Regulation for the Decarbonisation of IWT in Europe

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Abstract. To ensure its future, the response of IWT to climate change must be twofold: it must adapt to the changing climate and mitigate its carbon footprint. The former will make IWT resilient against adverse effects of climate change, the latter will bring IWT in line with the Paris Agreement and decarbonise IWT. PIANC, in its 2019 Declaration on Climate Change, stated that "… PIANC and its members will strive to develop approaches to decarbonise the operation of port and navigation infrastructure (i.e. move to net zero emissions), whilst at the same time enabling the reduction of greenhouse gas (GHG) emissions from vessels by providing the necessary facilities, infrastructure and, where appropriate, incentives…" The European Union (EU) and the Central Commission for the Navigation of the Rhine (CCNR) more explicitly aim at zero-emission vessels and eliminating GHG emissions from inland navigation vessels by 2050. For doing so, EU and CCNR will go beyond the measures foreseen in PIANC's declaration and will employ regulations and standards as well, since regulations and standards are important policy instruments to facilitate the transition towards carbon neutral IWT. This paper will present respective regulations and standards which are already in place, currently under development or whose development is foreseen to effectively support the transition towards a zero-emission IWT fleet in Europe. Vessel technical requirements are at the core of the contribution, but requirements concerning vessel operation and crew training are also considered. The paper analysis the basic content of the regulations and standards and provides general recommendations for the way forward.

Keywords: Decarbonisation · IWT · Regulation · CCNR · CESNI

1 Policy Context

The European Commission's Green deal for Europe (European Commission, 2019) and Smart and Sustainable Mobility Strategy (European Commission, 2020a) lay out priority actions to be realised for achieving a GHG emission reduction target of roughly 55% by 2030 compared with 1990 (for all sectors), and a GHG reduction target of 90% by 2050 (for the transport sector). In line with the above, the European Commission's NAIADES III Action plan (European Commission, 2021) includes the core objective

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of facilitating the transition to zero-emission vessels by 2050. In the Declaration signed in Mannheim in 2018 (Central Commission for the Navigation of the Rhine, 2018), the inland navigation ministers of the Member States of the CCNR, namely Belgium, Germany, France, The Netherlands and Switzerland, defined similar targets of largely eliminating GHG emissions by 2050.

Regulations and standards are important policy instruments to enable and stimulate the transition towards carbon neutral IWT. Regulations and standards provide for legal certainty, which in turn facilitates investments in new technologies. Indeed, legal uncertainties and long administrative procedures could be a bigger obstacle to decarbonising the fleet than strictly technological issues. Furthermore, regulations and standards ensure safe deployment as well as public support and confidence in the new technologies and energy carriers, which are all needed to overcome the many challenges arising with the decarbonisation of IWT.

Presently, IWT in Europe views battery electric propulsion as well as fuel cells using hydrogen or methanol as the most promising solutions for decarbonisation of the fleet. They are therefore at the centre of the current work on new regulations and standards.

2 Scope

This paper considers regulations and standards adopted by the EU and the CCNR, which can be seen as having established a shared governance for IWT in Europe. The paper takes into account this shared governance in order to provide analysis and recommendations aiming at a smooth and coordinated transition of regulatory frameworks towards decarbonized IWT in Europe.

The scope of this paper is limited to fleet related regulations: vessel construction and equipment, vessel operations including bunkering as well as crew qualification and manning. These regulations have significant effects on the total cost of ownership and the legal certainty.

There are numerous technologies which can be applied in possible pathways for the decarbonisation of inland navigation vessels. However, when developing regulations

Table 1. TRLs defined within the Horizon 2020 Programme (European Commission, 2020b)

	DEFINITION
TRL 1	basic principles observed
TRL 2	technology concept formulated
TRL 3	experimental proof of concept
TRL 4	technology validated in lab
TRL 5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	system prototype demonstration in operational environment
TRL 8	system complete and qualified
TRL 9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

and standards for new technologies, only those technologies can be considered, which are already sufficiently developed and understood. An accepted method for expressing their development stage is the technology readiness level (TRL). Table 1 depicts the TRL as defined within the Horizon 2020 Programme.

