydrogen propulsion, has an equivalent level of safety compared to a conventional ship.[51]

Formally, the process has two phases with 14 steps. The first phase is preliminary design, in which the goals are to develop a preliminary design and obtain its approval. The second phase is development of a final design, and the goals are to complete the development of a final design, its testing and analysis, and obtain its approval.

The phases are set out in arts. 4.4 to 4.18 of the Guidelines.[52] These articles describe in detail the steps through which the process must go and what is to be expected from the national authority at each stage. The entire process includes comprehensive technical, risk and environmental assessments with significant stakeholder involvement. Furthermore, the process might include additional prescriptive requirements stemming from national regulations, as is the case for example for hydrogen ships in

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[50] International Maritime Organization (2013), Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments, MSC.1/Circ.1455.

[51] *Supra* note 40, DNV, p.33.

[52] *Supra* note 50, Guidelines for Approval of Alternatives, arts. 4.4-4.18.

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Norway and Canada. Detailed steps of how the process occurs will depend on the national administration rules, but the DNV Handbook for Hydrogen-Fuelled Vessels, provides an overview of the process.

Overall, what can be said about the process is that it is not a compliance-based approach, but one modified for the entry of new technologies in the sector. Whilst it is comprehensive, it is also a process with a high degree of uncertainty. For example, despite obtaining approval for a preliminary design, it is not guaranteed that a final approval will be given. Moreover, some steps of the process may need to be repeated to comply with the requirements and comments made by the national administration. In general terms, this increased thoroughness equates to increased costs.[53]

In September 2021 the IMO's Sub-Committee on Carriage of Cargoes and Containers, in its 7th Session, agreed on Draft Interim guidelines for ships using fuel cells. The guidelines cover issues related to fire safety and gas/vapour detection, attempting to ensure the safe and reliable operation of fuel cells in ships, while more experience on the operation of fuel cells is gathered before the regulations become part of the IGF Code. The regulations are expected to be approved in the 105th session of the Maritime Safety Committee of the IMO, scheduled for 20-29th April 2022. It is further expected that the final fuel cells requirements will enter into force under Chapter E of the IGF Code in 2028. While the Sub-Committee has agreed to initiate the development of guidelines for the safety of ships using hydrogen as a fuel, the interim guidelines above, do not apply to hydrogen storage as a fuel.[54]

A level of simplification of this process can come in the form of Class rules developed by Classification societies. Usually, they are more detailed to reflect the safety level of international regulations. Examples of class rules for fuel cells are the ones developed by Bureau Veritas,[55] DNV,[56] and the American Bureau of Shipping.[57] These rules can simplify the Alternative Design process, if they are accepted by the national administration from which approval is required. It is important to note that the approval of a class society is not the same as an approval from a Flag State Administration. It is possible for a class society to act as a Recognized Organization, if agreed as such by the Flag State agreements, in which it is regulated what exactly is delegated. However, some Flag States do not

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[53] *Supra* note 40, DNV, p. 32-34

[54] *Id.* p. 31 and IMO (2021), Sub-Committee on Carriage of Cargoes and Containers, 7th session (CCC 7), 6-10 September 2021, < https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/CCC-7th-session.aspx > (last accessed 30/03/2022)

[55] Bureau Veritas (2022), Ships using Fuel Cells, < https://erules.veristar.com/dy/data/bv/pdf/547-NR_2022-01.pdf > (last accessed 30/03/2022).

[56] DNV (2021), Rules for Classification – Part 6 Additional class notations, Chapter 2 – Propulsion, power generation and auxiliary systems, < https://rules.dnv.com/docs/pdf/DNV/RU-SHIP/2021-07/DNV-RU-SHIP-Pt6Ch2.pdf > (last accessed 30/03/2022).

[57] American Bureau of Shipping (2019), Guide for Fuel Cell Power Systems for marine and Offshore Applications, < https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/other/312_guidefuelcellpowersystemsmarineoffshoreapplications/fuel-cell-nov-2019.pdf > (last accessed 30/03/2022).

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delegate. In the EU context, only Class Societies members of the International Association of Classification Societies can act as Recognized Organizations.[58]

An additional possible simplification in this process can come from technical standards. As hydrogen use is developing, so are standards which serve to increase the acceptance, safety and to facilitate trade. The standards identified below were not developed for the maritime industry, thus until the development of such, these standards can serve as guidelines. Most of them were developed in relation to hydrogen use in land transport, but despite higher technological maturity, this field is still rapidly evolving.

The standardization work at the international level comes from Technical Committee 197 in the International Organization for Standardization. This committee is responsible for standardization in relation to systems and devices for the production, storage, transportation, measurement and use of hydrogen. Below are presented some of the relevant standards, as identified by the Handbook for Hydrogen-Fuelled Vessels:[59]

ISO Standards with relevance for H_2 systems in shipping		
Standard	Title	Description
ISO/TR 15916:2015	Basic considerations for the safety of hydrogen systems	Guidelines for the use and storage of H_2 in its gaseous and liquid forms. It identifies safety issues, hazards and risks.[60]
ISO 16111:2018	Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride	Requirements applicable to the material, design, construction and testing of transportable hydrogen storage systems[61]
ISO 19880-1:2020	Gaseous hydrogen — Fuelling stations — Part 1: General requirements	Minimum design, installation, commissioning, operation, inspection & maintenance requirements for the safety & operation of HRS for light-duty road vehicles[62]
ISO/TC 220	Cryogenic vessels	Design and safety of insulated vessels for storage and

[58] *Supra* note 40, DNV, p.38

[59] International Organization for Standardization (2022), ISO/TC 197, < https://www.iso.org/committee/54560.html > (last accessed: 14/02/2022)

[60] International Organization for Standardization (2015), ISO/TR 15916:2015 Basic considerations for the safety of hydrogen systems, < https://www.iso.org/standard/56546.html > (last accessed: 14/02/2022)

[61] International Organization for Standardization (2018), ISO 16111:2018 Transportable gas storage devices — Hydrogen absorbed in reversible metal hydride, < https://www.iso.org/standard/67952.html > (last accessed: 14/02/2022)

[62] International Organization for Standardization (2020), ISO 19880-1:2020 Gaseous hydrogen — Fuelling stations — Part 1: General requirements < https://www.iso.org/standard/71940.html > (last accessed: 14/02/2022)

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		transportation of refrigerated liquefied gases[63]
ISO 26142:2010	Hydrogen detection apparatus — Stationary applications	Performance requirements and test methods of hydrogen detection apparatus[64]
ISO 15649:2001	Petroleum and natural gas industries — Piping	Requirements for design of piping within facilities and for packaged equipment[65]
ISO 19882:2018	Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers	Minimum requirements for pressure relief devices intended for use on hydrogen fuelled vehicle containers[66]
ISO 14687:2019	Hydrogen fuel quality — Product specification	Minimum quality characteristics of hydrogen fuel as distributed for utilization in vehicular and stationary applications[67]

Table 1 - List of ISO standards with relevance for hydrogen use in shipping

2.2.1.2 Inland navigation (Europe)

Starting with the UNECE rules on vessel approval, it has published Recommendations on Harmonized Europe-wide Technical Requirements for Inland Navigation Vessels.[68] The aim of these recommendations is to establish a pan-European regime of technical requirements for inland navigation vessels, thereby unifying divergent regulations in different intergovernmental organizations and members of UNECE. Furthermore, they aim to simplify the mutual recognition of certificates and limit air, water and noise pollution.[69] In relation to hydrogen however, Chapter 8 of the Recommendations on engine design, provides that the liquid fuel for the main or auxiliary machinery shall have a flashpoint above 55ºC, with some exceptions to be determined by the national authorities, such as lifeboat engines.[70]

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[63] International Organization for Standardization (1999), ISO/TC 220 Cryogenic vessels < https://www.iso.org/committee/54990.html > (last accessed: 14/02/2022)

[64] International Organization for Standardization (2021), ISO 26142:2010 Hydrogen detection apparatus — Stationary applications < https://www.iso.org/standard/52319.html > (last accessed: 14/02/2022)

[65] International Organization for Standardization (2018), ISO 15649:2001 Petroleum and natural gas industries — Piping < https://www.iso.org/standard/28195.html > (last accessed: 14/02/2022)

[66] International Organization for Standardization (2018), ISO 19882:2018 Gaseous hydrogen — Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers < https://www.iso.org/standard/64655.html > (last accessed: 14/02/2022)

[67] International Organization for Standardization (2019), Hydrogen fuel quality — Product specification < https://www.iso.org/standard/69539.html > (last accessed 12/04/2022)

[68] UNECE (2020), Recommendations on Harmonized Europe-wide Technical Requirements for Inland Navigation Vessels, Resolution No. 61, Revision 2.

[69] *Ibid.*

[70] *Id.* art. 8-1.1.2.

Moving to the level of the river-specific commissions, the issue of vessel approval is settled through the cooperation between the EU and CCNR, under the framework of the CESNI. The functions of the Committee are to adopt technical standards, work on uniform application of those standards and the following derogations and equivalences for specific crafts, as well as other priority topics regarding the safety of navigation, protection of the environment and other areas related to inland navigation.[71]

Under the framework of CESNI, the main standard developed is the European Standard laying down Technical Requirements for Inland Navigation vessels (hereinafter ES-TRIN). The standard is applicable in EU member-states by virtue of Directive (EU) 2016/1629 laying down technical requirements for inland waterway vessels.[72] In a similar, yet different way from the UNECE recommendation, the standard only allows the use of internal combustion engines, burning fuels with a flashpoint of more than 55ºC, under art. 8.01(3). However, an exception for LNG is open by virtue of Chapter 30 (Special provisions applicable to craft equipped with propulsion or auxiliary systems operating on fuels with a flashpoint equal to or lower than 55°C) in combination with Annex 8 (Supplementary provisions applicable to craft operating on fuels with a flashpoint equal to or lower than 55°C). As it stands at the time of writing, the annex is comprised of only one, that is concerns LNG.[73] Clearly however, the structure of the standard allows for the easier inclusion of additional technologies in the future. Furthermore, the development of the standard for the inclusion fuel cells is taking place under the CESNI/PT/FC - Temporary working group on technical requirements for fuel cells aboard inland navigation vessels. Additionally, as part of 2022-2024 work programme of the Committee, the drafting of requirements for the use of alternative fuels in inland navigation vessels is envisaged. The priority is firstly on storage of methanol, then on hydrogen storage (liquid or gaseous).[74]

Thus, while the development of the standard to include alternative propulsion systems is ongoing, the introduction of hydrogen as fuel in inland maritime vessels is generally prohibited. The directive allows the possibility to apply for individual exemptions. This process is similar to the alternative assessment process for maritime vessels.[75] This is done on the basis of art. 25 of Directive 2016/1629, and such a derogation was granted to two ships - Innogy and Alsterwasser, upon a request by the German authorities.[76]

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[71] CESNI (2022), About CESNI, < https://www.cesni.eu/en/about-cesni/ > (last accessed 12/04/2022)

[72] Directive (EU) 2016/1629 of the European Parliament and of the Council of 14 September 2016 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC, < https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02016L1629-20220101 >

[73] CESNI (2021), European Standard laying down Technical Requirements for Inland Navigation Vessels (ES-TRIN), Edition 2021/1, < https://www.cesni.eu/wp-content/uploads/2020/10/ES_TRIN_2021_en.pdf >

[74] CESNI (2021), CESNI work programme 2022-2024 < https://www.cesni.eu/wp-content/uploads/2021/12/CESNI_work_prog_22_24_EN.pdf >

[75] IEA's Hydrogen TCP Task 39(2021), Hydrogen in Maritime, < https://www.ieahydrogen.org/wp-admin/admin-ajax.php?juwpfisadmin=false&action=wpfd&task=file.download&wpfd_category_id=17&wpfd_file_id=3991&token=abad9fa9a0f0a9c00152edff03825bf4&preview=1 > (last accessed 13/04/2022), p. 63

[76] European Commission (2020), Commission Implementing Decision (EU) 2020/980 of 6 July 2020 authorising Germany to derogate from technical requirements of Annexes II and V to Directive (EU) 2016/1629 of the European Parliament and of the Council for passenger vessels Innogy and Alsterwasser (notified under document C(2020) 4435), < https://eur-

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2.2.2 Bunkering

Moving to the regulatory aspects of bunkering, the situation is similar to the process of vessel approval. Concrete regulations, requirements and technical guidelines for bunkering of hydrogen are lacking. This is true for hydrogen bunkering for inland navigation vessels, use of swappable containers, as well as for bunkering standards, procedures and checklists.[77]

Once again, the IGF Code is applicable and provides technical and functional requirements on equipment for bunkering. The focus is mostly on the receiving vessel and the preparation for safe bunkering. Issues such as the entire process from start to finish, connections and shore-side bunkering are not covered by the Code. Additionally, as already mentioned the Code is focused on LNG.[78] Thus, the alternative design approach would need to be used to approve hydrogen bunkering processes.[79]

In this situation, issues not covered by the international regime are to be covered by national regulations. Specifically, port regulations and health, safety and environmental regulations will apply. National legislation in those fields has extensive provisions on hazardous, flammable, explosive materials such as hydrogen. At the present moment, and similarly to vessel approval, further technological developments, knowledge and testing are required for hydrogen bunkering so that the appropriate procedures and regulatory frameworks can be developed.[80]

It is important to note however, that these developments are taking place. The International Association of Ports and Harbors (hereinafter IAPH) has established an IAPH Clean Marine Fuels Working Group.[81] The WG is working with a wide variety of stakeholders, on adapting the existing tools for port authorities, operators and companies, so that they include hydrogen.[82]

Until these developments take place, national regulations applicable to flammable gases or risk-based assessments will have to be used to define safe distances and procedures for H_2 bunkering.

As already established, guidance can be found in technical standards and regulations from other sectors.[83] Examples of such, are the following:

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lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020D0980&qid=1649938512184&from=EN > (last accessed 14/04/2022)

[77] RH2INE (2021), RH2INE Kickstart Study: Regulatory & Safety Analysis, < https://www.rh2ine.eu/wp-content/uploads/2021/10/RH2INE-Kickstart-Study-Regulatory-and-Safety-Analysis-Regulatory-and-Standards-Gap-Assessment.pdf > (last accessed 14/04/2022)

[78] *Supra* note 40, DNV, p. 52.

[79] DNV GL (2017), Study on the Use of Fuel Cells in Shipping, < https://www.emsa.europa.eu/newsroom/latest-news/download/4545/2921/23.html > (last accessed 14/04/2022)

[80] *Ibid.*

[81] International Association of Ports and Harbors (2021), IAPH Clean Marine Fuels WG, < https://www.iaphworldports.org/clean-marine-fuel-cmf/ > (last accessed: 23/02/2022)

[82] World Ports Sustainability Program (2022), Hydrogen as fuel, < https://sustainableworldports.org/clean-marine-fuels/hydrogen-as-a-fuel/ > (last accessed: 23/02/2022)

[83] *Supra* note 40, DNV, p. 52-53

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ISO Standards with relevance for H_2 bunkering		
Standard	**Title**	**Description**
ISO 17268:2020	Gaseous hydrogen land vehicle refuelling connection devices	Defines the design, safety and operation characteristics of gaseous land vehicle refuelling connectors[84]
ISO 4126-1:2013	Safety devices for protection against excessive pressure - Part 1: Safety valves	General requirements for safety valves irrespective of the fluid[85]
ISO/TS 18683:2015	Guidelines for systems and installations for supply of LNG as fuel to ships	Guidance on minimum requirements for the design and operation of LNG bunkering facility[86]
ISO 20519:2017	Ships and marine technology — Specification for bunkering of liquefied natural gas fuelled vessels	Requirements for LNG bunkering transfer systems and equipment[87]
ISO 13984:1999	Liquid hydrogen — Land vehicle fuelling system interface	Characteristics of liquid hydrogen refuelling and dispensing systems on land[88]
ISO 13985:2006	Liquid hydrogen — Land vehicle fuel tanks	Specifies the construction requirements for refillable fuel tanks for liquid H_2 in land vehicles[89]
ISO 21012:2006	Cryogenic vessels — Hoses	Design, construction, type and production testing and marking

[84] International Organization for Standardization (2020), ISO 17268:2020 Gaseous hydrogen land vehicle refuelling connection devices, < https://www.iso.org/standard/68442.html > (last accessed: 15/02/2022)

[85] International Organization for Standardization (2019), ISO 4126-1:2013 Safety devices for protection against excessive pressure — Part 1: Safety valves, < https://www.iso.org/standard/50826.html > (last accessed: 15/02/2022)

[86] International Organization for Standardization (2015), ISO/TS 18683:2015 Guidelines for systems and installations for supply of LNG as fuel to ships, < https://www.iso.org/standard/63190.html > (last accessed: 15/02/2022)

[87] International Organization for Standardization (2017), ISO 20519:2017 Ships and marine technology — Specification for bunkering of liquefied natural gas fuelled vessels, < https://www.iso.org/standard/68227.html > (last accessed: 15/02/2022)

[88] International Organization for Standardization (2021), ISO 13984:1999 Liquid hydrogen — Land vehicle fuelling system interface, < https://www.iso.org/standard/23570.html > (last accessed: 15/02/2022)

[89] International Organization for Standardization (2021), ISO 13985:2006 Liquid hydrogen — Land vehicle fuel tanks, < https://www.iso.org/standard/39892.html > (last accessed: 15/02/2022)

		requirements for non-insulated cryogenic flexible hoses[90]

Table 2 - List of ISO standards with relevance for hydrogen bunkering

At the European level, Directive 2014/94 on the deployment of alternative fuels infrastructure provides standards to be used in public hydrogen refuelling stations and those can serve as guidance for maritime applications. These standards were defined under the framework of the European Committee for Standardization and are listed in table 3. A possible development will come from the CEN/TC 268/WG 5 – Technical committee on Cryogenic vessels and specific hydrogen technologies applications, working group on specific hydrogen technology applications, which is considering the development of European standards for refuelling points and bunkering of gaseous/liquified hydrogen, methanol and ammonia for maritime and inland vessels.[91]

Standard	Title	Description
EN 17127:2018	Outdoor hydrogen refuelling points dispensing gaseous hydrogen and incorporating filling protocols	Minimum requirements for interoperability of public hydrogen refuelling points[92]
EN 17124:2022	Hydrogen fuel - Product specification and quality assurance for hydrogen refuelling points dispensing gaseous hydrogen - Proton exchange membrane (PEM) fuel cell applications for vehicles	Specifies quality characteristics of H_2 fuel at hydrogen refuelling stations for use in proton exchange membrane[93]

Table 3 - List of EN standards with relevance for hydrogen bunkering

2.2.3 Storage

In relation to hydrogen storage at a port location, different set of rules might apply depending on the hydrogen project. The applicable legislation can stem from energy law, land use regulations, and health and safety regulations. In general, the common rules applicable to hydrogen storage and refuelling would be applicable to storage for bunkering. Most of these are to be found in national or regional legislation, yet some common obligations stem from the transposition of EU directives in national law. Thus, while the general principles might be the same, significant differences in interpretation and implementation can exist across member-states.[94]

[90] International Organization for Standardization (2006), ISO 21012:2006 Cryogenic vessels — Hoses, < https://www.iso.org/standard/34376.html > (last accessed: 15/02/2022)

[91] *Supra* note 77, RH2INE

[92] Bulgarian Institute for Standardization (2018), Outdoor hydrogen refuelling points dispensing gaseous hydrogen and incorporating filling protocols, < https://bds-bg.org/en/project/show/cen:proj:60892 > (last accessed: 15/02/2022)

[93] Bulgarian Institute for Standardization (2022), Hydrogen fuel - Product specification and quality assurance for hydrogen refuelling points dispensing gaseous hydrogen - Proton exchange membrane (PEM) fuel cell applications for vehicles < https://bds-bg.org/en/project/show/bds:proj:109478 > (last accessed: 15/02/2022)

[94] Alexandru Floristean (2019) HyLaw: Production, Storage, and Hydrogen Refuelling Stations, Deliverable 4.3 – Horizontal Position Paper

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In relation to energy law, the provisions of EU energy law and their transposition in national law might be applicable depending on the activities which are part of the hydrogen port project (production, distribution, storage, end-use), the purposes of the storage, the source of hydrogen and the connections with other energy infrastructure (gas or electricity distribution or transmission systems). While the issue is not settled in current EU energy legislation,[95] this might change with the adoption of the Hydrogen and Decarbonised Gas Market package.

