IKEM

LEGAL STUDY

# Regulatory framework for a German-Australian hydrogen bridge

Commissioned for the project "HySupply – German-Australian Feasibility Study on Hydrogen from Renewable Energies"

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## Regulatory framework for a German-Australian hydrogen bridge

This study examines key issues associated with the regulatory framework for the development of a hydrogen import from Australia to Germany via liquefied hydrogen, ammonia, methanol, and liquid organic hydrogen carriers. It analyses the legal feasibility of the import with a focus on substance-related barriers.

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# Contents

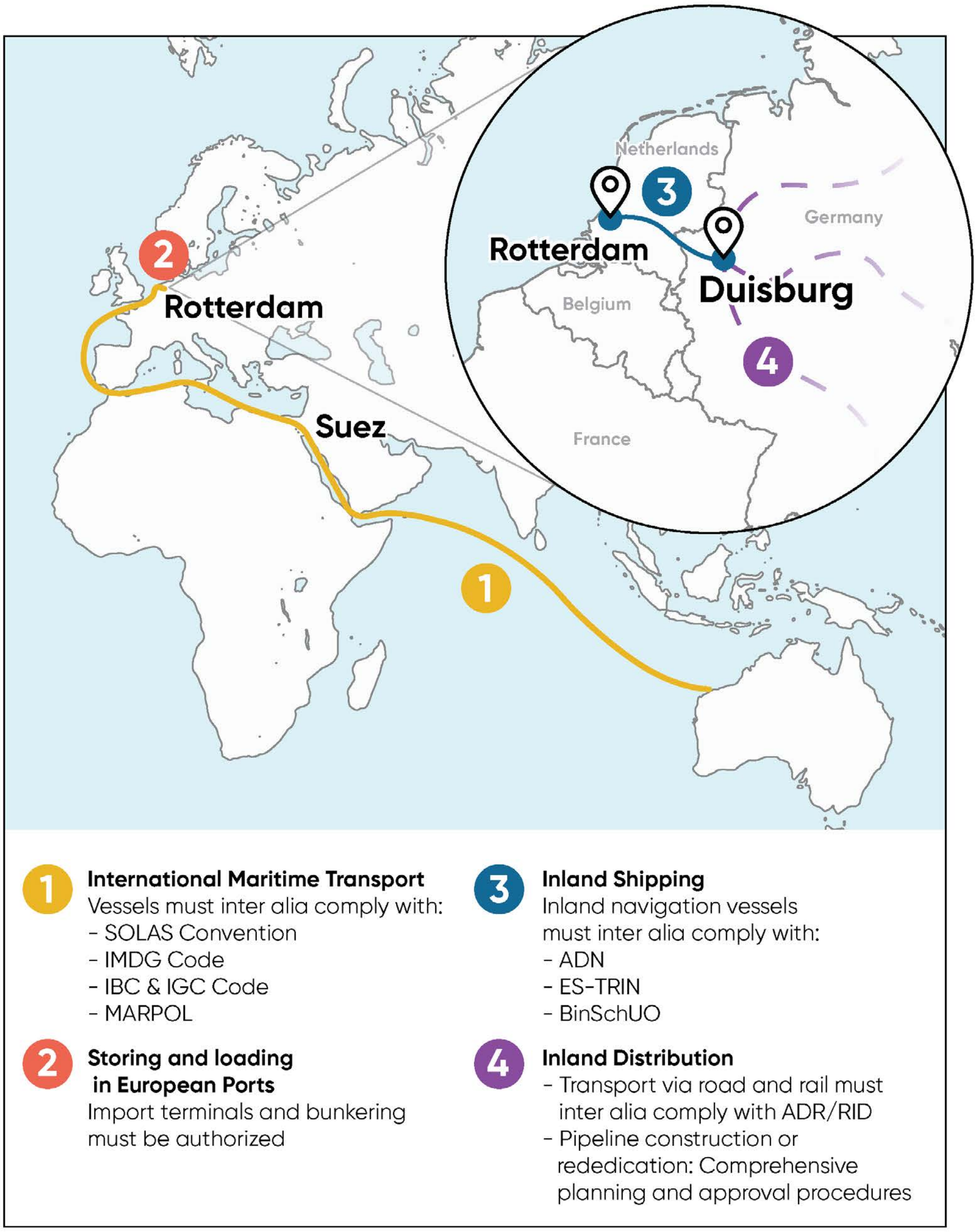
# Executive summary

Commissioned for the project “HySupply – German-Australian Feasibility Study for Renewable Hydrogen”, this study examines the regulatory framework for the import of renewable hydrogen from Australia to Germany via four transport options: liquefied hydrogen ($LH_2$), ammonia ($NH_3$), methanol (MeOH) and liquid organic hydrogen carriers (LOHC). With regard to LOHC, HySupply focuses on benzyltoluene (BT) and to a lesser extent on dibenzyltoluene (DBT).

While market regulation and trade law are equally important for achieving a reliable import infrastructure, this study primarily examines **substance-related regulation**, as this may present the most imminent obstacle to the vision of a German-Australian ‘hydrogen bridge’. The study further examines the simultaneous use of the above-mentioned hydrogen **transport options** as **fuel** and provides an overview of the most relevant **policy makers and stakeholders** involved in the development of the legal framework at international and European level. The aim of the study is (1) to **assess the general legal suitability** of the existing legal framework and, in particular, (2) to **identify potential legal barriers** that may present an obstacle to the establishment of a hydrogen bridge between Australia and Germany.

The review of the regulatory framework conducted for this study revealed that (1) **this framework generally allows for the establishment** of the **import infrastructure** for all four transport options. However, the regulatory framework contains (2) **extensive legal requirements** – and thus presents high legal hurdles – for the construction of the vessels, safe handling, documentation and staff, and requires several authorisations at various levels. This may result in **legal barriers for specific implementation steps** when it is impossible to comply with the requirements for factual reasons. The extent to which these requirements may impede implementation of the infrastructure thus mainly depends on individual conditions and must be **thoroughly assessed for each individual implementation step**.

While it remains to be individually assessed on a case-by-case basis, legal requirements that could hinder the implementation of the envisaged hydrogen infrastructure are outlined along the transport route, starting with the **classification of the carrier substances** as the determinant for the relevant regulatory framework. The following figure visualises the steps examined along the transport route:



The study found that three of the four transport options examined here are internationally classified as dangerous goods: **$LH_2$, ammonia** and **methanol**. This leads to significant differences concerning substance-related regulations, as LOHC are not subject to regulations governing the transport of dangerous goods. However, uncertainty remains regarding the classification of LOHC, as relevant data has not yet been obtained. Therefore, according to current knowledge, the transport of LOHC[1] should not be as restricted as the transport of $LH_2$, ammonia and methanol. The latter is extensively regulated by a complex system of international, European, and national laws that contain detailed technical provisions to ensure the safe handling of these dangerous goods.

Along the **transport route**, international, European, and national regulation applies. International regulation on the transport of dangerous goods has almost entirely been adopted into national law. Thus, while operating at different levels, the content of the regulation remains similar. The regulation differentiates between the carriage of dangerous goods **in bulk** (gas carriers, chemical tankers) and in **packaged form** (e.g. receptables for gases). Depending on the dangerous good and the carriage in bulk or packaged form, the study found that the following applies to the international transport of seagoing vessels:

- $LH_2$ and ammonia in bulk is within the scope of the IGC Code (gas carriers).
- $LH_2$, ammonia and methanol in packaged form fall within the scope of SOLAS Convention and the IMDG Code.
- Methanol in bulk falls within the scope of the IBC Code (chemical tankers).
- Because MARPOL classifies methanol as a noxious substance, methanol transport must also comply with the requirements of parts of MARPOL.

**Vessels** carrying $LH_2$, ammonia and methanol therefore **must comply** with various technical provisions of the above-mentioned codes and **must be certified accordingly** by the competent authority, e.g., the flag state administration. The transport of all three is **otherwise not allowed**; notably, **transit through the Suez Canal** may not be permitted. Navigating vessels that are not in compliance with the relevant regulation or not certified accordingly may be fined under national law.

This study found that these requirements do not apply to the carriage of **LOHC**. Transport of LOHC is **not regulated** in this regard, meaning the transport is subject neither to mass limitations, package requirements and safety obligations nor to the certification requirements. However, maritime transport of LOHC may require a **provisional assessment under MARPOL**, as potentially noxious characteristics of LOHC have not yet fully been determined.

Regarding import to Europe, the study found the following: prior to arrival at Europe's borders, the **import of quantities of 1 tonne** or more per year of all four carrier substances must be **registered** at the European Chemical Agency. **Import terminals** must be built for the respective hydrogen carriers in European ports; this requires a **concession** by the state-controlled port authority. New terminals must be **authorised**. Different requirements apply to the four hydrogen carriers due to their different chemical characteristics. LOHC import terminals require a building permit as well as authorisation in accordance with the Federal Nature Conservation Act and the Federal Water Act, depending on local conditions. **Storage facilities** with a storing quantity of three tonnes or more of $LH_2$, ammonia and methanol fall within the scope of **the Federal Immissions Protection Act**, the **Environmental Impact Assessment Act**; for methanol, the **Industrial Safety Regulation** also applies.

The study found that, depending on the characteristics of the good, different **national obligations** apply with regard to **commercial supply and handling**: in Germany, **authorisation** may be required for the commercial supply of **ammonia** and **methanol**, though not for that of LOHC and $LH_2$. For the handling of LOHC, a **preliminary risk assessment** may be necessary, as the hazardous characteristics of LOHC have not yet been fully determined; the preliminary risk assessment is intended to determine whether the employees are exposed to hazardous substances.

This study found that, when transferring from international shipment to inland shipping, vessels operating on the Rhine and on waterways of the EU must be certified either with a **Rhine navigation certificate** or a **Union certificate for inland waterway vessels**. Both certificates are issued by the national authority and confirm the full compliance of the vessel with the technical requirements of the ES-TRIN. For seagoing vessels on inland waterways, it is sufficient to possess a proof of compliance with SOLAS or MARPOL or an equivalent certificate (e.g. according to the IGC and IBC Code).

1 The study's assessment of LOHC is limited to BT and DBT.

On inland waterways, the transport of the four hydrogen carriers is further regulated:

- **$LH_2$** may only be transported on inland waterways in **packaged form**, not in bulk on tankers.
- The **ADN** requires vessels transporting $LH_2$, ammonia and methanol to obtain a **certificate of approval** confirming full compliance with the technical requirements of the ADN.
- For all ships carrying $LH_2$, ammonia and methanol (and therefore falling under the scope of the ADN), **the port authority must be notified prior to entrance into the ports in North Rhine Westphalia.**

With regard to **landside distribution**, **transport routes are limited** for certain dangerous goods:

- **Ammonia** being liquified at -33°C may only be transported via tank vessels on inland waterways, not via road.
- Transport routes **for $LH_2$, methanol** and **ammonia** are limited by the **tunnel restrictions** of the ADR.
- German national legislation requires the transport of $LH_2$, ammonia and methanol in principal to be shifted from roads to **rail or inland waterways or highways**, depending on the mass quantity of the carried substance and the distance of the transport route.

The study also analyses the relevant regulatory framework for transport via pipeline. The regulations of the Energy Industry Act (EnWG) require a **planning approval procedure** for the **construction of new pipelines for hydrogen**. The **repurposing of existing natural gas infrastructure** for pure hydrogen networks is facilitated by current legislation and will often require a much less comprehensive notification procedure. In principle, § 65 UVPG provides a **legal basis for the construction of new pipelines for ammonia, methanol and LOHC**. However, in contrast to the legislation concerning gaseous hydrogen networks, there are no legal facilitations in place to enable a pipeline infrastructure for hydrogen carriers. Constructing new pipelines will require comprehensive planning and approval procedures. The success of such planning projects can be assessed only on a case-by-case basis.

The **simultaneous use of the hydrogen transport options as fuel** during transport is regulated to a varying extent: the IGF Code and ES-TRIN only provide technical provisions for LNG as marine fuel. LOHC, $LH_2$ and ammonia are not yet regulated as marine fuels. For methanol as a marine fuel, interim guidelines exist, although these are not yet legally binding. CESNI, the European committee that develops standards in the field of inland navigation, has **begun to draw up standards for the use of alternative fuels on inland navigation vessels** and expects to **publish them in 2024**.[2] In general, the process of drawing up new standards can be expected to take up to five years. Until fully regulated, the use of alternative fuels (including LOHC, $LH_2$, ammonia and methanol) must be **authorised** by the flag state's government or, for inland navigation vessels, by the national authority undergoing the procedure for the **alternative design approach**, which aims to ensure a level of safety equal to that of conventional marine fuels, for example through a comprehensive risk assessment and identification of hazards. However, the IGC Code does **not currently permit ammonia as a marine fuel for gas carriers**. Because a ship carrying ammonia in bulk qualifies as a gas carrier, the **option of bulk transport with simultaneous use as marine fuel is not available for ammonia**.

Regarding **bunkering**, this study found that bunkering low-flashpoint fuels requires **authorisation** by the port authority and, under certain conditions, a **preliminary risk assessment** in most ports of Germany. However, German law offers no uniform legal approach to the bunkering authorisation for alternative marine fuels. This may result in differing authorisation requirements and practice and hence to legal uncertainty. The Havenverordening Rotterdam currently **prohibits the use of fuels with a flashpoint below 55°C** (thus including $LH_2$, ammonia and methanol). This threshold serves as a crucial limit both in German national law on bunkering and in the regulation on inland navigation vessels. Consequently, the bunkering of fuels below this flashpoint either is not permitted or requires a preliminary risk assessment and separate authorisation.

2 CESNI, work programme 2022-2014, PT-1. The Timeline is as follows: 1) storage of methanol, 2) storage of hydrogen (liquefied and gaseous), 3) methanol in internal combustion engines, 4) storage and use of compressed natural gas, 5) other alternative fuels.

# 01 Aim of the analysis

The project "HySupply – German-Australian Feasibility Study for Renewable Hydrogen" (HySupply) investigates the **feasibility of an Australian-German supply chain** for renewable hydrogen that includes steps for production, storage, and transport. For long-distance hydrogen transport, only two transport modes are available: pipelines and marine vessels. However, it is not feasible for pipelines to bridge the vast distance between Australia and Germany. To enable transport at scale by marine vessels, gaseous hydrogen must be converted into carriers, which offer a higher volumetric density and allow for better handling during carriage. HySupply analyses the following four carrier options: $LH_2$, LOHC (specifically BT and DBT[3]), ammonia and methanol.[4]

3 In the following discussion, references to LOHC include both benzyltoluene and dibenzyltoluene unless stated otherwise.

4 For further details, see: BDI and acatech - National Academy of Science and Engineering, 'HySupply. A Meta-Analysis towards a German-Australian Supply-Chain for Renewable Hydrogen', 2021, 14. and UNSW Sydney, The Case for an Australian Hydrogen Export Market to Germany: State of Play Version 1.0, 2021.

The following analysis evaluates the **general suitability of the existing legal framework** for a hydrogen supply chain from Australia to Germany via these transport options. The analysis examines the transport of the four hydrogen carriers by marine vessels to the port of Rotterdam or to a German port, as well as the distribution via inland waterway, road, rail, and pipeline within Germany. It also assesses the regulatory framework for the use of the carriers as fuel. The legal analysis **focuses on substance-related regulation** for the respective transport options, as this has the potential to present the most imminent barrier to the implementation of a German-Australian Hydrogen Bridge. Due to the limited scope of the study, market regulation and trade law are not assessed, although both are nonetheless key factors for the implementation of a reliable supply chain. The extent to which transport is regulated depends strongly on the specific properties of the respective substance, the most relevant of which are shown in the table below.

In many cases, these properties determine the applicability of certain regulations. For the most relevant regulations, this analysis identifies the scope of application and outlines the legal consequences. While providing a general overview of the applicable regulation, this study specifically aims to

- **assess the legal feasibility** of the existing legal framework for establishing a German-Australian hydrogen bridge for each of the four transport options as well as for the simultaneous use of the four transport options as fuel.
- **identify legal gaps and barriers** that could hinder the implementation of hydrogen import infrastructure for each of the four transport options or the simultaneous use as fuel.
- **provide an overview of the stakeholders and policy makers** that are most relevant to the development of a regulatory framework at the international and European level.

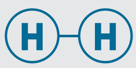
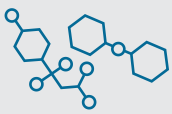
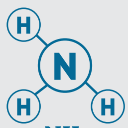
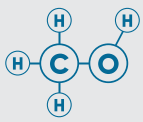
| Substance | Chemical Formula | Aggregate | Vapor pressure at 20 °C | Flash point | Prevalence as a traded commodity |
|---|---|---|---|---|---|
| **Liquid hydrogen** |  $LH_2$ | Liquid at -253 °C and 1 bar | - | Low flashpoint | Currently used in niche applications, not yet a globally traded commodity |
| **Liquid Organic Hydrogen Carriers (LOHC): Benzyltoluene** |  $C_{14}H_{26}$ / $C_{14}H_{14}$ | Liquid at ambient conditions | 0.66 Pa | 137 °C | Limited experience of large scale handling, no established global market |
| **Ammonia** |  $NH_3$ | Liquid at -33 °C and 1 bar | 8,5737 bar | Low flashpoint | Globally traded commodity, extensive experience in handling, processing and transportation |
| **Methanol** |  $CH_3OH$ | Liquid at standard conditions | 0,129 bar | 9 °C | Globally traded commodity, extensive experience in handling processing and transportation |

*Table 1: Properties of the four hydrogen transport options ($LH_2$, LOHC, ammonia and methanol). Source: Own presentation.*

# 02 Methodology

To evaluate the general suitability of the current legal framework for the introduction of a German-Australian hydrogen bridge, it is necessary to outline the existing regulatory framework at international, European, and national level. Therefore, the analysis conducted for this study examines the legal framework that applies to each section of the transport route.

The descriptive presentation of the legal status quo is complemented by an analysis of the applicability of the relevant legal provisions to each of the carrier options. In this way, legal barriers and obstacles that may prevent or impede transport can be identified along each section of the transport route for the four hydrogen transport options. The applicable legal framework for all transport steps also greatly depends on the international classification of the hydrogen carriers as dangerous goods. Therefore, the following legal areas are explored:

- the classification of substances as dangerous goods
- international maritime law
- national law on bunkering and storing in European ports
- national law on inland shipping
- national law on the landside distribution via streets, railroads, and pipelines

The relevant stakeholders at international and European level that were identified in the legal analysis were compiled into a list and prioritised during the research process. The results indicate which stakeholders might be considered in the further development of the legal framework.

**The study is structured as follows:**

The legal analysis opens with an overview of the relevant provisions concerning the international classification systems for dangerous goods and presents a basic categorisation of the four hydrogen carriers according to this system (chapter 3.1). This serves to increase the comprehensibility of the subsequent examinations of the study: the substance-related legal framework is significantly influenced by classification systems, which are largely harmonised in the multi-level structure of international, European, and national law. Along the entire transport route and across all levels of law, the legal requirements will often refer to and depend on the classification of the carrier substance in question. Due to the limited scope of this study, the equally vast and important field of technical standards is excluded from the discussion.

In order to assess the fundamental suitability of the existing legal framework and identify potential legal barriers, the analysis proceeds in accordance with the prospective transport route. It first examines the applicable regulation for transport by marine vessel from Australia to either the port of Rotterdam or a German port (chapter 3.2) and considers the applicable legal framework for unloading and storage in these ports (chapter 3.3). It then explores different modes of inland transport within Germany, including the transport of the identified substances by road, inland waterway, rail, and pipeline (chapter 3.4). Because hydrogen carriers may be reconverted into hydrogen upon arrival in mainland Europe, the subsection on pipeline transport also covers the transport of gaseous hydrogen. Finally, the study explores the applicable legal framework and legal barriers for cross-sectional use, i.e. the use of the above-mentioned transport options for fuels (3.5).

Each chapter opens with an overview of the potential regulatory barriers associated with specific legal requirements, then outlines these legal requirements in greater detail. The study closes with an overview of the relevant stakeholders (chapter 4), a summary of findings, and summary sheets for each hydrogen carrier (chapter 5).

03

# Regulatory framework

The regulatory framework governing transport from Australia to Europe consists of provisions from various kinds of laws and conventions. The following chapter provides an overview of some of the most relevant aspects of the regulatory framework and describes the existing framework for the import of LOHC, LH2, ammonia and methanol. As three of the four hydrogen carriers are classified as dangerous goods, most of the regulations discussed are related to safety issues and technical specifications. The chapter examines the international classification of the four transport options (3.1), international maritime law for the maritime transport via vessels from Australia to Europe's borders (3.2), German regulation in seaside and inland ports (3.3), and regulations governing landside distribution (3.4). The chapter also analyses the legal framework for use of the four hydrogen carriers as fuel (3.5).

## 3.1 International classification of the hydrogen transport options

The applicable regulatory framework heavily depends on the nature of the transported goods. Goods with hazardous characteristics and which are frequently being transported are classified as dangerous goods and thus fall within the scope of the regulation on the transport of dangerous goods. This chapter explains the classification system and enumerates the classification of the four hydrogen transport options respectively.

### 3.1.1 Classification of dangerous goods

The transport of dangerous goods is **internationally regulated.** The United Nations have issued Recommendations on the Transport of Dangerous Goods – Model Regulations[5] (Orange Book), which lays the groundwork for regulation on all levels for the transport of dangerous goods. It provides for general recommendations on safety and construction measures as well as definitions. The Annex to the Orange Book lists all dangerous goods that are subject to classification in **nine different classes**. This **classification system is ubiquitous** in the international law on the transport of dangerous goods. The classification system is as follows:

| Class | Substances |
|---|---|
| 1 | Explosive Materials |
| 2 | **Gases** |
| 3 | **Flammable liquids** |
| 4 | Flammable solids |
| 5 | Oxidising Substances & Organic Pesticides |
| 6 | Toxic and Infections Substances |
| 7 | Radioactive Materials |
| 8 | Corrosive Materials |
| 9 | **Miscellaneous dangerous items & environmentally hazardous substances** |

*Table 2: Classification system of dangerous goods*
*Source: Own presentation based on ADR/RID/ADN/IMDG Code*

Based on the Orange Book, 3.2 IMDG Code/ADR/RID/ADN[6] equally list all dangerous goods subject to the respective regulation. The classification is the basis for the applicable technical rules. Once a substance is classified, tables in 3.2 IMDG Code/ADR/RID/ADN assign them respective technical requirements through a code system. These requirements refer inter alia to special tanks (T) or packaging (P).

**$LH_2$** is a **flammable refrigerated gas (3F)** within **class 2.1** (sub class 2.1 stands for flammable gases). It carries the **UN-No 1966** with the hazard label code 2.1 (+13). It can be transported in cryogenic tanks (T75) or closed cryogenic packages (P203). For inland shipping, only transport in cryogenic packages is allowed.

**Ammonia** (**UN No 1005**) is a **toxic and corrosive gas (2TC)** within **class 2**. It has properties, which are **particularly dangerous for water bodies (N1).** The transport can be carried out via **portable tanks** (T50)**, pressure equipment** (P200) and is allowed in **tankers and packaged form** (T) for inland shipping. **Refrigerated ammonia** is listed separately (**UN No 9000**) as **cryogenic liquefied toxic and corrosive gas (3TC)**. It only is allowed to be transported in **tanker vessels** (section 3.2 table A column 13 ADN).

**Methanol** (UN No 1230) is classified as a liquid within **class 3**, being **flammable and toxic (FT1)** with the hazard label 3+6.1. It can be transported **both in tanks** (T7) **and as package** (P001, IBC02). The **tank vessel** needs to be of **type N** for liquid.

**LOHC** are not thus listed. Some conclude that this means that LOHC are not classified as dangerous goods.[7] However, this might be due to the fact that LOHC are not yet transported on a large scale (see e.g., 2.0.2.2 IMDG Code) as the law on the transport of dangerous goods strongly follows the expertise and knowledge gained through practical experience. Therefore, in the following possible classification options for LOHC are depicted.

Goods **that are not yet listed as having hazardous characteristics** must be **assigned** to an appropriate class in an assignment procedure (2.1.3.1 ADR/RID, 2.1.3.1 ADN, 2.0.2.7 IMDG Code). The hazards of a substance shall be determined based on its physical, chemical, and physiological characteristics (2.1.3.1 ADR/RID/ADN). If hazardous characteristics fall

5 United Nations, New York and Geneva, 2019.

6 International Maritime Dangerous Goods Code adopted by the Maritime Safety Committee of the Organization by resolution MSC.122(75); Agreement concerning the International Carriage of Dangerous Goods by Road, ADR, applicable as from January 2021; Convention concerning International Carriage by Rail (COTIF), Appendix C – Regulations concerning the International Carriage of Dangerous Goods by Rail as applicable from January 2021; European Agreement concerning the International Carriage of Dangerous Goods by Inland waterway, including the Annexed Regulations, applicable as from January 2021. The study assesses these Codes in further detail below.

7 Prof. Dr. Wolfgang Arlt. and Dr.-Ing. Jonas Obermeier, 'Machbarkeitsstudie. Wasserstoff Und Speicherung Im Schwerlastverkehr', 2017, 32, https://www.encn.de/fileadmin/user_upload/Studie_Wasserstoff_und_Schwerlastverkehr_WEB.pdf.

into more than one class, the assignment follows the predominant hazardous characteristics (2.1.3.5.3 ADR/RID/ADN, 2.0.3.1 IMDG Code). The transport of goods not being explicitly named must be assigned a technical correct term or be classified as **"Not Otherwise Specified (NOS)"** goods (see e.g. 2.0.2.6 IMDG Code).

Because their characteristics are similar to diesel, it may be useful to look at the **classification of diesel (UN No 1202)** which falls into **class 3** and is listed in 3.2 IMDG Code/ADR/RID/ADN. However, Class 3 only comprises **flammable liquid substances** and desensitised explosive liquid substances. According to 2.3.1.2 IMDG Code, 2.2.3.1.1 ADR/RID/ADN, flammable liquid substances are substances with a flashpoint up to and including **60°C.** Therefore, having a flashpoint exceeding 60°C by far, it is highly unlikely that LOHC fall into class 3.

LOHC also could fall within the NOS entry **UN No 3082** in class 9 (category M6) for substances being **environmentally hazardous** but not otherwise specified. Class 9 encompasses all substances, which are **hazardous during transport** and do not fall within the other 8 classes (2.2.9.1 **ADR/RID/ADN**; see also 2.9.2.1 IMDG Code). Substances are environmentally hazardous, when they check criteria for acute aquatic toxicity or chronic aquatic toxicity of respective first degree (2.9.3.3 IMDG Code; 2.2.9.1.10.1 ADN; 2.2.9.1.10.2.1 ADR/RID). Tables 2.9.1 IMDG Code and 2.2.9.1.10.3 ADR/RID/ADN list the critical values. **Acute aquatic toxicity** is the substance's intrinsic characteristic to harm organisms being **temporarily exposed** to the substance (2.9.3.2.2 IMDG Code; 2.2.9.1.10.2.3 ADR/RID/ADN). For **chronic aquatic toxicity**, the same hazards due to toxic characteristics are being determined for exposure in relation to an **organism's life cycle** (2.9.3.2.4 IMDG Code; 2.2.9.1.10.2.4 ADR/RID/ADN). A substance's classification as environmentally hazardous is to be carried out **independently** (self-classification) predominantly according to the criteria laid down in 2.2.9.10.3/4/5 ADR/RID/ADN. Secondly, the classification may follow the substance law criteria of the CLP Regulation[8] (2-18.1 RSEB[9]).

While not specifically being subject to the harmonised classification system (GHS), the substance information of LOHC has been submitted to the European Chemicals Agency (ECHA), and hazard classification has been done via a **notification procedure**. Whether this substance information will lead to admission in the GHS remains an open question. **ECHA preliminarily labels benzyltoluene as possibly very toxic to aquatic life with long-lasting effects**. If they thus fall within the scope of international regulation on the transport of dangerous goods depends on whether crucial toxicity limits of the IMDG Code and the ADN/ADR/RID are surpassed. Currently, research indicates that benzyltoluene may not surpass crucial toxicity limits and therefore will remain out of the dangerous goods classification system.[10]

However, the possibility cannot be eliminated that LOHC will fall within UN No 3082 and thus be subject to the regulation of transport of dangerous goods, depending on the exact LOHC in use. Yet, based on current knowledge, the transport of LOHC is not restricted with regard to mass or routes. For further legal assessment, the study assumes that LOHC are not classified as dangerous goods. However, an early integration of hazard assessment is crucial to the development of a safe and reliable import infrastructure.

8 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. See chapter 3.1.2.

9 Richtlinien zur Durchführung der Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB) und weiterer gefahrgutrechtlicher Verordnungen. The RSEB only applies within German jurisdiction but can nevertheless function as a guide for international classification, as it follows international standards.

10 Deutscher Bundestag, 'Wasserstoffträgersysteme. Einzelfragen Zu Liquid Organic Hydrogen Carrier (LOHC)', 2020, 8, https://www.bundestag.de/resource/blob/816048/454e182d5956d45a664da9eb85486f76/WD-8-058-20-pdf-data.pdf.; Energie Campus Nürnberg, Wasserstoffspeicher, https://www.encn.de/forschung/energiespeicher/wasserstoffspeicher/.

### 3.1.2 CLP Regulation

**Regulation No 1272/2008 on classification, labelling and packaging of substances and mixtures**[11] **(CLP Regulation)** aims at ensuring a high level of protection of human health and the environment as well as the free movement of chemical substances[12] through harmonising the provisions and criteria for the classification and labelling of substances, mixtures and certain specific articles within the Community referring to the **Globally Harmonised System of Classification and Labelling of Chemicals** (hereinafter referred to as 'the **GHS**').[13] Its objective is to determine which properties of substances and mixtures should lead to a classification as hazardous.[14] The CLP Regulation is **referred to in many international and national regulations** and thus **central for classification**. Hazards are categorized in three categories from one to three, one being the highest threat.

The CLP Regulation lists **hydrogen** under Index Nr. 001-001-00-9 and classifies it as **flammable gas of category 1** as well as pressurised gas. Its hazard note is H220 (extremely flammable gas of the hazard category 1).

The CLP Regulation lists **ammonia** under Index Nr. 007-001-00-5 and classifies it as **flammable gas of category 2**, pressurized gas with the characteristics of being **acute toxic level 3**, skin corrosive level 1B and hazardous to aquatic life 1. Its hazard notes are H221(flammable gas of the hazard category 2), H331(toxic if inhaled of the hazard category 3), H314 (causes severe skin burns and eye damage of the hazard category 1B), H400 (very toxic to aquatic life of the hazard category 1).