The CCNR commissioned an assessment of technologies in view of zero-emission IWT, using these TRL definitions. Figure 1 summarizes suitable technologies and the respective TRLs.

The technologies listed in Fig. 1 reflect the current state of knowledge. The CCNR decided to focus on a set of technologies with a TRL of 5 and above. Other technologies like lithium-air batteries or LOHC (Liquid Organic Hydrogen Carrier) could be studied at later stage. Even if ammonia seems to be a serious candidate for seagoing vessels, it presents major safety issues, especially while bunkering (Heitink et al. 2021), and is therefore excluded from this analysis.

Technologies considered in the pathways	Description	TRL (1-9) vessel application	TRL (1-9) fuel / energy production and supply
Stage V, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits EU Stage V.	9	9
LNG	Liquefied Natural Gas in an internal combustion engine which complies with the emission limits EU Stage V.	9	9
Stage V, HVO	HVO in an internal combustion engine which complies with the emission limits EU Stage V. HVO stands for hydrotreated vegetable oil itself (without blending with fossil fuels) and all comparable drop-in biofuels (including e-fuels) as well as synthetic diesel made with captured CO_2 and sustainable electric power.	9	9
LBM	Liquefied Bio Methane (or bio-LNG) in an internal combustion engine which complies with the emission limits EU Stage V.	9	8
Battery	Battery electric propulsion systems, with fixed or exchangeable battery systems.	8	7
H_2, FC	Hydrogen stored in liquid or gaseous form and used in fuel cells.	7	7
H_2, ICE	Hydrogen stored in liquid or gaseous form and used in internal combustion engines.	5	7
MeOH, FC	Methanol used in fuel cells.	7	6
MeOH, ICE	Methanol used in internal combustion engines.	5	6

Fig. 1. Technologies on possible pathways for the decarbonisation of inland navigation vessels

with TRLs for application on the vessels as well as TRLs for the fuel / energy production and supply.

(Dahlke-Wallat et al. 2021).

3 Vessel Design and Propulsion System

In the legal context of the EU and the CCNR the vessel technical requirements and regulations applicable to engines or energy converters determine the legal feasibility of the use of alternative energies for the propulsion of IWT vessels.

3.1 Vessel Technical Requirements

A vessel operating on EU waterways or the Rhine must carry either a Union inland navigation certificate or a Rhine vessel inspection certificate. Both certificates are issued by the competent national authorities (inspection bodies) and confirm full compliance of the vessel with the European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN) (European Committee for drawing up Standards in the field of Inland Navigation, 2021a). This standard contains provisions on inland navigation vessel construction and equipment as well as special provisions for certain categories of vessels such as passenger or container vessels. The objective of these technical requirements is to guarantee a high level of safety in inland navigation, thereby also protecting the environment and the people on board. ES-TRIN is updated every two years by the European Committee for drawing up standards in the field of inland navigation (CESNI). References to ES-TRIN are included in the legal frameworks of the EU and the CCNR, Directive (EU) 2016/1629 (EU, 2016a) and Rhine Vessel Inspection Regulations (RVIR) (Central Commission for the Navigation of the Rhine, 2020) respectively.

ES-TRIN foresees that vessels use conventional diesel as fuel. Its Article 8.01(3) states that "Only internal-combustion engines burning fuels having a flashpoint of more than 55 °C may be installed." Article 8.05 includes safety requirements for diesel tanks and piping. However, in 2017 the first step was taken to recognize alternative fuels in ES-TRIN, by including general provisions for low flash point fuels (Chapter 30) and an annex dedicated to liquefied natural gas (LNG) (Annex 8). But at present, ES-TRIN does not permit the use of other low flash point fuels (such as hydrogen). Edition 2021 of ES-TRIN also regulates lithium-ion batteries (especially the design of rooms where such batteries are stored) (Article 10.11).