It is important to note that depending on how hydrogen storage is defined under national law, different conditions will apply in terms of land-use regulations. In any case hydrogen storage units, can be installed only in places where this is allowed under the applicable land use plans.[96]

At the European level, some of the more relevant legal acts include Directive 2012/18 on the control of major-accident hazards involving dangerous substances (Seveso Directive). This directive prescribes risk assessments for storage facilities that intend to store more than 5 tons of H_2 and additional requirements for facilities storing more than 50 tons. In their transposition of the directive, EU member-states can impose stricter requirements than the ones prescribed by the directive.

Another set of requirements includes the health and safety requirements and conformity assessment procedures under Directive 2014/34 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (ATEX Directive). The obligations for hydrogen storage facilities from this directive, result due to the nature of hydrogen as flammable gas since the directive applies to areas where potentially explosive atmospheres can take place.

Lastly, under Directive 2001/42 on the assessment of the effects of certain plans and programmes on the environment (SEA Directive) and Directive 2014/52 on the assessment of the effects of certain public and private projects on the environment (EIA Directive), member-states may decide or not, to impose obligations on hydrogen storage projects.[97]

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[95] Ruven Fleming (2021), Clean or renewable – hydrogen and power-to-gas in EU energy law, Journal of Energy & Natural Resources Law, 39:1, 43-63

[96] *Ibid.*

[97] *Ibid.*

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2.3Conclusions and Recommendations

The process of decarbonisation of the maritime and the inland water transport sectors is already taking place. Thus, in the coming years hydrogen propulsion will have an increasing impact in both sectors. Yet, as this analysis has shown there are several issues that can serve as an obstacle for hydrogen propulsion.

At the policy level, in the context of the IMO, the ambition level targeted seems rather mismatched, when compared to the urgency of climate change.[98] Having this in mind, a first recommendation for parties involved in the process (governments, authorities, shipowners, shipbuilders, classification societies, etc.) is to negotiate for higher GHG emission reduction commitments. Otherwise, the sector runs the risk of being misaligned with the trajectories needed to achieve the target of the Paris Agreement.

Furthermore, targets and voluntary commitments by themselves might not be sufficient to create the necessary incentives to switch to alternative propulsion technologies soon enough. Considering that ship fuels are tax-free,[99] in order accelerate hydrogen propulsion deployment in the shipping sector, the environmental externalities ought to be internalised. While there are several mechanisms that can achieve this with varying levels of efficiency, a carbon tax on fuels might be a simpler way to achieve emission reductions and incentivise the uptake of alternative propulsion systems.[100]

In the context of the EU, the political situation is much clearer in relation to both the maritime and inland shipping industries. The EU has established the goal to achieve carbon neutrality as of 2050, with the intermediate goal of 55% GHG emissions reduction by 2030. Furthermore, the commitments are followed by an extensive legislative review under the Fit for 55 package. As mentioned, the specific impacts for both maritime and inland shipping will depend on the content of the final provisions of the legislative acts, however an incentive for uptake of alternative propulsion systems will most certainly exist. A recommendation in this regard, is that the development of mechanisms at the European level is followed by push for similar global rules. The creation of international rules will work to prevent significant impacts on the competitiveness of the European shipping sector, and it will foster demand for alternative propulsion systems, including hydrogen propulsion technologies, globally.

At the European level in relation to the regulation of the inland water transport sector, a clear issue highlighted by the literature reviewed, is the complex regulatory regime applicable to the sector. While the creation of CESNI is an

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[98] Aldo Chircop (2019), The IMO Initial Strategy for the Reduction of GHGs from International Shipping: A Commentary, The International Journal of Marine and Coastal Law 34(3): 483-512, p. 511

[99] DNV GL (2019), Assessment of selected alternative fuels and technologies, < https://brandcentral.dnvgl.com/dloriginal/gallery/10651/files/original/aef2db35bec7425c88370b6fa4340430.pdf?f=Alt-Fuels_guidance_complete_2019-08_web.pdf > (last accessed 17/03/2022), p. 11

[100] Beatriz Garcia, Anita Foerster and Jolene Lin (2020), The Shipping Sector And GHG Emissions: The Initial Strategy For A Zero-Carbon Pathway, NUS Law Working Paper 2020/013, < https://law.nus.edu.sg/apcel/wp-content/uploads/sites/3/2020/06/013_2020_Jolene.pdf > (last accessed 16/03/2022), p. 23

important improvement, further consolidation between the regulatory regimes, could reduce the administrative burden for operators in the sector.

Additionally, while the interest for alternative propulsion technologies is increasing, there are still technological barriers preventing their rapid deployment.[101] Therefore, an integrated approach regarding financial support might be necessary. While for maritime, the financial support might be necessary mostly in relation to R&D, to foster the development of hydrogen propulsion systems for sea-going ships, for inland waterway more support might be needed.

The reason for this lies in the structure of the inland waterway transport sector. The sector is defined by a large share of owner-operators (SMEs) with a specific cost structure, which leads to low readiness to proactively invest and innovate.[102] Thus, for the adoption of hydrogen propulsion in this sector to take place, additional funding and financing schemes, as well as fiscal incentives will be necessary. Moreover, whatever approach is chosen to support the adoption of hydrogen propulsion systems, it should include not only the propulsion systems themselves, but also the necessary port infrastructure to allow for their operation, aiming to solve the problem of lack of first-mover advantage in relation to the adoption of alternative fuels.[103]

Continuing from policy to regulations, it is clear that both in terms of international and European legislation specific to hydrogen vessels approval and hydrogen bunkering, regulation is simply lacking

For vessels approval at both levels, the regulatory regimes are uncertain, lengthy and costly. While, *prima facie* this certainly seems a barrier to the rapid uptake of hydrogen propulsion systems, it is important to take into account the issue of safety. Considering that hydrogen is still not widely adopted, and that the reports analysed as part of this report have shown, that more knowledge and experience with the technology is needed, before rules for hydrogen propulsion systems in shipping can be enacted.[104] Moving too fast with regulation can risk major accidents, that can sink the development of the technology for a long time or set it on a non-efficient path. Furthermore, the development of vessel approval rules is already on the agenda both at the international and European levels.

Consequently, while moving forward with regulation and the development of the wider hydrogen ecosystem, several recommendations are put forward. Firstly, pilot and demonstration project ought to be encouraged and facilitated by the applicable regulatory regimes, in this line the use of regulatory sandboxes can be increased.[105] Secondly, as the technology matures and moves from demonstration projects to a wider level of adoption, legislators and national administrations ought to not lag behind, both in terms of regulation and technical capacity. Technological

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[101] *Id.*, p. 16.

[102] *Supra* note 33, NAIADESIII and note 11 Platz and Ruijgrok

[103] *Supra* note 79, DNV GL p. 63

[104] *Supra* note 28, UNECE 2011, p. 6

[105] General Secretariat of the Council (2020), Council Conclusions on Regulatory sandboxes and experimentation clauses as tools for an innovation-friendly, future-proof and resilient regulatory framework that masters disruptive challenges in the digital age, < https://www.consilium.europa.eu/media/46822/st13026-en20.pdf > (last accessed 23/02/2022)

development ought to be accompanied by an appropriate level of sound regulation that guarantees safety based on experience and knowledge but does not become too costly to implement by the industry, thereby resulting in no technological uptake.[106] Thirdly, when enacting the legislation applying to hydrogen powered vessels and bunkering, consideration must be taken on how do new the regulations fit within the existing legal regime. Two areas where existing rules might conflict with future regulatory regimes applicable to hydrogen propulsion are the conventions and regulations applying to the carriage of dangerous good (e.g. ADN and ADR conventions) and the other IMO Codes. Another example concerns hydrogen storage and energy law provisions. Further research is needed on the interaction of existing legal regimes not directly applicable to maritime and inland water transport, but which through the nature of hydrogen as an energy carrier can impact the shipping sectors.[107] Lastly, while standardization will have a significant impact, it is clear that its role is limited at the moment. Existing hydrogen standards were adopted for different applications, and they can provide limited guidance, since vessels, especially maritime ones, operate in a significantly different conditions compared to hydrogen vehicles, for example. Thus, when drafting regulations, the special operating conditions of the sectors, must be taken into account.

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[106] *Supra* note 28, UNECE 2011, p. 6

[107] *Supra* note 79, DNV GL

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3 National regulations

The second part of this report focuses on the national regulations pertaining to hydrogen propulsion in the maritime and inland water transport sectors. The chapter will present the key issues in relation to vessel approval, hydrogen bunkering and storage in ports, identified as part of the regulatory analysis carried out as part of the WP of the project in Belgium, France and the Netherlands. The structure from the previous chapter will be followed, as each country section will start by presenting the policies and place and then moving on to the regulatory issues.

3.1 Belgium

Before turning our attention to the Belgian national and regional levels of regulation applicable to hydrogen propulsion systems in waterborne transportation, it is of paramount importance to explain the legal and political framework under which these are developed.

Belgium is a federal state subdivided into Communities and Regions. The Federal government, the Communities and the Regions can all enact legislation for which they are exclusively competent. The legislation enacted by the latter two is on the same level as the federal legislation. The Communities are mainly competent in relation to "personal matters". The Regions (Flemish, Walloon and Brussels-Capital) have, mainly and exclusively, competence in certain economic matters: environment, agriculture, energy, area development and planning, water policy, public works. The federal government has powers over issues not expressly left to the Regions or Communities. Examples of such are social security, foreign policy, fiscal policy and others.[108]

Considering this arrangement and the fact that in the next chapter the analysis will mostly focus on national and regional legislation related to zoning and health, safety and environment, it becomes clear that the sources of law will be diversified and split across multiple regional jurisdictions. Therefore, in order to achieve some meaningful analysis, the approach taken is to start with the legislation at the federal level. Should there be none, the analysis will move to the regional legislation focusing on the Flemish region. The reason for this is the location of the Oostende Port, which is in Flanders.

3.1.1 Policies

Starting with the national policies, the long-term climate strategy of Belgium under the Paris Agreement, does not contain concrete commitments for reduction of GHG emissions. This is due to the aforementioned Belgian constitutional arrangement.

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[108] Maurice Adams (2014), Disabling constitutionalism. Can the politics of the Belgian Constitution be explained?, International Journal of Constitutional Law, Volume 12, Issue 2, p. 283-284;, Tomi Toharudin (2010), Individualism, Nationalism, Ethnocentrism and Authoritarianism Evidence from Flanders by means of Structural Equation Modeling, < https://pure.rug.nl/ws/portalfiles/portal/33279496/10_thesis.pdf >, (last accessed 18/02/2022), p.23-31 and Belgium.be (2022), The powers of the Regions, < https://www.belgium.be/en/about_belgium/government/regions/competence#:~:text=So%20the%20Flemish%20Region%2C%20the,credit%2C%20foreign%20trade%2C%20supervision%20of > (last accessed 18/02/2022)

As part of the national strategy, each of the three regions has developed its own strategy and these three strategies together, cover all national GHG emissions.[109]

At the regional level, the Flemish long-term strategy aims to reduce GHG emissions from sectors not covered by the EU ETS by 85% by 2050 compared to 2005. For the sectors covered by the ETS, the Flemish strategy follows the EU targets.[110]

Specifically for transport, the strategy sets the aim to reduce CO_2 emissions by 23% by 2030 and to have zero emissions by 2050. However, international air and shipping are not included in this target.[111] On the topic of maritime shipping, the strategy calls for cooperation at European and international levels under the scope of the IMO. No other targets or goals are indicated however.[112]

At the time of writing the maritime sector is not included in the EU ETS scheme, yet considering the developments at the European level, this might change in the near future with the proposal for revision of the EU ETS directive.[113]

Another set of relevant policy documents are the national or regional hydrogen strategies. In the case of Belgium, the hydrogen strategy considers that the maritime sector will transition from diesel and heavy fuel oil to ammonia or methanol, based on renewable hydrogen.[114] As for the regional strategy of Flanders, it highlights the role of hydrogen for decarbonization of heavy transport, including shipping either through direct use or transformed in other molecules. The strategy focuses mainly on research and development and pilot projects located in Flanders. Additionally, the strategy presents a project in the Oostende Port with three developmental phases for the large-scale production of green hydrogen for transport.[115]

In general, both hydrogen strategies are rather vague in their specific commitments and even more so in relation to the maritime sector. Yet, it is envisaged that hydrogen or hydrogen derived molecules will play a key role in decarbonizing the sector.

Having identified the main policy documents, it is possible to highlight some of the most important national legislation applicable to the subject matter of the report. Regarding vessel approval, a starting point of the analysis will be the new Belgian Navigation Code (hereinafter BCN). It entered into force from 1st September 2020 and applies to all seagoing vessel or transport by such.[116] Additionally, for the vessel approval process there are several decrees which further develop the rules for waterborne vessels. As to the question of hydrogen storage, the main

[109] Climat.be (2020), Stratégie à long terme de la Belgique, < https://climat.be/politique-climatique/belge/nationale/strategie-a-long-terme > (last accessed 16/02/2022), p. 1-2

[110] *Id.* p. 3.

[111] *Id.* p. 32.

[112] *Id.* p. 36.

[113] *Supra* note 5, ETS Proposal.

[114] Tinna Van der Straeten (2021), Visie en strategie Waterstof, < https://www.tinnevanderstraeten.be/federale_waterstofstrategie > (last accessed: 16/02/2022)

[115] Hilde Crevits (2020), Mededeling aan de Vlaamse Regering: Vlaamse Waterstofvisie "Europese koploper via duurzame innovatie", VR2020 1311 MED.0357/1BIS, p. 10, 14-15

[116] Conseil d'Etat (2019), Code belge de la Navigation (BCN), < https://www.ejustice.just.fgov.be/eli/loi/2019/05/08/2019A12565/justel >, (last accessed 17/02/2022), art. 2.1.1.1.

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legislation is related to zoning laws and health, safety and environment laws. As to zoning laws, they are spread among the different regional, municipal and local jurisdictions. The health, safety and environment laws are mostly derived from the transposition of the identified directives in section 3 of this report. The national instruments which transpose the directive are located at different legislative levels.

Lastly, on the question of hydrogen bunkering the focus will be on legislation applicable to ports, such as the Flemish Port Decree and the Port Regulations in force at the Oostende Port.

3.1.2 Vessel approval

The applicable legislation regarding ship approval and certification starts with the new Belgian Code of Navigation. The new act entered into force in September 2020, replacing the existing code. It provides the general laws and principles applicable to shipping, both maritime and inland.[117]

Below the BCN, there are three royal decrees implementing its provisions. The first is the Royal decree regulating maritime inspection. It regulates the inspection regime, through which all ships must go to receive their certificate of seaworthiness.[118] Unfortunately an analysis of this decree will not be included in the present report, due to the unavailability of a consolidated version, or any version for that matter, in the Belgian legislative database. In lieu of that, as much as possible on the maritime inspection regime will be gathered from secondary sources.

Secondly, the Royal decree relating to the registration of seagoing vessels will be looked at. This decree provides further clarification as to procedure, documents and actors, and their responsibilities, in relation to the registration of vessels.[119]

Lastly, regarding passenger ships, the provisions of the Royal decree laying down safety rules and standards for passenger ships used for national voyages will be analysed.[120]

Starting with the BCN, the code establishes the general provisions regulating maritime and inland navigation. According to art. 2.2.1.2, any ship intending to sail under the Belgian flag must be registered with the Belgian Ship Register.[121] The process of vessel registering is further defined in the recast Royal decree relating to the registration of seagoing vessels.[122] Under the provisions of this decree, all vessels under construction in Belgium must be registered with the

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[117] *Ibid.*

[118] Conseil d'Etat (1973), Arrete royal portant règlement sur l'inspection maritime, < https://www.ejustice.just.fgov.be/cgi_loi/change_lg_2.pl?language=fr&nm=1973072013&la=F > (last accessed 17/02/2022).