The CLP Regulation lists **methanol** under Index-Nr. 603-001-00-X and classifies it as a **flammable liquid of category 2** with the characteristics of **acute toxicity level 3**. Its hazard notes are H225 (highly flammable liquid and vapour of the hazard category 2), H331 (toxic if inhaled of the hazard category 3), H311 (toxic in contact with skin of the hazard category 3), H301 (toxic if swallowed of the hazard category 3), H370 (causes damages to organs of the hazard category 1).

Although **LOHC** have very similar characteristics to diesel, they are not classified equally under the CLP Regulation, nor can they be subsumed under the diesel classification when of synthetic nature, as the classification for diesel requires the production via distillation of crude oil. LOHC are thus equally not part of the harmonised classification system according to the CLP Regulation.

11 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

12 Regulation (EC) No 1272/2008, Reason (1); Article 1 No 1.

13 Regulation (EC) No 1272/2008, Reason (8); Article 1 No 1 lit. a.

14 Regulation (EC) No 1272/2008, Reason (10).

## 3.2 International maritime transport

For international shipment, international maritime law applies, which comprises various conventions and codes, most of which are published by the International Maritime Organisation. The following graph summarises the underlying system of international and national regulation. As European law does not play a crucial role, the outline focuses on international law and its implementation into (German) national law.

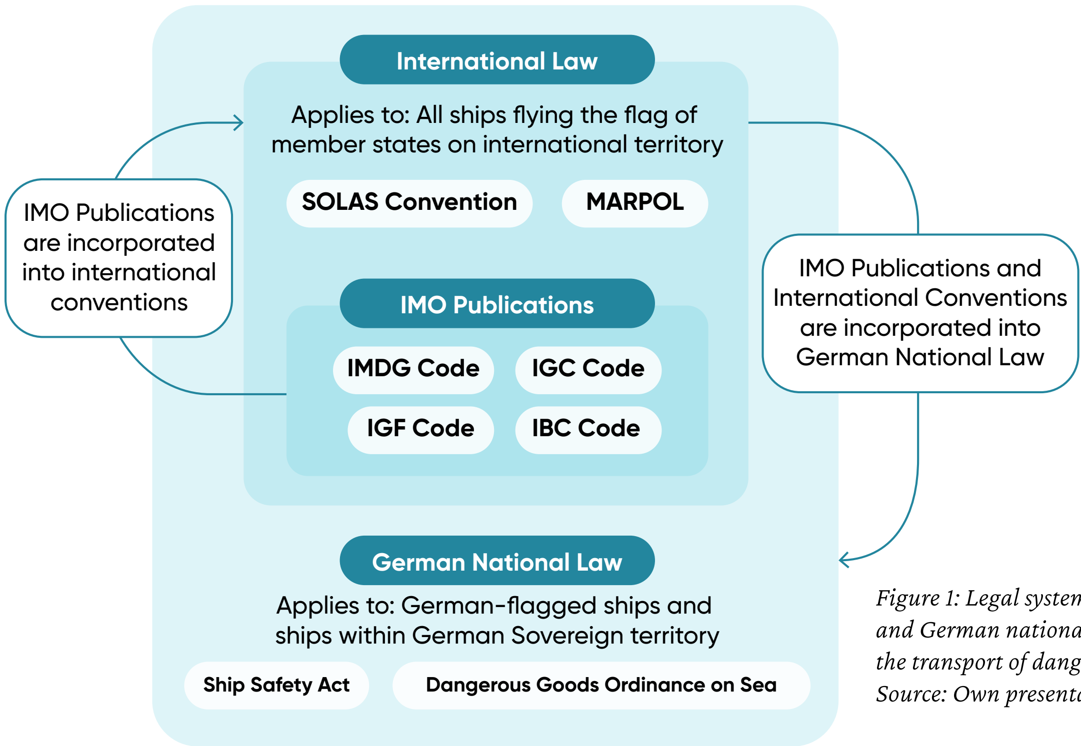



*Figure 1: Legal system for international and German national maritime law on the transport of dangerous goods*
*Source: Own presentation.*

The following chapter discusses the conventions and codes for the international transport via vessels and identifies potential regulatory barriers, which are summarised in an opening chapter.

### 3.2.1 Potential regulatory barriers

According to the study's analysis, international maritime transport of the four hydrogen transport carriers on sea-going vessels such as gas carriers and chemical tankers is (1) generally **possible within the existing regulatory framework**.

International maritime law is comprehensive of the constant technical development and innovation in the shipping sector and IMO Regulations rather provide support and increase safety standards instead of resulting in legal barriers for shipment of dangerous goods. They have a **dynamic approach** and IMO committees (notably the MSC and its sub-committee CCC, for further details see chapter 4.1.1.1) constantly **monitor technical innovations**. IMO Regulations thus tend to be open to new technology, which leads to the general conclusion that they **provide support and increase safety standards** and do not present legal barriers to the shipment of dangerous goods. The aim of most of the examined regulation is to provide for an international safety standard. Thus, being within the scope of an IMO Regulation should rather be of an advantage to the implementation of an import infrastructure as it provides standards and expertise. In general, technical expertise is crucial. Ammonia and methanol are globally traded commodities, for which such technical expertise exists and helps to understand the substances hazardousness and to adequately address it. Being new to the global trade, equal expertise for LOHC and $LH_2$ does not yet exist and is thus not incorporated into the IMO Regulations (see chapter 3.2.5). In conclusion, the level of legal feasibility also depends on the respective hydrogen carrier.

Under the umbrella of the SOLAS Convention with more general regulation (see chapter 3.2.2), the international maritime transport of $LH_2$ and ammonia in bulk on seagoing vessels is mainly regulated by the IGC Code (chapter 3.2.4). The transport of methanol in bulk on sea-going vessels is regulated by the IBC Code (chapter 3.2.6) and MARPOL (chapter 3.2.7). For the transport of these three hydrogen carriers in packaged form, the SOLAS Convention and the IMDG Code (chapter 3.2.3) apply. The different regulation in place adapts to the respective transport mode and to the substance's properties (e.g., gas or liquid) yet contains the same level of regulation. The regulation of the international maritime transport of LOHC cannot be assessed conclusively, but to the study's findings, it is not regulated by the examined international law of the transport of dangerous goods. However, **a provisional**

**assessment** of its hazardousness under MARPOL for the carriage of LOHC in bulk might be necessary. This mainly depends on its noxious characteristics (bio accumulation, acute and chronic toxicity, long-term hazardous health effects, impact on marine flora and fauna).

The regulation in place entails (2) **significant legal requirements** for the construction of vessels, safety measures, technical standards, and staff requirements, which can increase cost and decrease efficiency but do not **present an absolute hindrance to the implementation of the envisaged infrastructure**. For example, according to the study's findings, no absolute limits on ship or tank size are laid down in the respective regulations. Furthermore, **extensive documentation requirements** apply: for $LH_2$, ammonia, and methanol, all vessels must be certified to be fit for the transport of the respective hydrogen carrier according to the respective applying regulation by the flag state. The certification is a (though lengthy) formality to document the vessels compliance with the applicable provisions. Prior to certification, the vessel is surveyed. The certificate and all respectively necessary documentation is to be on board throughout the whole journey. Non-compliance might be fined under National Law. The certification is especially important when entering the **Suez Canal**:

According to Art. 1 of the Rules of Navigation for Suez Canal, transit through the Suez Canal is open to vessels of all nations subject to their complying with the Rules of Navigation and with the provisions of SOLAS and MARPOL. The Suez Canal Authority reserves the right to refuse access to the Canal waters to vessels considered dangerous or troublesome to navigation in the Canal or to delay a vessel for the purpose of investigating any allegation of violation of the laws of the canal (Art. 5 Rules of Navigation for Suez Canal) and thus also the violation of SOLAS and MAROL. Dangerous cargoes that are not listed on the ship certificate of fitness **cannot be transported through the Suez Canal** (see Art. 110 para 15 Rules of Navigation for Suez Canal). The certificates must be submitted to the Suez Canal Authority upon arrival (Art. 117 Rules of Navigation for Suez Canal). According to Art. 123 Rules of Navigation for Suez Canal, the Suez Canal Authority reserves the right to inspect the stowage of dangerous goods, and if the information given is found to be incorrect, access to the Canal may be forbidden.

### 3.2.2 SOLAS Convention

The **International Convention for the Safety of Life at Sea**[15] **(SOLAS Convention)** is an international UN Convention regarding ship safety and is translated into national law in Germany through the Federal Ship Safety Act[16] (SchSG). It is **published by the IMO** and has been ratified by 167 of the IMO Member States, for all of which the SOLAS Convention is thus legally binding, including Australia, Germany, and the Netherlands.

The SOLAS Convention generally **applies** to ships with more than 500 gross tonnages, entitled to fly the flag of States of Contracting Governments (Art. II SOLAS), which are engaged on international voyages (Reg. I/1, 3 SOLAS). Within its scope, the SOLAS-Convention overrides all other treaties, conventions and arrangements relating to safety of life at sea, or matters appertaining thereto (Art. VI SOLAS).

The SOLAS Convention is central when it comes to safety rules in international shipping. It **specifies minimum standards for the construction, equipment, and operation of ships**[17] and is divided in 14 Chapters only some of which contain specific regulation for the transport of the hydrogen carriers in question. Whereas Chapter I provides General Regulation applicable to all international shipping, Chapter II-1 and II-2 contain – among other provisions - **specific regulation for chemical tankers and gas carriers**, which explicitly deals with the **carriage of liquefied gases** and requires **additional safety measures** for **liquid cargo** with a **flashpoint of less than 60°C** (low flashpoint).

Cargo ships carrying methanol in **bulk** classify as chemical tankers under the IBC Code (see chapter 3.2.6) and cargo ships carrying $LH_2$ or ammonia in bulk as gas carriers under the IGC Code (see chapter 3.2.4). Ships carrying LOHC do not fall within the scope of either the IGC Code or the IBC Code. A **chemical tanker** is generally a cargo ship constructed or adapted and used for the carriage in bulk of any liquid product listed in chapter 17 of the IBC Code[18] (Reg II-1/3 No 19 SOLAS). Chapter 17 IBC Code lists methyl alcohol with its index name Methanol but not LOHC. Equally, according to Reg II-1/3 No. 20 SOLAS a **gas carrier** is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products listed in chapter 19 IGC Code[19]. Chapter 19 IGC Code lists ammonia but not $LH_2$, which, as a liquefied gas, nevertheless is within the scope. **Chapter II-2** only applies, when the liquid or gas is of **flammable nature** (Reg II-2/3 No 11 and 25 SOLAS). Regulation of chapter II-2 SOLAS thus applies to the carriage of $LH_2$, ammonia and methanol but not LOHC.

15 International Convention for the Safety of Life at Sea, 1974, as amended.

16 Schiffssicherheitsgesetz vom 9. September 1998 (BGBl. I S. 2860), das zuletzt durch Artikel 1 der Verordnung vom 19. Oktober 2021 (BGBl. I S. 4717) geändert worden ist.

17 IMO, https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx.

18 International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by the Maritime Safety Committee by resolution MSC.4(48) as amended.

19 International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the Maritime Safety Committee by resolution MSC.5(48).

The carriage of dangerous goods and thus $LH_2$, ammonia and methanol in **packaged form** is **prohibited, except in accordance with the provisions of Chapter VII SOLAS** and in compliance with the relevant provisions of the **IMDG Code** (Reg VII/3 SOLAS). Package means the complete product of the packing operation, consisting of the packaging and its contents prepared for dispatch. The term includes receptables for gases. Chapter VII SOLAS provides **specific regulation** for the carriage of dangerous goods. Reg VII/12 SOLAS further requires for any **gas carrier** to comply with the provisions of both Chapter VII SOLAS as well as the IGC Code.

The regulations of Chapter VII SOLAS are divided into **three parts**:

- **Part A** provides rules for the classification, packing, marking, labelling, and placarding, documentation, and stowage of dangerous goods. Contracting Governments are required to issue instructions at the national level.
- **Part B** covers construction and equipment of ships carrying liquid chemicals in bulk.
- **Part C** covers construction and equipment of ships carrying liquefied gases in bulk and gas carriers to comply with the requirements of the International Gas Carrier Code (IGC Code).

Control provisions allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention - this procedure is known as **Port State Control**.

When certain requirements of the SOLAS Convention, notably of chapter II, cannot be met due to technical challenges, or the nature of the transported goods, it is possible to deviate from certain requirements with an **alternative technical design**, e.g. for $LH_2$ with its extensive safety requirements and cryogenic challenges. Such alternative design, however, must undergo a lengthy approval procedure outlined in the following. While the alternative design method is generally more relevant for alternative fuel systems (see chapter 3.5.2), the according regulation in SOLAS will be depicted in this chapter.

Regulation II-1/55 SOLAS provides general criteria for alternative design and arrangements. The purpose of this regulation is to provide a methodology for alternative design and arrangements for machinery, electrical installations, and low-flashpoint fuel storage as well as distribution systems. According to the regulation, design and arrangements may deviate from the requirements set out in part C, D, E, and G of Chapter II-1 SOLAS, provided that the alternative design and arrangements meet the intent of the requirements concerned and provide an **equivalent level of safety** to this chapter. To prove that this equivalent level is achieved, an **engineering analysis, evaluation and approval** of the design and arrangements shall be carried out in accordance with Reg II-1/55 SOLAS, which is referred to in various other IMO Codes. The following table presents the requirements for the alternative design method according to SOLAS laid down in regulation 55 and 17 for the scope of the respective chapter.

<table>
<tr><th></th><th>SOLAS<br>Chapter II-1</th><th>SOLAS<br>Chapter II-2</th></tr>
<tr><th>Regulation</th><td>55</td><td>17</td></tr>
<tr><th>Authority</th><td colspan="2">Government of the State whose flag the ship is entitled to fly (Flag Administration)</td></tr>
<tr><th>Legal consequence</th><td>Machinery, electrical installation and low-flashpoint fuel storage and distribution systems design and arrangements may deviate from the requirements set out in parts C, D, E or G</td><td>Fire safety design and arrangements may deviate from the prescriptive requirements set out in parts B, C, D, E or G</td></tr>
<tr><th rowspan="2">Requirements</th><td>Alternative design and arrangements must meet the intent of the requirements concerned and provide an equivalent level of safety to Chapter II-1</td><td>The design and arrangements must meet the fire safety objectives and the functional requirements (of Chapter II-2).</td></tr>
<tr><td colspan="2">Engineering analysis with detailed technical determination and identification of the design and the reasons for the design (varying requirements for Reg 55 and Reg 17) must be provided to the flag state's government<br>• Evaluation by the flag state's government<br>• Approval by the flag state's government</td></tr>
</table>

*Table 3: Requirements for the alternative design method according to SOLAS*

### 3.2.3 IMDG Code

The transport of $LH_2$, ammonia, and methanol in **packaged form** falls within the scope of the International Maritime Dangerous Goods Code[20] (IMDG Code) and is thus subject to detailed technical provisions as well as requirements for labelling, classification, and documentation. A **Dangerous Goods Manifest** is necessary for all three transport options in packaged form. As depicted in chapter 3.1, it is unlikely that LOHC fall within the scope of the IMDG Code. However, it cannot be entirely ruled out yet.

Through its incorporation into the SOLAS Convention, the IMDG Code is international binding law to all states having ratified the SOLAS Convention. The IMDG Code thus applies to all vessels that fall within the application scope of the SOLAS Convention and that carry dangerous goods in packaged form according to the definition in Reg VII/1 No 2 SOLAS (1.1.1.1 IMDG Code). For German-flagged vessels and other vessels within German territory (12 sea miles from coastal lines), the Dangerous Goods Ordinance on Sea[21] implements the IMDG Code into national law (see chapter 3.2.10).

The IMDG Code "aims to increase the safety of transporting dangerous goods at sea while simultaneously enabling an unimpeded transport and preventing environmental pollution" (Preamble No 1 IMDG Code). It provides detailed **technical rules** for individual substances, materials and articles and several rules for good operational practice. However, the provisions of the code are mainly directed at the mariner[22] and of technical nature, which is why this study will not go into details of the code. It can be seen as a **basic rulebook for classification, packaging, labelling and documentation** of dangerous goods transported via ships.[23] The IMDG Code also lays down the requirement of the **Dangerous Goods Manifest** (5.4.3 IMDG Code), which must list the dangerous goods being transported. The basis for this Manifest is all necessary documentation according to the IMDG Code. The total quantity of the transported dangerous goods must be indicated.

### 3.2.4 IGC Code

For the carriage of **$LH_2$ and ammonia** the **International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk**[24] **(IGC Code)** applies.

It generally applies to ships regardless of their size carrying liquefied gases having a vapour pressure exceeding 0,28 MPa absolute at a temperature of 37.8°C, and certain other substances listed in chapter 19 of the Code (**gas carriers**). Being incorporated in Chapter VII SOLAS, the IGC Code is binding law for all states having ratified the SOLAS Convention. Within German jurisdiction the Dangerous Goods Ordinance on Sea (see chapter 3.2.10) incorporates the IGC Code.

For gas carriers, an **International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk** to certify the compliance with the IGC Code must be issued after an initial or renewal survey that shows its compliance with the relevant provisions of the Code (1.4.4.1 IGC Code). A **model form** is given in chapter 19 appendix 2 of the IGC Code. The certificate shall be always available on board for examination (1.4.4.3 IGC Code). A gas carrier also must be **regularly surveyed** (1.4.2 IGC Code) in intervals not exceeding five years.

The IGC Code aims at providing an international standard for design and construction of the carrying ships to ensure safe carriage by sea. Based upon present knowledge and technology, the requirements in the code intend to minimize risks to a practicable extent.[25] The IGC Code thus contains **detailed technical provisions**. **17.12 IGC Code** contains **specific material requirements for ammonia**. These provisions could apply for marine fuel storage tanks as well. [26] Regarding liquefied hydrogen, the IGC Code does not provide such detailed requirements, but the IMO has already noticed this gap and issued Interim Recommendations for the Carriage of Liquefied Hydrogen (see chapter 3.2.), which confirm that the IGC Code shall nevertheless apply to the carriage of $LH_2$ in bulk.

20 International Maritime Dangerous Goods Code adopted by the Maritime Safety Committee of the Organization by resolution MSC.122(75).

21 Gefahrgutverordnung See in der Fassung der Bekanntmachung vom 21. Oktober 2019 (BGBl. I S. 1475), die zuletzt durch Artikel 16 des Gesetzes vom 12. Dezember 2019 (BGBl. I S. 2510) geändert worden ist.

22 IMO, Flyer on the IMDG Code, https://wwwcdn.imo.org/localresources/en/publications/Documents/IMDG%20Code/IM200E%20Flyer.pdf.

23 Deutsches Maritimes Zentrum e.V, 'Bunker Guidance Für Alternative Kraftstoffe in Deutschen Seehäfen', 2021, 16, https://www.dmz-maritim.de/handlungsfelder/wettbewerbsfaehigkeit/leitfaden-zum-betanken-von-schiffen-mit-fluessiggas-beauftragt/.

24 Resolution MSC.370(93) of 5 January 2016.

25 IMO, https://www.imo.org/en/OurWork/Safety/Pages/IGC-Code.aspx

26 American Bureau of Shipping, 'Sustainability Whitepaper. Ammonia as a Marine Fuel', 2020, 14, https://absinfo.eagle.org/acton/attachment/16130/f-157fdb59-8b2c-4c12-a6c0-be887d7417ae/1/-/-/-/-/Ammonia_as_Marine_Fuel_Whitepaper_20188.pdf.

The IGC Code thus functions as a **construction manual** with detailed construction requirements regarding stress resilience of the construction, various safety measures, material, and the position of the tanks, also providing **concrete technical parameters** (e.g., on design vapor pressure of tanks). It does not limit ships or tanks to a certain size, but limitations can result from other technical parameters laid down in the code. This must be assessed for each individual case with technical expertise. Vessels within the scope of the IGC Code shall be designed to the standards of either Type 1G, 2G, 2PG, and 3G Ships. The numbers indicate the level of preventative measures required, with type 1G ships requiring maximum preventative measures to preclude the escape of cargo (2.1.2 IGC Code):

| Ship type | Definition |
|---|---|
| 1G | Gas carrier intended to transport the products indicated in chapter 19 that require **maximum preventive measures** to preclude their escape. |
| 2G | Gas carrier intended to transport the products indicated in chapter 19, that require **significant preventive measures** to preclude their escape. |
| 2PG | Gas carrier of 150 m in length or less intended to transport the products indicated in chapter 19 that require **significant preventive measures** to preclude their escape, and where the products are carried in type C independent tanks designed (4.23 IGC Code) for a MARVS of at least 0.7 MPa gauge and a cargo containment system design temperature of -55°C or above. A ship of this description that is over 150 m in length is to be considered a type 2G ship |
| 3G | Chemical tanker intended for the carriage of chapter 17 products posing such serious environmental and safety hazards that a **moderate level of spill prevention is required to enhance the ship's floatability in the event of a spill**. |

*Table 4: Ship types according to the IGC Code*
*Source: Own presentation based on the IGC Code*

For ammonia, the type 2G/2PG ships are permitted. For hydrogen, only the type 2G ship is permitted. Therefore, they require significant preventative measures, but not the maximum level.

### 3.2.5 Interim Recommendations for the Carriage of Liquefied Hydrogen

While the IGC Code generally applies to the carriage of $LH_2$ in bulk, it however does not provide corresponding specific requirements. The IMO has recognized a need for the development of such regulation and has thus published the **Interim Recommendations for the Carriage of Liquefied Hydrogen in Bulk**[27] in 2016. The Interim Recommendations were inter alia intended to facilitate establishment of a tripartite agreement between the concerning administrations and port authorities for a **pilot ship** - one meanwhile has been developed (the $LH_2$ Vessel Suiso Frontier) - for the research and demonstration of safe long-distance overseas carriage of liquefied hydrogen in bulk. Furthermore, the recommendations have been developed under the assumption that a liquefied hydrogen carrier does not carry liquefied gases other than liquefied hydrogen. Not yet being incorporated in the IGC Code, the Interim Recommendations are not legally binding, but merely a **technical guide** for construction and safe handling for the transport of $LH_2$.

The development of interim recommendation is **standard procedure** for implementing new regulation as the Preamble No 5 IGC Code states that requirements for new products and their conditions of carriage will be circulated as recommendations prior to the entry into force of the appropriate amendments. It is thus to be expected that these provisions will be incorporated in the IGC Code in the future. However, these processes do take time as the Interim Recommendations have been published in 2016, which gives an idea of the time spectrum that the IMO needs to establish new regulation (see for further details chapter 4.1.1.1).

The recommendations have been developed based on the results of a **comparison study** of **similar cargoes** listed in chapter 19 of the Code, e.g. **LNG** (2.1 Resolution MSC.420[97]). They further confirm that ships carrying $LH_2$ in bulk (liquefied hydrogen carrier) should comply with the IGC Code (1.2 Resolution MSC.420[97]). Regarding the ship type the Recommendations (3.2.1.2) state the following:

> *"Type 2PG is not applicable to liquefied hydrogen for the reason that the design temperature is lower than -55°C. Taking into account that liquefied hydrogen is a class 2.1 dangerous good, it is appropriate to allocate 'type 2G' to liquefied hydrogen".*

Furthermore, they provide detailed **safety instructions** for various aspects of handling liquified hydrogen none of which would be of hindrance to an import infrastructure.

### 3.2.6 IBC Code

For the carriage of **methanol**, the **International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code)** applies. Chemical tankers with methanol as a cargo must be **approved** with an **International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk** after an initial survey conducted by the administration. A chemical tanker also must be regularly surveyed (1.5.2 IBC Code) in intervals not exceeding five years.

The IBC Code is equally part of the SOLAS-Convention (SOLAS Chap VII Part B). Within German jurisdiction, the Dangerous Goods Ordinance on Sea (see chapter 3.2.10) incorporates the IBC Code. As its title indicates, it enshrines regulation for the construction and equipment of ships **carrying dangerous chemicals in bulk**. It applies to ships regardless of their size, which **carry hazardous chemicals or dangerous liquids**, except for crude oil. Generally, the Code applies to ships carrying **products with increased flammability or flammable products** imposing substantial danger due to health hazard, threat of spontaneous severe reactions, and pollution of the sea. It lists chemicals that the code applies to with further information on safety and minimum transport requirements. As mentioned before, chapter 17 IBC lists methyl alcohol as an index name for methanol.

Equal to the IGC Code, the IBC Code functions as a **construction manual for chemical tankers**. It provides detailed construction requirements and provisions on documentation and operation as well as safety measures. Ships subject to the Code shall be designed to comply with one of the ship types in the table below (2.1.2 IBC Code).

For the carriage of methanol, **the type 3 ship** is permitted. The IBC Code also does not limit ships or tanks to a certain size, but limitations can result from other specific technical parameters (e.g., regulation on tank arrangements, materials, and wall thickness of tanks) laid down in the code. This must be assessed for each individual case with technical expertise.

**LOHC** – to current knowledge – do not show increased flammability. Therefore, the IBC Code should **not apply** to the carriage of either. However, liquids with a vapour pressure of less than 0,28 MPa (absolute) at a temperature of 37°C fall within the scope of the IBC Code. Depending on the specific LOHC that will be used, an uncertainty remains to that extent.

27 Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk, adopted by the Maritime Safety Committee of the Organization by resolution MSC.420(97) on 25 November 2016.

| Ship type | Definition |
| --- | --- |
| 1 | Chemical tanker intended for the carriage of Chapter 17 products posing very serious environmental and safety hazards requiring the **highest degree of preventive measures** to prevent leakage of such cargo. |
| 2 | Chemical tanker intended for the carriage of chapter 17 products with significantly serious environmental and safety hazards for which **significant preventive measures** are required to prevent leakage of this cargo |
| 3 | Chemical tanker intended for the carriage of chapter 17 products posing such serious environmental and safety hazards that a **moderate level of spill prevention is required to enhance the ship's floatability in the event of a spill**. |

*Table 5: Ship types according to the IBC Code*
*Source: Own presentation based on the IBC Code*

### 3.2.7 MARPOL

The **International Convention for the Prevention of Pollution from Ships**[28] **(MARPOL)** is the main international convention providing regulation to prevent and minimise pollution from ships both accidental pollution and pollution from routine operations. It currently includes six technical annexes, most of which have provisions on strict controls on operational discharges.[29]

**Annex II MARPOL** covers the **pollution by noxious liquid substances** in bulk and applies to all vessels certified to carry noxious liquid substances in bulk (Reg II/2 MARPOL). It further provides additional technical requirements on construction and safety. To vessels within the scope of Annex II MARPOL, an **International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk** must be issued by the administration (flag state), or any organisation authorised to do so (Reg II/9 MARPOL) The vessel must also be regularly surveyed (Reg II/8 MARPOL). However, chemical tankers, which have been surveyed and certified in accordance with the provisions of the IBC Code (see chapter 3.2.7) shall be deemed to comply with the applicable provisions of MARPOL. The certificate issued under the IBC Code thus shall have the same force and recognition as the certificate issued under Reg 9/II MARPOL.

Chemical tankers carrying methanol fall within the scope of Annex II MARPOL but not LOHC (see below for provisional assessment) nor $LH_2$ or ammonia. Noxious liquid substances in the scope of MARPOL are any substances indicated in the pollution category column C of chapter 17 or 18 IBC Code or provisionally assessed under the provisions of Regulation II/6 MARPOL as falling into category X, Y or Z (Reg II/1 No 10 MARPOL). Being listed in chapter 17 IBC Code, Methanol thus falls into category Y. For substances in category Y **limitations on the quality and quantity of the discharge into the marine environment are possible**, which will have an impact on the construction of the ship and tanks.

For the carriage of LOHC in bulk a **provisional assessment** under MARPOL might be necessary. This mainly depends on its noxious characteristics (bio accumulation, acute and chronic toxicity, long-term hazardous health effects, impact on marine flora and fauna). The LOHC being examined in HySupply are not listed in the IBC Code nor have been provisionally assessed under MARPOL yet. For provisional assessment of substances not listed in the IBC Code, the IMO has issued a provisional categorization[30], neither listing LOHC. The carriage of a liquid substance in bulk which has **not been categorized** is **prohibited,** until the Governments of Parties to the Convention involved in the carriage have established and agreed upon a **provisional assessment** for the carriage on basis of the **guidelines given in Appendix I of Annex II MARPOL** (Reg II/6 MARPOL). Within 30 days after the agreement, the Government of the producing or shipping country shall **notify** the Organization and provide details of the substance and the provisional assessment for annual circulation to all parties for their information in the provisional categorization of the IMO. The level of the hazardousness might also determine the length of such a provisional assessment.

**Annex III MARPOL** provides regulation on the maritime transport of substances in packaged form which are hazardous or chronically toxic to aquatic life thus, too, applying to **methanol**.

28 International Convention for the Prevention of Pollution from Ships, MEPC.39(29).

29 IMO, https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx

30 Provisional Categorization of Liquid Substances in Accordance with MARPOL Annex II and the IBC Code, MEPC.2/Circ.27.

### 3.2.8 Federal Ship Safety Act

The **Federal Ship Safety Act**[31] **(SchSG)** determines the measures to be taken in the implementation of the respective applicable international regulations on ship safety and environmental protection at sea as well as occupational safety directly related thereto (§ 1 para 1 SchSG). Ships within the scope of the SchSG are sea-going vessels flying the German State Flag or inland navigation vessels, which are registered in the **German shipping register** as well as vessels flying a foreign flag operating commercially on maritime waterways (see chapter 3.4..8) or in the seaward adjacent area of the German territorial sea.

In its Annex, the SchSG uses a **dynamic reference** to international and European law. Dynamic references refer to the **respective current version** of the referred law. It enshrines unified principles regarding the implementation of international and European law. According to § 7 SchSG, the **owner of the vessel is responsible** for the fulfilment of requirements regarding e.g. management, monitoring, construction, and state of the vessel, unless explicitly stated otherwise in the respective international regulation (§ 4 SchSG).

### 3.2.9 Dangerous Goods Ordinance on Sea

The Dangerous Goods Ordinance on Sea[32] (GGVSee) enshrines German national regulation on the transport of dangerous goods for **sea going vessels** on **maritime routes** and **adjacent seaports** but **not on inland waterways**, in which case the GGVSEB is applicable, § 1 para 1 GGVSee. The GGVSee applies to German-flagged ships in general and ships flying a foreign flag within German territory (12 sea miles from German coastal lines). According to the study's analysis and current technical knowledge, the GGVSee does not apply to the transport of LOHC.