Gaining knowledge and experience from pilot projects facilitates the development of regulations and standards for innovative technologies. This is one reason, why the regulatory frameworks of the EU and the CCNR foresee derogations from ES-TRIN. For example, on 17 June 2021, the CCNR granted a derogation for the motor vessel MAAS which will use hydrogen as fuel and a fuel cell as energy converter (Central Commission for the Navigation of the Rhine, 2021). In 2019 CESNI published a guidance (European Committee for drawing up Standards in the field of Inland Navigation, 2019a) describing the procedure for derogations with the objective to facilitate administrative procedures and actively support the greening of the fleet.

In 2020, CESNI established a temporary working group to prepare amendments to ES-TRIN allowing the use of fuel cells but also the storage of methanol and hydrogen on board of inland navigation vessels. The composition of the group reflects the CCNR's experience that intensive stakeholder involvement is an important success factor for regulatory and standardisation work. Members of the group are therefore not only drawn from the member states' administrations, but also from relevant industries (European Committee for drawing up Standards in the field of Inland Navigation, 2021b). The group has chosen an approach based on a combination of prescriptive rules and risk analysis (like the LNG rules currently in ES-TRIN). The amendments prepared by the group foresee a revision of Chapter 30 and reorganisation of Annex 8 of ES-TRIN to distinguish between different energy converters (engine or fuel cell), but also between energy converters and fuel storage. This allows for a stepwise integration of new fuels and energy converters in the future. But most importantly, the amendments contain technical requirements for fuel cells installed in inland navigations vessels. It is expected that the amendments will be included in ES-TRIN 2023 which could enter into force in January 2024 (European Committee for drawing up Standards in the field of Inland Navigation, 2022). CESNI expects to finalise the standardisation work on methanol storage and use in combustion engines by end of 2022. The temporary working group is now deliberating requirements for the storage of hydrogen, which introduces complex technical and regulatory issues and requires therefore more time. Because almost all hydrogen pilot projects rely on swappable fuel tanks, the group will consider such arrangements in future amendments of ES-TRIN.

3.2 Regulations Applicable to Engines or Energy Converters

Since 2003, the engines of inland navigation vessels are subjected to specific requirements regarding emissions of air pollutants. Indeed, first limits for air pollutants were introduced in the RVIR in 2003 (so called CCNR stage I). These limits only applied to newly installed engines onboard inland navigation vessels. Just four years later, the CCNR and the EU introduced more stringent emission limits in the RVIR and the Directive 2004/26/EC (so called CCNR II or EU IIIa). Taking effect as of 1 January 2019, new emission limits (so called EU Stage V limits) were introduced by the "NRMM Regulation" (EU) 2016/1628 (EU, 2016b). Seeing no further need for parallel emission requirements within its own regulatory framework, the CCNR decided to align it with that of the EU and to refer to this regulation. A summary of the successive limits of air pollutants emissions is given in Fig. 2.

As pointed out in the EU funded project Prominent (Stichting Projecten Binnenvaart, 2016), most vessels of the European inland navigation fleet are equipped with engines installed before 2003. These engines are not subject to any emission limits because the emission requirements apply only to newly installed engines. The reason for the slow renewal of engines used for inland navigation is their long technical lifetime.

To reflect LNG becoming a fuel for inland navigation vessels, the NRMM Regulation includes specific provisions on total hydrocarbon (HC) limits for fully and partially gaseous-fuelled engines. The objective was notably to limit the emission of unburned methane (which is a potent GHG) from the combustion engine, the so-called

methane slip. Indeed, on-board measurements suggest that marine engines using LNG show a significant methane slip, particularly at low loads (Ushakov et al. 2019), which are typical for the operation of inland navigation vessels. Thus, the reduction of pollutant emissions by using LNG may lead to higher GHG emissions in comparison with conventional diesel engines. At least, the reduction of GHG emission associated in theory with the use of LNG does not translate in IWT practice.