[119] Conseil d'Etat (2020), Arrêté royal relatif à l'enregistrement des navires de mer, < https://www.ejustice.just.fgov.be/eli/arrete/2020/06/26/2020031121/justel > (last accessed 17/02/2022)

[120] Conseil d'Etat (2002), Arrêté royal établissant des règles et normes de sécurité pour les navires à passagers utilisés pour effectuer des voyages nationaux, < https://www.ejustice.just.fgov.be/eli/arrete/2002/03/11/2002014073/justel > (last accessed: 17/02/2022) and Conseil d'Etat (2019), Arrêté royal modifiant l'arrêté royal du 11 mars 2002 établissant des règles et normes de sécurité pour les navires à passagers utilisés pour effectuer des voyages nationaux, < http://www.ejustice.just.fgov.be/eli/arrete/2019/03/14/2019030504/justel > (last accessed 17/02/2022)

[121] *Supra* note 116, BCN, art. 2.2.1.2

[122] *Supra* note 119, Conseil d'Etat (2020)

abovementioned Register. The responsibility to do so lies with the shipbuilder. As he has to register the ship and provide all necessary documentation pertaining to the registration. For other ships that operate in Belgium, the registration is optional. They can do so, as long as the owner or operator is a natural person having its domicile in Belgium or is a national of another EU or EEA member state.[123] Should someone intend to register a ship, the registration is made upon the request of the relevant party and under the instructions provided in the decree and in website of the Belgian Ship Register.[124]

For the registration to take place, a series of documents identifying the ship and the owner are required, nonetheless the Ship Register has the authority to request additional information necessary for the registration. Including information regarding the propulsion machinery, manufacturer type and power in kilowatts.[125]

Regarding safety and certifications, the authority entrusted with this task is the Belgian Maritime Inspectorate. Its task is to carry out technical inspections, without which it is impossible to have a certificate of seaworthiness. The necessary documents for such inspections include general information on the ship, copies of all valid certificates, copies of the main construction drawings, plate thickness report, stability data and other relevant data. The result of the inspection is a report. If the latter is positive, the Inspectorate issues the national and international certificates under the Royal decree regulating maritime inspection.[126]

Regarding ships carrying passengers the situation in relation to hydrogen propulsion systems is clearer. The Royal decree laying down safety rules and standards for passenger ships used for national voyages directly addresses the issue of use of gases or other low-flashpoint fuels. By virtue of Annex 1, Chapter II-2, art. 2.2.N1, p. 10.1-4 the use of liquid fuels with a flashpoint lower than 43ºC is forbidden. Fuels with flashpoints between 43ºC and 60ºC are allowed for the use of standby generators. Additionally, vessels constructed after 1 January 2003 can use liquid fuels with flashpoints between 43ºC and 60ºC, as long as they comply with the additional requirements laid down in subsequent paragraphs.[127] These provisions apply to ships which do not travel beyond 20 nautical miles away from the coast i.e. limited to zone B, as defined in art. 3 of the decree.[128]

3.1.3 Hydrogen storage

Hydrogen storage can take several forms, but generally can be categorized in two ways: physical-based storage and material-based storage. Physical-based storage consists of storing H_2 as a compressed gas, cryogenically compressed gas or in its

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[123] SPF Mobilite (2020), Registre des navires de mer, < https://mobilit.belgium.be/fr/navigation/registre_naval_belge/navires_de_mer/enregistrement_des_navires_de_mer/registre_des?language=fr >, (last accessed 17/02/2022)

[124] Registre Belge des Navires (2020), Enregistrement de Navires dans le Registre Belge des Navires: Documents A Produire, < https://mobilit.belgium.be/sites/default/files/registratie_zeeschepen_fr.pdf > (last accessed: 17/02/2022)

[125] *Supra* note 119, Conseil d'Etat (2020), art. 5, 12, 13, 14, 22, 21

[126] Royal Belgian Shipowners' Association (2020), Technical inspection of the ship, < https://kbrv.be/technical-inspection-ship/# > (last accessed 17/02/2022)

[127] *Supra* note 120, art. 2.2.N1, p. 10.1-4

[128] *Supra* note 120, art. 3

liquid state. Material based storage involves adsorbents, liquid organic compounds, interstitial hydrides, complex hydrides or chemical hydrogen storage materials.[129] Despite the different possible ways to store hydrogen, the focus of this section will be only on storage of pure hydrogen in gaseous or liquid form.

The legislation regulating hydrogen storage is separated in land-use planning law and health, safety and environment law. In Belgium, zoning and environmental permits are a regional competence. The regions delegate the responsibility for spatial planning to the regional governments or administrations, and provincial and municipal authorities. In Wallonia and Brussels, the municipal authorities are the ones entrusted with special plans and permitting for Class I installations.[130]

Specifically for Flanders, land use plans exist on different levels (region, province, municipality). In principle, in regional land-use plans there are no general exclusions for hydrogen installations. Thus, irrespective of the land categorization, safety is the most important parameter. In order to obtain an environmental permit, a Quantified Risk Analysis is mandatory. This analysis is used to decide how many and how close industrial, installations can be installed in the different categories of areas. A second requirement is that the function of the installation is compatible with or related to the other functions in the area.[131] Thus, despite the lack of general exclusions hydrogen storage must be located in areas defined as industrial. The criteria are further defined in the Flemish planning codex.[132]

Moving to the health, safety and environment regulations, generally speaking there are several requirements to hydrogen storage installations that come from the transposition of European law into national legislation. Highlighted here are the Seveso directive, the ATEX directive and the SEA and EIA directives.

Firstly, the requirement for risk assessments coming from the Seveso directive apply. These requirements apply for storage facilities that will contain more than 5 tons of H_2 and the installation will be subject to stricter conditions, if the storage capacity is for more than 50 tons of H_2. The directive is transposed into national law under the scope of the Cooperation agreement of between the Federal State, the Flemish Region, the Walloon Region and the Brussels-Capital Region regarding the control of major-accident hazards involving dangerous substances.[133]

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[129] Hydrogen and Fuel Cell Technologies Office (2022), Hydrogen /Storage, < https://www.energy.gov/eere/fuelcells/hydrogen-storage >, (last accessed: 18/02/2022)

[130] "The classification of the installation depends on the expected environmental burden of an installation. If there is hydrogen storage included in the installation or a hydrogen distribution system, it is always Class I. Class I and II need a permit, for class III a notification is sufficient." In Isabel François (2018), HyLaw: National Policy Paper – Belgium, < https://www.waterstofnet.eu/_asset/_public/HyLaw/National-policy-paper_-Belgium_v2-0.pdf > (last accessed 18/02/2020), p.5

[131] *Ibid* and Koninklijk Besluit betreffende de inrichting en de toepassing van de ontwerp-gewestplannen en de gewestplannen, < https://codex.vlaanderen.be/Portals/Codex/documenten/1000635.html > (last accessed: 18/02/2022)

[132] *Ibid* and Flemish Government (2021), Vlaamse codex ruimtelijke ordening, < https://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&table_name=wet&cn=2009051536 >, (last accessed 18/02/2020)

[133] Brussels-Capital Region, Flemish Government, Walloon Government Service, Employment, Labor And Social Consultation (2016), Cooperation agreement of 16 February 2016 between the Federal State, the Flemish Region, the Walloon Region and the Brussels-Capital Region regarding the control of major-accident hazards involving dangerous substances, < https://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&cn=2016021613&table_name=wet > (last accessed 18/02/2022)

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Secondly, health and safety requirements and conformity assessment procedures come from the ATEX directive. The directive applies to areas where potentially explosive atmospheres can occur and the fact that hydrogen is a flammable gas. The directive is transposed in national law by virtue of the Royal decree concerning the placing on the market of equipment and protective systems intended for use in explosive atmospheres.[134]

The third requirement is for environmental impact assessment procedures, as envisaged under the SEA and EIA directives. Under the EIA directive, it is for the member-states to determine whether a project shall be made subject to an environmental impact assessment, either on a case-by-case basis or in the form of threshold set *a priori*. The reason for this is that underground storage of combustible gases is included in Annex II(3) of the Directive. The transposition of this directive is spread across multiple national legislative acts.[135]

3.1.4 Hydrogen bunkering

As identified before, the land side of bunkering is not covered by the IGF Code and the provisions therein are focused on LNG bunkering. Thus, in general, the port authority is the responsible institution in relation to bunkering, as no uniform approach is to be found. Generally, as established under the international and European law section of this report, the use of other standards for safe bunkering is recommended.[136]

In the case of Flanders, by virtue of art. 4 of the Decree on the policy and management of seaports,[137] only port authorities can exercise port administrative powers. These administrative powers include: the management and operation of the port, the definition and organization of port services and the exercise of special administrative policing in the port area.[138] Furthermore, the harbourmaster's office is the entity responsible for safeguarding public order, tranquillity and security. Lastly, port authorities establish and organize all public port services.[139]

Taking the case of the Oostende Port as an example, bunkering is defined as supplying a ship with fuels such as fuel oil, lubricating oil and liquefied natural gas (LNG).[140] According to the Port Regulations, the Port Authority is the one authorised to provide public port services as bunkering and debunkering and it can decide to grant a concession or authorisation for those services to a third party.[141]

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[134] Service public fédéral Economie, P.M .E., Classes moyennes et Energie (2016), Arrêté royal concernant la mise sur le marché des appareils et des systèmes de protection destinés à être utilisés en atmosphères explosibles, < https://www.ejustice.just.fgov.be/eli/arrete/2016/04/21/2016011165/justel >, (last accessed 18/02/2022)

[135] EUR-Lex (2021), National transposition measures communicated by the Member States concerning Directive 2014/52/EU, < https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=celex:32014L0052 >, (last accessed 18/02/2022)

[136] *Supra* note 79, DNV GL 2017, p. 68-72

[137] Vlaamse Gemeenschap (2019), Decreet houdende het beleid en het beheer van de zeehavens, < https://www.ejustice.just.fgov.be/eli/decreet/1999/03/02/1999035415/justel > (last accessed 21/02/2020)

[138] *Id.* art. 2(2)

[139] *Id.* art. 14 and art. 16

[140] Haven Oostende (2021), Politieverordening Haven Oostende, < https://www.portofoostende.be/sites/default/files/2021-01/Politieverordening_2021_01_29.pdf > (last accessed: 21/02/2022), art. 1(9)

[141] *Id.* art. 2(6)(1)

Chapter 12 of the Port regulations further stipulates the rules applicable to bunkering in Oostende. Bunkering is only permitted when compliant with the regulations issued by the harbourmaster's office and when it is approved in advance.[142] Bunkering only takes place if a ship is properly moored, and the pipes are in good conditions. Additional safety requirements include that the bunkering lines must be suspended properly and have sufficient clearance; all bolts, clamps or quick connectors must be tightened to prevent leakage; there are sufficient ways to prevent any leakage; the quantity, maximum pump flow and pressure are correctly agreed; the measures regarding emergency stops are known; there is continuously agreed communication between vessels and lastly, there is no welding, smoke or open fire or sparks taking place.

[142] *Id.* art. 12(2)

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3.2 France

3.2.1 Policies

At the policy level, the French commitments for climate and energy are codified in Book I of the French Energy Code. According to art. L100-4, France is committed to a reduction of GHG emissions by 40% by 2030 and to achieve climate neutrality by 2050. An additional target is set, to reduce the primary energy consumption of fossil fuels by 40% by 2030. Furthermore, the share of renewables must be at least 33% by 2030 and in the final fuel consumption, the share of RES must be 15%. Additionally, in relation to hydrogen, the same article codifies the prospect of achieving between 20% to 40% of total hydrogen consumption coming from low-carbon or renewable hydrogen.[143]

Furthermore, the development of clean hydrogen mobility is one of the three objectives of the National strategy for the development of decarbonized hydrogen in France. In particular, the strategy also includes the development of pilot projects for river shuttles and hydrogen-powered ships, under priority three of the Strategy - Support research, innovation and skills development to promote the uses of tomorrow.[144]

Zooming to the city of Paris, in its Climate Action Plan 2020 the following targets for 2030 are put in place: 50% reduction of local GHG emissions, 45% of renewable energy in overall consumption and conformity with WHO recommendations on air quality. For 2050 the targets are: zero local GHG emissions, 100% of renewable energy and 50% of reduction of energy consumption. The city is aiming to phase-out diesel mobility by 2024, through the establishment of a Low Emissions Zone in the Greater Paris Metropolitan Area. Additionally, inland waterway freight is seen as an ecologic alternative to road freight transport, thanks to its efficiency, and it will be promoted with emphasis on the development of clean-engine technologies for barges. Additionally, the city is drafting a hydrogen development strategy.[145]

In this way, both at the national level and at the level of the city of Paris, hydrogen powered vessels are seen as an important avenue to achieve climate and energy goals.

3.2.2 Vessel approval

Starting with vessel approval under French law, the requirements from Directive 2016/1629 have been transposed in French law by decree nº2018-1091 of 5th December 2018, now codified in the Transport Code. According to articles L-4221-1 and L-4221-2 of the Transport Code any boat must have on board a navigation permit corresponding to its category and that of the waterway or body of water used. This can be a Union certificate, Rhine vessel inspection certificate, a vessel certificate or a floating establishment certificate, that guarantees the technical conformity of the construction to the standards of its category. The obtention of

[143] Légifrance (2022), Code de l'énergie, < https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000023983208/LEGISCTA000023985174/#LEGISCTA000023985174 >, art. L100-4

[144] Gouvernement (2020), Stratégie nationale pour le développement de l’hydrogène décarboné en France, p. 6, 12

[145] City of Paris (2020), Paris Climate Action Plan 2020, < https://cdn.paris.fr/paris/2020/11/23/257b26474ba3ba08ee02baa096f9c5dd.pdf >, p. 16-17, 25-32

the certificate is made in accordance with the rules to the issuance of navigation titles, defined in arts. D 4221-1 *et seq*. of the Transport Code.[146]

The relevant requirements are specified in the ES-TRIN. Until the adoption of an updated version of the standard which includes technical criteria for hydrogen propulsion, the homologation of hydrogen powered vessels is possible in three ways: CCNR process, the rules described in section 3.2.1.1 under Directive 2016/1629 or under the national process with the Ministry of Ecological Transition (hereinafter MTE) to allow derogation from the rules of the Directive in the context of technological developments.

The Order of 20th August 2019 relating to the issuance of navigation titles in a restricted navigation area, defines the national exemption procedure. The navigation title based on this order is limited to geographic areas within France. The procedure is similar to the traditional title request with the exception that additional documents are required. The procedure and additional documents are prescribed in Annex II: Examination of a derogation request for an innovative project.[147]

Thus, in the intermediate period between the adoption of ES-TRIN rules pertaining to hydrogen powered vessel, homologation is possible under CCNR, EU or national rules with the appropriate tests and risk analysis.

3.2.3 Hydrogen storage

In relation to the issue of hydrogen storage, the presence of hydrogen in gaseous or liquid form in storage modules, tanks or process equipment is regulated by the Nomenclature on classified installations for environmental protection (ICPE), and in specific item nº4715 - Hydrogène (numéro CAS 133-74-0). The item prescribes that depending on the quantity of hydrogen likely to be present the installation can be subjected to either a declaratory or an authorization regime. The regulatory regime is based on the Seveso directive and is set out in national law under Book V of the Legislative part of the Environmental Code, with the authorisation regime being set on Title I of Book V. [148] Installations likely to contain less than 100 kg of hydrogen do not require a declaration nor an authorization. If the quantity likely to be present in the installation is more than 100kg, but less than one tonne, then the installation is subject to a declaration. If the quantity is more than one tonne, then the installation is subject to the authorization regime.

If the installation is subject to the declaration regime it has to comply with Order of 12th February 1998 relating to the general requirements applicable to installations classified for the protection of the environment subject to declaration

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[146] Legifrance (2022), Code des transports, < https://www.legifrance.gouv.fr/codes/texte_lc/LEGITEXT000023086525/2022-04-19/ > (last accessed 19/04/2022).

[147] Legifrance (2022), Arrêté du 20 août 2019 relatif à la délivrance de titres de navigation sur une zone de navigation restreinte, < https://www.legifrance.gouv.fr/loda/id/JORFTEXT000039050476/2022-04-19/ > (last accessed 22/04/2022)

[148] Legifrance (2022), Code de l'environnement, < https://www.legifrance.gouv.fr/codes/texte_lc/LEGITEXT000006074220/2022-04-19/ > (last accessed 19/04/2022)

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under heading No. 4715,[149] while if it is subject to the authorisation regime, the requirements will be laid out in a prefectural environmental authorisation order, granted to the site at the end of the examination of environmental authorisation application file, which will include a hazard study and an environmental impact assessment study. The main regulatory requirements are laid out in the aforementioned Order of 12th February 1998.

In relation to regulatory gaps, technical information on other forms of hydrogen storage (such as LOHC) is not sufficiently present to allow their classification under the ICPE regime. Furthermore, there are several possible constraints to the installation, due to the requirements set out in Annex I of the Order of 12th of February 1998 relating to fire safety in the case of aboveground storage. In relation to underground storage, constraints might exist in relation to the existence of underground water, or the areas affected by the Flood Risk Prevention Plan. The Seveso threshold are quite low (1 ton for the declaratory regime and 5 tons for the authorisation), thus a substantial permitting process is to be expected, with a time frame between 9 and 18 months, with uncertain results of the public inquiry.