According to § 3 GGVSee, the **transport of dangerous goods** (thus $LH_2$, ammonia and methanol) on sea-going vessels is **only permitted**, if the according **international regulation** is **complied with**. The transport in packaged form (possible for all three transport options) must comply with chapter VII part A SOLAS (see chapter 3.2.2) and the IMDG Code (see chapter 3.2.3), the transport of dangerous liquids (thus methanol), must comply with Reg 16/II-2 and chapter VII part B SOLAS (see chapter 3.2.2) and the IBC Code (see chapter 3.2.), the transport of liquefied gases in gas carriers ($LH_2$, ammonia) with Reg 16/II-2 and chapter VII part C SOLAS and the IGC Code (see chapter 3.2.). For this purpose, the GGVSee refers to the respective codes. Contrary to a dynamic reference, where a law refers to the respective current version of another law, the GGVSee takes the approach of a **static reference** referring to the codes and conventions in a certain version. Thus, if the codes and conventions were to be amended, the references must be equally updated to incorporate such amendments into the GGVSee.

In §§ 4 – 6, the GGVSee provides for **general safety instructions**, also referring to international regulation. For example, all necessary precautions in light of the nature and extent of foreseeable dangers must be taken (§ 4 para 1 GGVSee). In addition, the GGVSee lays down rules inter alia for competencies, obligations of responsible participants in transport and misdemeanours.

Compliance with the applicable regulation is monitored by the authorities responsible under state law of the respective state in which the port is situated (§ 9 GGVSee) – **Port State Control**. Not complying with the depicted regulation is an **administrative offense**, which can result in a fine up to €50,000 depending on the offense (§ 27 GGVSee, § 10 Dangerous Goods Transport Act). Competent authority for prosecution is the **Generaldirektion Wasserstraßen und Schifffahrt** (§ 27 para 2 GGVSee).

## 3.3 Unloading and storing in European ports

Upon arrival in European ports, import terminals in maritime ports are necessary. The extent of **existing import terminals** varies depending on the hydrogen carrier and the national maritime ports. **Ammonia** and **methanol** already are globally traded commodities with an existing import infrastructure, however this is not the case for every maritime port. Synergies with existing import infrastructure for petroleum or diesel might be possible for **LOHC** as its hazardous characteristics are less dangerous and its properties are similar to e.g. diesel. Import infrastructure for **$LH_2$** does not exist yet, synergies with LNG Terminals might be possible to a certain extent. The technical details remain to be scrutinized.

The following chapters outline the planning and approval law for new import terminals, and the regulation on safe handling regarding work protection, and substance law. While providing some information for the Port of Rotterdam, the study focuses on German law and thus German ports.

31 Schiffssicherheitsgesetz vom 9. September 1998 (BGBl. I S. 2860), das zuletzt durch Artikel 1 der Verordnung vom 19. Oktober 2021 (BGBl. I S. 4717) geändert worden ist.

32 Gefahrgutverordnung See in der Fassung der Bekanntmachung vom 21. Oktober 2019 (BGBl. I S. 1475), die zuletzt durch Artikel 16 des Gesetzes vom 12. Dezember 2019 (BGBl. I S. 2510) geändert worden ist.

### 3.3.1 German ports

In Germany, import infrastructure in maritime ports is currently limited for each of the four hydrogen transport options. The study thus focuses on the planning and approval law for new import terminals, as the repurposing of existing import terminals is of secondary importance. Approval of facilities in the scope of import terminals for an entire import infrastructure of hazardous substances is a thoroughly complex procedure for which this study can only give an overview citing the most relevant regulation. Site-specific regulation in Germany works on three levels: Federal State Law, State law and municipal law. For the administration of the federal state's waterways and ports as well as for ensuring the safety of shipping within the state's borders, the Federal States ("Länder") have the competence to implement their own regulation. The regulation being examined in this chapter on all three levels is shown in the graph on the right. Some of the regulations (especially on State Law Level) are more relevant for bunkering and thus depicted in chapter 3.5.4.

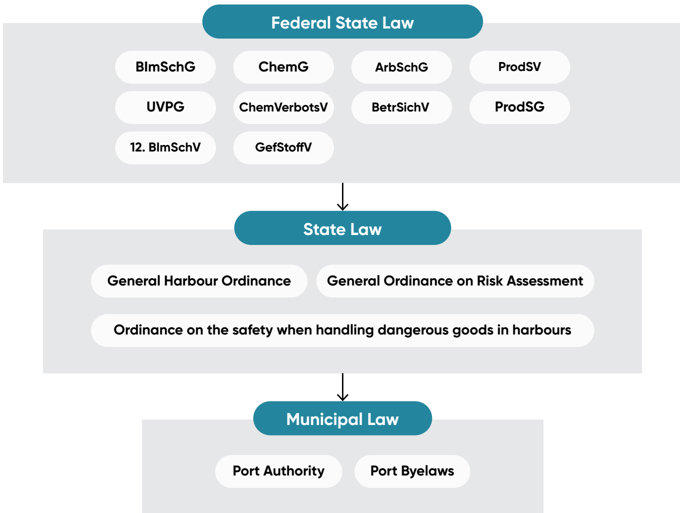



*Figure 2: Overview of the regulation for import and import terminals in Germany*
*Source: Own presentation.*

**Regulation on Federal State Level** equally works on different levels: On the first level is formal legislative law passed by the parliament, which in many cases authorizes the executive to issue law on a second level to regulate on a more detailed level. Both levels closely work together and are equally binding and democratically legitimized. On a third level, technical guidelines are issued, which are not legally binding, but contain technical parameters to support interpretation of some the law on the first and second level. The following graph gives an overview of the System of the examined Federal State Regulation.

The following analysis examines the presented regulation on the first and second level and identifies potential regulatory barriers, which are summarized in an opening chapter. Regulation on the third level are mostly technical standards, which are excluded in the scope of the study. They mainly contain concrete technical provisions to help in the application of regulation on first and second level.

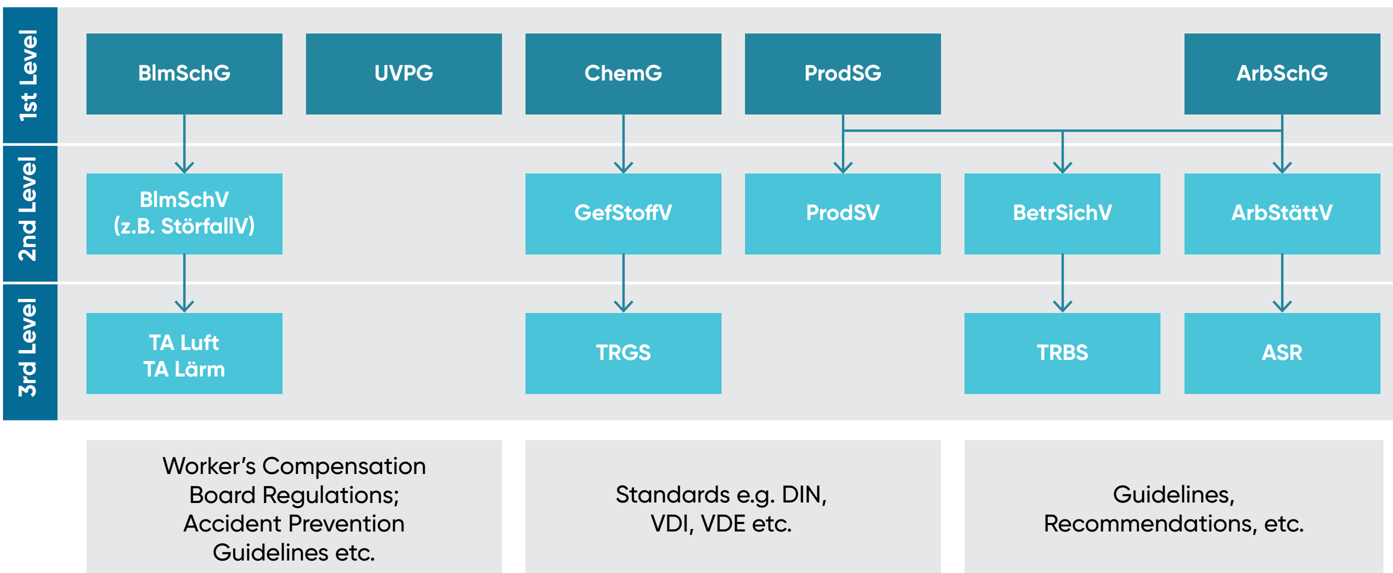



*Figure 3: Levels of site-specific regulatory framework in Germany*
*Source: Own presentation based on RH2INE Consortium (2021).*

### 3.3.1.1 Potential regulatory barriers

As the study only thoroughly assesses the German legal framework for import terminals, the following outline of potential regulatory barriers focuses on German national law. However, most of the law is widely harmonised by European law, especially regulation on safety distances. Therefore, some general conclusion derived from the German legal framework may also apply to the Dutch legislation.

The examined regulatory framework for the construction of import terminals (1) **generally provides for the legal groundwork** to build the necessary import terminals. Potential **regulatory barriers** (2) are mainly to be found in **extensive safety requirements**, e.g. safety distances to adjacent infrastructure, which may potentially exceed the feasibility threshold.

Storing capacity is a major factor regarding the legal feasibility. The approval of new import terminals mainly follows the requirements of Immissions Control Law (if exceeding the quantity of three tonnes, and in the case of methanol of 10 tonnes), which increase with the storing quantity. The higher the storing quantity the higher the legal requirements. For example, import terminals (at least for $LH_2$, ammonia, and methanol) with a storing capacity of 200,000 tonnes and more need an environmental impact assessment, which is a lengthy procedure prior to (yet also part of) the approval procedure according to the Federal Immissions Control Act. Import terminals for $LH_2$ (≥ 3 tonnes) ammonia (≥ 50 tonnes) and methanol (≥ 500 tonnes) are within the scope of the **Hazardous Incident Ordinance** (see chapter 3.3.1.2), which also lays down extensive requirements. Import terminals within the upper class according to the hazardous incident ordinance need a complex hazard management system. If such requirements are not adequately met, legal consequences may follow in the case of incidents.

The legal feasibility of **new import terminals** for the import of the four hydrogen transport options also heavily depends on site-specific conditions of the ports due to the respective substance's hazardousness, which is reflected in the planning and approval law inter alia by **regulation on distance and plant safety**. SEVESO III[33] requires adequate safety distances to certain adjacent infrastructure, without further determining what adequate means. Being examined through either provisions of the Federal Building Act or the Federal Immissions Control Act, adequate safety distances must be determined by the competent authority for each individual approval leaving in some cases project developers with **no predictability**. The recommendations of KAS-18 are the only technical guidelines regarding safety distances.

Even if the regulatory framework generally provides for the legal groundwork to build import terminals, one further issue is the **lack of safety standards** – especially for $LH_2$ due to its extreme characteristics. The lack of safety standards and respective guidelines can lead to **differing authorisation praxis,** especially when the competent authority has no prior knowledge of authorising such facilities. This may result in **a legal** and thus **planning uncertainty,** which can be of hindrance to the implementation of infrastructure. Notably, authorisation processes can take much **more time** when there is no clear legal framework, as details must be assessed for each individual case.

### 3.3.1.2 Immission Control Law

BImSchG

Storing facilities – and thus import terminals – for three tonnes and more of **$LH_2$, ammonia** and **methanol** require authorisation according to the **Federal Immissions Control Act**[34] **(BImSchG).** The study's analysis concludes that storage of LOHC is not within the scope of the BImSchG and thus does not require an equal authorisation.

The BImSchG is the **central regulation** for immissions control at the national level, applying to the building and operation of land-based plants and facilities (§ 2 para 1 No 1 BImSchG – site-specific regulation) as well as to producing, placing on the market, and importing facilities, fuels, and substances (§ 2 para 1 No 2 BImSchG action-related regulation). It lays down the rules for **two types of approval processes**: a **standard approval process** that comprises public participation and can therefore take up to **several years** and a **simplified approval process** that goes without public participation. Hence, whether a facility is to be approved through the standard or simplified approval process is a question with a major impact on planning aspects. For import terminals for the hydrogen carriers, the question depends on storing quantities (see table below).

| BImSchG | No approval required | Simplified approval process | Standard approval process |
|---|---|---|---|
| $LH_2$ | < 3 T | ≥ 3 T | ≥ 30 T |
| Ammonia | < 3 T | ≥ 3 T | ≥ 30 T |
| Methanol | < 10 T | ≥ 10 T | ≥ 30 T |
| LOHC | - | - | - |

*Table 6: Storing quantities of the hydrogen transport options within the scope of BImSchG Source: Own presentation.*

33 Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending, and subsequently repealing Council Directive 96/82/EC. For further details see the following chapter.

34 Bundes-Immissionsschutzgesetz in der Fassung der Bekanntmachung vom 17. Mai 2013 (BGBl. I S. 1274; 2021 I S. 123), das zuletzt durch Artikel 1 des Gesetzes vom 24. September 2021 (BGBl. I S. 4458) geändert worden ist.

Regardless of the approval process, the immissions law approval comprises on a **formal level** other necessary authorisation (concentration effect, § 13 BImSchG). Therefore, for facilities within the scope of the BImSchG only **one application** must be handed in to the respective competent authority. The authority then reviews the facility's compliance with **all applicable** regulation. The following authorisation thus **comprises administrative decisions according to other laws** (e.g. the Federal Building Act and the Federal Act for the Protection of Nature or the Industrial Safety Regulation). Excluded are permissions according to §§ 8, 10 Federal Water Act. Such concentration effect works on several levels. A planning approval procedure according to § 75 Federal Administrative Procedure Act[35] (VwVfG) in turn comprises the authorisation according to the BImSchG. If no authorisation according to the BImSchG is needed but the facility is within the scope of the Industrial Safety Regulation, this authorisation in turn comprises the building permit according to the Federal Building Act.

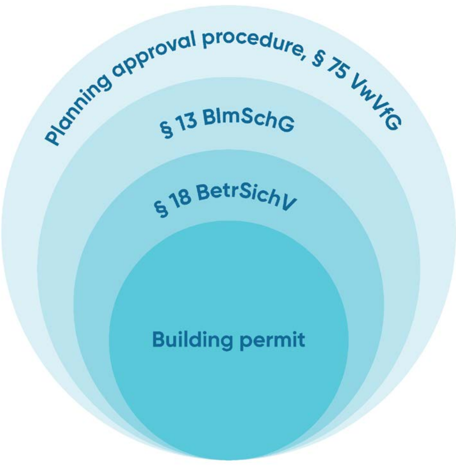



*Figure 4: Levels of concentration effect*
*Source: Own presentation.*

The BImSchG works together with several second level decrees (Federal Immissions Control Decrees [BImSchV]). The 9. BImSchV[36] enshrines detailed procedural rules for the approval processes. The **4. BImSchV**[37] hereby is crucial as it **lists** all **facilities subject to approval** and assigns them to one of either approval processes in Annex I. No 9.3 Annex I 4. BImSchV lists facilities for storage of substances named in Annex II 4. BImSchV. Annex II assigns the substances to one of either approval process depending on the storing or loading quantities. Annex II lists **ammonia** (No 9 Annex II 4. BImSchV), **hydrogen** (No 17 Annex II 4. BImSchV) and substances classified as acute toxic category 1, 2 or 3 under the CLP Regulation (No 30 Annex II 4. BImSchV). **Methanol** is thus classified (see chapter 3.1.2). Hence, for those three hydrogen carriers, **No 9.3 Annex I in conjunction with Annex II 4. BImSchV applies.** By contrast, LOHC are not listed in Annex II 4. BImSchV but could be within the scope of No 9.2 Annex I 4. BImSchV. No 9.2 Annex I 4. BImSchV applies to the storage of **liquids** not within the scope of No 9.3 Annex I 4. BImSchV but only with a flashpoint below 100 °C and thus equally **does not apply to LOHC**. Therefore, to current knowledge, LOHC would not fall within the scope of the BImSchG and thus not need an according authorisation, but only a building permit.

### UVPG

Import terminals with a storage capacity of **three tonnes** and more for **$LH_2$ and ammonia** need a **site-specific preliminary test** according to the Environmental Impacts Assessment Act[38] (UVPG), 30 tonnes and more a **general preliminary test** and 200.000 tonnes and more need an **environmental impact assessment**. The corresponding storage capacities for **methanol** are 10 tonnes, 200 tonnes and 200.000 tonnes. According to the study's findings, import terminals for LOHC should not be within the scope of the UVPG and thus neither need a preliminary test nor an environmental impact assessment.

The environmental impact assessment is a **dependent part of the administrative procedure** according to the BImSchG (§ 1 para 2 9. BImSchV), which serves to determine and present the environmental impact of the respective project for the authorisation. The UVPG requires an **environmental impact assessment** or a **preliminary test** for all facilities that fall within the scope of the UVPG. Annex I UVPG lists all facilities, which are within the scope of the UVPG, inter alia depending **on storing quantities**. **No 9.3** Annex I UVPG lists the construction and operation of storing facilities for substances listed in **Annex II 4. BimSchV** and is thus synchronised with the scope of application of the BImSchG, applying to import terminals for the storage of $LH_2$, ammonia and methanol. **No 9.2** Annex I UVPG lists the **construction and operation of storing facilities for liquids** that are not within the scope of No 9.3 Annex I UVPG, with a flashpoint below 100°C. LOHC, which have a flashpoint over 100°C, also fall outside that scope.

35 Verwaltungsverfahrensgesetz in der Fassung der Bekanntmachung vom 23. Januar 2003 (BGBl. I S. 102), das zuletzt durch Artikel 24 Absatz 3 des Gesetzes vom 25. Juni 2021 (BGBl. I S. 2154) geändert worden ist.

36 Verordnung über das Genehmigungsverfahren in der Fassung der Bekanntmachung vom 29. Mai 1992 (BGBl. I S. 1001), die zuletzt durch Artikel 2 der Verordnung vom 11. November 2020 (BGBl. I S. 2428) geändert worden ist.

37 Verordnung über genehmigungsbedürftige Anlagen in der Fassung der Bekanntmachung vom 31. Mai 2017 (BGBl. I S. 1440), die durch Artikel 1 der Verordnung vom 12. Januar 2021 (BGBl. S. 69) geändert worden ist.

38 Gesetz über die Umweltverträglichkeitsprüfung in der Fassung der Bekanntmachung vom 18. März 2021 (BGBl. I S. 540), das durch Artikel 14 des Gesetzes vom 10. September 2021 (BGBl. I S. 4147) geändert worden ist.

For the hydrogen carriers in question, Annex II BImSchG and Annex I UVPG in conjunction with the 4. BImSchV state the following **storing quantities**:

| UVPG | No UVP required | Site-specific preliminary test | General preliminary test | UVP required |
|---|---|---|---|---|
| $LH_2$ | < 3 T | ≥ 3 T | ≥ 30 T | ≥ 200.000 T |
| Ammonia | < 3 T | ≥ 3 T | ≥ 30 T | ≥ 200.000 T |
| Methanol | < 10 T | ≥ 10 T | ≥ 200 T | ≥ 200.000 T |
| LOHC | - | - | - | - |

*Table 7: Storing quantities of the hydrogen transport options within the scope of UVPG*
*Source: Own presentation.*

The **preliminary test** aims to **determine** the requirement for an environmental impact assessment and applies to new facilities in planning. It either is carried out as a **general preliminary test** (§ 7 para 1 UVPG) or as a **site-specific preliminary test** (§ 7 para 2 UVPG). The first roughly estimates if the planned facility can in general have considerable negative impact on the environment according to the criteria laid down in Annex III UVPG, which would lead to the requirement of an environmental impact assessment. The latter examines in two steps if (1) the local circumstances check more concrete criteria laid down in Annex III No 2.3 UVPG (e.g. local nature conservation areas) and if so (2) if the planned facility can have considerable negative impact on the environment.

Facilities are generally to be assessed regarding size and design, interaction with other existing or authorised facilities and projects, the use of natural resources (e.g. area, soil, water, animals, plants, and biological diversity), the production of waste, environmental pollution, **the risk of incidents, accidents, and catastrophes**, notably regarding the substances being handled, and the risks for human health, e.g. through water or air pollution (No 1 Annex III UVPG). Site-specific criteria are the existing use of the site (e.g. area for settlement and recreation, agricultural use or other economic and public use, traffic) or its quality of natural resources regarding area, soil, landscape, water, biological diversity. Within the site-specific preliminary test, next to nature conservation areas, also areas with high density population are to be taken into special account.

Therefore, the UVPG lays down **narrow criteria** to be considered within the authorisation according to the BImSchG (§ 6 para 1 No 2 BImSchG, § 1a 9. BImSchV). Such narrow criteria **are able to rule out various sites for the establishment of import terminals** (depending on the storage quantity) for the hydrogen carriers.

### StörfallV (12. BImSchV)

Import terminals for **$LH_2$** (storage capacity of three tonnes and more)**, ammonia** (storage capacity of 50 tonnes and more) **and methanol** (storage capacity of 500 tonnes and more) are within the scope of the **Hazardous Incident Ordinance**[39] **(StörfallV – 12. BImSchV)**. Again, according to the study's conclusion, import terminals for LOHC are not within the scope.

The StörfallV is one of the Federal Immissions Control ordinances and translates the **SEVESO-III-Directive**[40] into German law. It regulates the handling of hazardous goods in land-based facilities. However, its scope of application in this regard is limited: According to § 1 para 3 StörfallV in conjunction with Art. 2 para 2 lit c of the SEVESO IIII Directive, it **does not apply to the transport** of dangerous substances and **directly related intermediate temporary storage** by road, rail, internal waterways, sea, or air, outside the establishments covered by this Directive, including loading and unloading and transport to and from another means of transport at docks, wharves or marshalling yards. German Courts have specified this restriction to the effect that the Hazardous Incident Decree **does not apply for temporary storage** in **transhipment terminals** within an intermodal transport if there is a **spatial, functional, and temporal link to the transport**.[41]

Within the scope of application, § 3 StörfallV imposes **general obligations** on operators such as the duty to take appropriate precautions depending on nature and level of possible dangers. The appendix lists all hazardous goods within the application scope and classifies the **operating range in two classes** (upper class and lower class) in relation to the stored quantity. Contrary to LOHC, $LH_2$, ammonia, and methanol are listed with the following storing quantities:

| StörfallV | Lower class | Upper class |
|---|---|---|
| $LH_2$ | ≥ 5 T | ≥ 50 T |
| Ammonia | ≥ 50 T | ≥ 200 T |
| Methanol | ≥ 500 T | ≥ 5.000 T |
| LOHC | - | - |

*Table 8: Storing quantities according to the StörfallV*
*Source: Own presentation.*

39 Störfall-Verordnung in der Fassung der Bekanntmachung vom 15. März 2017 (BGBl. I S. 483), die zuletzt durch Artikel 107 der Verordnung vom 19. Juni 2020 (BGBl. I S. 1328) geändert worden ist.

40 Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending, and subsequently repealing Council Directive 96/82/EC.

41 OVG Münster NJOZ 2005, 4653.

For the hazardous goods in an operation range that falls in the lower class, the Hazardous Incident Decree requires **general safety measures** (§§ 3-8a StörfallV) whereas all operating ranges that fall in the upper class come with **extended obligations** (§§ 9-12 12. StörfallV). Among general safety measures are inter alia the equipment with **sufficient warning, alarm, and safety devices** (§ 5 para 1 StörfallV), and the **constant monitoring and maintenance in terms of safety** (§ 6 para 1 No 1 StörfallV). According to § 7 StörfallV, the operator has an obligation to notify the competent authority at least one month before the installation of an operating range that falls within the scope of application. He also must develop a **written concept** for preventing accidents and submit to the authority upon request (§ 8 StörfallV). Extended obligations are inter alia a complex safety report, in which potential incident scenarios have been determined and which must be updated every five years (§ 9 StörfallV), alarm and emergency plans (§ 10 StörfallV) as well as other documentation and information obligations (§§ 11, 12 StörfallV). Facilities within the scope of the upper class thus require a **detailed hazard management system**.

In general, all land-based facilities within the scope of the BImSchG and within the scope of the StörfallV, thus import terminals for $LH_2$, ammonia and methanol must respect **safety distances from adjacent objects of protection** (§ 3 para 5 lit d BImSchG). Adjacent objects of protection are all areas used exclusively or predominantly for residential purposes, buildings and areas used by the public, recreational areas, important traffic routes and areas that are particularly valuable or sensitive areas from the point of view of nature conservation. The appropriate safety distance is the distance between an operating area and an adjacent protected object that limits the impact on the adjacent protected object due to accidents. The appropriate safety distance is to be determined on the basis of accident-specific factors (§ 3 para 5c BImSchG).

**Safety distances** as a tool to prevent major accidents is laid down in Art.13 No 2 lit a SEVESO III according to which Member States shall ensure that their land-use maintains appropriate safety distances between establishments covered by the Directive and residential areas, buildings and areas of public use, recreational areas, and as far as possible, major transport routes. This requirement has only been insufficiently implemented into German National law (notably in § 50 Federal Building Act[42] - BauGB) resulting in some **legal uncertainty regarding concrete safety distances.** § 50 BauGB generally states that in spatially significant planning, areas are to be allocated to each other in such a way that major accidents are avoided as far as possible. Spatially significant planning includes spatial development plans, projects and other measures that take up space or influence the spatial development or function of an area (§ 3 No 6 Spatial Planning Act[43] [ROG]). Also, according to § 9 para 1 No 24 BauGB development plans may define protected areas to be kept free from development, which is one of the implementations of Art. 13 SEVESO III. However, on the level of sectoral planning, not many development plans have implemented such safety distances yet. In this case, the **adequate safety distances must be determined by the competent authority for each individual approval**[44]. The term appropriate safety distance is an indeterminate legal term, which can however be technically determined. The determination of the appropriate distance by the authority is thus subject to full judicial review and has no margin of assessment and discretion.[45] The determination of the safety distances follows recommendations of the **commission of plant safety** (Kommission für Anlagensicherheit – KAS-18). Local authorities **only authorise new facilities complying with the recommendations** based on individual reports. Nevertheless, it must be noted that the recommendations are non-binding and not yet official technical guidelines. Hence, they cannot be enforced in court or provide third party protection.

#### 3.3.1.3 Substance Law

ChemG

Very close to work protection law and partly overlapping is the **substance law,** whose central regulation on national level is the **Law for Protection against Hazardous Substances**[46] **(ChemG)**, which translates various European Directives into German Law and lays down ground rules for the handling of hazardous substances. Substance law is mainly regulated on European level by the **REACH-Directive**[47] and the **CLP Regulation** (see chapter 3.1.2)**.** The REACH-Directive lays down requirements for registration, evaluation, authorisation, and restrictions of chemicals.

Art. 6 REACH-Directive requires registration for the import of substances in quantities of 1 tonne or more per year. The import of substances listed in Annex XIV REACH-Directive must be authorised and Art. 67 – 73 REACH-Directive lay down restrictions on the import of substances listed in Annex XVII

42 Baugesetzbuch in der Fassung der Bekanntmachung vom 3. November 2017 (BGBl. I S. 3634), das zuletzt durch Artikel 9 des Gesetzes vom 10. September 2021 (BGBl. I S. 4147) geändert worden ist.

43 Raumordnungsgesetz vom 22. Dezember 2008 (BGBl. I S. 2986), das zuletzt durch Artikel 5 des Gesetzes vom 3. Dezember 2020 (BGBl. I S. 2694) geändert worden ist.

44 BVerwG, NVwZ 2013, 719 (720).

45 BVerwG, NVwZ 2013, 719 (721).

46 Chemikaliengesetz in der Fassung der Bekanntmachung vom 28. August 2013 (BGBl. I S. 3498, 3991), das zuletzt durch Artikel 115 des Gesetzes vom 10. August 2021 (BGBl. I S. 3436) geändert worden ist.

47 Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

REACH-Directive. Neither of the four hydrogen transport options are listed in either Annex. However, the **import of more than 1 tonne of all four hydrogen carriers requires registration at the European Chemicals Agency** (ECHA).

#### ChemVerbotsV

The Ordinance on prohibition and restriction of placing on the market and supply of hazardous chemicals, compounds, and products according to the Chemicals Act[48] (ChemVerbotsV) contains, as the title indicates, further bans and restrictions of placing certain hazardous chemicals on the market (thus import) as well as regulation regarding the supply of such chemicals. It has been issued in accordance with the ChemG. Bans and restrictions of placing hazardous chemicals on the market apply (1) to substances within the scope of Art. 67 in conjunction with Annex XVII REACH-Directive as well as (2) to substances that are listed in Annex I Column 1 (§ 3 para 2 ChemVerbotsV). None of the hydrogen carriers in question fall within the scope of the REACH-Directive or are listed in Annex I Column 1 ChemVerbotsV. Thus**, no bans and restrictions** of placing them on the market **apply** in this regard.

However, **commercial supply** of methanol and ammonia needs **authorisation** by the competent authority under state law (§ 6 ChemVerbotsV). **Regulation** regarding the **supply of hazardous chemicals** applies to substances that fall within **Annex II Column 1 ChemVerbotsV** according to their **harmonized classification** with the hazard pictograms GHS06. Being classified with the hazard pictogram GHS06, such regulation thus **applies to methanol** and **ammonia**. Neither **$LH_2$ nor LOHC fall within the scope**. Supply means the handover or shipment to the purchaser or the receiving person (§ 2 No 1 ChemVerbotsV). Commercial supply is all supply carried out within an economic enterprise or with the intention of making a profit in the context of an activity, which is carried out not only once (§ 2 No 2 ChemVerbotsV). The authorisation depends on (1) proven expertise (§ 11 ChemVerbotsV) and (2) sufficient reliability (§ 6 para 2 ChemVerbotsV). Sufficient reliability is an established legal term that defines as the guarantee to properly conduct the business in the future. Courts have developed criteria to determine this guarantee. According to § 5 para 2 ChemVerbotsV, for the supply to **resellers** or **professional users**, **only facilitated requirements** apply such as a notification requirement (§ 7 para 1 ChemVerbots) and general obligations (§ 8 ChemVerbotsV). Furthermore, an identity statement and documentation are necessary (§ 9 ChemVerbotsV) and the dispatch route is limited to certain recipients, mainly excluding private recipients (§§ 10, 5 para 2 ChemVerbotsV).

### 3.3.1.4 Work protection law

#### ArbSchG

During the import of **all four hydrogen transport options** several work protection laws must be complied with. Central is the **Federal Work Protection Act**[49] **(ArbSchG)** which aims to ensure and increase safety and health protection at work and applies to all activities. It lays down general obligations for employer and employees. Measures of work protection in that regard are all measures to prevent incidents during work, work related health hazards including measures towards an appropriate work environment (§ 3 ArbSchG). One **major principle** within the work protection law is a **risk assessment** (§ 5 ArbSchG) to determine which exact protection measures are required. The Federal Work Protection Act also authorizes for executive decrees in the field of work protection law, some of which are named below and address various sub-areas as well as provide for more concrete provisions regarding the risk assessment.