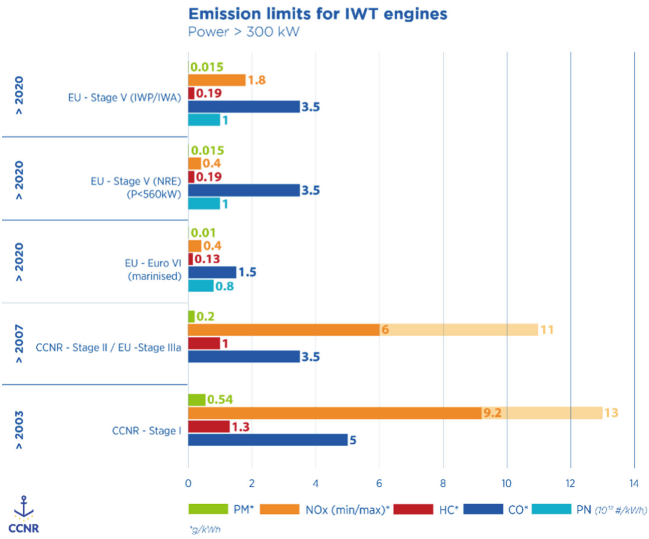

Fig. 2. Summary of mandatory limits of air pollutants emissions (source: CCNR)

4 Vessel Operation

In Europe, vessel operations are generally covered by national and international police regulations. In the following, the police regulations applicable for the Rhine and equivalent recommendations adopted by the United Nations Economic Commission for Europe (UNECE) are considered. There is no EU legal instrument in the field of police requirements.

The Police Regulations for the Navigation of the Rhine (RPR) (Central Commission for the Navigation of the Rhine, 1995) contain the core rules applicable to the traffic on the Rhine such as visual and sound signals, radiotelephony, waterway signs and markings, as well as navigational, crossing and berthing rules. It also regulates for example the electronic reporting or mandatory use of the Automatic Identification System (AIS) equipment and provides a list of paper or electronic documents required on board.

The RPR constitute the legal basis for the international navigation of the Rhine and inspire significantly national regulations of the CCNR member states.

After having temporarily authorised 15 vessels using LNG as fuel for trial purposes, the CCNR updated in 2015 its core regulations, among them the RPR, to allow

the use of LNG as regular fuel for vessels sailing on the Rhine (Central Commission for the Navigation of the Rhine, 2015). In close cooperation with the inland navigation profession and technical experts who already had experience in the use of LNG, the CCNR incorporated in the RPR requirements concerning markings, passing through locks, electronic reporting, safekeeping and surveillance as well as bunkering of LNG. For the latter, a dedicated checklist was drawn up based on a list developed for maritime ports. More generally, the LNG requirements contained in the RPR were an important source of inspirations for national or international instruments.

To implement the objectives of the Mannheim Declaration, the CCNR included in its work programme 2022–2023 updating the RPR to facilitate the use of alternative fuels other than LNG, in particular hydrogen and methanol (Central Commission for the Navigation of the Rhine, 2021). Here again, the experience gained with pilot vessels will be of major importance. The main challenge will be to determine, whether additional rules are necessary at all to ensure an equivalent of safety when using these new fuels. The design of possibly necessary rules could be a lesser challenge, as the already existing rules for vessels using LNG as a fuel provide a suitable template. The best outcome for the navigation industry and also for accelerating the decarbonisation of IWT would probably be a scientifically sound reasoning, that no additional rules are needed.

The European Code for Inland Waterways (CEVNI) contains the core rules applicable to the traffic on inland waterways in the UNECE region such as marks and draught scales on vessels, visual and sound signals on vessels, waterway signs and markings, as well as navigational, crossing and berthing rules.

CEVNI is not legally binding but constitutes a technical basis to facilitate the harmonisation of the police requirements for inland navigation in Europe. Indeed, CEVNI is regularly updated to follow the evolution of the navigation regulations of River Commissions or national rules.

The sixth revised edition of CEVNI (United Nations Economic Commission for Europe, 2021) takes into account best practices from the existing up-to-date traffic regulations. In particular, this edition contains the provisions for the safety of vessels using LNG.