3.2.4 Hydrogen production

As to the question of hydrogen production by electrolysers, ICPE item nº4715 is applicable, as well as item nº3420 (Fabrication de produits chimiques inorganiques). The second item, stems from the transposition of the IED Directive into French law. Item nº4715 is applicable because the production of hydrogen involves at least some temporary storage, yet the approval procedures is under an authorisation regime, because item nº3420 applies to any production, without thresholds being set.[150]

However, under an interpretative note from the Risk Office of the Energy and Chemical Industries of the General Directorate of Risk Prevention (hereinafter DGPR) of the MTE, whether or not a submission should be made to under ICPE item nº34XX (e.g. 3420) for water electrolysis depends on the local situation. In relation to the water needed for the process, a submission might depend on whether the installation is in water sensitive area and on the volume of water to be withdrawn. Therefore, for electrolysers a systematic classification of hydrogen producing units is not present. Consequently, it is recommended that project owners communicate with local authorities at the earliest of the project stages, in order to know the approach to be followed under the ICPE procedure.[151]

In the case of port operations, taking water from rivers and discharges into them may be affected by the legislation on water discharges.[152] Thus, depending on the

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[149] Legifrance (2022), Arrêté du 12 février 1998 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 4715, < https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000571176/2022-04-19/ > (last accessed 19/04/2022)

[150] Ministère de la Transition écologique (2019), 3420. Fabrication de produits chimiques inorganiques, < https://aida.ineris.fr/consultation_document/25136 > (last accessed 22/04/2022)

[151] Ministère de la Transition écologique (2022), Notion de fabrication en quantité industrielle, < https://aida.ineris.fr/consultation_document/sites/default/files/gesdoc/95886/IR_180116%20fab%20quantit%C3%83%C2%A9industrielle%20sous%20IED.pdf > (last accessed 19/04/2022)

[152] *Supra* note 148, Code de envrironment, Partie reglementaire, Live II, Title I, Chapter IV, Section 1.

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installation characteristics the electrolysis production project may be subject to authorisation or declaration under the Water Law, in addition to the possible submission to authorisation under item nº3420 ICPE.

If the installation is subject to an authorisation regime, it is the prefectural order granted to the site, after an environmental authorization procedure, applicable to the entire site, that will set the site-specific requirements. In terms of layout, safety distances and risk control constraints, may arise from the Order of 4th October 2010 relating to the prevention of accidental risks within installations classified for the protection of the environment subject to authorization,[153] or the under the Order of 12th February 1998 relating to the general requirements applicable to installations classified for the protection of the environment subject to declaration under heading No. 4715, or from the results of the hazard study carried out within the environmental authorisation procedure.

An important requirement in this aspect is set by ISO 22734:2019 that defines the construction, safety and performance requirements for modular equipment or apparatus for generating gaseous hydrogen, using electrochemical reactions. It prescribes the requirements for the manufacturer to specify the safe environmental conditions for which the generator is designed; it sets the standards to be observed for the components and the requirements for protection against risk of fire and explosion and it requires a risk assessment by the manufacturer on the design under other international standards. On top of the standard, local regulations might prescribe different methods and levels of detail for the risk assessments, that the owner/operator might have to carry out.

In this way, while the regime under ICPE item nº 3420 has been relaxed by the abovementioned note from DGPR, the exact applicable regime to which an installation will be subject will depend on the characteristics of the installation and on the location. Again, the main criteria can be expected to be the amount of hydrogen to be stored (more than 1 ton or more than 5 tons). Consequently, it is recommended that project owners for production of hydrogen by electrolysis discuss the project with local authorities from the earliest stages of the project, to understand the path to be followed.

3.2.5 Hydrogen bunkering

3.2.5.1 Gaseous hydrogen fuel service stations for boats on quay

The operation of hydrogen gas distribution stations falls under item nº1416 (Stockage ou emploi d'hydrogène) of the ICPE nomenclature, with service stations for boats being treated under the same regime. However, the Order of 22nd October 2018, which sets the general requirements for hydrogen refuelling stations, applies only to gas stations servicing road and rail,[154] the DGPR indicates that the operation

[153] Legifrance (2022), Arrêté du 4 octobre 2010 relatif à la prévention des risques accidentels au sein des installations classées pour la protection de l'environnement soumises à autorisation, < https://www.legifrance.gouv.fr/loda/id/JORFTEXT000023081900/ > (last accessed 19/04/2022)

[154] Legifrance (2022), Arrêté du 22 octobre 2018 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 1416 (station de distribution d'hydrogène gazeux) de la nomenclature des installations classées et modifiant l'arrêté du 26 novembre 2015 relatif aux

of service stations for boats could be governed by a special prefectural order, taken on the basis of L512-12 of the Environmental Code. The Prefect may require the petitioner to provide the necessary information to ensure that the risks of the installation are controlled and to determine the appropriate separation distances from the interests to be protected and mentioned in art. L. 511-1 of the Environmental Code.

As to the equipment, all pressurized components (compressors, tanks, pipes, etc) must comply with Directive 2014/68. In relation to the refrigeration units, using fluorinated greenhouse gases, they are subject to ICPE item nº1185, which prescribes that depending on the capacity of the closed equipment and the amount of fluorinated GHG present, the installation may be classified under a regime of declaration with controls (checks). Thus, if this is applicable the operator of the facility must comply with Order of 4^{th} August 2014 relating to the general requirements applicable to installations classified for the protection of the environment subject to declaration under heading No. 1185. The order prescribes layout rules and means of firefighting and intervention that the installation has to comply with.[155]

Despite not being applicable the Order of 22^{nd} October 2018, prescribes certain requirements that can be considered in the context of a feasibility study, design and choice of location for a hydrogen refuelling station. The requirements are related to design, layout, breakdowns and accessibility. Additional relevant requirements concern the protection of pipes and hoses, the transposed ATEX Directive and earthing of equipment. Furthermore, with the appropriate adaptations, the requirements relating to emergency device and system safety, could be implemented.

In this way, a gaseous hydrogen distribution station for boats is subject to item nº 1416 of ICPE - "Service stations: installations, whether or not open to the public, where the gaseous hydrogen is transferred to the facilities. Vehicle tanks”. The applicable regime is only declaratory with control. However, in the absence of prescriptions since the Order of 22^{nd} October 2018 is not applicable, the prefect can ask the petitioner to provide the necessary information to ensure that the risks of the installation are controlled. On the basis of these elements, the prefect can regulate the installation by a prefectural order of special prescriptions made on the basis of article L 512-12 of the Environmental Code.

Since, such station will often be accompanied by storage of hydrogen, the amount of hydrogen to be stored will play an important role in the determination of which regime is applicable under item nº4715. In general, the rules laid down in ministerial orders are minimum requirements to be observed. Stricter separation

prescriptions générales applicables aux installations mettant en œuvre l'hydrogène gazeux dans une installation classée pour la protection de l'environnement pour alimenter des chariots à hydrogène gazeux lorsque la quantité d'hydrogène présente au sein de l'établissement relève du régime de la déclaration pour la rubrique n° 4715 et modifiant l'arrêté du 4 août 2014 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 4802, < https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000037519292 > (last accessed 22/04/2022)

[155] Legifrance (2022), Arrêté du 4 août 2014 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 1185, < https://www.legifrance.gouv.fr/loda/id/JORFTEXT000029359291/ > (last accessed 19/04/2022)

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rules and distances may be imposed following the site hazard study, which takes into account the environment (natural, urban, industrial) specific to each site, and all facilities and the related operations necessary for the operation of the station.

3.2.5.2 Hydrogen station for boats on pontoon

The operation of a hydrogen bunkering station on a fixed pontoon or on a one with vertical mobility and related equipment, are covered by the ICPE legislation. Since these are fixed on foundations, they are equivalent to a quay extension. For a floating docked to the quay pontoon, which is not intended to move, *a priori,* a service station would also be subject to the ICPE regulations. Thus, the discussion in the previous sections, would be applicable in a similar way.

The main difference, in the regards of hydrogen stations on pontoons would be in relation to the creation of the pontoon in a public river domain, which is regulated by the General Code of ownership of public entities and the Environmental Code.[156] Thus, an authorisation from the public entity which is the owner of the public river domain must be obtained. Additionally, the creation of a fixed pontoon may be subject to Water Law procedure and an environmental impact assessment under the Environmental Code. Depending on the project, it may be subject to a declaratory or an authorisation regime. Pontoons located in flood zones must comply with the corresponding Flood Risk Prevention Plan.

3.2.5.3 Fuelling hydrogen from a truck

In relation to bunkering from trucks, the fluvial ports parking areas are not subject to a hazard study under art. L.551-2 of the Environmental Code, unless the lot has a capacity of more than 150 heavy-goods vehicles.[157] However, the platform on which the trucks park may be subject to a hazard study, if the total annual traffic of goods, dangerous or not, is greater than 1 million tons per year, by virtue of art. R551-9 of the Environmental Code. An exception is made if the operation is regulated by a prefectural order as an installation or related equipment under an ICPE.

If the parking area is not operated under an ICPE regime, it is subject to compliance with the Order of 29 May 2009 relating to the transport of dangerous goods by land (TMD order), for parking outside depots.[158] In case a hazard study is submitted, the wharf may be subject to a prefectural order with specific requirements for the installations, environmental protection and risk control measures, both at the parking area and during unloading.

For unloading, and unloading operations from the truck the applicable legislation is to be found in the French Labour Code, Regulatory part, Fourth part: Health and safety at work, Book V: Prevention of risks related to certain activities or operations, Title I: Work carried out in an establishment by an external company,

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[156] Legifrance (2022), Code général de la propriété des personnes publiques, < https://www.legifrance.gouv.fr/codes/id/LEGITEXT000006070299/ > (last accessed 19/04/2022)

[157] *Supra* note 141, Environmental Code, R551-7

[158] Legifrance (2022), Arrêté du 29 mai 2009 relatif aux transports de marchandises dangereuses par voies terrestres (dit « arrêté TMD »), < https://www.legifrance.gouv.fr/loda/id/JORFTEXT000020796240/2022-04-19/ > (last accessed 19/04/2022)

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Chapter V: Loading and unloading operations (Articles R4515-1 to R4515-11), which refers to the safety protocol for loading and unloading operations; the ADR Convention and the TMD order. On the boat side, since hydrogen for this purpose is considered an energy carrier and not a commodity within the meaning of the ADN Convention, the latter is not applicable, with the TMD order not being applicable as well.

The unloading of tanks does not require special authorizations, but the operation must be carried out in a place not accessible by the public traffic. If packages are being unloaded, the criteria do not apply, but it is still recommended that it is complied with. These obligations come from the Agreement Concerning the International Carriage of Dangerous Goods by Road (hereinafter ADR Convention).[159]

Despite this, it is recommended that the guidance documents and checklists, which are mandatory for LNG bunkering are followed in order to guarantee the safety and technical feasibility of the procedure. Examples of such are EMSA Guidance on LNG Bunkering to Port Authorities and Administrations and the Police regulations for the navigation of the Rhine art. 15.07(5) (b) and (6),[160] as well as the Standard for a Liquified Natural Gas (LNG) Bunker Checklist: Truck to Ship.[161]

3.2.5.4 Bunkering hydrogen from a boat

The bunkering of hydrogen from boat-to-boat is governed by the ADN Convention, the TMD order and the Transport Code - Regulatory part, Part four: Inland navigation and river transport and Regulatory part – Orders, Part four: Inland navigation and river transport. The relevant parts of the Transport Code are organized in a single document titled Inland navigation police regulations.[162] These are applicable in all navigable rivers in France, with the exception of the Rhine, which is governed by the Police regulations for the navigation of the Rhine.[163] For the Seine-Yonne rivers, the applicable police regulations are established by an inter-prefectural decree - Inter-prefectural decree laying down special police regulations for inland navigation on the Seine – Yonne route.[164]

In relation to the vessel, according to the provisions of the Table A, Chapter 3.2 of the ADN Convention, liquid, gaseous or solid hydrogen can only be transported by a dry cargo vessel. Furthermore, the vessel has to comply with all relevant

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[159] UNECE (2021), Agreement Concerning the International Carriage of Dangerous Goods by Road, < https://unece.org/adr-2021-files >, (last accessed 19/04/2022)

[160] EMSA (2018), Guidance on LNG Bunkering to Port Authorities and Administrations, < https://www.parismou.org/sites/default/files/EMSA%20Guidance%20on%20LNG%20Bunkering.pdf > (last accessed 20/04/2022) and CCNR (2022), Règlement de police pour la navigation du Rhin, < https://www.ccr-zkr.org/files/documents/reglementRP/rp1fr_012022.pdf > (last accessed 20/04/2022)

[161] CCNR (2015), Standard for a Liquified Natural Gas (LNG) Bunker Checklist: Truck to Ship, < https://www.ccr-zkr.org/files/documents/reglementRP/L_ctrl_avitaillement_GNL_cb_en.pdf > (last accessed 20/04/2022)

[162] Minisére de la Transition Écologique et Solidaire (2019), Police de la navigation intérieure: Règlements de police, < http://www.fluvial.developpement-durable.gouv.fr/IMG/pdf/recueil_rgpni___2019_09.pdf > (last accessed 20/04/2022)

[163] *Supra* note 161, CCNR

[164] Préfecture de la Région d'Ile de France, Préfecture de Paris (2019), Arrêté inter-préfectoral portant règlement particulier de police de la navigation intérieure sur l'itinéraire Seine – Yonne, < https://www.prefectures-regions.gouv.fr/ile-de-france/content/download/60542/398233/file/RPP_SEINE-YONNE_2019.pdf > (last accessed 20/04/2022)

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standards such as ES-TRIN, ADN Convention and the specific provisions applicable to transport of dangerous goods of class 2F (flammable gas). Additional special requirements might come from police regulations which set the maximum authorized dimensions of the boat, as well as maximum authorized speed and restrictions on navigation modes.

In general transhipment is allowed only on the premises approved for this purpose (article 7.1.4.9 ADN Convention), a request for transhipment in other areas can be made to the prefect of the department where these operations are carried out under the TMD order. As to parking distances, for parking outside of the areas indicated by the competent authorities, boats must not park at a distance of less than 100 m from residential areas, structures or reservoirs and they must be marked with a blue cone or light (art. 7.1.5.4.3 ADN Convention). Additionally, the Police regulations (art. 4241-54-7 state that the minimum distance between two boats is 10 m, if one of them has a sign for carrying certain flammable gases.

Art. 7.1.4.7.1 of ADN Convention prescribes the rules for loading and unloading of dangerous goods. They can only be loaded or unloaded at places designated or approved for this purpose. An approval request can be made by a letter or included in the ICPE regulatory file.

The authorities authorized to exercise supervision and control in this regard are listed in art. L1252-2 of the Transport Code.

In this way, the transhipment of goods from ship-to-ship is currently regulated mainly by the ADN Convention and its implementation in national law. Under the existing regime, each transhipment has to be approved by the prefect of the department. Bunkering with modules through unloading on the quay, would require the establishment of an evacuation plan in case of an emergency. While boat-to-boat bunkering by hose is not possible or narrowly limited due to the ADN Convention restrictions stating that hydrogen cannot be transported by a tanker and that a special authorization for emptying the tank on board of a boat is necessary.

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3.3 Netherlands

3.3.1 Policies

At the policy level, under the Climate Act, the Netherlands aims to achieve a 49% reduction in GHG by 2030 and a 95% reduction of GHG emissions in 2050. To achieve these targets, a climate plan was adopted in 2019, setting the main aspects of the climate policy to be followed by ministers in the next ten years. A new version of the plan is to be adopted every five years.[165] According to current plan, the Netherlands aims to achieve a 27% share of renewable energy by 2030 and to establish a Hydrogen Programme which will focus on gradually scaling up the generation of green hydrogen from renewable electricity.[166] As it stands, the plan is largely based on the 2019 Climate Agreement.

The Climate Agreement is an agreement between the Dutch government and the different industrial sectors to achieve the climate targets and commitments in a cost-effective manner, giving certainty and predictability to all industrial sectors. For the purposes of this report, the relevant sections of the 2019 Climate Agreement are C2 Mobility and C5.7 Hydrogen.[167]

Under the C2 Mobility heading, hydrogen is seen as a vital energy carrier for mobility, despite the section being mainly focused on road and rail. Under heading C2.5 Sustainability improvements in logistics, the government will advance the development of zero-emission vehicles and vessels by manufacturers in the Top Sectors (Logistics, High Tech Systems and Materials, and Water) and will support them through the Demonstration of climate technologies and innovations in transport (DKTI) scheme. Additionally, a Green Deal for Inland shipping was envisaged, with the focus on incorporating at least 5 PJ of sustainable energy carriers and 150 zero-emission vessels by 2030.[168]

The Green Deal on Maritime and Inland Shipping and Ports is an agreement between the Dutch central government, the provincial authorities, trade associations in both sectors, ports, shippers, banks, knowledge institutions and non-governmental organizations. It sets out the ambitions, goals, efforts and actions to achieve substantial environmental gains in the maritime and inland shipping sectors. Under the agreement, for 2030 the parties agree to the ambition to reduce the Dutch inland fleet GHG emissions by 40%-50% (compared to 2015) and to have at least 150 zero-emission powered inland vessels. By 2050 the commitment is to have a zero-emission and climate-neutral inland fleet. Specific goals for 2030 for the inland shipping sector are the development of instruments to avoid the need for government mandated emissions standards; achieve a carbon emissions reduction of at least 20% (relative to 2015) and achieve reduction of emissions of environmental pollutants of at least 10% (in relation to 2015).

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[165] Overheid.nl (2022), Klimaatwet, < https://wetten.overheid.nl/BWBR0042394/2022-03-02/0 > (last accessed 22/04/2022), art. 2(1) and 2(2), art. 4, art. 3

[166] Ministry of Economic Affairs and Climate Policy (2019), Integrated National Energy and Climate Plan (2021-2030), < https://energy.ec.europa.eu/system/files/2020-03/nl_final_necp_main_en_0.pdf > (last accessed 22/04/2022), p. 34, 33

[167] Platform Klimaatakkoord (2019), Climate Agreement, < https://www.klimaatakkoord.nl > (last accessed 20/04/2022).