#### BetrSichV

The **Industrial Safety Regulation**[50] **(BetrSichV)** aims at ensuring the safety and health protection of employees when handling work equipment and thus **applies to the handling of work equipment in general** (§ 1 para 1 BetrSichV). Work equipment is defined in § 2 para 1 BetrSichV as tools, devices, machines, or facilities which are used for work as well as systems requiring monitoring. Requirements for the handling of work equipment are laid down in section 2 (§§ 3 -14) containing **general provisions** on protection measures and requirements for work equipment. Section 3 BetrSichV also lays down **additional requirements** for protection measures within hazard areas of systems requiring monitoring (§§ 15-18 BetrSichV).

The **storage of methanol** with a storage capacity of more than 10 000 litres needs **approval** according to the BetrSichV as well as methanol transhipment terminals where transport containers are filled with a capacity of more than a 1000 litres per hour. For **$LH_2$** or **ammonia** such an approval is only necessary for **terminals where transportable pressure equipment is filled**. However, as outlined in chapter 3.3.1.2, such approval is comprised by the authorisation according to the BImSchG (for import terminals with a storage capacity of three tons and more). According to the study's preliminary assessment, import terminals for **$LH_2$, ammonia, and methanol** also are **systems requiring monitoring**. To the study's conclusion, import terminals for LOHC are not within the scope of the BetrSichV. However, there remains an uncertainty to that extent.

48 Chemikalien-Verbotsverordnung vom 20. Januar 2017 (BGBl. I S. 94; 2018 I S. 1389), die zuletzt durch Artikel 300 der Verordnung vom 19. Juni 2020 (BGBl. I S. 1328) geändert worden ist.

49 Arbeitsschutzgesetz vom 7. August 1996 (BGBl. I S. 1246), das zuletzt durch Artikel 12 des Gesetzes vom 22. November 2021 (BGBl. I S. 4906) geändert worden ist.

50 Betriebssicherheitsverordnung vom 3. Februar 2015 (BGBl. I S. 49), die zuletzt durch Artikel 7 des Gesetzes vom 27. Juli 2021 (BGBl. I S. 3146) geändert worden ist.

**Systems requiring monitoring** are generally defined in § 2 No 1 Law on systems requiring monitoring[51] (ÜAnlG), which authorizes for second level law to further define such systems (§ 31 ÜAnlG). The BetrSichV as such second level law defines systems requiring monitoring as (1) all systems that **require approval** according to § 18 para 1 BetrSichV or (2) are **named in Annex II** BetrSichV as § 2 para 13 BetrSichV clarifies.

§ 18 para 1 BetrSichV lists all plants and facilities the construction and operation of which need approval of the authority (competence regulated under state law). In the following the most relevant are listed:

- Installations with **pressure equipment** as defined in Annex II section 4 No 2.1 lit c, in which, with a filling capacity of more than 10 kilograms per hour, **transportable pressure equipment** within the meaning of Annex II section 4 No 2.1 lit b are **filled** with compressed gases for supply to others (No 2).

- Rooms or areas including the fixed containers and other **storage facilities** provided in them or other storage facilities intended for the storage of **flammable liquids** with a total volume of more than 10 000 litres (**storage facilities**) (No 4).

- **Fixed installations** or installations permanently used on the same site with a handling capacity of more than 1 000 litres per hour, intended to be used for **filling transport containers** with **flammable liquids** (**filling stations**) (No 5).

Hence, whether import terminals need approval according to the BetrSichV and thus are systems requiring monitoring depends on the respective hydrogen carrier, the storing capacity, and the further use of the stored carriers: if merely reloaded to an inland-navigation vessel (gas carrier), import terminals for $LH_2$ and ammonia would not be within the scope of § 18 para 1 BetrSichV. However, if reloaded into transportable pressure equipment (e.g. cryogenic transportable tanks), import terminals would be within the scope. The need of an approval according to § 18 para BetrSichV thus needs to be thoroughly scrutinized for each individual case. The **Technical Rules on Plant Safety (TRBS 1122)** substantiate the requirements for the approval.

**Section 3 Annex II** BetrSichV mentions facilities within **explosion hazard areas**. Explosion hazard areas are all areas, where hazardous explosive atmosphere can arise (§ 2 para 14 GefStoffV). Thus, for all respective import terminals, it must be examined if such explosive atmosphere may arise (notably $LH_2$ import terminals). **Section 4** No 1 Annex II BetrSichV lists **pressure plants** which are inter alia defined in section 4 No 2.1 lit b BetrSichV as **pressurised container systems**. Storage facilities for gases and liquids with vapour pressure exceeding atmospheric pressure by 0,5 bar are pressure plants (see Directive 2014/68/EU). Thus, **import terminals for $LH_2$, ammonia and methanol should be systems requiring monitoring according to the BetrSichV**.

Systems requiring monitoring within the scope of the Industrial Safety Regulation must **be examined prior to commissioning** (§ 15 BetrSichV) and then be **regularly monitored** with regard to their safety (§ 16 BetrSichV) in addition to general obligations and mandatory safety measures prescribed by the Industrial Safety Regulation.

Also central to the BetrSichV is the general requirement of a **preliminary risk assessment** (§ 3 BetrSichV) prior to handling work equipment, which assesses and addresses the risks stemming from handling work equipment. § 3 BetrSichV lays down ground rules for such a preliminary risk assessment, which would be necessary for **all import terminals**. Not duly conducting a preliminary risk assessment is an **administrative offense** (§ 22 para 1 No 1 BetrSichV).

### GefStoffV

The **Hazardous Substances Ordinance**[52] **(GefStoffV)** aims to protect people and the environment from substance-related damage through provisions on classification, labelling and packaging of hazardous substances, protective measures for employees handling as well as restrictions on producing and using such substances. The Hazardous Substances Ordinance translates the provisions of the **CLP Regulation** into national law. Section 2 GefStoffV applies to the placing on the market of hazardous substances (§ 1 para 2 No 1 GefStoffV) whilst sections 3 to 6 GefStoffV apply to activities, during which workers may be exposed to risks to their health and safety from substances, mixtures, or articles (§ 1 para 3 GefStoffV). The Hazardous Substances Ordinance thus has a **substance-related** and an **activity-related** scope. A substance is hazardous according to the Hazardous Substances Ordinance when it corresponds with criteria in Annex I of the CLP Regulation (§ 3 para 1 GefStoffV). Hence, $LH_2$, ammonia, and methanol fall within the substance-related scope of the GefStoffV. For these substances, classification, labelling and packaging must follow the provisions of the CLP Regulation (§§ 3, 4 GefStoffV). The CLP Regulation regulates the substance's identification label in detail, including provisions on the arrangement of content (Art. 17 – 33 CLP Regulation). Each hydrogen carrier must be **labelled with an according identification label**. Albeit Art. 35 CLP Regulation also regulates packaging, the provisions remain general and do not exceed those of the regulation on transport of dangerous goods.

Section 3 GefStoffV enshrines **detailed provisions for a preliminary risk assessment (§ 6 GefStoffV)** - as part of the assessment of working conditions according to § 5 ArbSchG (See above) - which applies to all activities during which employees shall be exposed to health hazards or be at risk due to exposure to dangerous substances. It is thus **mandatory** for all import infrastructure for all four hydrogen transport options, where workers are employed.

51 Gesetz über überwachungsbedürftige Anlagen vom 27. Juli 2021 (BGBl. I S. 3146, 3162).

52 Gefahrstoffverordnung vom 26. November 2010 (BGBl. I S. 1643, 1644), die zuletzt durch Artikel 2 der Verordnung vom 21. Juli 2021 (BGBl. I S. 3115) geändert worden ist.

### 3.3.1.5 Relevant Federal State Law not included in the scope

For every import terminal, the **BauGB** applies. For import terminals with a storing capacity of less than 3 tonnes, a building permit must be obtained (if not in the scope of the BetrSichV). Generally, a building development plan should be necessary for the envisioned scope of import infrastructure.

Also important to mention is the **Product Safety Act**[53] (ProdSG), which applies when products are being placed on the market (§ 1 para 1 ProdSG) and - like the Federal Immissions Control Act - equally works together with several ordinances on product safety, one of which is the **Ordinance on Pressure Equipment**[54] **(14. ProdSV)** containing **obligations for all parties involved with fixed pressure equipment**.

Not included in the scope of the study, yet of relevance on Federal State Level as well as State Level is **Water Law** and **Nature conservation law,** both of which would need to be examined prior to the authorisation of both import terminals and bunkering stations.

### 3.3.1.6 Regulation on state and municipal level

Most of the States (Länder) have **State Harbour Ordinances** and **Harbour Safety Acts,** which apply to all seaside and inland harbours within state borders. They mostly provide for general regulation and translate European Directives into national law. Insofar, they contain similar regulation. However, some contain **specific regulation** in relation to the infrastructure being examined in this study but mostly regarding bunkering in Germany and thus are dealt with in chapter 3.5.4. Each port has its **own port byelaws** with provisions on administration and operations.

In general, the state-controlled port authority is the proprietor of the port area and the essential infrastructure. The Port authority is responsible for the port supervision. For private companies to develop port infrastructure and provide port services, the port authority transfers the use of defined port areas through **concession contracts.**

## 3.3.2 Port of Rotterdam

Regulations for ammonia, methanol, and LOHC do exist in the Netherlands whereas regulation for large scale terminals for $LH_2$ yet needs to be developed. However, the Port of Rotterdam already is in an early stage of planning $LH_2$ unloading and transhipment terminals.

The **Shipping traffic law (sheepvartverkeerswet)** translates the **SOLAS Convention** and some **CCNR police regulation** into national law and thus applies for both Maritime Shipment and Inland Waters. The **Inland shipping law** (binnenvaartwet) and the **Inland shipping police regulation** (binnenvaartpolitiereglement - BPR) translate the **CCNR regulations into national law**. The **law on the transportation of hazardous substances** (wet Vervoer gevaarlijke stoffen, WVGS) translates the **ADR, ADN, RID** into national law and therefore should be similar to the German regulation as it, too, translates the European regulation into national law. In general, the transport of dangerous substances is an internationally deeply harmonized regulation system and should thus not differ to a great extent on a national level.

National **guidelines** contain rules on onshore storage and handling of **ammonia**. These are covered by the **Publication series on Dangerous Substances (PGS 12)**. PGS 12 covers environment and fire safety on storage and loading of ammonia. It extends to both pressurised and refrigerated storage regardless of storage volume. It provides **qualitative guidelines for ammonia storage and loading**.

Art. 5.4 of the port byelaws of the Port of Rotterdam (2020) states that tankers carrying dangerous goods may only berth in a **petroleum harbour.** This requirement only applies to sea vessels as Art. 5.5 of the byelaws states an exemption for inland shipping tankers carrying dangerous goods that may also berth outside a petroleum harbour if it berths for a short period of time at an establishment for the purpose of taking fuel on board, or at a designated location for the purpose of taking drinking water on board, or the ship is a reception facility and complies with the requirements of the ADN for an inland shipping vessel type C whose cargo tanks or slop tanks contain an inert atmosphere. The byelaws also provide rules for the transhipment of dangerous liquid substances in bulk. According to Art. 6.2 of the byelaws a checklist must be completed and signed whereas the transhipment of a gas referred to in the IGC Code or the ADN is prohibited (Art. 6.4).

53 Produktsicherheitsgesetz vom 27. Juli 2021 (BGBl. I S. 3146, 3147), das durch Artikel 2 des Gesetzes vom 27. Juli 2021 (BGBl. I S. 3146) geändert worden ist.

54 Druckgeräteverordnung vom 13. Mai 2015 (BGBl. I S. 692), die zuletzt durch Artikel 28 des Gesetzes vom 27. Juli 2021 (BGBl. I S. 3146) geändert worden ist.

## 3.4 Landside distribution inside German borders

This chapter examines the legal framework for landside transport of the four hydrogen carriers. Regarding the distribution by road, inland waterway, and rail, this study first lays out regulation applicable to all three modes of transport (chapter 3.4.1), before examining specific legislation for each mode of transport. The study then assesses potential legal barriers for each mode of transport in the respective section (see chapters 3.4.2, 3.4.3, and 3.4.4).

This study also explores the legal framework **for pipeline-bound infrastructure** of both hydrogen and hydrogen carriers (see chapter 3.5). Pipelines offer a transport possibility with great potential especially for the scaled-up transport of gaseous hydrogen on the European mainland. Efforts are already underway to integrate gaseous hydrogen with the existing infrastructure for natural gas. While in some cases direct use of the carriers will be beneficial, gaseous hydrogen could in principle be retrieved from the carriers before further transport upon arrival. Therefore, this study will lay out the legal framework and possible hindrances for the pipeline transport of gaseous hydrogen. It will then examine the transport of the hydrogen carriers themselves via pipeline.

### 3.4.1 Transport via streets, inland waterway, and rail: regulation applicable across all modes of transport

Dangerous goods are generally **regular goods** within the meaning of the EU provisions on the free movement of goods (Art. 28 et seq. TFEU) insofar as they have a certain monetary value and as such can form the basis of a commercial transaction.[55] They are therefore **in particular subject to the prohibition of quantitative restrictions on imports and measures having equivalent effect under Art. 34 TFEU**. When regulating European cross-border transport of dangerous goods, the Member States must avoid provisions that are likely to hinder, directly or indirectly, actually, or potentially, trade within TFEU - in the area of the transport of dangerous goods, in particular for reasons of public safety and health protection.[56]

Current annual freight transport in Germany amounts to 3,2 billion tonnes on road, 320,1 million tonnes via railway and 188 million tonnes by inland waterway.[57] The total amount of the **transport of dangerous goods** in Germany divided between these three modes of transport was 310 million tonnes in 2017.[58] Only **internationally harmonised dangerous goods regulations** can ensure the smooth handling of dangerous goods while guaranteeing the greatest possible safety. For this reason, **the national law on the transport of dangerous goods is determined by international regulations to a large extent.**[59] Original European law is less important regarding the area of dangerous goods transport[60] but is mostly derivative of international regulation. Hence, European Directives (see chapter 3.4.1.1) primarily transpose international law on the transport of dangerous goods into European law, which in turn is transposed into national legislation. The following graph shows the depicted interrelations between international treaties and German national law.

In the following, legislation applicable for all three modes of transport is presented, before examining legislation applicable for each mode of transport in particular.

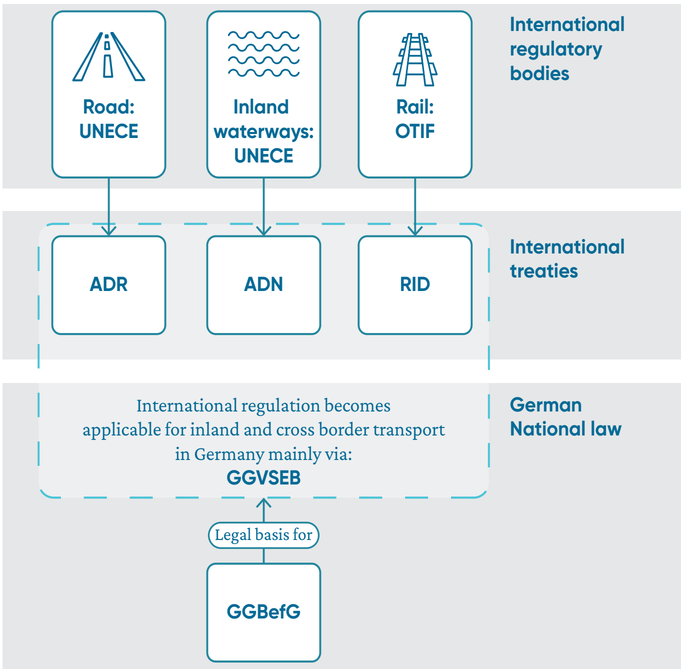



*Figure 5: International and national system of the regulation of the transport of dangerous via rail, road, and inland waterways*
*Source: Own presentation*

55 Michael Kloepfer and Nico David Neugärtner, 388.

56 Michael Kloepfer and Nico David Neugärtner, 395.

57 DESTATIS, 'Transport Und Verkehr: Güterverkehr', Statistisches Bundesamt, 2022, https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Transport-Verkehr/Gueterverkehr/_inhalt.html.

58 Sarah Keller, 'Beförderungsmenge von Gefahrgut in Deutschland Im Jahr 2017 Nach Verkehrsträgern (in Millionen Tonnen)', statista, 21 January 2022, https://de.statista.com/statistik/daten/studie/163275/umfrage/befoerderungsmenge-der-gefahrguttransporte-in-deutschland/.

59 Michael Kloepfer and Nico David Neugärtner, 'Stoffrecht (§ 19: Recital 1 - 453)', in Umweltrecht, 4. Auflage, 2016, 388.

60 Michael Kloepfer and Nico David Neugärtner, 392.

### 3.4.1.1 Directive 2008/68/EC

The **Directive 2008/68/EC on the inland transport of dangerous goods**[61] includes regulation on **the transport of dangerous goods by road, rail, or inland waterway within or between EU Member states.** It applies to activities of transfer to or from another mode of transport and the stops necessitated by the circumstances of the transport.[62] In addition, it includes the admissibility of exemptions and the procedures to be followed in these cases. Permitted exemptions and national derogations for Member states are attached to the Directive in its annexes.[63] Through its Annexes, the Directive also transfers the international regulatory framework (The Agreement concerning the International Carriage of Dangerous Goods by Road[64] **(ADR),** the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways[65] **(ADN)** and Regulations concerning the International Carriage of Dangerous Goods by Rail[66] **(RID)** and into European law.[67] Directive 2008/68 was adapted to scientific and technical progress by Directive (EU) 2016/2309 of 16 December 2016.[68]

### 3.4.1.2 Directive 2010/35/EU

The **Directive 2010/35/EU of the European Parliament and of the Council of 16 June 2010 on transportable pressure equipment**[69] 'sets out detailed rules concerning transportable pressure equipment to enhance safety and ensure free movement of such equipment within the Union' (Article 1 Directive 2010/35/EU). According to Art. 2 para 1 Directive 2010/35/EU, it encompasses all pressure receptacles, their valves, and other accessories when appropriate, as covered in Chapter 6.2 of the Annexes to Directive 2008/68/EC, thereby referring to the annexes of the international regulation of ADR, RID and ADN. It also includes tanks, battery vehicles/wagons, multiple-element gas containers (MEGCs) as covered in Chapter 6.8 of the annexes to the directive.

#### GGBefG

The **Dangerous Goods Transport Act**[70] **(GGBefG)** serves as the **basic regulation** encompassing the transport of dangerous goods by rail, magnetic levitation train, road, and air vehicles. It also encompasses the manufacture, importation and placing on the market of packaging, transport containers, and vehicles for the transport of dangerous goods, § 1 para 1 GGBefG. The GGBefG only provides **general provisions** and contains above all the legal basis for issuance of ordinances with more specific regulation, § 3 GGBefG.

The GGBefG contains a general **definition of dangerous goods** (§ 2 para 2 GGBefG), which applies within the scope of the GGBefG:

> *Dangerous goods are substances and objects, which, due to their nature, their properties, or their condition in connection with the transport, pose a risk to public safety or order, in particular for the general public, for important common property, for the life and health of people, for animals and property.*

The general legal definition of dangerous goods is specified in the regulations for the individual modes of transport (see chapters 3.4.2, 3.4.3, and 3.4.4), which in turn refer to international regulations with respective lists and classification of individual goods.[71]

61 Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods (Text with EEA relevance).

62 Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods (Text with EEA relevance), Art. 1.

63 Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods (Text with EEA relevance), Annex I, II, III.

64 Agreement concerning the International Carriage of Dangerous Goods by Road, ADR, applicable as from January 2021 (ADR).

65 European Agreement concerning the International Carriage of Dangerous Goods by Inland waterway, including the Annexed Regulations, applicable as from January 2021 (ADN).

66 Convention concerning International Carriage by Rail (COTIF), Appendix C – Regulations concerning the International Carriage of Dangerous Goods by Rail as applicable from January 2021 (RID).

67 Michael Kloepfer and Nico David Neugärtner, 'Stoffrecht (§ 19: Recital 1 - 453)', 393.

68 Commission Directive (EU) 2016/2309 of 16 December 2016 adapting for the fourth time the Annexes to Directive 2008/68/EC of the European Parliament and of the Council on the inland transport of dangerous goods to scientific and technical progress (Text with EEA relevance).

69 Directive 2010/35/EU of the European Parliament and of the Council of 16 June 2010 on transportable pressure equipment and repealing Council Directives 76/767/EEC, 84/525/EEC, 84/526/EEC, 84/527/EEC and 1999/36/EC (Text with EEA relevance).

70 Gesetz über die Beförderung gefährlicher Güter, Gefahrgutbeförderungsgesetz vom 6. August 1975 (BGBl. I S. 2121), das zuletzt durch Artikel 13 des Gesetzes vom 12. Dezember 2019 (BGBl. I S. 2510) geändert worden ist.

71 Michael Kloepfer and Nico David Neugärtner, 'Stoffrecht (§ 19: Recital 1 - 453)', 407.

### 3.4.1.4 GGVSEB

The **Dangerous Goods Ordinance for Street, Railroad, and Inland Shipping** [72] (GGVSEB) regulates the transport of dangerous goods by road with vehicles, by rail with railroads and on all navigable inland waterways, § 1 para 1 GGVSEB. It transposes the Directive 2008/68/EC into national law.

Via § 1 para 3 GGVSEB, **international regulation** for the transport of dangerous goods for the respective mode of transport becomes applicable**:**

| | | |
|---|---|---|
| Road Transport | Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) | § 1 para 3 No 1 a, b GGVSEB |
| Inland Waterway | European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) | § 1 para 3 No 3 a, b GGVSEB |
| Rail Transport | Regulation concerning the international carriage of dangerous goods by rail | § 1 para 3 No 2 a, b GGVSEB |

*Table 9: Transfer of the international regulatory framework on transport of dangerous goods into German national law. Source: Own presentation.*

**ADR, RID, and ADN** apply for both **national and cross-border transport** as the ordinance regulates the national and international carriage, including carriage to and from Member States of the European Union of dangerous goods, § 1 para 1 GGVSEB. The ordinance further **limits possible transport routes** for certain dangerous goods, §§ 35 et seq. GGVSEB.

**Dangerous goods may only be transported** if carriage is **not excluded** according to the corresponding parts of ADR, ADN and RID, referred to in § 3 GGVSEB or Annex II of GGVSEB, § 3 GGVSEB. In accordance with **§ 6 GGBefG**, the **Dangerous Goods Exemption Ordinance**[73] **(GGAV)** allows for general exemptions from this principle.[74] § 5 GGVSEB allows exemptions for **individual cases** or **generally for certain applicants** when in compliance with the requirements of Art. 6 of Directive 2008/68/EC.

The GGVSEB also regulates the **safety obligations** and the respective **responsibilities** of all parties involved along the transport chain. Parties involved in the transport of dangerous goods must take the **necessary precautions** according to the type and extent of the foreseeable dangers to prevent or mitigate damage, § 4 para 1 GGVSEB. For this purpose, § 2 GGVSEB defines the different participants, while §§ 17 et seq. GGVSEB regulate in detail the specific safety obligations that can affect the participant in question.

In part, these provisions relate to all transport modes, in part specifically to road, rail or inland waterway.[75] §§ 6 to 16 GGVSEB clarify the responsible authorities in connection with the transport of dangerous goods.

Breaches of this regulation by the responsible participants during transport can amount to administrative offenses according to § 37 GGVSEB and § 10 para 1 No 1 lit. b GGBefG. The transport of dangerous goods in violation of obligations under the GGVSEB may also constitute a violation of obligations under administrative law. Therefore, if a participant has at least negligently endangered the health of another, animals or plants, water, air or soil or other property of significant value through the violation, this can be punishable as a criminal offense, § 328 para 3 No 2 StGB.[76]

### 3.4.1.5 RSEB

The **guidelines on the application of the Dangerous Goods Decree for Street, Railroad and Inland Shipping**[77] **(RSEB)** aim to ensure **uniform application** and **interpretation** of the regulations on the transport of dangerous goods that are issued by the federal and state governments. They contain inter alia application instructions for GGVSEB, ADR, ADN and RID. In addition, its annexes include forms, samples, and a catalogue of fines amongst other things. The federal states implement the RSEB in general administrative regulations.[78]

72 Verordnung über die innerstaatliche und grenzüberschreitende Beförderung gefährlicher Güter auf der Straße, mit Eisenbahnen und auf Binnengewässern, Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt in der Fassung der Bekanntmachung vom 26. März 2021 (BGBl. I S. 481), die zuletzt durch Artikel 3 Absatz 5 des Gesetzes vom 2. Juni 2021 (BGBl. I S. 1295) geändert worden ist.

73 Gefahrgut-Ausnahmeverordnung in der Fassung der Bekanntmachung vom 11. März 2019 (BGBl. I S. 229), die zuletzt durch Artikel 2 der Verordnung vom 26. März 2021 (BGBl. I S. 475) geändert worden ist.

74 The exemptions laid out in its annex are generally applicable, yet have a very specific scope. They are not relevant for the transport of the examined hydrogen carriers.

75 Michael Kloepfer and Nico David Neugärtner, 'Stoffrecht (§ 19: Recital 1 - 453)', 430.

76 Strafgesetzbuch in der Fassung der Bekanntmachung vom 13. November 1998 (BGBl. I S. 3322), das zuletzt durch Artikel 2 des Gesetzes vom 22. November 2021 geändert worden ist.

77 Richtlinien zur Durchführung der Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB) und weiterer gefahrgutrechtlicher Verordnungen (Durchführungsrichtlinien – Gefahrgut) vom 15. April 2021.

78 Uwe Jacobshagen, Umweltschutz und Gefahrguttransport für Binnen- und Seeschifffahrt: Internationale, nationale und kommunale Übereinkommen (Wiesbaden, 2019), 223, https://doi.org/10.1007/978-3-658-25929-7.

#### 3.4.1.6 ODV

The **Ordinance on transportable pressure equipment**[79] **(ODV) applies to the conformity assessment, testing, approval, manufacture**, marking, placing, and making available on the market, periodic inspections and exceptional checks, intermediate inspections, use and market surveillance of **transportable pressure equipment** defined in Annex 1, § 1 para 1 ODV. It transposes the Directive 2010/35/EU into national law. The ODV in its Annex refers to ADR/RID to determine what constitutes transportable pressure equipment. The rules in question are also applicable to transportable pressure equipment transported via inland waterways.[80]

#### 3.4.1.7 GbV

The **Ordinance on the appointment of dangerous goods safety advisor**[81] (GbV) applies to any enterprise whose activities include the carriage of dangerous goods by road, rail, navigable inland waterways, and sea-going vessels, § 1 para 1 GbV. According to § 3 GbV, a company must, as soon as it is involved in the transport of dangerous goods and is assigned duties as a participant in the Dangerous Goods Regulations for Road, Rail, and Inland Navigation or in the Dangerous Goods Regulations for Sea, appoint **at least one safety advisor** for the transport of dangerous goods in writing.

### 3.4.2 Distribution via streets

Transport via roads remains the **most important mode** of transport for dangerous goods: in 2017, 147 million tonnes of dangerous goods were transported on roads in Germany.

#### 3.4.2.1 Potential regulatory barriers

The currently applicable regulation for road transport (1) **in principle allows for the carriage of ammonia (liquefied), methanol, $LH_2$ and LOHC**. However, it does **not allow for the transport of refrigerated ammonia by road**, which falls under UN 9000.

$LH_2$, ammonia and methanol are classified as dangerous goods under the ADR, which means that transporting them **requires adherence to extensive regulation** governing the handling of these substances during road transport. In its essence, the ADR serves as a **manual for the technical details** of the transport of dangerous goods. The international regulation is legally binding for national and cross-border transport under German law according to GGBefG and GGVSEB. **LOHC** is not explicitly classified as a dangerous good under the ADR. While it might be classifiable under UN 3082, current research indicates that LOHC does not amount to a dangerous good under international classification (see chapter 3.1.1). Consequently, the transport of LOHC would not have to adhere to the strict regulation on the transport of dangerous goods for transport via road.

Regarding the classified substances for which transport by road is allowed, (2) **regulatory barriers** exist in the form of **route limitations**. Routes are limited by tunnel restrictions, which prohibit the transit through certain tunnels. Route limitations also follow from the principle, **that certain dangerous goods are primarily to be transported via rail or inland waterway**, as road transport is the mode of transport with the highest risks in case of an accident. The ADR itself lays out **tunnel restriction codes** for the hydrogen carriers classified as dangerous goods. Federal states are obliged with the categorisation of tunnels, for which the ADR then specifies requirements. **Ammonia, methanol and $LH_2$** all have tunnel restrictions codes in part depending on their packaging, with $LH_2$ being the substance with the strictest restrictions (see chapter 3.4.2.2).

According to §§ 35 et seq. GGVSEB **ammonia in tanks** of 1000 kg or more must be transported by rail or waterway if it is transported over more than 200 km and the circumstances allow for it. If suitable connections do not exist and the transport must be carried out over more than 400 km, multimodal transport must be chosen. There is no obligation to shift to rail or waterway or multimodal transport if the distance would more than double the distance by road. If transport then takes place via road, it must be carried out on highways. In addition, the GGVSEB requires **methanol in tanks** to be transported mainly on highways, starting at a net quantity of 6000 litres. For **$LH_2$ in tanks**, these restrictions are relevant as well, starting at a net quantity of 9000 kg.

#### 3.4.2.2 ADR

The **Agreement concerning the International Carriage of Dangerous Goods by Road** (ADR) is an international treaty that entails detailed regulation on the transport of dangerous goods in its annexes A and B. These annexes are integrated in Directive 2008/68/EC, which is transposed into national law by the GGVSEB (see chapter 3.4.1.4 ). As a result, the international regulation of the ADR is applicable across all legislative levels.

Under the ADR, **ammonia** (UN 1005), **methanol** (UN 1230) and **$LH_2$** (UN 1966) are listed and classified as dangerous goods and their transport via road is **regulated by the ADR.** Refrigerated ammonia (UN 9000- anhydrous, deeply refrigerated) cannot be transported via road.[82] LOHC is currently

79 Ortsbewegliche-Druckgeräte-Verordnung vom 29. November 2011 (BGBl. I S. 2349), die durch Artikel 491 der Verordnung vom 31. August 2015 (BGBl. I S. 1474) geändert worden ist.

80 The ADN widely refers to the relevant chapters of the ADR/RID; See part 4, part 6 ADN.

81 Gefahrgutbeauftragtenverordnung in der Fassung der Bekanntmachung vom 11. März 2019 (BGBl. I S. 304), die durch Artikel 3 der Verordnung vom 26. März 2021 (BGBl. I S. 475) geändert worden ist.