5 Crew Qualification and Manning

The Regulations on Navigation Personnel on the Rhine (RPN) (Central Commission for the Navigation of the Rhine, 2022) lay down the rules for personnel on board vessels sailing on the Rhine. The regulations' primary objective is safety of navigation. They cover the qualifications of personnel, particularly the skills required of boat-masters and the manning requirements of crews (i.e. number and qualification of the crew for specific vessels types). In 2015, the CCNR added provisions concerning the expertise of crew members of inland navigation vessels fuelled by LNG (Chapter 4a) (Central Commission for the Navigation of the Rhine, 2015). It stipulates that all crew members involved in the bunkering procedure shall have sufficient expertise. It lays down also the content of training courses and examinations.

The respective regulations of the EU and the CCNR are currently reviewed with the aim of referring in the future to CESNI's standards related to professional qualifications

in inland navigation (ES-QIN) (European Committee for drawing up Standards in the field of Inland Navigation, 2019a). The latter lays down details of a new competence-based approach for deck crew members to improve navigational safety with competent, well-trained personnel, creating interesting career opportunities and easing job mobility within Europe. The CESNI work programme for 2022–2024 (European Committee for drawing up Standards in the field of Inland Navigation, 2021b) also includes the development of "competence standards for new and innovative technologies including the use of relevant alternative fuels, batteries and electric propulsion systems".

Moreover, the EU and the CCNR strive for a sweeping modernisation of the manning regulations. Taking into account the organisations' policy objectives (Central Commission for the Navigation of the Rhine, 2018; European Commission, 2021) and specifically commissioned research work (Henn et al. 2019), the CESNI drafted a roadmap with the aim to investigate all important subjects for developing standards for manning regulations, including innovation and technology changes. A sector (stakeholder) consultation event dedicated to the roadmap for European manning regulations was organised in December 2021 (European Committee for drawing up Standards in the field of Inland Navigation, 2021c). The sector' comments on the roadmap will feed into the future work of CESNI under its new work programme 2022–2024.

6 Conclusions

Table 2 indicates the progress of the regulatory work for the decarbonisation of IWT in Europe. For vessel technical requirements, necessary standards for the deployment of LNG, hydrogen and methanol as well as electric batteries are already drafted or at least under development. For police and crew related requirements, necessary work is foreseen in the respective work programmes, but still in the phase of needs evaluation.

Table 2. Summary of the status of regulations and standards for the use of new technologies for the propulsion of IWT vessels in Europe

Energy carrier for IWT propulsion	Vessel technical requirements	Police requirements	Qualification and manning requirements
Diesel (or Bio-Diesel)	Ready	Ready	Ready
LNG (or Bio-LNG	Ready	Ready	Ready
Battery	Ready (for Lithium-ion batteries but ongoing work for swappable battery containers)	Evaluation of the need of safety requirements	Evaluation of the need of safety requirements / Reseach work
Hydrogen (combustion engines or fuel cells)	Ready for fuel cells. On-going for storage and use in combustion engine	Evaluation of the need of safety requirements	Evaluation of the need of safety requirements / Research work
Methanol (combustion engines or fuel cells)	Ready for fuel cells. On-going for storage and use in combustion engine	Evaluation of the need of safety requirements	Evaluation of the need of safety requirements / Research work

Nevertheless, the authors, being involved in this work already for many years chiefly regarding vessel technical requirements, are convinced, that the remaining work will also achieve the objectives stipulated in the respective work programmes. Important research projects, often funded by the EU, and numerous pilot vessels, initiated by forward-looking shipowners, are creating knowledge and experience, from which the CCNR and the EU can draw. Possibly the most important success factor for this work is the direct involvement of experts from equipment manufacturers, shipyards and shipping companies as well as classification societies in the development of necessary standards and regulations, not only consulting them on draft documents, but rather involving them already early on in the drafting process.

IWT needs to decarbonise not only in Europe, but everywhere. The authors hope that sharing the results of the ongoing regulatory and standardisation work as well as the lessons learned in Europe will be useful for experts involved in the development of standards and regulations elsewhere in the world and will eventually kickstart a worldwide exchange on this existential challenge for IWT.

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