[168] *Id p. 54. 73*

In relation to efforts and actions, the creation of sustainability funds is envisaged, as well as the ease of regulations in relation to sustainable vessels and the promotion of the creation of adequate infrastructure for alternative sustainable fuels. Specifically for hydrogen propulsion, several of the parties make commitments towards supporting and researching hydrogen propulsion as well as the production and supply of hydrogen for bunkering. An important note, is that under art. 31 the compliance with the commitments under the Green Deal are not enforceable by law.[169]

As to the Dutch hydrogen strategy, it mentions the abovementioned Green Deal which will contribute to the use of hydrogen in the shipping industry.[170] Further information about the policies applicable to hydrogen can be found in the HyLaw National Policy Paper – Netherlands.[171] While an analysis of the Dutch legal regime can be found in the RH2INE Kickstart study.[172]

3.3.2 Vessel approval

In relation to vessel approval, since the Netherlands is a member of the IMO, the Ministry of Infrastructure and Water Management has implemented the SOLAS Convention and the IGF Code into national regulations. Compliance with the national regulations is carried out by the Human Environment and Transport Inspectorate (ILT). The inspectorate conducts ships inspections. As to their certification, that is carried out by classification societies such as Veritas or Lloyd's Register.

Furthermore, the questions in relation to ship type approval and certification, and the development of the regulatory issues in those fields at the national level fall under the scope of the work done by the Ministry of Infrastructure and Water Management, the Ministry of Social Affairs and Employment, and the Ministry of Finance. At the regional level, the responsible institutions are the Environment Agency, the municipalities and port authorities. In this regard, the port authorities have a facilitating role in the development of regulatory issues.

3.3.3 Hydrogen storage

Moving to the question of hydrogen storage, according to the national regulatory report, written as part of WP2 of the project, the applicable rules in the field of safety are not yet set up in relation to hydrogen storage in ports.

Generally, the storage of hazardous substances in the Netherlands is subject to strict regulations. All physical activities conducted by a company at a given location

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[169] Green Deals (2019), C-230 Green Deal on Maritime and Inland Shipping and Ports, < https://www.greendeals.nl/sites/default/files/2019-11/GD230%20Green%20Deal%20on%20Maritime%20and%20Inland%20shipping%20and%20Ports.pdf > (last accessed 20/04/2022)

[170] Government of Netherlands (2020), Government Strategy on Hydrogen, < https://www.government.nl/documents/publications/2020/04/06/government-strategy-on-hydrogen > (last accessed 22/04/2022), p. 10

[171] Jan Piet van der Meer et. al, HyLaw National Policy Paper – Netherlands, < https://www.hylaw.eu/sites/default/files/2019-03/HyLAW_National%20Policy%20Paper_Netherlands.pdf > (last accessed 24/04/2022)

[172] *Supra* note 77, RH2INE, p. 24-31

will be covered by a permitted, which is referred as the all-in-one permit (*omgevingsvergunning*). This permit provides project developers with all necessary permissions in one go. It combines several permits, among which are the planning and zoning permit, the building permit, and the environmental permit, as well as sub-permit such as the fire safety permit. The exact contents of the permit are to be determined based on the specific activities that will take place at the site.[173]

The guidelines for storing hazardous substances are to be found in the Hazardous Substances Publication Series (*Publicatiereeks gevaarlijke stoffen*, hereinafter PGS). Furthermore, if large quantities of hazardous substances are to be stored, compliance with additional regulations might be required. These come from the Major Accidents Risks Decree 2015 (*Besluit risico's zware ongevallen* 2015 or, abbreviated, hereinafter Brzo 2015).[174] Thus, it is recommended that project initiators contact the Directorate-General for Public Works and Water Management on whether the Brzo 2015 applies to the project.[175]

As to the PGS, the publication represents guidelines for companies that produce, transport, store or use hazardous substances and for the governmental entities tasked with the supervision and licensing of those activities. They are guideline documents about specific activities, which comprehensively describe the main risks associated with those activities in relation to environmental safety, fire safety and the safety of employees.[176] They are formulated under a management organization, placed under the Dutch institute for standardization, in a process of mutual consultation between business and authorities.[177]

At the moment, the only guideline in relation to hydrogen refuelling under the PGS is PGS 35:2021 on Hydrogen installations for delivering hydrogen to vehicles and equipment (*Waterstofinstallaties voor het afleveren van waterstof aan voertuigen en werktuigen*). The guideline states explicitly that is not applicable to delivery of hydrogen to vessels, but it can serve as general guidance on what the requirements might be for such an installation.[178]

In relation to spatial planning, a project developer wanting to operate within a port area, has to contact the relevant port authority, due to the regulatory model applicable to Dutch ports. To decide upon the location of the hydrogen storage facility, importance has to be paid to zoning plans, which are drafted by municipal and provincial authorities on the basis of the Spatial Planning Act. Zoning plans are

[173] Liv Malin Andreasson, *et al.* (2020) Regulatory Framework: Legal Challenges and Incentives for the Development of Hydrogen Infrastructure in Port Areas, < https://www.newenergycoalition.org/custom/uploads/2021/04/Havenschets-Report-Final-Regulatory-Framework-Liv-Malin-Andreasson-1.pdf > (last accessed 29/04/2022), p. 22.

[174] Netherlands Labour Authority (2022), Major hazard control, < https://www.nllabourauthority.nl/topics/major-hazard-control > (last accessed 25/04/2022)

[175] Netherlands Enterprise Agency (2022), Storing hazardous substances, < https://business.gov.nl/regulation/storing-hazardous-substances/ > (last accessed 25/04/2022)

[176] Stichting Nederlands Normalisatie-instituut (2022), Publicatiereeks Gevaarlijke Stoffen, < https://publicatiereeksgevaarlijkestoffen.nl/ > (last accessed 25/04/2022)

[177] Stichting Nederlands Normalisatie-instituut (2022), Over PGS, < https://publicatiereeksgevaarlijkestoffen.nl/over-pgs.html > (last accessed 25/04/2022)

[178] Stichting Nederlands Normalisatie-instituut (2021), 35 - Waterstofinstallaties voor het afleveren van waterstof aan voertuigen en werktuigen, < https://publicatiereeksgevaarlijkestoffen.nl/publicaties/online/pgs-35/2021/1-0-augustus-2021#top > (last accessed 25/04/2022)

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legally binding and contain detailed rules on how land can be used.[179] If the zoning plan does not explicitly allow for the construction and operation of a hydrogen storage facility, the project owner/operator can request either an amendment of the plan or a permission to deviate from it. The logic of the zoning plan is to provide 'good spatial planning', which is to be determined by the municipal council through the choice of spatial structure, land use in the different areas and the exclusion of certain activities in given areas. In the decision-making process, different interests have to be balanced and different regulations might come in play. Examples of such are air quality requirements or requirements for external safety. For hydrogen it will be especially important to account for safety distances.[180]

For example, the Port of Amsterdam is separated in three zones. Zone I primarily offers space to existing risk companies, called bevi-companies and it is not suitable for the arrival of new nor the expansion of existing risk nor self-reliant functions. Zone II contains risk companies and labour-intensive industry. The zone serves to remain available for risk companies, but must also accommodate labour-intensive industries, with permission of the environmental authority. Zone II has fewer expansion or location options in comparison with zone I. This zone is also not suitable for expanding of existing nor self-reliant functions. Zone III offers space for activity and is considered less suitable for the arrival of new activities and the expanding of existing risk drivers. Some risk companies are located in zone III. Given the relatively short distance to the city, large offices and recreational areas are mainly located in this zone. Besides the different zones, there are other guidelines to take into account to map the correct location for hydrogen storage.

Firstly, there is the Safety contour, which is a drawn area where the risk contour should not exceed the safety contour. The following basic principles have been taken into account in determining the exact location of the safety contour: The Westpoort External safety area vision, the presence of high-risk establishments, the presence of vulnerable objects and their functional bonding and the future developments that can be reasonably expected. [181]

Consideration must also be given to the issue of cumulation of risks and the options for limiting them. In this regard, the Decree on External Safety of Establishments obliges the competent authorities to maintain safety distances between high-risk establishments and sensitive objects (vulnerable objects).[182] High-risk establishment are listed in art. 2(1) of the Decree, but in general they are companies where large quantities of hazardous substances are produced or processed. The Decree defines 'site-specific-risk' as the chance that an imaginary person dies as a direct result of an accident involving dangerous substances. According to art. 6 of the Decree the site-specific risk to a sensitive object cannot exceed 10^{-6} per year, meaning that the probability of a fatal situation cannot

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[179] Overheid.nl (2022), Wet ruimtelijke ordening, < https://wetten.overheid.nl/BWBR0020449/2021-07-01 > (last accessed 29/04/2022)

[180] *Supra* note 173, Andreasson, p. 20-21

[181] Royal Haskoning (2009), *Gebiedsvisie externe veiligheid Westpoort.* Amsterdam: Royal Haskoning

[182] Overheid.nl (2022), Decree external security establishments, < https://wetten.overheid.nl/BWBR0016767/2016-01-01 > (last accessed 29/04/2022)

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exceed one in a million, in any given year. Another provision from the Decree relates to 'group risk'. This means the cumulative probability that a present group of 10, 100 or 1000 people die as a direct result of an accident involving dangerous substances. These deaths must be a direct result of their presence in the area impacted by a high-risk company and a result of an unusual incident attributable to that establishment.[183] This risk is calculated using the SAFETI-NL calculation model.[184]

3.3.4 Hydrogen bunkering

Bunkering can be done through different technologies. Most often, it is done from truck-to-ship or ship-to-ship. The regulatory issues differ in the maritime and inland shipping sectors. In case of bunkering from truck-to-ship the environmental law is applicable.[185] The Environment Agency grants permits to companies that bunker in this way. In the case of ship-to-ship bunkering port law is applicable.[186]

When bunkering gas hydrogen or $NaBH_4$ hydrogen from truck-to-ship the environmental agency is the organisation that grants bunker permits. Important to note is that the environmental agency is not a department of the city of Amsterdam, but it has different departments and works for different provinces and municipalities. In the North Sea canal there are two environmental agencies, one for areas of Amsterdam and Zaanstad and one for area of Ijmond.

When bunkering from ship to ship the port bye-laws are applicable. For the different port areas, separate port bye-laws are applicable and these are for the municipalities of Velsen/Ijmuiden, Beverwijk, Zaanstad and Amsterdam.[187] Additionally, for those municipalities, the Harbour Master's Division of the Port of Amsterdam and the legal department play an important role in the designation of bunkering standards and procedures for hydrogen in the port bye-laws.

Besides the designation of hydrogen bunkering in the port bye-law, port authorities mandate in the bye-laws that bunkering takes place according to the checklists developed under the IAPH. These checklists give an overview on a step-by-step basis on how to bunker in a safe and correct manner. As established, in the first chapter of this report, currently there is no bunkering checklist for hydrogen. Although, the development of such is taking place.

In relation to port authorities, their role is to facilitate the cooperation between the organisations and to develop a regulatory understanding by the companies that have interests in bunkering hydrogen. With this, companies can react faster and more correctly on the regulatory part of the development of hydrogen and as a consequence, are more willing to invest in the development of the hydrogen supply chain.

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[183] *Supra* note 173 Andreasson, p. 22 and *supra* note 181, Royal Haskoning

[184] National Institute for Public Health and the Environment (2022), Safeti-NL, < https://www.rivm.nl/safeti-nl > (last accessed 29/04/2022)

[185] Overheid.nl (2022), Wet milieubeheer, < https://wetten.overheid.nl/BWBR0003245/2022-04-05/0 > (last accessed 20/04/2022)

[186] Port of Amsterdam (2021), Regional Port Bye-laws, < https://www.portofamsterdam.com/en/shipping/inland-shipping/regional-port-bye-laws > (last accessed 22/04/2022)

[187] *Ibid.*

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As to the Port of Amsterdam, bunkering is regulated under section 8 of the Regional Port Ordinance North Sea Canal Area 2019. In this regard, the Port has a different approach, since art. 8.1 states that "The fuels or energy sources designated by the Mayor and Aldermen may only be bunkered and debunkered with a permit from the Mayor and Aldermen." This approach to "fuels or energy sources" is kept through the entire section on Bunkering, meaning that any fuel or energy source can be bunkered in the port, as long as it is designated and approved by the municipality. In support of this is art. 8.3(2) of the Port Ordinance that states that the municipality may require additional information for the granting of a permit to bunker, furthermore an audit might be necessary, upon the discretion of the municipality, for the bunkering and debunkering operations carried out by a company. Additionally, by virtue of para. 2 of the same article, the perming may impose restrictions on locations for bunkering, procedures, safety and distances, among others. This approach is in contrast to the ones analysed so far, where a strict limit on the bunkering of fuels with a flashpoint below certain degrees, is imposed.[188]

[188] Port of Amsterdam (2021), Regionale Havenverordening Noordzeekanaalgebied 2019, < https://www.portofamsterdam.com/sites/default/files/2022-01/20220105%20dec%20versie%202021%20RHN%201_0-EN.pdf > (last accessed 22/04/2022), p. 22-23

4 International policy framework

4.1 A GHG strategy has been agreed at global level

While it is clear that the maritime sector is a critical enabler of global trade and an indispensable part of the world's economy it is also becoming increasingly clear that urgent action is needed to tackle the sector's ever-growing emissions. The global shift towards renewable and sustainable energy to limit the most severe effects of climate change is a challenge for every sector including maritime. Maritime transport emits around 940 Mt of CO2 annually and was responsible for about 2.8% of global greenhouse gas (GHG) emission in 2018. At EU levelCO2 emissions of maritime shipping amounted to over 142 Mt in 2018 and 136 Mt in 2019. This amounts to ~4% of total EU GHG emissions. These emissions are projected to increase significantly if mitigation measures are not put in place swiftly.

Ships are mobile entities having the biggest engines in the world on board and flying the flag of nations with different ideas and motivations on how to tackle GHG emissions. It is a global and very competitive sector and being a first mover doesn't come without risks

4.1.1 Prior to 2018

IMO has been working to address greenhouse gas (GHG) emissions from ships since 1997 when it adopted "Regulations for the prevention of air pollution from ships" aimed at targeting SOx, NOx, and ozone depleting substances, and other volatile organic compounds.

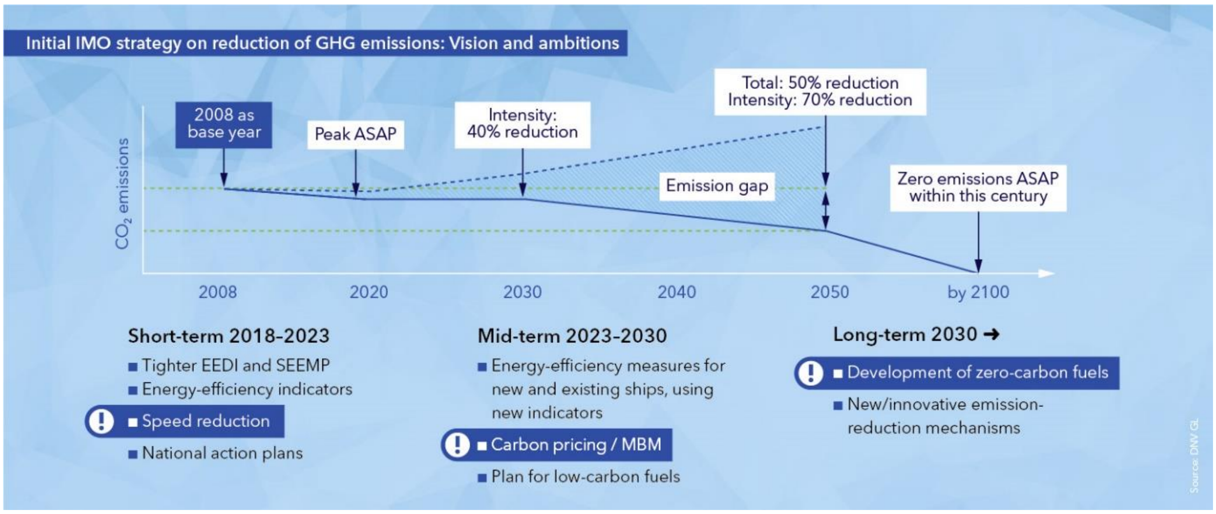
To reduce GHG emissions the IMO adopted in 2011 a package of technical and operational measures for all ships. These regulations on energy-efficiency of ships entered into force on 1 January 2013. These measures represent the first GHG reduction rule for a global industry and consist of two parts:

- Energy Efficiency Design Index (EEDI) requires new ships to perform above a certain minimum carbon intensity threshold with increasing mandatory improvements becoming stricter over time. The EEDI has put pressure on both shipowners and shipyards to find new ways to improve the energy-efficiency but has so far not sufficiently led to the uptake of alternative fuels.
- Ship Energy Efficiency Plan (SEEMP) establishes a mechanism to be used by shipowners to improve the energy efficiency of both new and existing ships. The guidance on the development of the SEEMP incorporates best practices for fuel efficient ship operation such as weather routing, trim and draught optimization, speed optimization, just-in-time arrival in ports, use of alternative fuels, ... The SEEMP encourages the identification of opportunities to reduce emissions but does not mandate setting of improvement targets.

4.1.2 Agreed IMO ambitions set in 2018

Reducing the GHG emission from ships has been a major challenge for the IMO the past 15 years because it's members have very different opinions on the size and urgency of how the problem should be addressed. The International Maritime Organization (IMO) adopted it initial Greenhouse Gases (GHG) reduction strategy in 2018 to be updated in 2023 The IMO sets outs a number of ambitions to reduce CO2 emissions by 50% in 2050 and to reduce the carbon intensity of international shipping by at least 40% by 2030 both compared to 2008 and to improve further the energy-efficiency of new vessels. As ships are generally in service for over 30 years, the maritime industry faces an enormous task to achieve this goal. Nevertheless, the commitment to the target constitutes a remarkable achievement given the, at times, competing and diverging interests and visions among IMO members.