82 UN 9000 can only be carried by tank vessels on inland waterways, ADN part 3, list of dangerous goods, column 13.

not explicitly classified as a dangerous good; as a result, there is some uncertainty about whether regulation of the ADR applies (see chapter 3.1.1 above).

The Annexes consist of nine parts and can, like the IMDG Code, be considered a **manual for the technical details** of the transport of dangerous goods. **Annex A** includes parts 1–7. Part 1 encompasses **general provisions**, while part 2 lays out rules for **classifications.** Part 3 encompasses the **dangerous goods list**, special provisions and exemptions related to limited as well as excepted quantities. Part 4 contains regulation on **packing and tank provisions**, part 5 consignment procedures including marking and labelling, and Part 6 lays out requirements for the **construction and testing of packaging**, intermediate bulk containers (IBC), large packagings, tanks and bulk containers. Part 7 includes provisions concerning the condition of **carriage, loading, unloading,** and handling of dangerous goods. **Annex B** contains provisions which are concerned with the **transport equipment** and transport operations: part 8 entails requirements for **vehicle crews, equipment operation and documentation**, while part 9 involves requirements concerning the **construction and approval of vehicles.**[83]

Given the highly technical and detailed nature of the ADR, the scope of this study does not allow for an in-depth assessment of all the respective applicable rules. However, an exemption shall be made for a provision relevant for **route determination:** The ADR lays out **tunnel restriction** codes in column 15 of the classification table. This **limits possible routes** and is therefore highly relevant for the planning of the course of transport**.**

Tunnels through which not every hazardous substance may pass must be categorised and marked accordingly. The responsibility for the categorisation of tunnels in Germany and the corresponding labelling lies with the federal states.[84] The regulations on tunnel categorisation are specified in section 1.9.5 and in chapter 8.6 ADR. The tunnels are divided into five tunnel categories, which have been assigned the letters A to E. In general, the higher the tunnel category, the stricter the restriction for transported goods.[85] All substances investigated are subject to tunnel restrictions:

For **ammonia** the code is (C/D). This indicates that for tunnels of category A and B no restrictions apply. Tunnels of category C cannot be used if ammonia is transported in tanks. Driving through tunnels with the category D and E is prohibited. For **methanol** the code is (D/E). This indicates that no restrictions apply to tunnels of category A to C. Transit is not allowed for carriage of the substance in tanks through tunnels of category D. Transit through tunnels of category E is prohibited. The code for **$LH_2$** it is (B/D). This amounts to a transit ban through tunnels of category B and C if it is transported in tanks. Transit through tunnels of category D and E is prohibited.

Germany is furthermore allowed to conclude multilateral agreements for further development of the regulation in accordance with 1.5.1. ADR. These are promulgated and repealed in the ADR Exemption Ordinance.[86] New agreements concluded in the meantime – and, if applicable, revocations – are announced in the Transport Gazette of the Federal Ministry of Digital Affairs and Transport. Newly concluded agreements may be applied immediately in accordance with § 5 para 9 GGVSEB. [87]

### 3.4.2.3 GGVSEB: road-specific regulation

Next to general provisions, the GGVSEB lays out rules specific to the respective mode of transport. For road transport it lays out competences of the responsible authorities and refers widely to the transport specific regulations and obligations of ADR, see for example §§ 1 para 1 and para 3 No 1 a, b and 3 GGVSEB. According to No. 17.0 RSEB, in case of differences between the obligations according to ADR and GGVSEB, obligations according to GGVSEB apply. Annex II No 2 and 3 lay out restrictions for the applicability of Parts 1 to 9 of ADR for national transport operations.

**§§ 35 et seq. GGVSEB** lay out the principle that certain dangerous goods, which are considered particularly dangerous in case of an accident in road traffic, are primarily to be transported via rail or on inland waterways.[88] From a net quantity of **1000 kg** of **ammonia** per transport unit (= a motor vehicle without trailer or a unit consisting of a motor vehicle with trailer), these regulations are applicable to the transport of ammonia in tanks (not, however, to the transport in packages such as gas cylinders), § 35b no. 3 GGVSEB. Therefore, from a net quantity of 1000 kg over a transport route of more than 200 km (nationally or within Europe), **ammonia in tanks must be transported by rail or waterway** if

83 Agreement concerning the International Carriage of Dangerous Goods by Road, Annex A, B, UNECE, 'About the ADR- Agreement Concerning the International Carriage of Dangerous Goods by Road', The United Nations Economic Commission, 2021, https://unece.org/about-adr.

84 Bundesministerium für Digitales und Verkehr, 'Beschränkung Der Nutzung von Straßentunneln Gemäß Übereinkommen Über Die Internationale Beförderung Gefährlicher Güter Auf Der Straße (ADR)', BMDV, 21 February 2022, https://www.bmvi.de/SharedDocs/DE/Artikel/G/Gefahrgut/beschraenkung-der-nutzung-von-strassentunneln-gemaess-adr.html.

85 WEKA, 'Der Tunnelbeschränkungscode: Kategorisierung Für Gefahrgüter', WEKA MEDIA, 24 October 2021, https://www.weka.de/gefahrguttransport/tunnelbeschraenkungscode/.

86 Sechsundzwanzigste Verordnung über Ausnahmen von den Vorschriften der Anlagen A und B zu dem Übereinkommen über die internationale Beförderung gefährlicher Güter auf der Straße (ADR) (26. ADR-Ausnahmeverordnung - 26. ADR-AusnV.

87 Bundesministerium für Digitales und Verkehr, 'Gefahrgut - Recht / Vorschriften - Straße', BMDV, 15 December 2021, https://www.bmvi.de/SharedDocs/DE/Artikel/G/Gefahrgut/gefahrgut-recht-vorschriften-strasse.html.

88 Eisenbahn Bundesamt, 'Transportverlagerungen Nach §35 Abs. 4 GGVSEB', EBA, 2022, https://www.eba.bund.de/DE/Themen/Gefahrgut/Genehmigungstaetigkeit/Transportverlagerungen/transportverlagerungen_node.html.

the shipper, filler, and unloader have suitable connections for this purpose and the transport can be carried out by this route, § 35 para 1 GGVSEB. If these conditions are not met and the distance exceeds 400 km, the transport must be carried out by **multimodal transport** if the transport can be carried out by rail or ship over the greater part of the distance, § 35 para 2 GGVSEB. There is no obligation to shift to rail or waterway or multimodal transport if the distance would more than double the distance by road, § 35 para 3 GGVSEB. According to § 35 para 4 GGVSEB, a **written or electronic certificate** is required if the conditions for a transfer to rail and waterway according to § 35 para 1 and 2 GGVSEB do not exist and therefore a **transport by road is to be carried out**. In addition, if transported via road after all, § 35a GGVSEB regulates that the transport of ammonia must be **carried out on highways** within the limits specified therein, § 35a para 1 GGVSEB. This does not apply, if the distance is at least twice as great as the distance when using other suitable roads or when the use of the highway is excluded or restricted under the provisions of the Highway Traffic Regulations or the Vacation Travel Regulations, § 35a para 2 GGVSEB. According to § 35 para 3 GGVSEB, the route outside the freeways must be determined by the competent authority under state law for a single trip or, in comparable circumstances, for a limited or unlimited number of trips, upon request in writing or electronically. The route can also be determined by general order. In the event of closures, the designated detour routes may be used without a new route designation.

Regarding **methanol,** merely the provision of § 35a GGVSEB is applicable exclusively for the transportation in tanks starting from a net quantity of **6000 litres**, thereby shifting the transport mainly to **highways.**

Regarding **$LH_2$**, both § 35 GGVSEB and § 35a GGVSEB are applicable exclusively for tanks starting from a net quantity of 9000 kg. Exemptions from these provisions are laid out in § 35c para 1 and para 5- 8 GGVSEB. While § 35c para 1 GGVSEB allows for exemptions depending on the tanks and materials used, § 35c para 8 GGVSEB renders § 35 para 2 GGVSEB inapplicable. This means that even if the conditions for transport on inland waterway or via rail according to § 35 para 1 No 1 and 2 are not met and the distance exceeds 400 km, the transport need not be shifted to multimodal transport. As § 35 para 3 GGVSEB remains applicable, however, there is no obligation to shift to rail or waterway according to § 35 para 1 GGVSEB if the distance would more than double the distance by road.

### 3.4.3 Distribution via inland shipping

The share of dangerous goods transported by inland shipping is lower than by road or rail, with 47.3 million tonnes transported via inland waterway in 2017.[89]

#### 3.4.3.1 Potential regulatory barriers

The currently applicable regulation for transport via inland waterway (1) in principle **allows for the carriage of ammonia (liquefied and refrigerated), methanol, $LH_2$ and LOHC via inland shipping.** However, (2) the regulation lays out, that **$LH_2$ cannot be transported in tanks** on inland waterways but only in **packaged form**.

Transport via inland shipping is within the scope of the **ADN** and the European Standard of Technical Requirements for Inland Navigation Vessels (**ES-TRIN**). Like the ADR, the ADN serves as a manual for the technical details of the transport of dangerous goods. The international regulation is legally binding for national and cross-border transport under German law according to GGBefG, GGVSEB, and **Inland water vessel ordinance**[90] **(BinSchUO)**. According to the ADN, inland waterways are the **only mode of transport for refrigerated ammonia (UN 9000)**.

**LOHC** is not explicitly classified as a dangerous good under the ADN (see chapters 3.1.1 and 3.4.2.2) and the extensive legal requirements for the transport of dangerous goods do not apply to current knowledge.

To enable transportation via inland waterway**, certain certificates** must be obtained to ensure compliance with the relevant legal frameworks and technical standards. The ADN requires a **certificate of approval** that certifies the compliance with the **applicable technical** provisions of the ADN. To partake in traffic on **inland waterways** within German borders, ships must be **approved under the BinSchUO**. Notification requirements must be observed also regarding the use of ports along the transport routes. Albeit being lengthy formalities, the certification requirements do not present fundamental hindrances to the transport of the hydrogen carriers via inland waterways.

89 Sarah Keller, 'Beförderungsmenge von Gefahrgut in Deutschland Im Jahr 2017 Nach Verkehrsträgern (in Millionen Tonnen)'.

90 Binnenschiffsuntersuchungsordnung vom 21. September 2018 (BGBl. I S. 1398, 2032), die zuletzt durch Artikel 1 der Verordnung vom 5. Januar 2022 (BGBl. I S. 2) geändert worden ist.

### 3.4.3.2 ADN

The **European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways** (ADN), including its annexed regulations, constitutes the central regulatory framework for the transport of dangerous goods via inland waterways. It was implemented into European law by Directive 2008/68/EG, which was transposed into German national law via GGBefG and GGVSEB.

The annexed regulations of the ADN, too, contain nine parts. Within these parts, provisions are laid out for dangerous substances and articles, provisions concerning their carriage in packages as well as in bulk on board inland navigation vessels or tank vessels. Provisions also include rules concerning the **construction and operation of vessels**. In addition, procedures for inspections are regulated as well as the issuance of certificates of approval, recognition of classification societies, training and examination of experts and monitoring.[91]

The mode of classification is laid out in part two of the annexed regulation to the ADN. Under the ADN, **ammonia (UN 1005 and UN 9000), methanol (UN 1230) and $LH_2$ (UN 1966)** are listed and **classified as dangerous goods**. Their transport via inland shipping thus is regulated by the ADN. LOHC currently are not explicitly classified as dangerous goods, therefore there remains some level of uncertainty whether regulation of the ADN applies (see above chapter 3.1.1).

Whereas the classification of dangerous goods is widely harmonised, the ADN has been **adapted to the needs of inland navigation** and partially **differs from the ADR/RID and the IMDG Code** for example with regard to its table C:[92] T**able C** lists dangerous goods allowed to be **transported in tank vessels**, meaning a vessel intended for the carriage of substances in cargo tanks. Table A, column 8 explicitly permits the transportation of ammonia, anhydrous (UN 1005) and methanol in packaged form and by tank. Refrigerated Ammonia (UN 9000- anhydrous) on the other hand can (only) be transported in tanks via inland waterway according to 3.2.1 Table A, column 13 ADN. According to Table C, column 6 of the ADN, to transport ammonia (UN 1005 and UN 9000) via tank vessel, a tank vessel must be of type G, meaning to be able to transport pressurised or refrigerated gas. Methanol can be transported in tank vessels of type N, meaning intended for the carriage of liquids. For **inland shipping refrigerated $LH_2$** can only be transported as a **package** and **not by tank** according to 3.2.1. Table A, column 8.

Vessels transporting $LH_2$, ammonia and methanol need a **certificate of approval** according to the ADN (1.16.1), which certifies the compliance with the applicable technical provisions of the ADN (1.16.2.2). The **Directorate-General for Waterways and Shipping** is the **competent authority** for tasks following 1.16 ADN according to § 16 para 2 GGVSEB which includes the issuance of the certificate.

Procedural steps must be taken also with a view to the use of harbours along the transport route of inland waterways. For example, the **General Harbour Ordinance of NRW** (AHVO[93]) lays down general principles for the use of harbours within the borders of NRW. It requires that all ships, that fall within the scope of the **ADN**, undergo a **notification of the port authority prior to entering the port** (§ 12 AHVO).

In accordance with 1.5.1. ADN, competent authorities of the contracting Parties to the ADN may agree among themselves to authorize certain transport operations on their territories under temporary derogations from the provisions of ADN, if safety is not thereby compromised.

### 3.4.3.3 ADR

Of relevance for inland navigation are also the provisions of **parts 4 and 6 ADR**, as they are directly applicable for **construction** and **examination of packaging** regarding the transport via ADN. In principle, the provisions for packaging of chapter 4 ADR do correspond with those of the IMDG Code: For the use of portable tanks either the provisions of the ADR or the IMDG Code can be used. The carriage of ADR tanks on inland vessels is subject to the provisions of Table 3.2 ADR.[94] With regard to part 6, the packaging must each be provided with a code and marking corresponding to an indication in accordance with part 6 of the IMDG Code.[95]

### 3.4.3.4 GGVSEB: inland shipping specific regulation

For transport via inland waterways, the GGVSEB lays out competences of the responsible authorities and also refers to the transport specific regulations and obligations of the ADN,

91 UNECE, 'About the ADN - European Agreement Concerning the International Carriage of Goods by Inland Waterways', The United Nations Economic Commission, 2021, https://unece.org/about-adn.

92 Jacobshagen, Umweltschutz und Gefahrguttransport für Binnen- und Seeschifffahrt, 198.

93 Ordnungsbehördliche Verordnung über den Verkehr und den Güterumschlag in Häfen vom 8. Januar 2000, GV. NRW. S. 34; geändert durch Artikel 167 des Vierten Befristungsgesetzes vom 5.4.2005 (GV. NRW. S. 332), in Kraft getreten am 30. April 2005; VO vom 9. Dezember 2009 (GV. NRW. S. 836), in Kraft getreten am 22. Dezember 2009; VO vom 5. Juli 2010 (GV. NRW. S. 387), in Kraft getreten am 13. Juli 2010; VO vom 15. November 2010 (GV. NRW. S. 615), in Kraft getreten am 1. Januar 2011; VO vom 28. November 2011 (GV. NRW. S. 588), in Kraft getreten am 1. Dezember 2011; Verordnung vom 21. Oktober 2015 (GV. NRW. S. 733), in Kraft getreten am 14. November 2015; Artikel 17 des Gesetzes vom 8. Juli 2016 (GV. NRW. S. 559), in Kraft getreten am 16. Juli 2016; Verordnung vom 22. Mai 2017 (GV. NRW. S. 634, ber. S. 699), in Kraft getreten am 29. Juni 2017; Verordnung vom 18. Dezember 2018 (GV. NRW. 2019 S. 4), in Kraft getreten am 5. Januar 2019.

94 Jacobshagen, Umweltschutz und Gefahrguttransport für Binnen- und Seeschifffahrt, 215.

95 Jacobshagen, 216.

see for example §§ 1 para 1 and para 3 No 3 a, b and 3 GGVSEB. According to No. 17.0 RSEB, in case of differences between the obligations according to ADN and GGVSEB, obligations according to GGVSEB apply.

Annex II GGVSEB includes in its section 5 general **derogation** from parts 1-9 of the ADN. Notably, different from provisions of Annex II for ADR and RID, they apply for domestic and international transport. **Section 6** entails **derogation from part 1-9 ADN for the transportation on the Rhine**. Contrary to 7.1.5.1 and 7.2.5.1 ADN, vessels which carry dangerous goods or are not degassed may not be included in **pushed convoys whose dimensions exceed 195 x 24 meters,** 6.1 Annex II GGVSEB**.**

### 3.4.3.5 ES-TRIN and RheinSchUO

Vessels transporting hydrogen carriers as freight must be approved for partaking in traffic on inland waterways. On the **European level**, the approval of vessels navigating on inland waterways and applicable technical provisions is regulated via EU Directive 2016/1629.[96] The Directive aims at harmonizing the terms of approval on European inland waterways and lays out rules for the issuance of **Union certificates** for approval. For technical requirements for inland vessels, it refers to **ES-TRIN** - issued by **CESNI** -, containing:

> *"provisions regarding shipbuilding, fitting out and equipment for inland waterway vessels, special provisions regarding specific categories of vessels such as passenger vessels, pushed vessels and container vessels, provisions regarding vessel identification, model of certificates and register, transitional provisions as well as instructions for the applications of the technical standards"*[97].

A special feature is the **separate regulatory regime for navigation on the Rhine**. As an international organization, the **Central Commission for Navigation on the Rhine** (CCNR) issues regulations for navigation on the Rhine such as the Rhine Vessel Inspection Regulations[98] (RheinSchUO). According to the RheinSchUO, ships navigating on the Rhine generally **require a certificate** ("Schiffsattest"). Notably, the regulations of the EU and the CCNR have been harmonised and the RheinSchUO also refers to the ES-TRIN regarding the technical requirements (§ 1.03 RheinSchUO). Ship certificates issued under the RheinSchuO and Union certificates are mutually recognised: a ship with a Union certificate can operate on the Rhine and a ship with a ship certificate can also operate on EU waterways other than the Rhine. Both **certificates confirm the full compliance of the vessel with the technical requirements of the ES-TRIN** with the aim to ensure a high level of safety in inland navigation and the protection of the environment and persons on board.[99]

The following graph shows the interrelations of the regulation mentioned above.

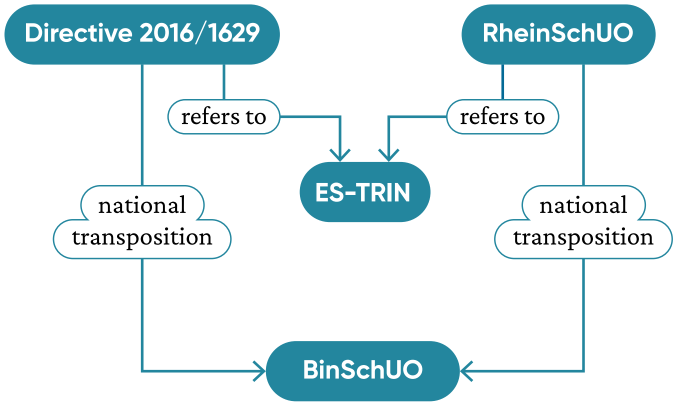



*Figure 6: Interrelation of European Inland Navigation regulation*
*Source: Own presentation.*

### 3.4.3.6 BinSchUO

Neither the Directive (EU) 2016/1629, nor the RheinSchUO or the ES-TRIN are directly applicable in Germany but require implementation through national legislation. In Germany, the implementation is mainly done by the **BinSchuO**.

The **scope of application** of the BinSchUO includes inter alia vessels of a length of more than 20 meters, floating installations, and floating bodies. It explicitly applies to vessels holding a certificate of approval in accordance with the ADN, § 1 para 5 BinSchUO. Its local scope on the waterways of the federation is specified in **Annex I** of the Ordinance. The Rhine belongs to the waterways of zone 3 of Annex I. Therefore, the BinSchUO applies in general applies for inland navigation on the Rhine, § 1 para. 1 BinSchUO.[100]

In detail, the ordinance contains regulation on the procedure for the requirements for construction, equipment and facilities, the requirements for the crew and the requirements for the carriage of passengers, § 1 para 1 BinSchUO. The BinSchUO

96 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.

97 Working Party on Inland Water Transport/Working Party on Standardization of Technical and Safety Requirements in Inland Navigation, Informal document SC.3/WP.3 No 5 (2018),II, available at: https://unece.org/fileadmin/DAM/trans/doc/2018/sc3wp3/ECE-TRANS-SC3-WP3-2018-inf_05e-Rev.1.pdf.

98 Rheinschiffsunersuchungsordnung, Stand 1. Januar 2022.

99 CESNI, Merkblatt zur Beratung über Abweichungen und Gleichwertigkeiten in Bezug auf die technischen Vorschriften des ES-TRIN für bestimmte Fahrzeuge (2019), 1, https://www.cesni.eu/wp-content/uploads/2019/04/Guide_Sp_craft_de.pdf.

100 Only Annex II Parts II to IV BinSchUO do not apply on the Rhine (§ 1 Para. 3 BinSchUO). These regulations contain special rules for shiptypes that are not of high relevance for freight transport, such as passenger ships.

widely refers to ES-TRIN for the technical requirements. According to § 5 BinSchUO, a ship must be **technically approved** before use on inland waterways. The admission to traffic is proven after the examination by an examination commission by the **General Directorate of Waterways and Shipping**[101] by issuing a certificate of fitness for navigation, § 6 para 1 BinSchUO. §7 BinSchUO contains a catalogue of certificates that are accepted as a certificate of fitness for navigation under the BinSchUO. According to this provision, technical admission to traffic is regularly evidenced by a **Union certificate for inland waterway vessels**.

Notably, the ordinance does **not apply** for **sea-going vessels,** which operate or are located on sea-waterways, including the Elbe River in the Port of Hamburg, or those that operate temporarily on waterways in zones 3 and 4 of Annex 1 (this includes inter alia certain sections of the river Danube, **Rhine** and Elbe as well as those not named in Annex 1), provided that they carry a proof of compliance with SOLAS or MARPOL or an equivalent certificate, § 1 para 7 No 1, No 2 BinSchUO.[102]

#### 3.4.3.7 BinSchStrO

The Inland Waterway Ordinance[103] (BinSchStrO) contains the transpositions of parts of the CCNR police regulations on navigation of the Rhine. The BinSchStrO includes requirements for the navigation on the waterways covered by its provisions.[104] Comparable to road traffic regulations, it regulates the traffic on inland waterways.

Special regulations apply on the inland waterways of the **Rhine, Moselle, and Danube**[105], as these rivers are subject to the sovereignty and thus the jurisdiction of several riparian states. The **traffic law applicable there is determined in international river commissions** and is **binding for all users of the waterways**. The provisions of the aforementioned traffic relations often coincide with the BinSchStrO in terms of content.[106]

#### 3.4.3.8 SeeSchStrO

The basis of the **Maritime Shipping Regulation (SeeSchStrO)**[107] is founded in the Maritime Tasks Act[108] (SeeAufgG). The local scope of application follows out of § 1 SeeSchStrO. It is applicable primarily in **coastal waters, i.e., on German seawater ways**. This area extends to a line three nautical miles seaward from the coastline or from the seaward limit of inland waterways, § 1 para 1 No 1. § 1 No 3 et seq SeeSchStrO specifies limited inland waterways adjacent to maritime waterways, to which the ordinance applies. The **scope of the ordinance** includes federally owned shipping facilities, the properties serving the traffic on the federal waterways and in the public federally owned ports, § 1 para 3 SeeSchStr. Via § 1 para 5 SeeSchStro and Annex III the local scope of the regulation is clarified by the map below.

101 Generaldirektion Wasserstraßen und Schifffahrt.

102 Depending on type of ship other verification methods may replace the requirements of the BinSchUO.

103 Binnenschifffahrtsstraßen-Ordnung vom 16. Dezember 2011 (BGBl. 2012 I S. 2, 1666), die zuletzt durch Artikel 5 der Verordnung vom 5. Januar 2022 (BGBl. I S. 2) geändert worden ist.

104 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 2021, 33, https://www.rh2ine.eu/wp-content/uploads/2021/10/RH2INE-Kickstart-Study-Regulatory-and-Safety-Analysis-Regulatory-and-Standards-Gap-Assessment.pdf.

105 See Rheinsschifffahrtspolizeiverordnung (RheinSchPV) vom 19. Dezember 1994 (BGBl. II Seite 3816 , Moselschiffahrtspolizeiverordnung vom 3. September 1997 (BGBl. 1997 II S. 1670 ), die zuletzt durch Artikel 3 iVm Anlage 4 der Verordnung vom 16. Februar 2022 (BGBl. 2022 II S. 82) geändert worden ist" (MoselSchPV), Donausschifffahrtspolizeiverordnung Donauschifffahrtspolizeiverordnung (DonauSchPV) vom 27. Mai 1993 (BGBl. I Seite 741).

106 Wasserstraßen und Schifffahrtsverwaltung des Bundes, 'Schiffahrt Verkehrsrecht - Binnenschifffahrtsrecht', Wasserstraßenund Schifffahrtsamt Oberrhein, n.d., https://www.wsa-oberrhein.wsv.de/webcode/1722986.

107 Seeschifffahrtsstraßen-Ordnung in der Fassung der Bekanntmachung vom 22. Oktober 1998 (BGBl. I S. 3209; 1999 I S. 193), die zuletzt durch Artikel 2 § 12 der Verordnung vom 21. September 2018 (BGBl. I S. 1398) geändert worden ist.

108 Gesetz über die Aufgaben des Bundes auf dem Gebiet der Seeschiffahrt, Seeaufgabengesetz in der Fassung der Bekanntmachung vom 17. Juni 2016 (BGBl. I S. 1489), das zuletzt durch Artikel 2 der Verordnung vom 19. Oktober 2021 (BGBl. I S. 4717) geändert worden ist.

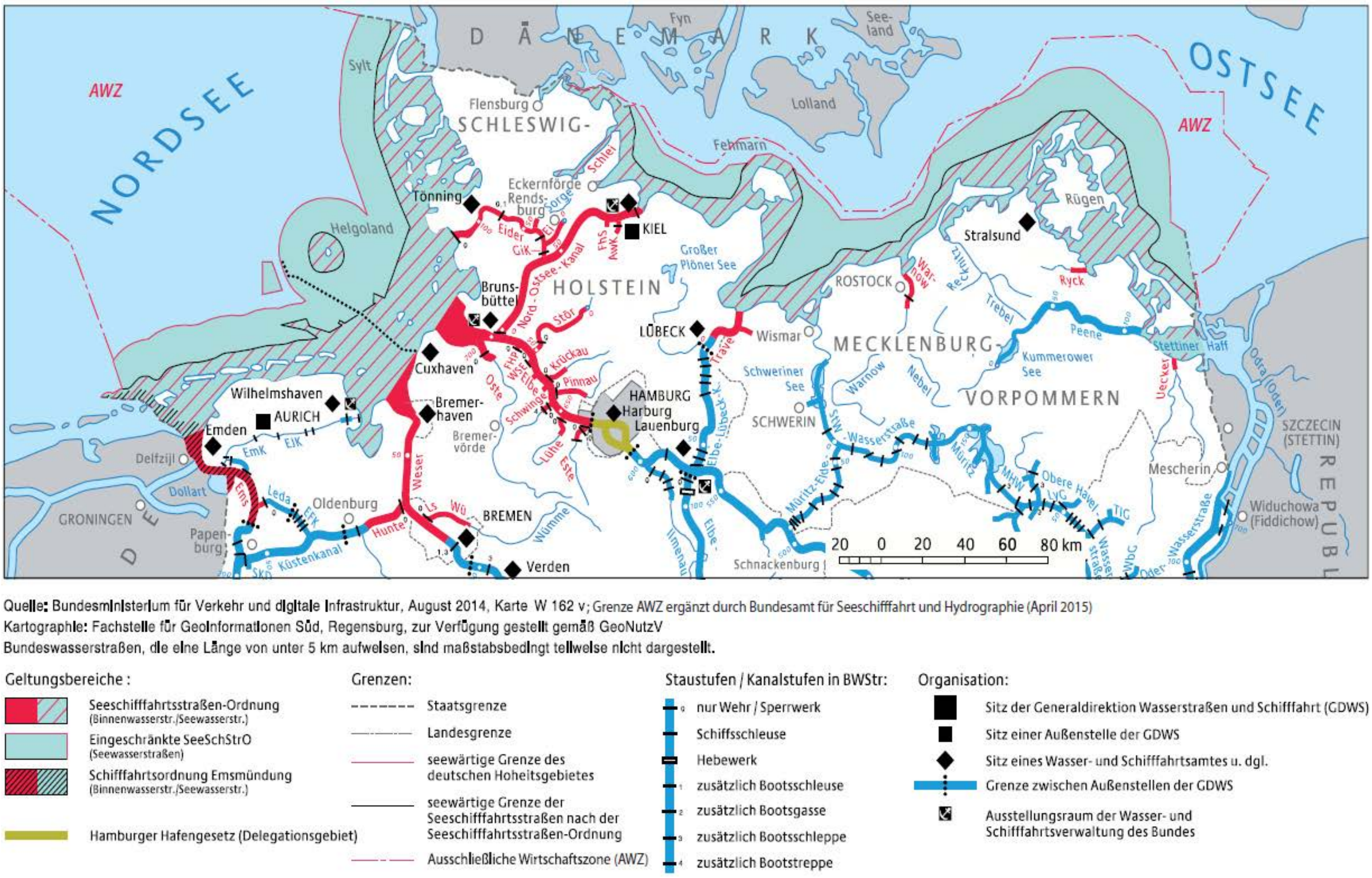



*Figure 7: Scope of the Maritime Shipping Regulation*
*Source: Maritime Shipping Regulation*

In principle, the ordinance contains all the legal provisions concerning the **conduct of participants in traffic on the waterways in question** (comparable to the legislative content of BinSchStrO). One of the main tasks of the Maritime Shipping Routes Ordinance is to define the **navigation rules on the waters concerned**.

## 3.4.4 Distribution via railroads

The proportion of hazardous goods transported by train is considerably lower than transport by road: In 2017, dangerous goods transported via railroad amounted to 70, 9 million tonnes.[109]

### 3.4.4.1 Potential regulatory barriers

The existing regulatory framework is (1) **in principle suitable** for the transport of **ammonia, $LH_2$ and methanol** via rail, as it allows for the safe transport of these carrier options by scale. Route limitations, in form of the requirement to shift to other modes of transport or tunnel restrictions do not apply, thus (2) the study identifies **no fundamental legal barriers** in this regard. However, equal to the ADR and ADN, $LH_2$, ammonia and methanol are classified as dangerous goods under the relevant regulation for rail transport, the RID, which means that transporting them requires adherence to extensive regulation governing the handling of these substances during transport by rail. The international regulation is legally binding for national and cross-border transport under German law according to GGBefG and GGVSEB.

### 3.4.4.2 RID

Regarding the transport of dangerous goods via rail, the **Regulation concerning the international carriage of dangerous goods by rail** (RID) applies. These regulations are part of the Convention concerning International Carriage by Rail (COTIF) and form its Appendix C. Like the ADR, the COTIF is a treaty under international law. RID consists of seven parts. Like the ADR, it was implemented in European law by the Directive 2008/68/EC and was transposed into national law via the GGBefG and the GGVSEB.

It is very similar to Annex A of the ADR in its structure and content. Just like under the **ADR, ammonia (UN 1005), methanol (UN 1230) and $LH_2$ (UN 1966)** are listed and classified as **dangerous goods** under the RID and their transport via rail is regulated by this regulation. Ammonia (UN 9000- anhy-

109 Sarah Keller, 'Beförderungsmenge von Gefahrgut in Deutschland Im Jahr 2017 Nach Verkehrsträgern (in Millionen Tonnen)'.

drous, deeply refrigerated) cannot be transported via rail.[110] LOHC again is not explicitly classified as a dangerous good (see chapter 3.1.1). The transport of dangerous goods via rail has less restrictions than e.g. the ADR, as it does not include limitations for the transport via tunnels as well limitations for the amount of shipments.[111]

The **competent authority** for monitoring of the dangerous goods transports via rail lies with the **Federal Railway Authority** (Eisenbahnbundesamt – EBA). It is also responsible for the issuance of certain permits, such as exemption permits from the rules laid out in RID according to § 5 para 2 GGVSEB or transport relocation according to § 35 para 2, 4 GGVSEB.

In accordance to 1.5.1 RID, Germany may also conclude multilateral special agreements to further develop the regulations. These are promulgated and revoked through the RID Exemption Ordinance[112] (RID-AusnV). Newly concluded agreements may be applied immediately in accordance with § 5 para 9 GGVSEB.

#### 3.4.4.3 GGVSEB: Rail Specific Regulation

In addition to general provisions, the GGVSEB lays out rules specific to the mode of transport. For rail transport it lays out competences of the responsible authorities and refers widely to the transport specific regulations and obligations of RID, see for example §§ 1 para 1 and para 3 No 2 a, b and 3 GGVSEB. According to No. 17.0 RSEB, in case of differences between the obligations according to RID and GGVSEB, obligations according to GGVSEB apply.

### 3.4.5 Distribution via pipelines

Pipelines can be an efficient mode of transport for gaseous hydrogen and potentially hydrogen carriers over long distances. It is technically possible to transport gas and liquids via pipeline and to let them operate over a range of pressures, thereby regulating the flow to balance supply and demand.[113] However, the feasibility, potential, and regulation of this mode of transport differs substantially depending on the carried substance.

Currently, **gaseous hydrogen** is transported via private networks to around 90 hydrogen gas stations in Germany. In addition, there are three hydrogen clusters that distribute hydrogen to refineries and industrial sites.[114] More ambitious projects regarding the transport of hydrogen are already underway. For example, the project *Delta Corridor* currently assesses the construction of pipelines between the Netherlands and Germany. The *Delta Corridor* aims at connecting industries by constructing four pipelines, running from the port of Rotterdam to Chemelot and North Rhine Westphalia.[115] If constructed, these pipelines will enable the transport of C4-LPG, propylene, $CO_2$ and hydrogen. The project is supported by the Dutch government financially as well as by a growing level of project organisation.[116]

Meanwhile, there is currently **no noteworthy pipeline infrastructure for the transport of the examined hydrogen carriers** on a European or national level. There are also no relevant initiatives on a European or national level for the far distance transport of these carriers via pipeline.

This study will in a first step look at transport options for **gaseous hydrogen** via pipeline.[117] It will summarise the **legal framework for a hydrogen gas infrastructure in Germany** with an emphasis on **regulation on market entry and market behaviour for** hydrogen nets and **planning and approval aspects** for hydrogen pipelines. This includes the legal framework of mixing in hydrogen with natural gas as well as the legal framework for pure hydrogen networks.

In a second step it will examine the regulatory aspects for a possible **transport via pipeline for hydrogen carriers**. Pipeline-bound transport of **$LH_2$ will not be examined**. $LH_2$ only

110 UN 9000 can only be carried by tank vessels on inland waterways, ADN part 3, list of dangerous goods, column 13.

111 Andrea Galieriková et al., 'Transport of Dangerous Goods by Rail', ed. J. Gašparik et al., MATEC Web of Conferences 235 (2018): 3, https://doi.org/10.1051/matecconf/201823500004.

112 Verordnung über die Ausnahmen von den Vorschriften über die Beförderung gefährlicher Güter (RID) - Anlage I des Anhangs B des Übereinkommens über den internationalen Eisenbahnverkehr COTIF (RID-Ausnahmeverordnung - RID-AusnV).

113 Climate Group, 'Sustainable Hydrogen, Industry Transition Platform', Report (Climate Group, October 2020), 13, https://www.theclimategroup.org/sites/default/files/2020-10/Industry%20Transition%20Platform%20-%20Sustainable%20Hydrogen.pdf.

114 Sachverständigenrat für Umweltfragen (SRU), 'Wasserstoff Im Klimaschutz: Klasse Statt Masse', Stellungnahme, June 2021, https://www.umweltrat.de/SharedDocs/Downloads/DE/04_Stellungnahmen/2020_2024/2021_06_stellungnahme_wasserstoff_im_klimaschutz.pdf?__blob=publicationFile&v=4.

115 Port of Rotterdam, 'Delta Corridor Connecting Industries', 2021, https://www.portofrotterdam.com/sites/default/files/2021-06/202104id-095_delta_corridor_en.pdf.

116 'Staatliche Hilfe Für Delta Corridor', Hafenzeitung, 4 March 2022, https://hafenzeitung.de/staatliche-unterstuetzung-fuer-delta-corridor.

117 Pipeline infrastructure limited for example to transport within an industrial site will not be part of the discussion.

exists at extremely low temperatures and evaporates easily. These conditions present enormous challenges, rendering transport via pipeline across long distances unfeasible in the near future.

#### 3.4.5.1 Potential regulatory barriers

Regarding the construction of **new pipelines for ammonia, methanol and LOHC**, the law (1) does provide a legal basis and therefore **in principle allows for their construction**. Planning pipelines for the transportation of the three hydrogen carriers may in specific cases also require a spatial planning procedure. The requirement of a planning approval procedure or a planning permission procedure follows from § 65 UVPG and Annex I No 19.3 and 19.5. Here, too, (2) the **legal examination scope will be extensive**. In contrast to the regulations for hydrogen pipelines in the **Energy Industry Act**[118] (EnWG), no procedural simplifications are evident. Also in this case, the legal feasibility of a project can be assessed only on a case-by-case basis. Because neither of the examined **carrier substances** is regulated as an energy carrier regarding market entry or market behaviour, compliance with general anti-trust law is required.

When **gaseous hydrogen** is **mixed in with natural gas** into the existing pipeline infrastructure within permitted limits, it is in principle considered 'gas' under § 3 No 19a EnWG. Rules on market entry and market behaviour for natural gas apply accordingly. However, the definition in § 3 No 19a EnWG has a technology specific approach and by wording only includes hydrogen produced by electrolysis. Therefore, there remains legal uncertainty to whether hydrogen conversed from hydrogen carriers through other technological methods than electrolysis falls under this definition. This in turn raises the question, whether the admixture of hydrogen stemming from reconverted hydrogen carriers is indeed governed by the regulatory framework for natural gas.

The legal framework for **pure hydrogen networks** is new and of a transitory nature. Regarding the rules on market entry and market behaviour, it is characterised by a facultative opt-in option for market regulation, such as unbundling requirements. While this for now does not pose a barrier but arguably offers a certain flexibility for network operators, it is crucial to understand that the regulation of hydrogen networks is highly dynamic and will be in the years to come. In particular, German legislation will heavily be influenced by pending and future European legislation.

In general, the construction of new pipelines for gaseous hydrogen does not encounter fundamental legal barriers. The **construction of new pipelines** for pure hydrogen may in specific cases require a **spatial planning procedure prior to construction**, § 43 l para 7 EnWG, § 15 ROG, and § 1 Nr. 14 **Spatial Planning Ordinance**[119] (RoV). For the **construction of new pipelines for hydrogen** with a diameter of more than 300 mm, a **planning approval procedure** under the regulations of the EnWG is mandatory, § 43 l para 2 EnWG. As the planning approval procedure for pure hydrogen pipelines is rooted in the EnWG, even certain rules on acceleration of the procedure can apply. Still, the realisation of new hydrogen pipelines requires comprehensive and time-consuming legal procedures. The planning approval procedure has a large scope of substantive legal examination and must take public and private interests into account along various procedural steps. The outcome will differ substantially depending on the project and location in question. The concrete legal feasibility can therefore only be evaluated on a case-by-case basis.

#### 3.4.5.2 Distribution of gaseous hydrogen via pipeline

The current legal framework regarding hydrogen networks is fundamentally shaped by **European Legislation**. The **European Hydrogen Strategy** provides a roadmap that includes a vision for the scaling up of a hydrogen economy in different phases. Due to this dynamic evolvement, current national regulation on hydrogen infrastructure must be considered **transitory legislation** which is bound to be changed and amended once a harmonised European Framework is implemented. The European Commission has launched its proposal for a **gas package** on 15 December 2021. It contains a proposal for a Directive as well as a Regulation.

The aim of both the Regulation and Directive is to **create a common infrastructure in the internal market for natural gas and renewable gases**, including **hydrogen**. For this purpose, the market shall be harmonised by setting common rules for transmission (Art. 1 of the Directive), distribution, supply, and storage of these gases. Another objective is the gradual introduction of a **Union-wide hydrogen interconnection network**, which is to contribute to reducing the net greenhouse gas emissions of sectors that are difficult to decarbonise. To this end, rules will be set for **the transport, supply and storage** of natural gas and the **transition of the natural gas system** to one based on **renewable and low-carbon gases**. The envisaged regulations focus on ensuring a competitive, consumer-oriented, flexible, and non-discriminatory market for gases (Art. 3 of the Directive). The European proposals, when adopted, will **strongly influence the national normative framework** laid out below. The European Parliament and Council must now consider the proposed Regulation and Directive through the ordinary legislative procedure. This procedure allows the Parliament and Council to modify the proposals. The Directive could potentially be adopted on 01.01.2023 and would then need to be translated into national law by 31.12.2023.

118 Energiewirtschaftsgesetz vom 7. Juli 2005 (BGBl. I S. 1970, 3621), das zuletzt durch Artikel 84 des Gesetzes vom 10. August 2021 (BGBl. I S. 3436) geändert worden ist.

119 Raumordnungsverordnung vom 13. Dezember 1990 (BGBl. I S. 2766), die zuletzt durch Artikel 6 des Gesetzes vom 3. Dezember 2020 (BGBl. I S. 2694) geändert worden ist.

The German National Hydrogen Strategy[120] includes the **enhancement and expansion** of a hydrogen infrastructure, including a **pipeline infrastructure**. A pipeline-bound hydrogen infrastructure on a larger scale can be realised by either **mixing hydrogen into natural gas infrastructure**, **constructing new pipelines,** or **repurposing existing natural gas infrastructure** for hydrogen transport. Crucial regulative legislation for transport and distribution **of gaseous hydrogen via pipeline** is the **EnWG** which – together with the Renewable Energy Act (**EEG**)[121] – forms the legal basis of the German energy industry. In accordance with § 1 para 1 EnWG, it aims to supply the general public with electricity and gas and – following a more recent amendment – hydrogen. It sets out the **main regulatory framework** for the energy sector. It encompasses inter alia unbundling requirements (part 2 EnwG) and the regulation of net operation (part 3 EnWG), including rules on connection and access to grid systems as well as the calculation of fees. It further sets out rules for the "basic supply" of customers in its part 4 and lays out legal requirements for **planning and construction** of grids (part 5 EnWG). Additionally, the EnWG is complemented by several legislative acts and ordinances. These legislative acts lay out detailed rules for the different sections of the value chain. On the federal level, the **Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway** (**Bundesnetzagentur - BNetzA**) is the most important **regulatory authority.** It oversees the regulation of networks and has several monitoring, investigation, and enforcement tools to ensure compliance with the applicable legal framework. Regulatory authorities exist at a state level as well. Here, they mainly deal with smaller electricity networks that fall outside the scope of the BNetzA.[122]

Under the EnWG, **gas supply networks**[123] are both **transmission networks** and **distributions networks**. The transmission networks offer infrastructure for **supra regional transport** and are operated by **transmission system operators (TSO)**. Distribution networks provide the **consumer** with gas and are operated by **distribution network operators (DSO).** For **operators of gas supply networks,** there is an **obligation** to **expand the network in line with demand**. This obligation relates to § 15a EnWG, which requires the **gas transmission system operators** (TSO) to carry out **formalised demand planning,** including the preparation of a **scenario framework** comprising several scenarios. After confirmation by the BNetzA, it is incorporated into a **network development plan (NEP)**. Pursuant to §15a EnWG, the **NEP** must contain all effective measures that are required in terms of network technology over the next ten years to ensure secure and reliable network operation. These include the optimization and reinforcement of the network in line with demand, the expansion of the network in line with demand, and ensuring security of supply. For DSO, there is currently no formalized demand planning procedure.[124]

**Pure hydrogen networks** generally do not fall under the definition of **gas supply networks**. For transmission networks this follows from the definition of § 3 No 19 EnWG, which is limited to the transmission of natural gas. For distribution networks, the definition of 'gas' is the decisive factor. Gas is defined in § 3 No 19a EnWG as:

> *"natural gas, biogas, liquefied petroleum gas within the scope of §§ 4 and 49,* ***and, if fed into a gas supply network, hydrogen produced by water electrolysis*** *and synthetically produced methane produced by hydrogen produced by water electrolysis and subsequent methanation"*

**Hydrogen** therefore only falls under the definition of gas if it is produced by electrolysis and a **share is mixed into the gas supply network**. An exception is a **distribution** network that exclusively transports hydrogen, which falls under the definition of **biogas**. Biogas according to § 3 No 10c EnWG includes:

> *"Biomethane, gas from biomass, landfill gas, sewage treatment plant gas and mine gas, as well as hydrogen produced by water electrolysis and synthetically produced methane, if the electricity used for electrolysis and the carbon dioxide or carbon monoxide used for methanation can each be shown to originate predominantly from renewable energy sources within the meaning of Directive 2009/28/EC"*

The definition of biogas includes hydrogen produced from electrolysis, if the energy used for production is predominantly renewable. "Predominantly renewable" is understood to mean a share of at least 80%. Currently there is therefore **no formalized obligation for demand planning for pure hydrogen nets.**[125]

120 BMWi, 'Die nationale Wasserstoffstrategie', 2020, https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf?__blob=publicationFile&v=20.

121 Erneuerbare-Energien-Gesetz vom 21. Juli 2014 (BGBl. I S. 1066), das zuletzt durch Artikel 11 des Gesetzes vom 16. Juli 2021 (BGBl. I S. 3026) geändert worden ist

122 Ulrich Scholz and Hendrik Wessling, 'Electricity Regulation in Germany: Overview', Thomson Reuters Practical Law, 1 June 2021, https://uk.practicallaw.thomsonreuters.com/5-524-0808?transitionType=Default&contextData=(sc.Default)&firstPage=true#co_anchor_a766481.

123 § 3 Nr. 20 EnWG.

124 Burkhardt Hoffmann et al., 'Auf Dem Weg Zum Wasserstoffwirtschaftsrecht? Rechtsgrundlagen Und Entwicklungslinien Für Die Regulierung Der Grünen Wasserstoffwirtschaft', Energiesysteme Der Zukunft (ESYS) (Würzburg: Stiftung Umweltenergierecht, 12 July 2021), 26, https://stiftung-umweltenergierecht.de/wp-content/uploads/2021/07/Stiftung_Umweltenergierecht_Wuerzburger-Studie-zum-Umweltenergierecht_21_Wasserstoffwirtschaftsrecht_2021-07-12-2.pdf.

125 Burkhardt Hoffmann et al., 26.

Since the amendment of the EnWG in July 2021, hydrogen is considered an **independent form of energy** next to electricity and gas, § 3 No 14 EnWG. The legal amendments lead to **a regulation of pure hydrogen nets separately from gas supply networks**. The **blending of hydrogen into existing gas supply networks,** however, still falls under the regulatory scope for gas supply networks.

### Blending hydrogen into existing gas infrastructure

While the admixture of hydrogen with natural gas is principle possible, blending is limited due to the physical effects of natural gas and hydrogen.[126] As pointed out above, network regulation is essentially subject to the EnWG for gas supply network in this case.

When **hydrogen produced through electrolysis is fed into existing gas pipelines together with natural gas**, it falls under the definition of gas, § 3 No 19a EnWG, **the regulatory framework for gas is generally applicable.**[127] Regulatory framework in this context means the legislation dealing with the **regulation of market entry and market behaviour**.

In the case of blending in hydrogen with natural gas, rules on **unbundling** according to § 6 et seq. EnWG apply. **Unbundling** requires the network operation to be separated from other activity areas of energy supply. The provisions serve the implementation of European regulation[128] and aim at providing transparency as well as ensuring non-discriminatory network operation.[129] It entails informational unbundling, the unbundling of accounting as well as management unbundling, legal unbundling, and ownership unbundling.[130] Furthermore, the operator can **charge fees** for the grid access according to the **Gas Network Ordinance**[131] (GasNEV).

If the hydrogen, which is admixed into the existing gas network also falls under the definition of **"biogas"** (see above for definition), the laid out regulatory principles apply. Beyond that, mixing biogas with natural gas comes with certain **privileges.** It is privileged in particular through the §§ 34 et seq. **Gas Grid Access Ordinance**[132] (GasNZV) with regard to grid connection and grid access. To be within the depicted regulatory scope, hydrogen must be defined as 'gas' or even 'biogas' according to the definitions of § 3 No 19a EnWG and § 3 No 10c EnWG. As has been pointed out before, both definitions include **hydrogen** that has been **produced by water electrolysis**. Strictly speaking, the **reformation of hydrogen carriers back to gaseous hydrogen** will be done using different technological processes such as **dehydration** or **cracking technology**. Whether or not gaseous hydrogen still falls under the definition regardless of the chosen technology remains uncertain. The wording of § 3 No 19a EnWG points to a **narrow definition of 'gas'**, given that it explicitly lists certain gas forms and – in the case of hydrogen – explicitly calls for a certain way of production, namely water electrolysis.[133] This leads most experts to the conclusion that hydrogen is not considered a gas under § 3 Nr. 19 a EnWG when it is produced using other technologies, such as steam reformation or pyrolysis.[134] Such a strictly technology-specific approach could therefore exclude technologies used to reform hydrogen carriers as well. However, others consider the definition of gas to be broader. Gas is often defined by literature as 'any energy carrier that is gaseous in its normal state and suitable for use in energy supply by combustion, regardless of its specific composition.'[135]In light of this definition, some see the inclusion of hydrogen produced by electrolysis into the legislation in 2011 merely as a clarification.[136] Consequently, hydrogen produced using different technologies than water electrolysis could still fall under § 3 Nr. 19a EnWG.[137] In the

126 Bundesnetzagentur, 'Regulierung von Wasserstoffnetzen', Bestandsaufnahme (Bonn: Bundesnetzagentur für Elektrizität, Gas,Telekommunikation, Post und Eisenbahnen, July 2020), 26, https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/NetzentwicklungUndSmartGrid/Wasserstoff/Wasserstoffpapier.pdf?__blob=publicationFile&v=2.

127 Burkhardt Hoffmann et al., 'Auf Dem Weg Zum Wasserstoffwirtschaftsrecht? Rechtsgrundlagen Und Entwicklungslinien Für Die Regulierung Der Grünen Wasserstoffwirtschaft', 28.

128 Directive 2009/72 for electricity and 2003/73 EG for gas Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance) and Commission Directive 2003/73/EC of 24 July 2003 amending Annex III to Directive 1999/94/EC of the European Parliament and of the Council (Text with EEA relevance) (gas).

129 Philipp Büsch, '§ 6 EnWG (Rn 1- 73)', in Energierecht, ed. Christian Theobald and Jürgen Kühling, 112. EL, vol. Band 2, 2021, 32.

130 Gabriele Britz, Johannes Hellermann, and Georg Hermes, '§ 6 (Rn 1 - 31)', in EnWG Energiewirtschaftsgesetz, 3rd ed., Gelbe Erläuterungsbücher, 2015.

131 Gasnetzentgeltverordnung vom 25. Juli 2005 (BGBl. I S. 2197), die zuletzt durch Artikel 3 der Verordnung vom 27. Juli 2021 (BGBl. I S. 3229) geändert worden ist.

132 Gasnetzzugangsverordnung vom 3. September 2010 (BGBl. I S. 1261), die zuletzt durch Artikel 8 des Gesetzes vom 16. Juli 2021 (BGBl. I S. 3026) geändert worden ist.

133 Lukas Assmann and Max Pfeiffer, 'EnWG § 3 Nr. 19 a (Gas) (Recital 1-19)', in BeckOK EnWG, 1st ed., BeckOK, 2021, 14.

134 Burkhardt Hoffmann et al., 'Auf Dem Weg Zum Wasserstoffwirtschaftsrecht? Rechtsgrundlagen Und Entwicklungslinien Für Die Regulierung Der Grünen Wasserstoffwirtschaft', 26.

135 Kment, Energiewirtschaftsgesetz, 2nd edition, 2019, § 3 no. 45.

136 Lukas Assmann and Max Pfeiffer, 'EnWG § 3 Nr. 19 a (Gas) (Recital 1-19)', 17–18.

137 Lukas Assmann and Max Pfeiffer, 17–18.

particular case at hand, another aspect to be considered is the fact, that the hydrogen stored in the carrier substance originally might have been produced using electrolysis. This opens the option of an overall consideration of the production and transport chain. A similar discussion must be had regarding the definition of biogas, which also explicitly only includes electrolysis as a mode of production.[138] Thus, there remains **uncertainty** to what extent the regulation includes gaseous hydrogen gained from hydrogen carrier reformation and mixed in with natural gas.

Next to market related regulation, legal obligations can also follow out of necessary construction on the facility to enable the admixture: Under certain circumstances, a **planning approval procedure** might be required according to § 43 No 5 EnWG if an extensive alteration of an existing gas supply pipeline is necessary. The scope of such a procedure will be discussed in more detail in the following section on the construction of new pipelines for hydrogen.

### Pure hydrogen networks

The EnWG includes regulatory provisions for **pure hydrogen nets** since July 2021. Hydrogen is defined as a **new commodity** and subsumed under the definition of energy according to § 3 No 14 EnWG, when being used **for grid bound transportation**. These pure hydrogen nets are **regulated separately from existing gas infrastructure** under the EnWG. For this purpose, legislators amended the definition of **energy supply networks** of § 3 No 16 EnWG by including hydrogen nets.[139] It introduced a definition for these **hydrogen nets** in § 3 No 39a EnWG, defining them as:

> *"Network for supplying customers exclusively with hydrogen, **which is not only designed from the outset for the supply of certain groups** that are already fixed or determinable when the network is set up, but **is fundamentally open for the supply of every customer**, and it includes hydrogen lines regardless of the diameter for the transport of hydrogen together with all facilities serving the line operation, in particular expansion, control and measuring systems as well as lines or line systems to optimize the hydrogen procurement and the hydrogen supply"*

According to this definition, hydrogen distribution systems that are spatially limited to a clearly defined operating area therefore do not fall under the definition of hydrogen net. Neither do those networks or pipelines that are constructed in such a way that only a group of customers already determined at the time of network construction is connected. However, a system consisting of several meshed lines, a single stub line or an interconnection of several stub lines (so-called beam network) can fall under the definition. Even a single hydrogen pipeline can be considered a hydrogen net according to § 3 No 39a EnWG in certain cases.[140]

While for **pure hydrogen nets**, rules on planning procedures, on jurisdiction and rules on legal protection always apply, the newly amended EnWG allows for merely facultative **opt-in options** for hydrogen operators[141] **regarding grid regulation.**[142] The opt-in regulations do not aim at providing financial advantages for operators but aim at giving the users a **higher legal protection in business transactions** with the network operators and can thus increase the activity of new hydrogen pipelines or networks for third parties.[143]

When choosing to opt-in, the operator must do so bindingly and for **all hydrogen nets he operates**. The "opt-in" declaration of the hydrogen network operator pursuant to § 28j para. 3 EnWG only become effective after the first positive review of the adequacy of demand according to § 28p EnWG has been obtained. The BNetzA must carry out the examination of the adequacy of demand as soon as the operator of the hydrogen network has submitted to it, in writing or in electronic form, the documents required for the examination.

**When opting in, §§ 28k to 28q EnWG are applicable** including inter alia provisions for the **unbundling** of hydrogen nets, which are comparable to those of § 6 EnWG**.** The provisions stipulate, that the operators of hydrogen networks must ensure the independence of network operation from hydrogen production, hydrogen storage and hydrogen sales. The provisions also include regulation for accounting and bookkeeping. They further contain the regulations for **connection and access** to the hydrogen networks, which also apply accordingly to hydrogen storage systems from operators who have submitted an "opt-in" declaration. § 28o EnWG contains **the conditions and fees for access** to the hydrogen networks subject to regulation.

The flow of information for the implementation of a future hydrogen network development plan is served by § 28q EnWG: Starting in 2022, the hydrogen network operators who have submitted an opt-in declaration and the gas TSOs must **annually** submit a **joint report** on the expansion status of the $H_2$ network and **the development of a future hydrogen network**

138 Lukas Assmann and Max Pfeiffer, 'EnWG § 3 Nr. 10 c (Biogas) (Recital 1-17)', in BeckOK EnWG, 1st ed., BeckOK, 2021, 10.

139 Hydrogen nets are energy supply nets only for section 5 of the EnWG.

140 Lukas Assmann and Max Pfeiffer, 'EnWG § 3 Nr. 39a (Wasserstoffnetz)' (Recital 1-18), in BeckOK EnWG, 1st ed., BeckOK, 2021, 7.

141 See § 3 Nr. 10 b EnWG: Hydrogen net operator is every natural or legal person who carries out the task of transporting or distributing hydrogen and is responsible for the operation, maintenance and, if necessary, the expansion of the hydrogen network.

142 This voluntary approach will likely be revised due to the European Energy Package.

143 'Entwurf Eines Gesetzes Zur Umsetzung Unionsrechtlicher Vorgaben Und Zur Regelung Reiner Wasserstoffnetze Im Energiewirtschaftsrecht', Pub. L. No. 165/21 (2021), 136, https://www.bundesrat.de/SharedDocs/drucksachen/2021/0101-0200/165-21.pdf?__blob=publicationFile&v=1.

**planning** with the target year 2035, § 28q para 1 EnWG. This report will form the legal basis for an **$H_2$-NEP** to be developed by the BNetzA.[144]

If operators choose the **opt-in**, the **hydrogen network ordinance**[145] (WasserstoffNEV) applies. The WasserstoffNEV lays out **basic principles** for the determination of charges for the operators of hydrogen networks. Notably, the WasserstoffNEV is only an interim legislation, until there is European legislation implemented. If operators **do not** choose to **opt-in,** there is no regulation of these market aspects under the EnWG. They do fall under **general antitrust law**. If interests of third parties are affected, on certain conditions, § 19 para 2 No 4 of the Act against Restraints of Competition[146] (GWB) enables access to the networks or other infrastructure facilities.[147]

### Construction of new pipelines for hydrogen

For the **construction of new pipelines** for hydrogen with a diameter of more than 300 mm, a **planning approval procedure** under the regulations of the EnWG is mandatory, § **43l para 2 EnWG**. Pipelines with a lesser diameter can in certain circumstances be subject to a facultative planning approval procedure, § 43l para 3 EnWG.

In general, **the planning approval procedure** is the **key tool** in sectoral planning law. Its aim is to determine whether a particular development project with spatial impacts is **permitted to proceed**. The procedure requires the weighing and balancing of both the interests of the developer and any public or private interest which might be affected by the development.[148] It concludes with the planning approval as a legally binding decision. The procedure is governed by federal and state administrative procedural law. The planning approval procedure must be understood as a comprehensive **concentrative and formative process** (for the concentration effect see chapter 3.3.1.2). It includes **extensive participation by public authorities and the public**.

Sectoral planning with a **significant impact on space is governed by distinct legislation**. In the case of energy related projects, regulation on planning approval procedure is governed by **§§ 43 et seq. EnWG**, which modify the general planning approval legislation of §§ 72 to 78 Administrative Procedure Act[149] (VwVfG). **The planning approval decision** is the **standard for further legal decisions,** such as a subsequent expropriation.[150] Competent authorities for the planning approval procedure are assigned at state level, § 43 para 1 EnWG. § 43 et seq. EnWG are applicable to **hydrogen nets** according **to § 43l para 1 EnWG**. § 43l para 2 EnWG makes a planning approval procedure mandatory for the construction, operation or alteration of **hydrogen pipelines** with a diameter of more than 300 mm. The same paragraph also explicitly stipulates that **Annex 1 No. 19.2 UVPG is applicable to hydrogen nets**. Hydrogen nets are therefore **subject to an environmental impact assessment** depending on their length and diameter, or there is an obligation to carry out a general preliminary assessment or a site-specific preliminary assessment of the individual case (see also chapter 3.3.1.2).

The substantive law which needs assessment during the **planning approval procedure** can inter alia include regulations from BImSchG and BNatSchG as well as the environmental regulations of the relevant state law, standards of the Land Consolidation Act[151] (FlurbG), the Closed Substance Cycle Recycling Management Act[152] (KrWG), the Federal Mining Act[153] (BBergG), and the laws on the protection of historical monuments are covered. It depends on the respective project, which federal and state regulations apply.[154]

144 Burkhardt Hoffmann et al., ‘Auf Dem Weg Zum Wasserstoffwirtschaftsrecht? Rechtsgrundlagen Und Entwicklungslinien Für Die Regulierung Der Grünen Wasserstoffwirtschaft’, 27.

145 Wasserstoffnetzentgeltverordnung vom 23. November 2021 (BGBl. I S. 4955).

146 Gesetz gegen Wettbewerbsbeschränkungen in der Fassung der Bekanntmachung vom 26. Juni 2013 (BGBl. IS. 1750, 3245), das zuletzt durch Artikel 10 Absatz 2 des Gesetzes vom 27. Juli 2021 (BGBl. I S. 3274) geändertworden ist.