We fully support these ambitions and wants to contribute to develop the building blocks that will ensure they are met. Hydrogen and hydrogen-based fuels will be an important piece of the puzzle, as they provide 0% GHG emissions and can therefore contribute to a rapid decrease of the average GHG emissions for shipping.



4.1.3 2030 target

The IMO 2030 reduction target to improve the carbon intensity of international shipping by at least 40% by 2030 compared to 2008 can be met with available technology, through a mix of short- and mid-term measures, including operational measures, such as lower speeds, improvements in operational efficiency through data analytics, limited use of low-carbon fuels, and energy efficient designs. In order to be able to achieve the 2050 target a somehow linear approach (by having a more stringent 2030 reduction target) would have been clearer. In this regard the EU is pushing for more stringent targets to be set by 2030 for all ships calling on EU ports and also to have a more robust system to measure the energy-efficiency of ships. We welcome this move as we need to start building zero emission ships now. The adoption of the IMO 2030 target will not, in absolute terms, prevent GHG emissions from peaking in the years to come.

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4.1.4 2050 target

To halve the GHG emissions by 2050 compared to the 2008 level is ambitious. To achieve the 2050 targets, alternative fuels and energy sources will be needed. The alternative fuels and technologies known at this time have limitations and no truly zero-carbon fuels are available on a larger scale. Although markets are powerful, they cannot, on their own, make the transition happen. An ambitious EU policy guiding this transition that includes clear goals, more research and innovation is needed This effort also requires the building of a worldwide dedicated infrastructure network meeting the demand for various alternative fuels. The current state of IMO discussions on the strategy to achieve the target are progressing slowly but the introduction of zero-emission vessels needs to start now.

4.2Air pollution – the shipping sector's other problem

Maritime shipping's essential role in our global economy is indisputable, but it is a significant contributor to global air pollution that harms both human health and the environment. The Fourth IMO GHG study estimates that international shipping emitted in 2018 approximately 17.1 million tonnes of NOx emissions and 9.6 million tonnes of SOx emissions compared to 16.9 and 9.6 million tonnes respectively in 2012. This represents an annual increase of 0.2% for NOx and 0.9% for SOx.

According to the IMO international shipping is responsible for approximately 13% and 12% of global nitrogen oxides (NOx) and sulphur oxides (SOx) emissions respectively annually.

It should be noted however that, the maritime sector has in recent years undertaken some significant steps to reduce the air pollution. To reduce SOx emission, limits have been set on the sulphur content of the fuels. Emission Control Areas (ECAs) with stricter limits were established to minimize airborne emissions from ships. The SOx emission limits apply to the existing fleet and NOx emission limits were set for new build ships.

As of 1 January 2021, all ships built after that date and entering Europe Emission Control Areas (the Baltic, North Sea and English Channel) must comply to the Tier III standard set by IMO . This standard aims to reduce nitrogen oxide emissions by approximately 85% compared to the Tier II standard which currently applies. The only way to achieve this is with alternative fuels e.g. hydrogen leading even to zero emissions if Fuel Cells are used. NOx abatement technology is required if hydrogen is burned in Internal Combustion Engines.

Because of significant negative environmental and health impacts, decarbonization efforts should also support the reduction of air pollution generated by the maritime sector.

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4.3Practical implications of the IMO-targets

4.3.1 Shipping emissions expected to continue to grow

The shipping sector's share in global emissions has reached 2.9% in 2018, surpassing the levels recorded the past decades with a peak in 2008. This shows, that even taking into account the ever-increasing energy efficiency of ships and though some improvement has been achieved, shipping is not on a trajectory to meet the 2050 ambition of reducing GHG emissions by 50%.

Assuming the COVID-19 pandemic has only a temporary effect on the world economy and trade, shipping is expected to continue to grow in the coming years and decades. As a result, although overall ships could improve their efficiency by a further 20% - 30% by technical and operational means – the growth in transport work will ensure that, even if those efficiency improvements are fully implemented, the absolute GHG emissions of the shipping sector will also continue to grow. The 4th IMO GHG Study predicts, that in a business-as-usual scenario, that include only continuation of efficiency improving actions, the absolute GHG emissions from shipping will remain stable at best but can potentially grow by more than 40%, depending on global GDP growth.

Improving the energy-efficiency of the ship only will not be enough. if the EU, in line with the European Green Deal targets, aims to reduce emissions overall by 55% in 2030 relative to 1990 and have a climate neutral economy by 2050, a shift from fossil fuels to zero-carbon fuels for shipping will be required.

4.3.2 From fossil ships to zero emissions ships

The key questions is how to trigger the uptake of hydrogen and hydrogen-based fuels for shipping and how to step away from fossil fuels in the near term, as widespread voluntary action by shipping stakeholders is unlikely due to significant cost penalties and IMO regulations mandating zero carbon fuels are not on the horizon

Heavy Fuel Oil (HFO) is the most used fuel in international shipping today and accounts for approximately 77% of all fuel burned in marine engines today marine gas oil the other main option. HFOis a residue from the refining industry andit has a very high energy density.

Before the 2018 IMO initial strategy to reduce GHG emissions was introduced, the maritime sector was focusing on selecting alternative fuels aimed at reducing air emissions, with GHG more an afterthought.

According to Clarksons Research, as of May 2020 the fleet of ships using alternative fuels consisted of 572 vessels, including ships using LNG, methane, ethane, or biofuel as a drop-in fuel. This amounts to a 0,6% of total vessels in operation.

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To succeed in the face of competition from currently used fossil fuels, alternative fuels will need to meet three characteristics:

1. The first one is the large energy density. The energy density of alternative fuel cannot compete with the energy density of existing marine fuels. As a matter of fact, it is the large energy-density of fuel oil (and the low price) that has made these fuels so successful the past 100 years.
2. The second very important characteristic is the availability and security of supply. Because shipping is a worldwide industry, alternative fuels need to be available all over the world, which is the case for current fossil fuels. This requires the building of a worldwide dedicated infrastructure network meeting the demand for various alternative fuels. The regulatory framework on alternative fuels and the lack of demand might raise hurdles on the path to develop said supply network. When there is a significant degree of market development for a certain fuel or energy carrier, new EU infrastructure obligations should be developed.
3. Future alternative fuels will need to be GHG-neutral from well-to-propeller. We are convinced that there will be a need to consider the upstream greenhouse gas emissions. It is the only sensible way to tackle the decarbonisation of our society.

Hydrogen offers a perfect zero tank to wake emission solution and would benefit from a well to tank regulation. Too often, when considering decarbonization of transport, the upstream emissions are not taken into account and this has also been the case for the maritime sector. The IMO is currently considering how to take into consideration the GHG intensity of alternative fuels, not only from tank-to-propeller but also from well-to-tank. It would be positive if the EU would take a leading role in those discussions.

4.3.3 Focus on zero emissions/low emission ships

Although there is certainly a potential to improve the energy-efficiency of the existing fleet pure hydrogen as a fuel for existing ships is technically challenging. . Hydrogen-based fuels (e-fuels) such as ammonia or methanol are more promising since they can be burned in internal combustion engines. The potential to use hydrogen-based fuels in existing ships needs to be further investigated but is outside of the scope of this paper.

In order to tackle the emissions of the biggest emitters which are deep-sea ocean going vessels, we will first need to further upscale hydrogen and hydrogen technologies through more research and innovation with inland and short sea shipping potential incubators for solutions in deep-sea shipping. There are still hurdles to overcome namely the price and the storage on board and the lack of consolidated and standardized solutions just to name a few.

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In many cases, where the necessity to store large amount of fuel to ensure autonomy or where the power needs are significant, technological solutions are still to be identified and research and innovation will represent a significant enabler for the development of a zero-emission ship at cost competitive conditions. This is notably the case of highly specialised large vessels, large passenger vessels and long- route shipping vessels

The greatest potential in the very short term lies in inland shipping and so-called vessels in ports and port areas such as urban ferries, tugboats and small dredging ships that maintain the depth of channels and rivers as these vessels have a relatively small fuel demand and can be supplied from a single location. Superyachts operating on hydrogen are also now early mover and show the potential of this fuel... Current projects depend on a patchwork of national legislation not designed for hydrogen for maritime applications which slows down the process A more broader EU/IMO harmonized regulation will be necessary to enable the building of larger ships and to create the conditions for designing ships with innovative components at cost competitive conditions.

It should be recognised that these vessels have a range of options where some are not suitable solutions for deep-sea shipping, for example batteries or compressed hydrogen.

The focus on small zero emissions vessels now will lead to the dedicated hydrogen supply chains for larger ships (short-sea-shipping) taking into account that the largest emitters namely deep-sea vessels will likely make use of hydrogen-based fuels (e-fuels) for their main engine power which will require different supply chains. We do not need to start from scratch and can make use of those experiences and integrating existing technologies on board those relatively small vessels easily. These small vessels can make use of Hydrogen refuelling Stations (HRS) on land.

It is likely as a first step that smaller ships in ports will be supplied with hydrogen from hydrogen tube trailers and/or fixed compressed hydrogen tanks and this will be done at HRS on land where hydrogen for other applications (trucks, tractors, busses, …) can be supplied as well. There are several plans to build such station but more demonstration projects are needed.

Our ambition should be to develop the supply chain for smaller vessels in port areas and cities and to make those ships commercially viable by 2030. From there the distribution, storage and bunkering of hydrogen and hydrogen-based fuels can be upscaled. This development will pave the way to hydrogen and hydrogen based-fuels and the required dedicated hydrogen infrastructure for the biggest emitters, ocean going vessels.

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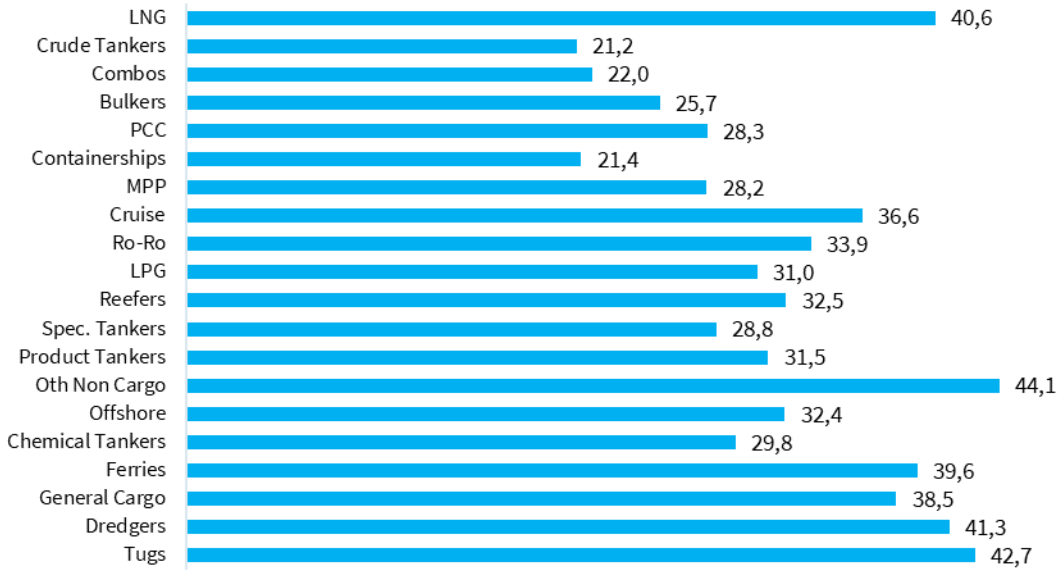
4.3.4 Ships have a very long lifetime; it's time to act now

The lifetime of ships (on average 30 years) highlights the urgency of enrolling hydrogen as a fuel as soon as possible. Due to the long lifetime of vessels, fleet renewal takes a long time and therefore the transition to alternative fuels needs to start now in order to avoid that fossil fuelled ships will still service global trade and EU-trade for decades to come.

Around half of all ships in operation are more 15 years old, with around 1/3 being more than 25 years old. The lifetime is even higher for smaller ships, such as general cargo ships, where it is close to 40 years on average. The average age of inland ships is even higher. Ironically, these are the ships where the potential for hydrogen and hydrogen technologies is the highest in the short term.



Source: own elaboration based on Clarksons World Fleet Register

If the emission reduction targets of the EU are to be achieved not only is decarbonization of the shipping sector needed, it needs to start now, as ships ordered in the next years will impact emissions of the shipping sector for decades to come.

A transition to new net zero emission fuels will be required to achieve the goals set out in the IMO Initial GHG Strategy and to put shipping on the pathway to decarbonization. Therefore to comply with the 2050 target we need to Introduce as soon as possible (1) zero emission ships and (2) ships with much lower emissions based on existing technologies and by investing in future proof technologies.

Concretely one can conclude that:

- **Before 2030:** The greatest potential in the very short term lies in inland vessels and so called vessels active in ports and port areas such as urban

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ferries, tugboats and small dredging ships that maintain the depth of channels and rivers. Before 2030, the technologies will be ready so that all European new-build short sea ships and new build inland vessels can be zero-emission and pave the way for long distance ships.

- **By 2030:** By 2030 many small ships will be running on hydrogen or e-fuels (dual and single fuel) depending on the chosen technology to power the ships. Technologies will be ready to already reduce substantially the emission of the rest of the ship fleets (existing ships and/or long distance ships). Hydrogen-based fuels will have been tested for main engine propulsion for larger ships and the first ships running on these fuels will be built by 2025. Hydrogen can already provide auxiliary power to larger ships which can significantly reduce emissions of air pollutants in ports and port areas. Consequently, by 2030 hydrogen can provide auxiliary power to the majority of ocean-going vessels (build after 2025) in ports and that the EU should lay down the legislative pathway to make this possible.
- **By 2050:** The worldwide fleet will have been even more hydrodynamically improved with highly automated machinery systems. The majority of ships with many of them fully autonomous will run on alternative fuels such as hydrogen and hydrogen based fuels.

4.4The role of hydrogen

4.4.1 The choice of the fuel of the future is still uncertain

The discussion about the sustainable fuel of the future lies essentially in a trade-off between cost and the easiness to store energy on board which is the main challenge from a technical point of view. There are also questions regarding the powering of the ships. Hydrogen can be used in multiple ways either in fuel cells or via combustion in internal combustion engines. Pure hydrogen being the basic element of all hydrogen-based fuels is the cheapest fuel. It is however not the easiest to store compared with other fuels that are made from hydrogen (ammonia, e-LNG, e-methanol and e-diesel) which have a better volumetric energy density. The relatively low volumetric energy density of hydrogen is, next to high production costs, the biggest techno-economical barrier for large scale adoption of hydrogen in maritime applications.

Hydrogen Europe has already looked at the available technology (see previous deliverables), their strengths and weaknesses, and their technology readiness levels (TRL), to propose deployment scenarios for ships and associated infrastructure. When it comes to fuel production costs alone, pure hydrogen options are always cheaper than fuels that require further ‘transformation’ – regardless of electricity price.

When it comes to fuel production costs alone, pure hydrogen options are always cheaper than fuels that require further ‘transformation’ – regardless of electricity price. We found that for large ships, ammonia is the cheapest synthetic fuel (based

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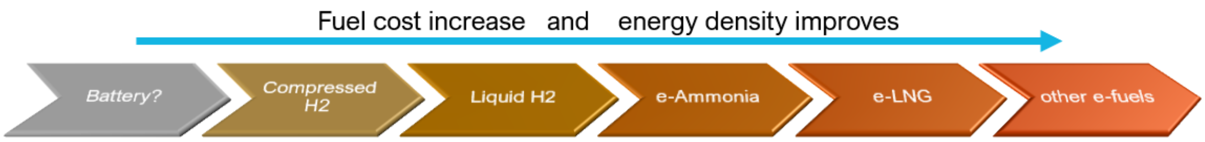
on renewable hydrogen). The trade-off lies in the fact that as the energy density of the fuels increases the cost also increases as can be seen in the figure bellow.



Even though the interest in hydrogen is growing, there are still some key barriers that need to be overcome before hydrogen can become a mainstream solution for shipping. One of the most important barriers is of course the high price of clean hydrogen and e-fuels as well as a lack of bunkering infrastructure. The regulatory framework is also lacking, both in terms of technical regulation as well as policies.

It is understandable that, given the long lifetime of ships, facing the risk of stranded assets, the shipowners are reluctant to invest in large vessels using alternative fuels. It is also understandable that, facing the same uncertainty, maritime ports are unwilling to invest in alternative fuels storage and bunkering infrastructure. Not to mention the fuel supplier that will need more demand/offtake security over a period of time.

Lack of consensus on what will be the future fuel of choice is one of the key barriers preventing hydrogen to move from R&D phase into wider adoption.

For short distance ships and inland vessels, it is clear that pure hydrogen is a convenient option and the cheapest one. These ships will kickstart the H2 transition. As indicated above, the necessary technologies are being developed and will make it possible to have zero emission new built ships in these categories by 2030. It is for long distance ships that the choice of the future fuels remains more uncertain.

On a more general note. Next to the obvious barriers such as price and infrastructure we should not forget the hydrogen production capacity. It should in this regards be stressed that hydrogen has a much broader role to play in the decarbonisation of the economy than just as a zero-emission fuel. Hydrogen is the only sufficiently available and scalable technology for sector coupling, which is essentially energy system optimization through production and consumption management in different sectors. Deep decarbonization across all sectors of the economy would be improbable and prohibitively expensive without hydrogen. The role of hydrogen in ongoing decarbonization efforts has also been recognized in the EU Energy System Integration Strategy and then in the EU Hydrogen Strategy,

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announced in July 2020, which sets out a target of at least 10 million tonnes of clean hydrogen production in the EU by the end of 2030.