147 Burkhardt Hoffmann et al., ‘Auf Dem Weg Zum Wasserstoffwirtschaftsrecht? Rechtsgrundlagen Und Entwicklungslinien Für Die Regulierung Der Grünen Wasserstoffwirtschaft’, 27.

148 Bernhard Stüer and Willi E. Probstfeld, Die Planfeststellung: Grundlagen, Fachrecht, Rechtsschutz, Beispiele, 2. Auflage, 2016, n. 1259.

149 Verwaltungsverfahrensgesetz in der Fassung der Bekanntmachung vom 23. Januar 2003 (BGBl. I S. 102), das zuletzt durch Artikel 24 Absatz 3 des Gesetzes vom 25. Juni 2021 (BGBl. I S. 2154) geändert worden ist.

150 In this respect, the plan approval decision, explicitly defined by § 45 para 1 No 1 para 2 EnWG, has a preliminary effect in that an expropriation for the realization of the plan-approved project is declared permissible.

151 Flurbereinigungsgesetz in der Fassung der Bekanntmachung vom 16. März 1976 (BGBl. I S. 546), das zuletzt durch Artikel 17 des Gesetzes vom 19. Dezember 2008 (BGBl. I S. 2794) geändert worden ist.

152 Kreislaufwirtschaftsgesetz vom 24. Februar 2012 (BGBl. I S. 212), das zuletzt durch Artikel 20 des Gesetzes vom 10. August 2021 (BGBl. I S. 3436) geändert worden ist

153 Bundesberggesetz vom 13. August 1980 (BGBl. I S. 1310), das zuletzt durch Artikel 1 des Gesetzes vom 14. Juni 2021 (BGBl. I S. 1760) geändert worden ist.

154 ‘Verfahrenshandbuch Zum Planfeststellungsverfahren von Vorhaben von Gemeinsamem Interesse (PCI)’ (Bonn: BNetzA, October 2018), 37, https://www.netzausbau.de/SharedDocs/Downloads/DE/Publikationen/PCI-Verfahrenshandbuch.pdf;jsessionid=0885AB98D250E79ACD686C505BB9A8D2?__blob=publicationFile.

The procedural steps are numerous and include **participation of public and private** entities. Here, the main procedural provision of § 73 VwVfG is modified by § 43a EnWG and leads in particular to the shortening of deadlines and the possible omission of the procedural step of the discussion meeting within the planning approval procedure for planned hydrogen networks.

Affected parties can raise objections to the projects. In addition, associations can participate in the proceedings, such es recognized environmental associations, § 3 Environmental Legal Remedies Act[155] (UmwRG). In addition to the project sponsor, municipalities affected by the plan, environmental and nature conservation associations or private third parties (property owners) may be entitled to file an action against the decision once its issued.[156] Considering the comprehensive scope of examination and the numerous procedural steps, the planning approval procedure is typically **time consuming**. This can be expected for the procedure for new hydrogen infrastructure as well.  A planning approval procedure for hydrogen pipelines with a **lesser diameter than 300 mm** is not mandatory under the EnWG, but there is the option for a **facultative planning** procedure in this case**, §** 43 l para 3 EnWG. When opting against the facultative planning procedure, necessary permits are not handled in a concentrative manner and must be obtained individually.

**Hydrogen nets** are privileged under **§ 35 para 1 No 3 BauGB,** § 43 l para 7 EnWG. This legal privileging substantially facilitates the construction of networks in **undeveloped outskirt areas**.

In specific cases, **hydrogen nets** may require a **spatial planning procedure** if they have **significant impact**, § 43l para 7 EnWG, § 15 ROG, and § 1 Nr. 14 **Spatial Planning Ordinance**[157] (RoV). Planning that takes up space or influences the spatial development or function of an area, including the use of public funds earmarked for this purpose, § 3 No 6 ROG, is spatially significant. Spatial planning procedures are carried out by the responsible authority on a state level. It assesses the locational compatibility of a particular plan or measure and determines whether spatially relevant plans and measures can be harmonized or carried out in conformity with spatial planning policy regional impact assessment. It also serves to safeguard environmental protection concerns. It is intended to enable fine-tuning of concrete measures at the supra-local level.[158] By way of the Spatial Planning Ordinance it is stipulated which plans and measures require a spatial planning procedure to be carried out, in so far as they have spatial and supralocal impacts. It is not an approval procedure but can be regarded as serving as a **fundament for the subsequent planning approval procedure.**

### Repurposing of existing pipelines exclusively for hydrogen transport

§ 43 l EnWG contains rules on the set up and expansion for hydrogen networks. The updated legislation aims at the acceleration of a hydrogen economy. It stipulates in its para 4 that:

> *"official approvals for the construction, modification and operation of a gas supply line for natural gas, including the systems required for operation, insofar as they have been integrated into a plan approval process and are not systems requiring approval under the Federal Immissions Control Act, also count as approval for the transport of hydrogen".*

This means, that the **"mere switch" from natural gas to hydrogen does not require a formal approval procedure.**[159] However, a **notification requirement** remains, §§ 43l para 4, 3, and 113c para 3 EnWG. Necessary documents to be presented during the notification include inter alia an **expert report** on technical safety requirements, § 113c para 3 EnWG.

Oftentimes, an alteration of the existing pipeline will be necessary before successfully repurposing it for the transport of gaseous hydrogen. A not "insignificant" alteration results in the necessity of the before mentioned planning approval procedure while if this is not the case, a simple **notification procedure** suffices. Under which circumstances such alteration is "insignificant" is regulated by § 43f EnWG. The question of "insignificance" depends to a certain extent on the necessity of an **environmental impact assessment**. Here, the new legislation of § 43l EnWG **offers facilitations for hydrogen infrastructure** by declaring an environmental impact assessment as not applicable in the instance where alterations are made to enable hydrogen transport in former natural gas pipelines.[160] This means, the criteria of "insignificance" is already met, when no public interests are affected, or if the necessary administrative decisions have been made instead § 43f para 1 No 2 EnWG, and if the rights of others are not infringed by the alteration, or if an agreement has been made with the affected parties (§ 43 para 1 No 3 EnWG).

155 Umwelt-Rechtsbehelfsgesetz in der Fassung der Bekanntmachung vom 23. August 2017 (BGBl. I S. 3290), das zuletzt durch Artikel 8 des Gesetzes vom 25. Februar 2021 (BGBl. I S. 306) geändert worden ist.

156 Maximilian Elspas, Corinna Lindau, and Stefanie Raissa Ramsauer, 'Die Neuen Regelungen Im EnWG Zum Wasserstoff', Netzwirtschaften Und Recht 06 (28 October 2021): 257–319.

157 Raumordnungsverordnung vom 13. Dezember 1990 (BGBl. I S. 2766), die zuletzt durch Artikel 6 des Gesetzes vom 3. Dezember 2020 (BGBl. I S. 2694) geändert worden ist.

158 Michael Kloepfer and Nico David Neugärtner, 'Umweltschutz Im Raum (§ 11: Recital 1- 610)',  Umweltrecht  (2016), 98.

159 Maximilian Elspas, Corinna Lindau, and Stefanie Raissa Ramsauer, 'Die Neuen Regelungen Im EnWG Zum Wasserstoff', 263.

160  See: § 43 l para 4, 5 EnWG and § 43 f para 2 No 1 EnWG.

### Security requirements

**Security Requirements** for hydrogen networks follow the general rules of § 49 para 1 EnWG, meaning that they need to be constructed and operated in a way that ensures technical safety. In addition, there is transitional regulation in § 113c para 1 EnWG for hydrogen pipelines made for an operating pressure of maximum 16 bars, deciding that the High-Pressure Gas Pipeline ordinance (GasHLV[161]) is applicable. Until there are specific rules on hydrogen facilities, the technical rules issued of the **German Technical and Scientific Association for Gas and Water**[162] (DVGW) apply accordingly, §§ 113c para 2, 2 EnWG, § 49 para 2 EnWG. In addition, hydrogen pipelines are considered **systems in need of monitoring** according to the **BetrSichV**: Pipelines are considered as pressure equipment according to annex 2, section 4 BetrSichV in conjunction with Directive 2014/68/EU. Such pressure equipment falls under the BetrSichV depending on the transported substance, annex 2 Section 4 No 2.1, lit. d. As Hydrogen is classified as a flammable gas (hazard information H220) under the CLP Regulation[163] it falls under annex 2, section 4 lit d lit aa) BetrSichV.

## 3.4.5.3 Distribution of hydrogen carriers via pipeline

**Ammonia** as a global commodity is transported via pipeline as a liquid. There is extensive pipeline infrastructure for this substance in place, most notably in the US and in Russia. For example, **TogliattiAzot** is a Russian company that produces up to 3 Mt of ammonia per year most of which is then transported to Odessa through roughly 2.500 km of pipelines, followed by global shipping to several locations.[164] Within the European Union and Germany in particular, the transport of ammonia via pipeline is, however, limited.[165] **Methanol** also is a widely traded commodity. It is mainly transported via ship, rail, truck, and barge. However, it is also possible to transport it via pipeline.[166] It is possible in principle to reuse existing pipeline infrastructure for diesel and gasoline for the transport of LOHC.[167] However, from a feasibility perspective it needs to be noted, that LOHC pipelines will require substantial investments, in particular because the return of the unloaded carrier would essentially make two pipelines necessary.[168]

**Neither of the scrutinized hydrogen carriers is regulated as an energy carrier** by the EnWG. As pointed out before, § 1 para 1 EnWG includes electricity, gas, and hydrogen. In a legal sense, hydrogen carriers do not equal hydrogen. A possible entry point for the applicability of existing regulation is the definition of gas according to § 3 No 19a EnWG, which does allow for a certain broadness of interpretation (see above, chapter 3.4.5.2). Given that only ammonia is gaseous in its natural state, it is the only carrier substance that does not fall out of this definition from the start. However, especially given the recent amendments to the EnWG, which chose not to simply let hydrogen fall under the existing regulatory framework for 'gas' but introduce a new regulatory regiment, it cannot be assumed that the legislator wants to extend the regulatory framework for other gases, at this point in time. In conclusion, **no energy-specific market regulation applies**, and compliance with general anti-trust regulation is required.

### Construction of new pipelines for hydrogen carriers

For the construction of pipelines that carry **ammonia** or **methanol** and are longer **than 40 km**, **a planning approval procedure** is mandatory according to § 65 para 1 UVPG, § 6 UVPG and Annex I, No 19.3.1. UVPG, as both substances pose a **water hazard** according to the **Pipeline Regulation**[169] (RohrFltgVO) and an **environmental assessment procedure** is required according to Annex 1.

Whether a substance is considered **hazardous for water** under Annex I No 19.3 UVPG, is laid out in § 66 para 6, 7 UVPG and § 2 RohrFltgVO, which refers to European classification, which in the meantime has been replaced by the CLP Regulation. According to § 2 para 1, 2 RohrFltgVO, water-polluting substances are the following: flammable liquids with a flashpoint of less than 100°C and flammable liquids that are transported at temperatures equal to or above their flash point, substances with R-phrases R 14, R 14/15, R 29, R 50, R 50/53 or R 51/53 as well as substances with the hazard category T, T+ or C.

161 Gashochdruckleitungsverordnung vom 18. Mai 2011 (BGBl. I S. 928), die zuletzt durch Artikel 24 des Gesetzes vom 13. Mai 2019 (BGBl. I S. 706) geändert worden ist.

162 ‚Deutscher Verein des Gas-und Wasserfaches' e.V. is a recognized standardization body.

163 ECHA, 'Summary of Classification and Labelling: Hydrogen', Inventory Database, Summary of classificarion- Annex VI of Regulation (EC) No 1272/2008 (CLP), n.d., https://echa.europa.eu/de/information-on-chemicals/cl-inventory-database/-/discli/details/53968.

164 International Renewable Energy Agency (IRENA), Innovation Outlook. Renewable Methanol (2021a),55.

165 Bärbel Egenolf-Jonkmanns et al., 'Bewertung Der Realisierbarkeit von Wasserstoffimporten Gemäß Den Zielvorgaben Der Nationalen Wasserstoffstrategie Bis Zum Jahr 2030' (Gelsenkirchen: SCI4climate, 2021), 33, https://www.iwkoeln.de/studien/bewertung-der-realisierbarkeit-von-wasserstoffimporten-gemaess-den-zielvorgaben-der-nationalen-wasserstoffstrategie-bis-zum-jahr-2030.html.

166 International Renewable Energy Agency (IRENA), 'Innovation Outlook. Renewable Methanol', 2021a, 29, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jan/IRENA_Innovation_Renewable_Methanol_2021.pdf.

167 Climate Group, sustainable hydrogen industry transition platform, a report for Climate Group (2020), 13.

168 Nicholas Salmon and René Bañares-Alcántara, 'Green Ammonia as a Spatial Energy Vector: A Review', Sustainable Energy & Fuels 5, no. 11 (2021): 2814, https://doi.org/10.1039/D1SE00345C.

169 ‚Rohrfernleitungsverordnung vom 27. September 2002 (BGBl. I S. 3777, 3809), die zuletzt durch Artikel 224 der Verordnung vom 19. Juni 2020 (BGBl. I S. 1328) geändert worden ist'

**Ammonia** (anhydrous) being a toxic (T) and corrosive (C) gas poses a water hazard according to RohrFltgVO as well as **Methanol,** being a flammable (F) and toxic (T) liquid with a flashpoint below 100°C. As a result, constructing pipelines for **ammonia** or **methanol** will **always require a planning approval procedure** for pipelines longer than 40 km. For pipelines transporting these substances with a lesser length, also depending on the diameter, a planning approval procedure remains mandatory when the general **preliminary testing** or the **site related screening** according to UVPG leads to the necessity of an environmental assessment procedure. If this is not the case, in principle, a **planning permitting procedure** suffices, § 65 para 2 UVPG.

According to the substance information on LOHC forwarded to ECHA, it can be deducted, that **LOHC** do not amount to a water hazard under the RohrFltgVO. It could however amount to a dangerous substance under § 3a ChemG. A dangerous substance, according to this provision, is, inter alia, a substance that fulfils criteria of physical dangers or dangerous for health according to Annex I, parts 2 and 3 of the CLP regulation. According to information forwarded to ECHA, LOHC could for example classify as posing a health hazard, with the hazard statement code being H304. This code is part of the classification system in Part 3 (health) of the CLP regulation.[170] The LOHC hence do not fall under the definition of being hazardous to water according to § 2 RohrFltgVO but might be a **dangerous substance according to § 3a ChemG.** Its approval procedure therefore would follow from §§ 65 UVPG and Annex I No 19. 6 UVPG. According to Annex I No 19.6.1 UVPG, an environmental assessment procedure including a planning approval is always mandatory when constructing a new pipeline of a length of **over 40 km** and a diameter of **more than 800 mm**. Regarding lesser diameters, the right procedure will again depend on the result of general preliminary testing or site related screening, Annex 1 19.6.2 to 19.6.3.

§ 66 UVPG regulates the **substantive requirements for the issuance of the planning approval decision**, including the ancillary provisions, and their specification in the decision. Accordingly, the usual rules for weighing the public and private interests affected by a project apply, also taking into account the substantive requirements of technical law. A planning approval permission can only be issued according to § 66 para 1 UVPG, when it is ensured, that the well-being of the general public is not impaired, in particular no hazards to the objects of protection are caused and precautions are taken against the impairment of the objects of protection, in particular by means of structural, operational or organizational measures in accordance with the state of the art (No 1). In addition, it must be ensured, that environmental regulations and other regulations under public law do not conflict with the project (No 2), regional planning objectives are observed and principles, other requirements of regional planning are taken into account (No 3) and occupational health and safety concerns are safeguarded (No 4). The **technical rules for far distance pipelines** (Technische Regeln für Rohrfernleitungen[171], **TRFL**), concretize § 66 para 1 No 1 UVPG with binding effect on courts.[172] They present "state of the art" – regulation and inter alia include rules on pipe layout, planning, technical details on construction, monitoring, security, planning and operationalisation.

The general public has a number of opportunities to participate in this procedure. Also here, there are possibilities for affected individuals or entities, as well as for certain associations to object during the procedure or take legal action against the final decision.

According to § 65 para 2 UVPG, a planning permitting procedure is required when an environmental assessment procedure is not necessary. The planning permitting procedure aims at accelerating the realisation of a project that is considered low risk with a view to environmental hazards. Like the planning approval procedure, it has a formal concentrative effect. Different from the planning approval procedure, general public participation does not take place. The decision of a planning permitting procedure neither has the preliminary effect regarding expropriation.

In specific cases, pipelines for hydrogen carriers classified as substances posing a water hazard (thus ammonia and methanol) may require a **spatial planning procedure**, provided they have significant impact and require an approval under § 65 UVPG, § 15 ROG and § 1 Nr. 6 RoV.[173] The catalogue of § 1 RoV does not list such a procedure for potential LOHC pipelines. However, the catalogue is not exhaustive. According to § 1 RoV, the competence of state level authorities responsible for regional planning to review **other spatially significant plans and measures of supra-local importance** in accordance with state law in a regional planning procedure remains unaffected.

170 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, Annex I, part 2, 3.10.4.

171 Technische Regel für Rohrfernleitungsanlagen (TFRL) nach § 9 Abs. 5 der Rohrfernleitungsverordnung vom 3. Mai 2017.

172 VGH Baden-Württemberg, Beschluss vom 14.11.2011 - 8 S 1281, recital 34.

173 ‚Raumordnungsverordnung vom 13. Dezember 1990 (BGBl. I S. 2766), die zuletzt durch Artikel 6 des Gesetzes vom 3. Dezember 2020 (BGBl. I S. 2694) geändert worden ist'.

Security requirements

§ 9 para 5 RohrFltgV serves as the basis for the issuance of the beforementioned technical rules for far distance pipelines (TRFL). These rules apply when constructing far distance pipelines for hydrogen carriers as well as for their operationalization and monitoring. In addition, the **BetrSichV** applies concerning review and monitoring requirements. Pipelines are considered as pressure equipment according to annex 2, section 4 BetrSichV in conjunction with Directive 2014/68/EU. Such pressure equipment falls under the BetrSichV depending on the transported substance, annex 2 section 4 No 2.1, lit. d). This is the case for two of scrutinized substances: Ammonia falls under lit. ee) as a corrosive substance with hazard code H 314. As methanol has a lower flashpoint below 55°C and features the hazard code H225, it falls under lit. bb). As LOHC is likely classified with the hazard code H304, which is not named in section 4 of Annex 2, it does not fall under the BetrSichV.

## 3.5 Cross-sectional use: cargo and fuel

Potentially, all four hydrogen carriers could be **marine fuels**. Therefore, the following chapter examines the regulatory framework for the use of the hydrogen carriers as fuel and identifies potential regulatory barriers, which are summarised in an opening chapter.

### 3.5.1 Potential regulatory barriers

The IMO has published the goal to reduce GHG emissions in the shipping sector and generally **opens regulatory doors for alternative fuel**. Therefore, on the regulatory side, a lot of development is taking place, both on international and European level (see e.g. Directive 2014/94/EU[174]). The **European Committee for Standardisation (CEN)** considers **developing standards** on gaseous compressed hydrogen, liquefied hydrogen, methanol, and ammonia refuelling points and **bunkering for maritime and inland waterways hydrogen-fuelled vessels**, which by the end of 2020 was still at **proposal stage** and is covered by CEN/TC 268/WG 5.[175] However, such development only occurs in the span of several years, up to a decade, when it comes to the IMO.

Current **concrete regulatory barriers** (1) only exist for the **simultaneous use of ammonia as cargo and fuel on gas carriers within the scope of the IGC Code**, which is not permitted under current regulation. Regulatory barriers also exist for bunkering: For the Port of Rotterdam, bunkering **of methanol and ammonia as fuel is currently not permitted**: Art. 12.12 of the Havenverordening Rotterdam currently **prohibits the use of fuels with a flashpoint below 55°C**. German Ports have different regulation, some of which do not permit bunkering either (see further below).

However, the main issue for all four hydrogen carrier options on the regulatory side is the **lack of safety standards and procedural rules** (2). Only for **methanol** extensive safety provisions have already been issued: sulphur-free methanol has been in the spotlight as an alternative maritime fuel and technology already exists for handling and using methanol in dual-fuel two-stroke diesel engines.[176] Thus, methanol is increasingly considered as one of the candidate fuels to be used in the decarbonisation of shipping.[177] In December 2020, the IMO has issued (not legally binding) interim guidelines for the use of methanol as a fuel. In July 2020, Lloyds's Register and the Methanol Institute published the Introduction to Methanol Bunkering – Technical Reference[178] to provide support for shipowners, ports, and bunker suppliers for the safe use of methanol as a marine fuel and the International Organization for Standardization (ISO) is currently developing a methanol marine fuel grade specification to standardise the regulation for the use of methanol as a fuel.[179] As a liquid fuel at ambient conditions, bunkering equipment and practices for methanol are much closer to that for conventional fuel oil bunkering.[180] The **use of methanol to power chemical tankers**, large ferries, and small vessels is becoming more common and projects for large **methanol powered cruise vessels** are in development. For example, the A.P. Moller-Maersk Group ordered a series of eight large container vessels capable of being operated on carbon-neutral methanol to be built to ABS Class by Hyundai Heavy Industries with a nominal capacity of approximately 16,000 containers.[181]

174 Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure.

175 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 20.

176 Alfa Laval et al., 'Ammonfuel - an Industrial View of Ammonia as a Marine Fuel', August 2020, 43, https://hafniabw.com/wp-content/uploads/2020/08/Ammonfuel-Report-an-industrial-view-of-ammonia-as-a-marine-fuel.pdf.

177 Lloyd's Register, 'Introduction to Methanol Bunkering. Technical Reference', 2020, 7, https://www.methanol.org/wp-content/uploads/2020/04/Introduction-to-Methanol-Bunkering-Technical-Reference-1.5.pdf.

178 https://ibia.net/wp-content/uploads/2020/11/Introduction-to-Methanol-Bunkering-Technical-Reference-1.5.pdf.

179 IBIA, Progress for methanol as fuel for ships, 2020, https://ibia.net/2020/12/17/progress-for-methanol-as-fuel-for-ships/.

180 American Bureau of Shipping, 'Sustainability Whitepaper. Methanol as a Marine Fuel', 2021, 14, https://safety4sea.com/wp-content/uploads/2021/02/Sustainability-Methanol-as-Marine-Fuel.pdf?__cf_chl_f_tk=Oc86xF15f.uKwetlNsoMMgGxM1A46YxHAUVXwvqHfDA-1642407979-0-gaNycGzNCD0.

181 ABS, Groundbreaking Maersk Methanol Vessel to be Built to ABS Class, https://news.cision.com/american-bureau-of-shipping/r/groundbreaking-maersk-methanol-vessels-to-be-built-to-abs-class,c3430682.

Such provisions are lacking for **$LH_2$, ammonia and LOHC**. As new bunker fuels, they will necessitate a **complete establishment of provisions and guidelines** for a successful start-up. It is foreseen that the previous experience from the fertiliser and chemical industry, and the recent development from LPG/LNG bunkering will help to inform the process.[182] However, it remains uncertain to what degree the solutions for LNG will be applicable for liquefied hydrogen[183] or the other three hydrogen carriers.

Thus, the **main factor** to be considered is the **alternative design approach** according to the IGF Code (see chapter 3.5.2.1) or for inland shipping according to the BinSchUO and the RheinSchUO (see chapter 3.5.3). The alternative design approach allows for vessels to deviate from current technical requirements if an equal level of safety is guaranteed. As a result, **each vessel fuelled by one of the four hydrogen transport options** must be **approved on a case-by-case basis** and entails a rather **complex and timely approval procedure.** However, as mentioned, this is not an option for ammonia as a marine fuel on gas carriers.

The **permission of bunkering** remains at the **discretion of the port authority**. Due to lacking safety standards and regulatory guidelines, there is **no certainty of approval**. Decisions may vary from one port authority to another, also depending on geographical conditions and level of expertise. Hence, there is a **need for guidelines standardising bunkering operations** to fulfil maritime safety and quality requirements.[184] Additionally, there is a need for guidelines to determine if the proposed bunkering location is acceptable from safety aspects.[185]

As mentioned, the IMO as the central policy maker for sea-going vessels has recognised the need for the development of corresponding regulation. Therefore, the IMO expects **amendments to the IGF Code to enter into force in 2024**, including those relating to regulations on **loading limit for liquefied gas fuel tanks**, regulations for fuel distribution outside of machinery space, and regulations for internal combustion engines of piston type and fire protection for fuel storage hold space, as well as provisions for the protection of the fuel supply for liquefied gas fuel tanks, which are intended to prevent explosions.

## 3.5.2 Seagoing vessels

The regulatory framework differentiates between sea-going vessels and inland navigation. The following chapters outline the requirements for marine fuels on sea-going vessels.

### 3.5.2.1 IGF Code

For the cross-sectional use of **methanol** as fuel**,** the **International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels**[186] (IGF Code) applies providing general safety principles for the use of low-flashpoint marine fuels. The IGF Code applies to ships within the scope of Part G Chapter II-1 SOLAS, which in turn applies to ships using low-flashpoint fuels (Reg II-1/56 SOLAS). The IGF Code and the IGC Code apply **alternatively**. Hence, the IGF Code does not apply to ships, that fall into the scope of the IGC Code (Preamble of the IGF Code). Thus, for the **cross-sectional use** of **$LH_2$ and ammonia**, the IGF Code does not apply, but only the IGC Code (see chapter 3.5.).

The IGF Code is the regulatory centre for international shipping using alternative energy sources as fuel and entered into force in 2017. It is connected with the SOLAS Convention through which it becomes binding international law and both of which contain several cross-references. The code provides:

> *"mandatory criteria for the arrangement and installation of machinery, equipment and systems for vessels operating with gas or low-flashpoint liquids as fuel to minimize the risk to the ship, its crew, and the environment, having regard to the nature of the low-flashpoint".*[187]

**Low-flashpoint fuel** means gaseous or liquid fuel having a flashpoint lower than permitted under Reg II-2/4.2.1.1 SOLAS (2.2.28 IGF Code). Reg II-2/4.2.1.1 SOLAS generally **prohibits** the use of fuels with a **flashpoint below 60°C.**, albeit according to Reg II-2/4.2.1.3 SOLAS, the use of fuels with a flashpoint **between 60°C and 43°C may be permitted** under strict conditions.

Currently, the code yet **only provides functional requirements for natural gas** being used as a fuel and provides specific rules for bunkering LNG that require cryogenic insulation to protect the ship steel from spills and leakages in the bunkering station and double piping for loading pipes.[188] Part A-1 IGF Code is in its application **explicitly restricted to LNG.**

182 American Bureau of Shipping, 'Sustainability Whitepaper. Ammonia as a Marine Fuel', 16.

183 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 53.

184 CEN, 'CWA on Methanol Bunkering Processes', 2020, 4, https://ec.europa.eu/research/participants/documents downloadPublic?documentIds=080166e5cfca8795&appId=PPGMS.

185 CEN, 10.

186 Resolution MSC.391(95) of 3 August 2016.

187 IMO, https://www.imo.org/en/OurWork/Safety/Pages/IGF-Code.aspx.

188 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 53.

However, these rules can provide a reference for the currently necessary approval process for $LH_2$ and methanol and eventually be the basis for a binding regulation.[189]

For all low-flashpoint fuels other than LNG the **alternative design method** applies (2.3 IGF Code; Reg II-1/55 SOLAS), which functions as a means to ensure a level of safety equal to the use of LNG as a fuel. The IGF Code provides for a detailed instruction for the approval of alternative technical design arrangements according to which the equivalent level of safety must be proven to and approved by the administration (flag state government) as is also stated in Chapter II-1 Regulation 55 of the SOLAS Convention (see chapter 3.2.2). The alternative design method is a process that comprises of several steps:

| Step | | Section | Key Points |
|---|---|---|---|
| 1 | Preliminary Hazard Identification (HAZID) | IGF Code Section 4.2.1 | Risk assessment to ensure that all risks occuring from the use of low flashpoint fuels regarding people on board, the environment, the construction, and integrity of the ship are addressed. |
| | | Section 4.2.3 | Appropriate and approved risk-evaluation techniques must apply and consider loss of function, component damage, fire, explosion and electric shock. |
| | | IACS Recommendation No. 146 | Further guidance on the risk assessment requirements. |
| 2 | Engineering analysis | SOLAS II-1/55<br>IMO Guidelines<br>MSC.1/Circ.1212<br>MSC.1/Circ.1455 | Must be based on the IMO Guidelines and submitted to the flag administration through the Global Integrated Shipping Information System (GISIS). |
| 3 | Evaluation and Approval | SOLAS II-1/55<br>IMO Guidelines | The Flag State shall engage with all stakeholders (designers, shipyard, owners, etc.) throughout the process.[190] |

189 RH2INE Consortium, 53.

190 American Bureau of Shipping, 'Sustainability Whitepaper. Ammonia as a Marine Fuel', 9.

The IMO has published **guidelines** (MSC.1/Circ.1455 of 24 June 2013) for the approval of alternatives and equivalents as provided for in various IMO instruments including the IGF Code The guidelines present a structured process that is predictable and reliable (1.1.4 MSC.1/Cir.1455) and are intended for use by both administrations and submitters when dealing with approval requests for an alternative and/or equivalent design (1.2.1 MSC.1/Cir.1455). Section 2 MSC.1/Cir.1455 provides for definitions useful within the approval process. Section 3.1 of the guidelines also contain a stakeholder involvement map:

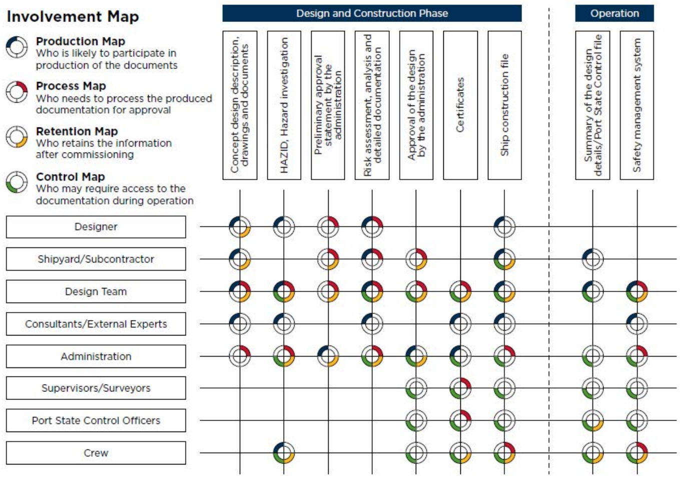



*Figure 8: Combined stakeholder involvement map*
*Source: IMO, MSC.1/Circ.1455 (2013), p. 4.*

The map shows the complexity of the process and the parties involved. Section 3 MSC.1/Cir.1455 also provides for detailed descriptions of the parties involved.