4.4.2 But what is certain is that a lot of clean H2 will be needed

As can be seen in the figure below, of all the fuels that have the potential to be zero-emission or carbon neutral quasi all are based on H2.

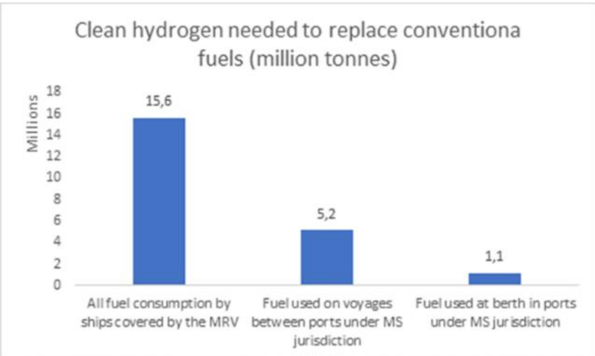
Table 1 - Energy source/zero-carbon fuels considered in this study

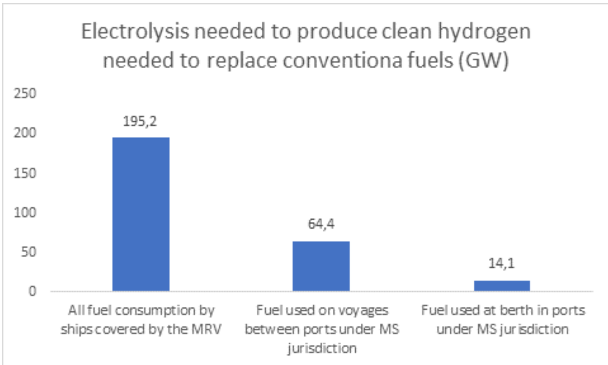
	Zero-carbon fuels				
Energy source	Methanol	Gas oil	Hydrogen	Ammonia	Electricity
Natural gas with CCS			NG-H_2	NG-NH_3	
Biomass	bio-methanol	bio-gas oil			
Renewable electricity	e-methanol	e-gas oil	e-H_2	e-NH_3	batteries

Note: Many types of biofuels exist depending on processes and feedstock (first, second and third-generation biofuels). In this study we considered only two cases that are regarded as representative for bio-methanol and bio-gas oil both as second and third-generation. Fuels produced from renewable electricity are referred to as electro-fuels.

Except for biofuels (and batteries), all zero-emission and carbon neutral fuels that are envisaged for shipping (hydrogen, ammonia, E-LNG, E-diesel, E-methanol) are made from hydrogen.

It is possible to make a calculation on the amounts of pure hydrogen that could in theory be required by ships calling on EU-ports and intra-EU shipping in the longer term. The left bar in the left figure below shows the required amount per year for all ships covered by the EU Monitoring Reporting and Verification (MRV) Regulation. The bar on the right shows the annual amount from ships at berth in EU ports.





4.5Ports as hydrogen hubs

It is important to point out the central role that the maritime ports have in the transition towards the hydrogen economy. Already today a large portion of hydrogen industrial production and consumption takes place in ports or in close proximity to ports. The biggest hydrogen consumers come from the oil refining, ammonia and chemical industries, which combined use around 90% of all hydrogen produced each year in the EU, and quite a lot of those facilities are located in EU ports.

Five industrial hubs in the Belgian and Dutch ports (Antwerp, Zeeland, Rotterdam, IJmond and Delfzijl) have a combined local hydrogen demand of 1.7 Mt per year,

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which is equal to around 20% of total EU consumption today. Most of that hydrogen is also produced locally, usually from natural gas through steam methane reforming the so called grey hydrogen.

This opens up an important opportunity as this grey hydrogen will gradually need to be replaced with renewable or low carbon hydrogen. Having a large hydrogen demand centre in port, makes it possible to develop a clean hydrogen supply chain for shipping. This would be further strengthened by the fact that many port areas have industrial facilities from the so called "hard-to-abate" sectors, like the steel industry, which are also increasingly looking at hydrogen as an option for decarbonisation.

Furthermore, hydrogen can also be used a fuel for most material handling vehicles used in port's terminals to decarbonise port operations and further increase demand for clean hydrogen.

The pace in which the maritime sector can decarbonize very much depends on how fast ports will be able to store sufficient amounts of green hydrogen.

Ports will become H2 hubs or "H2 Valleys" where hydrogen can be produced or imported, stored and distributed for use in different applications such as:

- H2 for trucks and rail (e.g. in port areas where electrification of the railway is not possible)
- H2 for inland waterways (for inland ports)
- H2 for onshore power
- H2 for the decarbonisation of terminal and cargo handling equipment
- H2 for the industrial hinterland (refineries, chemicals…)

The revision of the directive on alternative fuels infrastructure to put in place development plans for alternative fuels infrastructure will play a crucial role in this regard. As mentioned before it understandable that, facing the uncertainty on what the type of fuel shipping will use, maritime ports are unwilling to invest in alternative fuels storage and bunkering infrastructure. ports will first need to develop a roadmap with the users of these fuels but also with the fuel producers and storage terminal to come to an agreement on the timelines, conditions for use, quantities, etc. Hence our ask for a roadmap approach regarding the Fuel EU maritime initiative and the revision on the directive of Alternative Fuels Infrastructure (AFID). Adding complexity to this, ports will also need to consider the triple-S criteria (see figure bellow) when developing hydrogen infrastructure. Ports are bound by local legislation and lack of space which can hamper the storage of fuels that are more hazardous such as ammonia. The storability of alternative fuels or the lack thereof could also hamper the development of the supply chain. Security of supply inter alia through interoperability, secure and reliable system operation and transmission of hydrogen to major demand centres and storage sites which ports will be is a prerequisite to develop supply chains.

To ensure that the different greening and energy transition pathways for ports do not get stuck in a discussion about the chicken-and-egg dilemma, coalitions or framework agreements should be developed by key stakeholders. Such coalitions could initially involve shipping lines, port managing bodies and energy providers at port level and could in a later stage evolve into a deeper cooperation with connecting ports. Such a bottom-up approach would see an individual ports engage key stakeholders based on the ports' individual roadmap, which provides a detailed plan of pathways for the greening of the shipping and takes account of each port's particular circumstances. The roadmap should be accompanied by a timeline which engages all relevant stakeholders: the port, shipping lines, the energy sector (producers and providers), and other European ports where suitable.

It should also be noted that falling prices of offshore wind and solar are making this renewable energy technology, potentially the cheapest source of renewable hydrogen, especially in northern parts of Europe, where solar PV is less competitive, making ports ideally placed to become large renewable hydrogen production hubs and demand centres. It is also increasingly likely that Europe will not be able to locally produce enough hydrogen to cover the entire future demand. A solution will be to import clean hydrogen by ships from North Africa, Australia, Chile or other countries with favourable wind/solar resources. Here too ports are set to benefit.

The maritime sector will also be a major enabling partner to materialise those synergies between offshore renewables and hydrogen. Namely, hydrogen produced offshore could be transported by ships to demand hubs such as ports. Hydrogen-fuelled ships will bring crew to offshore platforms and wind turbines (for maintenance). Besides, those platforms could become hydrogen hubs at sea supplying hydrogen to ships in transit. The Offshore Renewable Strategy and the upcoming legislative initiative on FuelEU Maritime – Green European Maritime Space should therefore be consistent too. **Maritime ports are set to become key hubs of the emerging hydrogen economy**

5 Conclusions and Recommendations

5.1 Updating the regulatory framework

From the analyses carried out in this report, it is clear that the regulatory framework for hydrogen powered vessels is complex, but rapidly developing. In the rest of this chapter, the main conclusions will be highlighted and

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recommendations for both industry and policymakers, will be presented, considering the different parts of the hydrogen propulsion value-chain.

As described, the pressure to decarbonise all economic sectors is increasing and it will continue to increase with the increase of extreme weather events. Maritime and inland waterway transport are also under pressure to decarbonise, therefore alternative propulsion systems will be further integrated in both sectors. In this light, due to its characteristics, hydrogen propulsion is seen as a highly viable alternative to conventional propulsion technologies and the interest in it, is growing.

As part of the regulatory analyses carried out under the H2Ships project, the main conclusion to be drawn is that the regulatory regimes applicable to hydrogen propulsion in ships, bunkering and storage are complex. This complexity is characterized by a combination of existing and functioning rules, existing and non-functioning rules and a lack of harmonization between the different sets of rules applicable to hydrogen. While in general, the conclusions reached show that this complexity represents a barrier to the wider adoption of hydrogen propulsion technologies, this might not be the complete picture, especially when the interests of prevention of loss of human life, avoidance of property and environmental damage are taken into account. At the present time, several of the reports analysed as part of this inquiry identify the lack of knowledge and technical expertise in relation to the function and safety of hydrogen propulsion technologies in ships. Therefore, attempting to regulate the sector, before its functioning is understood can lead to a situation where its development is hampered or taken in a direction that is not efficient. This however, ought not to mean that legislative action is not necessary, but it should be taken appropriately as the sector develops. Thus, at the moment, it is recommended that a flexible approach is taken, to allow both the technological development and the better understanding of the technology.

Moving to the first part of the report, at the international level it was identified that more effort is needed to decarbonise the maritime sector. Without the proper stimuli for decarbonisation, the incentive to develop hydrogen powered vessels, can remain limited. This on the one hand will slow down the decarbonisation efforts, but it will also limit the knowledge and technical experience gathered in relation to hydrogen powered ships. As explained above, the latter two being a prerequisite for the creation of new regulatory acts and the harmonisation of existing ones, in an appropriate way.

In relation to vessel approval in both sectors, the approval and certification of hydrogen-powered ships is possible. Despite this, the process of approving and certifying a hydrogen powered ship involves an iterative, risk-assessment based, alternative design process, which tends to be more expensive and time-consuming in comparison with the prescriptive process applicable to a conventionally powered ship. This in itself, is not a problem, since the standard to be cleared is that a hydrogen powered ship ought to be as safe as a conventionally powered one, thereby balancing the interest of decarbonisation and technological development with the interests of safety and avoidance of environmental damage. Furthermore,

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legislative developments are taking place to adapt standards in order to facilitate the approval of hydrogen powered ships. For the inland waterway sector, the situation from a legal standpoint is similar, however considering the structure of the sector, from a political and economic perspective, more support is needed, so that the sector can transition faster to a decarbonized future.

As to hydrogen storage, the issue is primarily regulated at the national and regional levels. Existing land use, health, safety and environmental protection laws, and possibly energy laws are applicable. In this regard, the main challenge that legislators and regulators face is the need for harmonisation between applicable regulatory regimes. Due to its versatile role as an energy carrier, sector coupler, transport fuel and industrial feedstock, different legal regimes might be applicable to a hydrogen storage/production facility depending on how it is integrated in the wider port business ecosystem. Thus, further research focusing on the interaction between these different legal regimes is needed to identify possible areas, where harmonisation is needed. For project owners it is recommended that communication with authorities is established at the earliest of project stages.

On the issue of hydrogen bunkering, the situation is to a certain extent similar to vessel approval. Regulation is lacking, but under development, with the limited possibility to bunker hydrogen based on an exemption regime. Furthermore, it seems that the development of hydrogen bunkering protocols and checklists is moving at slower pace, since not much information is avaliable at the present time. Therefore, in the lack of international and European rules, local rules are applicable as exemplified by the Port of Amsterdam, where the municipality has the authority to authorize hydrogen bunkering. Different legal regimes however, can lead to technical barriers, stifling the wider adoption of hydrogen propulsion technology. Consequently, the development of checklist and protocols at the international or European levels is highly anticipated.

An additional recommendation to be made, concerns the need to support both fleet deployment and port-side infrastructure deployment. Without the possibility to bunker in different ports, the adoption of hydrogen powered vessels will remain limited.

5.2 Setting up an ambitious, clear and stable policy framework

In the European Green Deal Communication, the Commission affirms its focus on the production and deployment of sustainable alternative transport fuels for the different transport modes. In parallel, the Commission wants to review the Alternative fuels infrastructure directive and the Energy taxation directive and propose to extend the European emissions trading to the maritime sector. In its resolution on the European Green Deal, the European Parliament called for measures to move away from the use of heavy fuel oil and for urgent investments in research into new technologies to decarbonise the shipping sector, and in the development of zero-emission and green ships. In addition to that, there is another initiative called FuelEU Maritime aiming to increase the use of sustainable alternative fuels in European shipping and ports by addressing market barriers that

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hamper their use. This initiative is part of a package to bring the maritime transport sector in line with the EU's ambition of climate-neutrality by 2050.

We need a European regulation framework with clear and ambitious obligations for the use of hydrogen and hydrogen-based fuels by 2025 and 2030 in the maritime sector. The most relevant policy initiatives of the EU aiming at decarbonising the maritime sector are:

1. EU–policy on decarbonisation of ships through energy-efficiency improvements and direct carbon-pricing through the EU regulation on Monitoring, Reporting and Verification of GHG emission of ships (EU MRV 2015/757) and the European Emission Trading system (EU-ETS 2004/87/EC).
2. Broader regulation to facilitate the uptake of renewable and low carbon fuels for maritime through the FuelEUMaritime initiative.
3. The revision of the EU-directive on the deployment of Alternative Fuels Infrastructure (AFID) (2014/94/EU)
4. The revision of the Renewable Energy Directive (RED II) 2018/2001/EU
5. Revision of the energy taxation directive (ETD) as maritime fuels are currently exempt from taxes
6. Revision of the TEN-E regulation (347/2013)

Those initiative are all connected one way or another. We cannot afford to have a patchwork of legislation and regulation and need a European regulatory framework with clear and ambitious obligations for the use of hydrogen and hydrogen-based fuels by 2025 and 2030 in the maritime sector.

There is no silver bullet regulation to decarbonize the maritime sector nor any other sector. EU regulation should create a supply and demand for hydrogen and hydrogen based fuels at a pace where the shipowner has the option to actually choose this technology. At the same time, the EU should develop regulation that accelerates the pace at which the hydrogen technology for the maritime sector is developed. As is the case for other transport modes there is a tension field between both. Adding complexity to this is the storage and distribution of hydrogen and hydrogen based fuels. The review of the Alternative Fuel Infrastructure Directive in the context of the Green Deal offers an excellent opportunity to analyse the interdependence between hydrogen production, distribution and infrastructure, and demand.

On top of this, the FuelEU Maritime initiative will focus on ramping-up the production, deployment and uptake of sustainable alternative marine fuels. The FuelEU Maritime Initiative will have direct implications for alternative fuel infrastructures and must therefore be compatible and well-aligned with existing legislation, specifically the Alternative Fuels Infrastructure Directive as it will require targeted and effective investments in ports.

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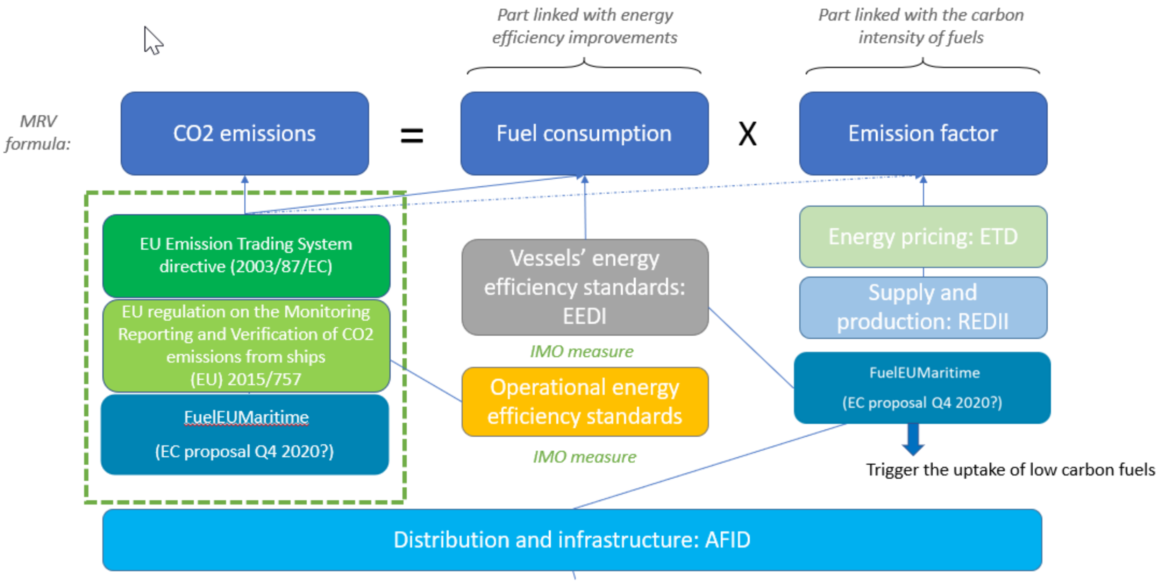

5.2.1 An operating emission standard applying to all ships entering in EU ports

The European Parliament adopted amendments requiring shipping companies to reduce on a linear basis their annual average CO2 emissions relative to transport work, for all their ships, by at least 40 % by 2030 compared to 2018 levels, with penalties for non-compliance. In order to obtain data on transport work, the reporting of 'cargo carried' per voyage would remain mandatory. In addition, the amendments introduce environmental performance labelling of ships, and calls for inclusion of methane and other greenhouse gases besides CO2, and better supply of shore-side electricity in ports. Since the numbers tell the tale, it is a positive initiative to have more robust data on emissions of all ships calling on EU ports in order to develop an emission standard.

5.2.2 FuelEU Maritime

We welcome the initiative from the European Commission to accelerate the uptake of alternative fuels for maritime transport through the FuelEU Maritime initiative, which will lead to goods being delivered in the most sustainable way. Hydrogen has a significant role to play not only for maritime transport but also for other transport modes, industry, and energy consuming sectors.

Regarding the pathway to sustainable alternative fuels, it would be preferable to have a goal-based performance requirements based on the carbon intensity of the energy used over mandating the use of specific sustainable alternative fuels.

The more open performance requirements are technology neutral which will lead to innovation. We acknowledge this could lead to uncertainty for sustainable fuel suppliers leading to investment uncertainty. Thus, while we prefer the performance requirement, it is not a black and white choice and very much depends on the details of the two options.

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Requirements on the share of specific sustainable fuels could be an interesting tool if they include also zero-carbon non-blendable fuels such a hydrogen and possibly ammonia. The minimum share of sustainable fuels should therefore not be limited to a blending requirement, as that would exclude some alternative fuels (like ammonia or hydrogen) and would therefore not be truly technologically neutral. Furthermore, the requirement should be defined on a fleet level and not at individual ship level – as that would enable to fulfil the obligation more smoothly by introducing a number of zero-emission vessels.

Renewable energy sub-targets and multipliers are essential instruments to (i) incentivise the uptake of renewables in the energy system and (ii) to close the financial gap between the cleaner yet more expensive option and its cheaper fossil alternative for end-customers. However, both instruments are interlinked. Sub-targets will result in an obligation to produce Renewable Fuels of Non-Biological Origin (RFNBO) and create a "push" in supply. In an emerging market, multipliers will create a stronger demand for RFNBO relative to the fossil alternative and create a "pull" effect. As such we advocate for an integrated framework, within the RED whereby both instruments are aligned with each other and are mutually reinforcing.

Specific targets regarding the share of Hydrogen and Hydrogen-based-fuels in the total fuel demand for maritime sector will lead to more certainty for producers, distributors and infrastructure providers and consumers.

5.2.3 The revision of the directive on alternative fuels infrastructure

The revision of the directive on alternative fuels infrastructure will play a crucial role for ports to become hydrogen hubs. We need to understand that clean hydrogen has to be produced and then transported affordably. Infrastructure is the backbone of our energy system; we need to ensure that EU infrastructure policy is aligned with the EU Green Deal and creates an enabling framework for hydrogen infrastructure.

Ports will first need to develop a roadmap with the users of these fuels but also with the fuel producers and storage terminal to come to an agreement on the timelines, conditions for use, quantities, etc. Hence our ask for a roadmap approach regarding the Fuel EU maritime initiative and the revision on the directive of Alternative Fuels Infrastructure (AFID).

We call for the establishment of a common regulatory framework to provide for the rapid expansion of hydrogen refuelling stations network across Europe. These hydrogen refuelling stations will be used to supply hydrogen to small ships in ports and set the seeds for dedicated hydrogen infrastructure. There is no chicken-and-egg dilemma: the deployment of infrastructure must occur alongside the deployment of ships.

We should also think of conversion parks and required infrastructure in ports where electrolysers convert renewable energy into green hydrogen for the supply of industrial plants and facilities to use the "waste streams", heat and oxygen power-

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to-gas facilities for the conversion of electricity to hydrogen and if applicable further to synthetic gas in so far as they perform network-related functions.

5.2.4 A special effort on port operation

Air emissions stemming from auxiliary engines on ships in ports lead to local air pollution. There are several alternative ways to provide auxiliary power to ships in ports, the main one being cold-ironing which is the process of providing electrical power to a ship at berth while its main and auxiliary engines are turned off. This can be done through electricity from the shore which puts a heavy burden on the electricity grid since the power required is very high. Moreover climate efficiency (CO_2-reduction per euro invested) of shore power depends strongly on the local circumstances of the port and the type of vessel (cruise ships, ferries, container ships or crane vessels, to name just a few).

Another way is to supply auxiliary power with fuel cells or dual-fuel hydrogen internal combustion engines that can be put on mobile barges or on shore. This is a much more flexible way to deliver auxiliary power to ships and is also an excellent way for ports to develop hydrogen refuelling infrastructure.

We believe that by 2030 hydrogen can provide auxiliary power to the majority of ocean going vessels (build after 2025) in ports and that the EU should lay down the legislative pathway to make this possible

5.2.5 The revision of the TEN-E regulation

The TEN-E regulation governs the development of energy related infrastructure. Since the adoption of the previous regulation the EU energy policy has evolved and has set more ambitious 2030 and 2050 targets. The EU's infrastructure policy needs to become better aligned with the overall energy and climate ambitions of the Union.

The revised TEN-E should provide an enabling framework for the development of a hydrogen economy and hydrogen backbones. The retrofitting/conversion of existing gas infrastructure to transport hydrogen from production sites to demand centres such as ports, in particular, brings with it significant societal savings for the energy transition. It also offers a cheap and cost effective option for transporting renewable energy.

We recommend the Introduction of "Clean hydrogen networks" as a new thematic area under the TEN-E Regulation. Both new infrastructure projects as well as hydrogen transport (including pipelines, maritime, road and other) solutions, intermediate storage and associated infrastructure projects should be encompassed in the framework of TEN-E.

The synergies between the Trans-European Transport Networks (TEN-T) and the Trans-European Networks for Energy (TEN-E) should be explored further to make a direct link between the fuel source, the optimisation of the production, use and transport of large quantities of hydrogen and the increase of hydrogen demand for the transport sector through the development of hydrogen infrastructure network.

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When TEN-T and TEN-E corridors are aligned geographically, the HRS network should be strengthened. The goal of the TEN-T network should be safe and sustainable EU transport system that promotes the seamless movement of goods and people.

5.2.6 The revision of the Renewable energy directive (RED)

The RED should promote further development of renewables, and especially renewable hydrogen. However, the current iteration of the directive (RED II) was drafted and agreed on in a different context and spirit to that of today. The European Green Deal (EGD) has set a clear pathway towards climate neutrality, and firmly underlines the importance of a well-balanced RED and a concerted regulatory environment that enables a positive investment environment for existing players and market challengers, to enable the scaling-up and deployment of hydrogen and hydrogen technologies

Under REDII, each Member State must set an obligation on fuel suppliers to ensure that renewable energy makes up at least 14% of the energy used in that Member State in the transport sector. Specific sub-targets for hard to abate sectors. (e.g. steel production, aviation and maritime) may also be considered in the upcoming revision of the RED to further incentivize and speed-up deployment and adoption of renewable energy in specific sectors and industrial segments.

When developing legislation and proposing targets and incentives, it is important to avoid duplication of efforts; as such if specific sectoral targets - e.g. in industry, maritime or aviation - are proposed within the context of RED revision, they should always be coherent with any other more specific and targeted sectoral legislative initiatives e.g. RE Fuel Maritime or RE Fuel Aviation.

5.2.7 Policy what does not disadvantage EU industries but favours it!

In the past a lot of the shipbuilding has been transferred from Europe to Asia due to unfair competition rules and this process needs to be stopped. Fortunately, the EU still has a solid position in building complex ships and a strong value chain of shipping equipment suppliers. It also aims at being a champion of H2 technologies.

EU maritime technology sector is strategic for Europe. It ensures access to trade at sea and enables EU into the Blue Economy. Europe is a worldwide leader as far as complex ships are concerned and in the production of the required maritime equipment, systems, and technologies. This worldwide leadership has been maintained by continuous investments in RDI and professionalization of the workforce, against a strong competitive Asian pressure supported by state aid policies.

EU shipbuilders and maritime equipment companies are at the edge of innovation on greening technologies, thus abating GHG and other air and water pollution. The competitive advantage is based on a knowledge-based economy that spans from industrial know-how to excellent research infrastructure and centres. Maritime operations are safely ensured by highly professionalised skills of sea operators,

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thus representing a complex European ecosystem that may ensure the transformation towards a green economy occurs.

The European industrial network composed by shipbuilding and maritime equipment companies has the capability to address the challenge of decarbonising waterborne shipping, taking a world leadership on those components of the maritime value chain which will have the highest marginality on the medium/long term. For this reason, this EU ecosystem has to be supported against non-EU companies, whilst taking the lead of green technologies for maritime

The rules that will trigger the uptake of hydrogen must be designed in such a way that they do not disfavor ships made in EU but rather encourages the promotion and production of "EU made zero-emission ships" for which the EU industry has a competitive advantage. This is a win-win situation.

Immediate EU regulatory focus on decarbonising Short-Sea-Shipping would be preferable in order to smooth the transition to zero emission shipping…

5.2.8 Short-sea-shipping paving the way for the whole sector

The European short sea shipping industry possesses many strategic advantages over other regions because of its extensive coastlines the European industry and consumer market and ports to serve the consumers. This bring opportunities for the European hydrogen industry. In Europe, market mechanisms are highly developed, there is an after-market for ageing vessels, and the technology is impressive. Short sea shipping in Europe faces challenges but it has proven to be innovative and viable with vigorous competition in most of its sectors.

In Europe many fast ferries are constructed and operated by European-based companies. This focused interest originates from the ever-increasing value of time to deliver goods from A to B and the funds needed for such investments. Faster and greener short sea ships can bring new opportunities for the hydrogen sector in Europe.

We are moving into an era where globalisation is no longer the issue. We will see more short sea shipping and local manufacturing short sea is 'the perfect way to test new forms of technology' as they do not spend as much time at sea as deep-sea ships.

5.3 Providing financial support and incentives to first movers

5.3.1 Ambitious R&I programmes such as ZEWT and CHE

The shipping sector encompasses a wide range of ship types each with their advantages and disadvantages for hydrogen technology. This variety highlights the importance of defining different strategies for hydrogen as a fuel for each vessel type. The most crucial bottleneck with hydrogen as a fuel, is likely not the production of renewable hydrogen or the end-point use but rather the storage both onshore and onboard the vessels. Power and autonomy are the key determining factors in this regard. Two joint undertaking Clean Hydrogen for Europe (CHE) will

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focus on hydrogen technology building blocks, which will be used in Zero Emission Waterborne Transport (ZEWT). CHE will research, develop and demonstrate technology to incorporate operational experience, but will do so for applications which are suitable for first movers and create synergies with for instance mobility and stationary sectors to increase the impact.

Europe has the skills, resources and potential to be a leading player in the supply and deployment of hydrogen technologies. Its diversity offers enormous strength if it can be harnessed and strategically guided, but European policy, research and development are presently fragmented both within and across the different countries.

5.3.2 Supporting first movers

Without action first movers are disadvantaged by paying and taking the risk without any rewards and others to wait for a reduction of cost and the investment uncertainty to reduce before investing in the technology. We therefore need to find a system such as the green ocean fund as soon as possible that rewards the first mover and need to be sure that the maritime sector benefits from the allocation of sufficient funds to innovate.

The European Commission should adopt an integrated approach in EU funding instruments to make sure that new bunkering infrastructure, as well as technology on board and vessels, can be stimulated simultaneously, preferably in the same subsidy call. Only in this way can we overcome the chicken-and-egg problem and stimulate the commercial scale up of low carbon fuels, clean energy and energy carriers.

5.3.3 Including the maritime sector in the ETS

On 16 September the European Parliament voted in favour of including include maritime shipping under the EU ETS Directive starting in 2022. It calls for an 'Ocean Fund' for the 2022-2030 period, financed by revenues from auctioning ETS allowances, which would be used to make ships more energy-efficient, to support investment in innovative technologies and infrastructure for decarbonising maritime transport, and to protect marine ecosystems impacted by climate change. The Commission would be required to assess any new global market-based emission reduction measures adopted by the IMO with respect to their ambition and environmental integrity.

The vote in the European Parliament to include shipping in the EU ETS is positive. The ocean fund is what is needed to trigger the uptake of hydrogen and boost hydrogen technologies. An extension of the EU ETS to maritime shipping should result in CO2 reduction, limit carbon leakage, accelerate the transition towards clean fuels, and not hamper the competitive position of the EU market.

We believe shipping should be incorporated into the EU ETS and that at least 50% of the income generated should be channelled back to the sector to finance innovation and first movers. The revenues of the Fund could be used to finance

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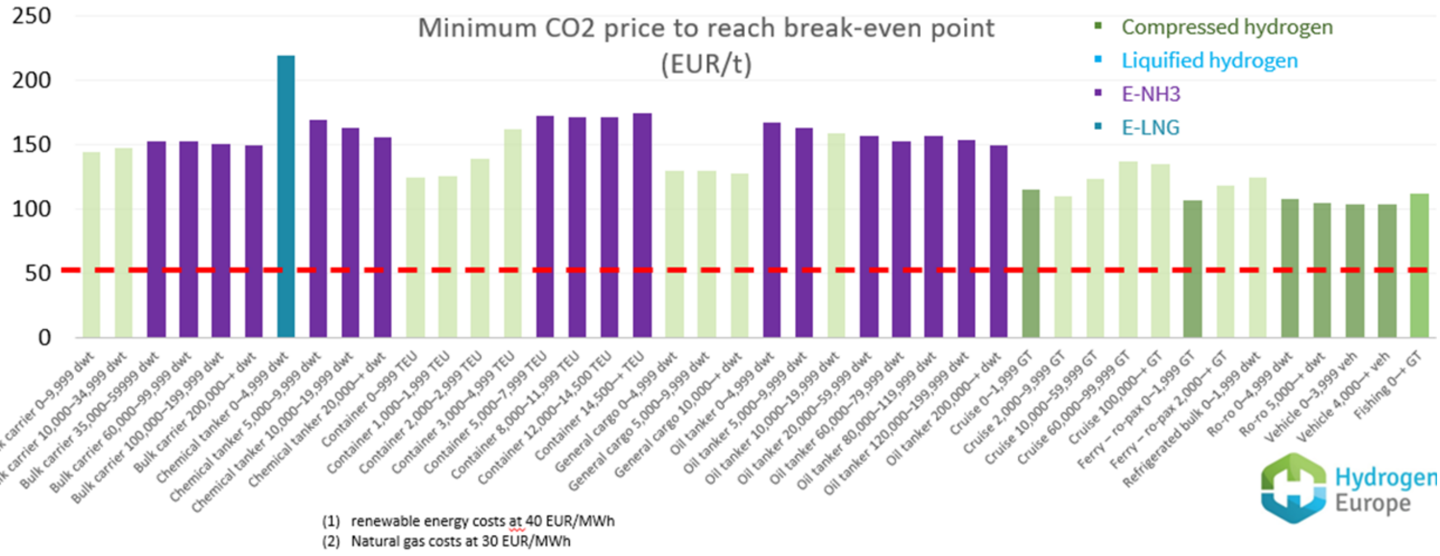
the uptake of energy saving technologies on ships, bunkering/charging infrastructure for zero-carbon fuels/energy in European ports and subsidising the uptake of zero-carbon fuels by ships via carbon contracts for difference.

The moderate price level of the EU Emissions Trading System (EU ETS) and the uncertain price development does however not provide sufficient incentives for significant investments in innovative climate-friendly options. Carbon Contracts for Differences offer the opportunity to guarantee investors in innovative climate-friendly technologies and practices a fixed price that rewards CO2 emission reductions above the current price levels in the EU ETS.

Climate targets can only be achieved with a shift to new technologies. Putting a price on shipping carbon emissions would be a welcome first step in establishing a regulatory framework, provided that the revenues flow back to the maritime sector where it can act as an important driver for necessary investments in sustainable fuels and innovative techniques on board.

Carbon pricing through an emission trading system seems straightforward but the current ETS has shown to have limited effect. Therefore it should be recognised that ETS is only a part of the solution. The figure below is a calculation that Hydrogen Europe made showing the price of emission allowances that would be needed per ship type in order to trigger the uptake of hydrogen which is much higher than the current price of emission allowances. The red line shows the price of emission allowances at 50EUR t/CO2. The bars show the price that would be needed per ship type to have a real impact. Even including shipping in the ETS will not be enough to drive the technology revolution needed to achieve the achieve the IMO 2050 target.



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5.4 Technical regulation allowing the introduction of new fuels and energy converters in ships and bunkering infrastructure in ports

In the absence of IMO regulation on how to build hydrogen fuelled ships safely, classification societies currently approve the use of other low flashpoint fuels including hydrogen based on alternative design. The alternative design is the process by which the safety, reliability and dependability of the systems must be demonstrated to be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery. The development of specific rules allowing for the type approval of hydrogen and HFC vessels at international level as well as for inland transport in EU waterways is needed in order for this sector to develop. Class Societies should group common practices for approval at a certain stage and use these as a standard development route for FC Systems in ships. In this regard standardization of hydrogen storage is also considered a key element.

Regarding bunkering and infrastructure, the development of national regulation has proven to be a barrier to the uptake of alternative fuels. Especially for short sea shipping harmonization of regulation/guidelines on e.g. bunkering (the ship-shore interface) needs to start now. A robust and sound alternative fuel framework both at IMO, European, national and local level is a prerequisite for the uptake of hydrogen in shipping.

Many lessons can be learned from the introduction of LNG as a fuel for ships prior to the implementation of the 0.1% Sulphur limit in the Emission Control Areas (ECAs) in 2015. Back then the mitigation of pollutants (SOx, NOx and PM) was the main focus of EU member states and ports, while CO2 has now become the key element to tackle.

In this context LNG was regarded a promising alternative fuel for the transition towards more sustainable shipping. The IMO focused on developing a code (IGF-code) allowing ships to burn LNG safely but could not consider the ship-shore interface (bunkering) and issues such as safe loading and unloading of ships while bunkering, standardization of connectors, methane slip, etc...In order to give certainty to shipowners that they could bunker LNG in a similar way to HFO/MGO the EU published EU bunkering guidelines for LNG-fueled ships in 2018. Port authorities have welcomed this but are bound by own local stricter regulations. Uncertainty about the availability of LNG in ports led to more uncertainty.

The lessons learned from those experiences should be leveraged in developing faster new and effective harmonized frameworks at EU level (e.g. on standardization, harmonization of local rules) and robust regulation on SAF-infrastructure for alternative fuels where hydrogen is given a prominent role.

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alimenter des chariots à hydrogène gazeux lorsque la quantité d'hydrogène présente au sein de l'établissement relève du régime de la déclaration pour la rubrique n° 4715 et modifiant l'arrêté du 4 août 2014 relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n° 4802, < https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000037519292 >

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