Section 4 MSC.1/Cir.1455 deals with the approval process, illustrated in the figure below. Contrary to what the figure might suggest, it is not a linear or sequential process but could be a series of iterations of a phase in a loop (4.1 MSC.1/Cir.1455).

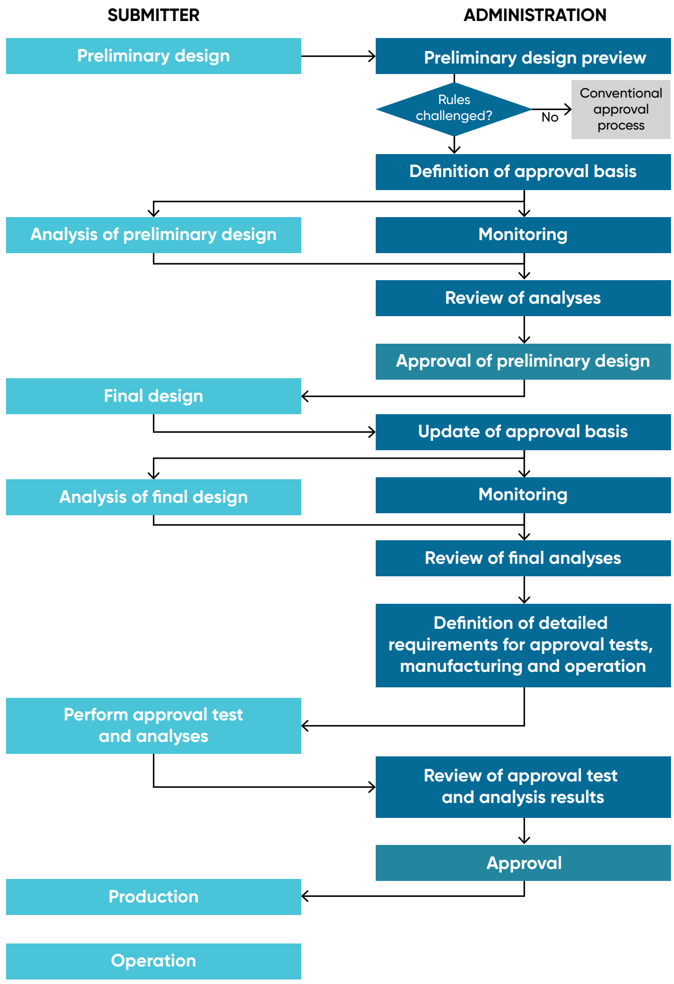



*Figure 9: Design and Approval Process of Alternative Fuel Use*
*Source: Own presentation based on IMO, MSC.1/Circ.1455 (2013), p.7.*

The approval process thus includes the following milestones (4.1 MSC.1/Cir.1455):

| | Milestone |
|---|---|
| 1 | Development of a preliminary design |
| 2 | Approval of preliminary design |
| 3 | Development of final design |
| 4 | Final design testing and analyses |
| 5 | Approval |

*Table 11: Milestones within the Alternative Design Method according to the IGF Code*
*Source: Own presentation based on IGF Code.*

Albeit the alternative design approach gives the opportunity to use alternative fuels, it is a **lengthy and complex procedure** with an **uncertain outcome** which leads to a higher business risk and additional costs.[191]

#### 3.5.2.2 IGC Code

Being within its scope, the cross-sectional use of $LH_2$ and ammonia is also regulated by the IGC Code. Chapter 16 of the IGC Code specifically deals with the **cross-sectional use of cargo as fuel**. 16.1 IGC Code explicitly states that **LNG currently is the only cargo the steam of which is allowed to be used in engine rooms**. However, 16.9 IGC Code contains exceptions for alternative fuels and technologies in that, if the administration (government of the flag state) so allows, alternative cargo steam may be used as fuel on the condition that an equal safety level to the use of LNG is provided (alternative design approach). 16.4.1, 16.4.2, 16.4.3, and 16.5 IGC Code must also be complied with when using other low-flashpoint fuels. However, **16.9.2 IGC Code** explicitly **prohibits** the **use** of **cargo gases being classified as toxic as fuel**. 1.2.53 IGC Code defines toxic substances as such substances being marked with a 'T' in Column 'f' of the table in Section 19. As **ammonia** is thus marked, it **classifies as a toxic substance** within the scope of the IGC Code and can therefore **not be used** as a fuel for ships that carry ammonia or other gases.[192]

#### 3.5.2.3 IMO Interim Guidelines for the use of methanol as fuel

As mentioned above, the IMO recognized the need for regulation exceeding that of the IGF Code and has published the **Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel**[193] (Interim Guidelines), the purpose of which it is to provide an international standard for ships using methyl/ethyl alcohol as fuel (1.1 Interim Guidelines). The Interim Guidelines include **provisions to meet the functional requirements** for methyl/ethyl alcohol as fuel (1.5 Interim Guidelines) and provide more **detailed safety instructions** for ship design and arrangement, fuel containment system, materials, pipe design, bunkering, fuel supply, power generation, fire safety, explosion prevention, hazard area classification, ventilation, electrical installations, control systems, and crew training. Albeit the Interim Guidelines are not yet incorporated into the IGF Code and thus not legally binding. Hence, the alternative design approach is still necessary for the use of methanol as a marine fuel. They may, however, facilitate and accelerate the approval process.

### 3.5.3 Inland navigation

For inland navigation vessels, **ES-TRIN**, implemented into German national law through the BinSchUO, applies. For inland navigation vessels navigating on the Rhine, additionally the RheinSchUO, equally implemented into German national law through the BinSchUO, applies.

According to **Art. 8.01 No 3 ES-TRIN**, only internal combustion engines burning fuels having a flashpoint of more than 55°C may be installed. This generally **excludes low-flashpoint fuels like $LH_2$, ammonia and methanol**. However, according to Art. 30.01 No 2 ES-TRIN, in derogation from Article 8.01 No 3 propulsion and auxiliary systems operating on fuels with a flashpoint equal to **or lower than 55 °C may be installed** on craft **provided that the requirements** for these fuels laid down in **Chapter 30** and **Annex 8** have been **complied** with. Hence, for all vessels using other fuels, a **deviation permit** on a case-by-case basis is necessary.

**Annex 8 ES-TRIN** currently only provides provisions for the use of LNG as a fuel. **Chapter 30 ES-TRIN contains special provisions** applicable to craft equipped with propulsion or auxiliary systems operating on fuels with a **flashpoint equal or lower than 55°C.** Propulsion and auxiliary systems meaning any system using fuel, including fuel tanks, and tank connections, gas preparation systems, piping and valves, engines and turbines, control and monitoring and safety systems (Art. 30.01 No 1 ES-TRIN). Among other documents, a **risk assessment** according to Annex 8 ES-TRIN must be provided to the competent authority prior to the authorisation process (Art. 30.01 No 5 ES-TRIN). According to Art. 30.02 No 1 propulsion and auxiliary systems operating on fuels with a flashpoint equal to or lower than 55 °C shall be **inspected** by an inspection body **before commissioning**, after any modification or repair, regularly, **at least once a year**.

191 DNV and Norwegian Maritime Authority, 'Ammonia as a Fuel. Safety Handbook', 2020, 11, https://grontskipsfartsprogram.no/wp-content/uploads/2021/01/Ammonia-as-a-Marine-Fuel-Safety-Handbook.pdf.

192 See also American Bureau of Shipping, 'Sustainability Whitepaper. Ammonia as a Marine Fuel', 11.

193 MSC.1/Circ.1621 of 7 December 2020.

However, following the alternative design method, § 2.20 RheinSchUO allows for vessels **to deviate from the technical standards laid down in ES-TRIN** and the RheinSchUO, provided they have an **equivalent safety level**. For each vessel, the deviation must be permitted for which the shipowner must apply to the national competent authority for a derogation from the provisions. After examining the case, the respective Member State shall apply to the CCNR or the CESNI Committee for a derogation from ES-TRIN.[194] The following table traces the required steps during such an authorisation process:

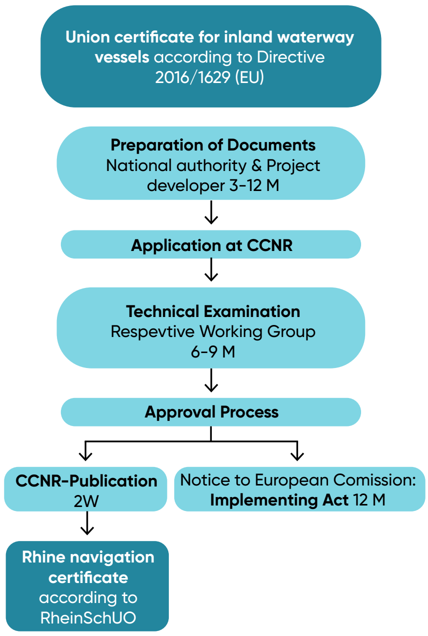



*Figure 10: Procedure for deviation approval at CCNR*
*Source: Own presentation based on CESNI (2019).*

The granting of an **international deviation permit** is the **usual procedure for innovative projects**, such as **vehicles that run on alternative fuels.** The permit is valid **indefinitely** if an **equivalent level of safety** is guaranteed and approximately five years if an **adequate** level of safety is guaranteed.[195]

### 3.5.4 Bunkering

Due to the limited scope of the study, the focus of the study lies on **land-based bunkering stations**: the analysis excludes ship-to-ship and truck-to-ship bunkering systems. In general, bunkering interfaces to ship systems (ship-to-ship, truck-to-ship) must be discussed with the port authority, as no uniform approach exists.[196] Land-based bunkering stations in Germany need **authorisation** according to several different laws depending on the holding capacity (see chapter 3.3.1). The table below lists the authorities for the relevant federal states:

| State | Competent Authority | |
|---|---|---|
| | Authorizing bunker stations according to BImSchG | Authorizing bunker stations according to BetrSichVO |
| Bremen | Gewerbeaufsicht des Bundeslandes Bremen | |
| Hamburg | Behörde für Umwelt, Klima, Energie und Agrarwirtschaft | Behörde für Justiz und Verbraucherschutz |
| Mecklenburg - Vorpommern | Staatliche Ämter für Landwirtschaft und Umwelt | Landesamt für Gesundheit und Soziales |
| Niedersachsen | Staatliche Gewerbeaufsichtsämter | |
| Schleswig-Holstein | Landesamt für Landwirtschaft, Umwelt und ländliche Räume | Staatliche Arbeitsschutzbehörde bei der Unfallkasse Nord |
| NRW | Landesamt für Natur, Umwelt und Verbraucherschutz NRW (LANUV) | Bezirksregierungen |

*Table 12: Competent federal state authorities to authorise bunker stations*
*Source: Own presentation based on RH2INE Consortium (2021).*

**Bunker stations for gases being classified as flammable** (H221) according to the CLP Regulation need **authorisation** according to **§ 18 para 1 No 3 BetrSichV**. Therefore, land-based bunkering stations for **$LH_2$** and **ammonia** would need such an authorisation. Equally, **fixed installations for fuelling vessels with flammable liquids need authorisation according to § 18 para 1 No 6 BetrSichV.** This applies to **Methanol** as a flammable liquid but **not to LOHC**.

194 CESNI, 'Merkblatt Zur Beratung Über Abweichungen Und Gleichwertigkeiten in Bezug Auf Die Technischen Vorschriften Des ES-TRIN Für Bestimmte Fahrzeuge', 2.

195 CESNI, 2.

196 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 52.

As facilities requiring authorisation according to § 18 para 1 BetrSichV, bunker stations for **$LH_2$**, **ammonia** and **methanol** are also **systems requiring monitoring** within the scope of the BetrSichV according to § 2 para 13 BetrSichV. For bunker stations for **$LH_2$** and **ammonia, Annex II section 4 No 1 BetrSichV** also applies, as it lists **pressure plants,** which are defined in **section 4 No 2.1 lit** c as installations for the filling of compressed, liquefied, or dissolved gases under pressure including storage and reservoir tanks (filling installations) **intended for the fuel use in land, water, or air vehicles**. The pressure equipment must also fall within the scope of the Directive 2014/68/EU[197] on pressure equipment (Annex II section 4 No 2.1 lit a BetrSichV). Systems requiring monitoring within the scope of the Industrial Safety Regulation must **be examined prior to commissioning** (§ 15 BetrSichV) and then be **regularly monitored** with regard to their safety (§ 16 BetrSichV) in addition to general obligations and mandatory safety measures prescribed by the Industrial Safety Regulation.

Bunkering in Germany is further regulated on **state level** (see graph in chapter 3.3.1). Here as well, the authorisation **depends on port byelaws and a decision by the port authority**. For example, the **Harbour Decree of Schleswig Holstein**[198] (HafVO S-H) only allows bunkering of liquid fuels from land-based facilities that are equipped with adequate safety installations (§ 25 para 4 HafVO S-H) and **bunkering with low-flashpoint fuels needs authorisation of the port authority** (§ 24 para 2 and 4 HSVO[199]) whereas bunkering with fuels with **a flashpoint above 55 °C during storing and unloading** is **permitted** for both land-side and sea-side bunkering options. This would thus be the case for **LOHC** bunkering options. The authorisation of bunkering cryogenic liquefied gases, compressed gases, or flammable liquids with a flashpoint below 55 °C requires a specific **preliminary risk assessment** being submitted to the port authority (§ 24 para 6 HSVO). Minimum requirements for such a risk assessment are laid down in a general decree by the highest port authority (§ 24 para 8 HSVO). Equally, according to § 22a **Harbour Decree of Mecklenburg-Vorpommern** (HafVO M-V[200]), bunkering of liquefied gases is only permitted with **authorisation** of the port authority. N**o additional risk assessment** is required by law but could still be required by the port authority. To that extent, uncertainty remains. The port of Rostock has for example required such a risk assessment for LNG bunkering stations.

Neither the Harbour Decree of Niedersachsen (NHafenO[201]) nor the Harbour Safety Decree of **Niedersachsen** (NHafenSG[202]) require such authorisations. However, this might be due to lack of experience with bunkering low-flashpoint fuels. Therefore, until enough experience with bunkering of all four hydrogen carriers is gained, it is likely that other Harbour Decrees follow the example and integrate authorisation and risk assessments. Such requirements mainly depend on knowledge of safety hazards and safety procedures. § 18 NHafenO regulates to a certain degree the handling of **goods hazardous to water**, yet only stating that it must be ensured that water is not polluted, and the handling is at all times monitored.

Central **regulations for stationary bunker facilities** or for mobile bunkering at berth in the **Netherlands** are to be found in the **environmental permit law** (Wet Algemene bepalingen omgevingsrecht) whereas a bunker vessel is regulated in the port byelaws. On a further level, port byelaws also regulate bunkering processes. But most do not contain any specific regulation. This needs to be checked with the respective port authority. The scope of the study generally does not extend to this level. The **Port of Rotterdam** developed new regulation when LNG was introduced as a bunker fuel and will equally develop new regulation for other new bunker fuels. Generally, under the **port byelaws** a **bunker permit** issued by the municipality is required and bunkering is only allowed in some areas of the port.

197 Directive 2014/68/EU of the European Parliament and of the Council of 15 May 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of pressure equipment.

198 Landesverordnung für die Häfen in Schleswig-Holstein vom 25. November 2014 (GOVBl. S. 298).

199 Landesverordnung über die Sicherheit beim Umgang mit gefährlichen Gütern in den schleswig-holsteinischen Häfen vom 6. Februar 2015 (GVOBl. S. 134).

200 Verordnung für die Häfen in Mecklenburg-Vorpommern vom 17. Mai 2006 zuletzt geändert durch Verordnung vom 14. Dezember 2017 (GVBl. M-V 2018, S. 2).

201 Niedersächsische Hafenordnung (NHafenO) vom 25. Januar 2007 (Nds. GVbl. 2007, 62) zuletzt geändert durch Verordnung vom 24.02.2012 (Nds. GVBl. S. 36).

202 Niedersächsisches Hafensicherheitsgesetz (NHafenSG) in der Fassung vom 16. Februar 2009 (Nds. GVBl. 2009, 15) zuletzt geändert durch Artikel 3 § 23 des Gesetzes vom 20.05.2019 (Nds. GVBl. S. 88).

04

# Policy makers and stakeholders

This chapter gives an overview of some of the most important policy makers and stakeholders involved in the regulatory framework and with influence on the amendment processes on international and European level.

| Body | | Purpose | Issued Regulation |
|---|---|---|---|
| International Level | | | |
| Policy Makers | IMO | Specialized United Nations Agency responsible for the safety and security of shipping as well as the protection of the environment from marine and atmospheric pollution by ships.<br>175 Member States, among which are Germany, Australia, and the Netherlands | **IMDG Code**<br>**IGC Code**<br>**IBC Code**<br>**MARPOL**<br>**Interim Guidelines** |
| | OTIF | Develops international unified railway regulation in Europe, Asia, and Africa | **COTIF**<br>**Annex C - RID** |
| | UNECE & ITC | ITC is the central body of the United Nations Economic Commission for Europe (UNECE) regarding inland transport | **ADN**<br>**ADR** |
| | CCNR | Regulates navigation on the Rhine in technical, legal, economic, social, and environmental areas | **RVIR**<br>**RPR**<br>**RPN** |
| Stakeholders | ABS | Provides classification services for marine assets | |
| | IEA | Intergovernmental energy organisation within the Organization for Economic Cooperation and Development (OECD) framework covering all fuels and technologies providing analysis and policy advice to support international cooperation | |
| | ICS | International, independent, non-profit trade association representing interests regarding ship and operational safety as well as environmental protection putting forward positions to the international regulators such as the IMO | |
| | IAPH | A non-governmental organisation that represents about 160 ports and 120 port-related businesses in 87 countries putting forward their interests at the regulatory level at the IMO | |
| | Lloyd's Register | A private company that disposes of technical expertise regarding international shipping and has published several technical guidance reports and White Papers and functions as Classification Society | |
| | SGMF | A non-governmental organization (NGO) with expertise on LNG as a marine fuel and the goal to promote gas as an alternative fuel option | |
| European Level | | | |
| Policy Makers | European Institutions | Legislative and administrative key role on European Level | **Directives (directly applicable) & regulation** |
| | CESNI | Main European body developing and issuing technical standards in various fields, particularly regarding vessels, crew, and information technology | **ES-TRIN** |
| Stakeholders | ECSA | A European inter-trade and industry association mainly representing its members' interest to European institutions | |
| | EMSA | A European Agency established to ensure a high, uniform, and effective level of maritime safety | |
| | ACER | An independent European body working on the integration and completion of the European Internal Energy Market for electricity and natural gas | |

## 4.1 International level

As the study has shown, international regulations are particularly relevant for the creation of an import infrastructure between Australia and Germany. In the following, those policy-makers and stakeholder at the international level will be presented which may influence the further development of existing regulations or can possibly contribute their means and expertise to the implementation of an Australian-German hydrogen bridge.

### 4.1.1 Policy makers

Policy makers for the purpose of this study include organisations, committees and initiatives responsible for or involved in formulating policies or influencing or amending regulatory processes.

#### 4.1.1.1 IMO

The International Maritime Organisation (IMO) is a specialized **United Nations Agency** and has responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.[203] The IMO was established via the Convention on the Inter-Governmental International Maritime Consultative Organization (IMO Convention). It currently has **175 Member States**, among them Australia, Germany, and the Netherlands.

The IMO has two governing bodies. The **assembly** is composed of all IMO member states and is the highest governing body. The **council** constitutes its executive organ, responsible for supervising the work of the IMO. **Principle organs of the IMO** are also its five standing **committees**. The **standing committees** provide a **platform for cooperation among governments** with the **aim of developing rules** concerning the specific agenda of each committee. Furthermore, there are **sub-committees,** which report to the Marine Environmental Committee (MSC) and the Marine Environment Protection Committee (TCC) the Marine Environment Protection Committee (MEPC).[204] Decisions in the governing bodies and committees are made by the representatives of member states.[205]

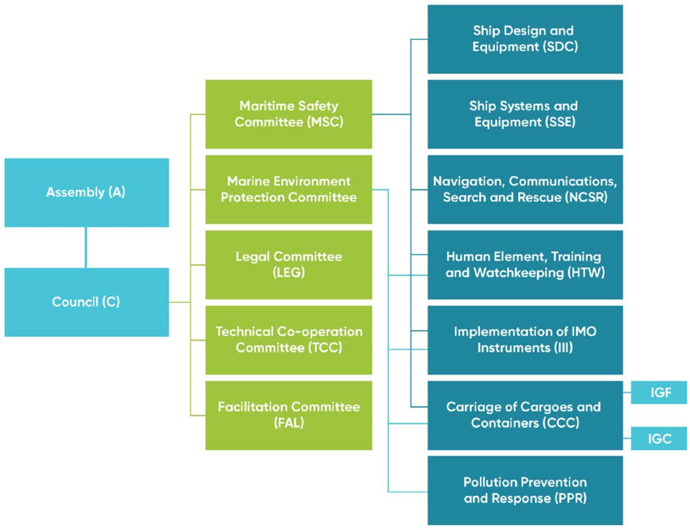



*Figure 11: IMO organisational structure*
*Source: Own presentation based on RH2INE Consortium (2021)*

The MSC and its sub-committee CCC are entrusted with all matters related to maritime safety and maritime security including **updating the SOLAS Convention** and **related codes.**[206] It is therefore of particular relevance for the regulation of the **transport of dangerous goods**.

The IMO has a decisively regulatory role and can be considered a **key policy maker** for the rules on safety, security, and environmental impact for international shipping.[207] It has the competency to develop and adopt regulations to foster its aims, in particular the protection of the marine environment and the safety of international shipping. It does so primarily by developing conventions, the most well-known being SOLAS and MARPOL. The IMO also makes use of 'soft law instruments', such as codes, guidelines or resolutions.[208] Decisions under the governing bodies and committees require complex coordination processes and mostly require consensus.[209] Consequently, these processes often are lengthy and it can take the IMO up to more than a **decade** to develop new regulation.

203 IMO, https://www.imo.org/en/About/Pages/Default.aspx.

204 Rosalie P. Balkin, 'The IMO and Global Ocean Governance: Past, Present and Future', in *The IMLI Treatiese On Global Ocean Governance: Volume III: THe IMO and Global Ocean Governance*, 2018, 6.

205 Rosalie P. Balkin, 6.

206 IMO, https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MSC-Default.aspx.

207 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 14.

208 Rosalie P. Balkin, 'The IMO and Global Ocean Governance: Past, Present and Future', 2.

209 Rosalie P. Balkin, 'The IMO and Global Ocean Governance: Past, Present and Future'.

While the regulation is developed under the auspices of IMO, they are not imposed on the governments by the organization. It remains the task of governments to legally implement the adopted regulation. The IMO also does **not** have the necessary administration and **competences to enforce** the IMO conventions. It constitutes a central characteristic of the IMO's regulatory function, that the states under whose authority or within whose jurisdiction relevant shipping activities take place are the parties responsible for compliance. Either the so-called flag states or the so-called port or coastal states must therefore ensure that the activities in question are in line with international regulation.[210]

#### 4.1.1.2 OTIF

Being active since 1893, the **Intergovernmental Organisation for International Carriage by Rail (OTIF)** is one of the oldest international organisations in the transport sector.[211] It is responsible for the development of homogeneous railway regulation in Europe, Asia and Africa. Basic legal instrument of OTIF is the **Convention concerning International Carriage by Rail**[212] **(COTIF 1999)**. Its aim is the promotion, improvement and the facilitation of international traffic. Objectives of OTIF include the establishment of **uniform law on the carriage of dangerous good**s in rail traffic. The relevant international treaty RID constitutes Appendix C to the COTIF. The RID Committee of experts is organized under the OTIF and is responsible for the decision on proposals regarding the amendment of the RID.[213]

OTIF works closely together with the European Union, the **European Union Agency for Railways**, the **International Rail Transport Committee (CIT)**, the **International Union of Railways (UIC)**, the **Organization for Cooperation between Railways (OSJD)**, and the **United Nations Economic Commission for Europe (UNECE).**

#### 4.1.1.3 UNECE and ITC

The Economic Commission for Europe (**UNECE**) is a regional commission of the United Nations with 56 member states. It is an international platform that aims at facilitating integration and cooperation between member states. Under its auspices, regulation, and norms for different fields of activities are developed.

The **UNECE Inland Transport Committee (ITC)** is the **central body** of the United Nations Economic Commission for Europe (UNECE) regarding inland transport. It provides an **intergovernmental forum**[214] for economic cooperation as well as adopting an international legal framework and technical regulations for the development of international road, inland water, rail, and dangerous goods transport.[215] Regarding the transport of **dangerous goods**, this forum publishes and maintains the relevant legal framework for road transport of dangerous goods **(ADR)** and transport on inland waterways of dangerous goods **(ADN),** while the relevant framework for rail (**RID**) is published by OTIF**.**

The ITC also can provide **advice and assistance** to its member countries through workshops, training, or other means, particularly with regard to developing sustainable transport systems and infrastructures.[216]

#### 4.1.1.4 CCNR

The **Central Commission for the Navigation of the Rhine (CCNR)** is an international institution dealing with all matters regarding inland navigation. It regulates navigation on the Rhine in technical, legal, economic, social, and environmental areas.[217] The Rhine being a central transportation route in the European transport network, the CCNR works closely together with the European Commission, the UNECE and the other river commissions, particularly the Danube Commission, the Moselle Commission, the Sava Commission and the International Commission for the Protection of the Rhine.

210 Rosalie P. Balkin, 22.

211 OTIF, https://otif.org/en/?page_id=15.

212 Convention concerning International Carriage by Rail of 01 March 2019.

213 Sevastian Cercel and Stefan Scurtu, 'Considerations on the Intergovernmental Organization for International Carriage by Rail (OTIF)', *Revue Des Sciences Politiques*, 2021, 67.

214 UNECE, https://unece.org/transport/inland-transport-committee.

215 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 21.

216 Terms of Reference of the Inland Transport Committee as adopted by the Committee at its eighty-first session (Geneva, 22 February 2019) and approved by the United Nations Economic Commission for Europe (ECE) at its 68th session on 9-10 April 2019, lit (k).

217 CCNR, https://www.ccr-zkr.org/files/communication/flyerCCNR2016_en.pdf, 4

## 4.1.2 Stakeholders

For the purpose of this overview, stakeholders at the international level mean initiatives and organisations which do not directly partake in regulatory processes for import and transport activities, but can operate in a consultative function or in the role of an advocate for certain interest groups.

### 4.1.2.1 ABS

Since 1862, the **American Bureau of Shipping** (ABS) is 'a global leader in providing classification services for marine and offshore assets'[218]. ABS provides inter alia surveys during and after construction, compliance audits, development of standards, engineering research and development, technical plan reviews and design analysis.[219] It regularly publishes white papers on technological development and innovation in all fields of the maritime industry. For those whitepapers, ABS examines current issues, looks into efforts to develop regulation at the IMO and proposes new technical requirements.

### 4.1.2.3 IEA

The **International Energy Agency** (IEA) is an intergovernmental energy organisation within the OECD framework. Being originally founded to intervene in the oil crisis, its main playing field is on the oil market. Still, the organisation covers all fuels and all technologies in providing analysis and policy advice to support international cooperation.[220] In addition, it fosters information sharing and technology transfer. Australia, Germany and the Netherlands are members of the organisation. It holds biennial IEA Ministerial Meetings with ministers from member countries, a forum where a certain direction can be suggested, or a focus be put on a specific issue.[221]

### 4.1.2.3 ICS

The **International Chamber of Shipping** (ICS) is an international, independent, non-profit trade association based in London. It serves as a trade association for shipowners and operators. It claims to represent the world's national shipowner associations and over 80% of the world merchant fleet.[222]

It aims to be a leading advocate for the regulatory framework regarding ship and operational safety as well as environment protection. It puts forward positions to the international regulators such as the IMO.[223] The national shipowners' associations of Australia, Germany, and the Netherlands are among the currently 32 full members of ICS.[224]

### 4.1.2.4 IAPH

The **International Association of Ports and Harbors** (IAPH) is a non-governmental organisation and represents about 160 ports and 120 port-related businesses in 87 countries. It **forwards their interests at the regulatory level at the IMO**, the World Customs Organisation (WCO), the International Standards Organisation (ISO) and other global organisations.[225] In Australia the Gladstone Ports Corporation Limited (GPLC), the NSW Ports and the Port of Brisbane Pty Ltd., in Germany the bremenports GmbH & Co KG, the Hamburg Port Authority and the JadeWeserPort Realisierungs GmbH & Co. KG and in the Netherlands the North Sea Port are member ports of the **IAPH.**[226]

### 4.1.2.5 Llyod's Register

Llyod's Register is a **private company** working in the field of engineering and technology services for the maritime industry and is a marine classification society.[227] It has technical expertise regarding international shipping and has published several technical guidance reports and White Papers.[228]

218 ABS, https://ww2.eagle.org/content/dam/eagle/publications/company-information/2-At-A-Glance_20144_Corporate.pdf.

219 ABS, https://ww2.eagle.org/content/dam/eagle/publications/company-information/2-At-A-Glance_20144_Corporate.pdf.

220 The International Energy Agency (IEA), 'The Future of Hydrogen', 2019, 15, https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf.

221 IEA, https://www.iea.org/about/structure.

222 ICS, https://www.ics-shipping.org/about-ics/.

223 ICS, https://www.ics-shipping.org/about-ics/.

224 ICS, https://www.ics-shipping.org/about-ics/members/.

225 ICS, https://www.iaphworldports.org/about-iaph/.

226 ICS, https://www.iaphworldports.org/memberports/?id=asia-2#asia-2-ank1.

227 ICS, https://www.lr.org/en/who-we-are/.

228 ICS, https://www.lr.org/en/resources/?page=2.

#### 4.1.2.6 SGMF

**The Society for gas as a marine fuel** (SGMF*)* is a **non-governmental organization** (NGO) with **expertise on LNG as a marine fuel**.[229] Although the SGMF currently focuses its work on LNG, it nevertheless sees **potential in hydrogen, ammonia, and methanol as part of a future gas fuel mix**.[230] The SGMF aims to **influence regulators** to consider and assess such alternatives.[231]

## 4.2 European level

The EU plays an important role in addition to the IMO.[232] According to Art. 4(2) of the Treaty on the Functioning of the European Union[233] (TFEU) the **EU and the Member States share competence** regarding transport. Thus, the EU and the Member States must be addressed simultaneously to achieve coherent legislative and administrative change in this field. However, in the long run it might be crucial to further develop the European **Common Transport Policy (CTP)** to facilitate new export routes and strategies as it is mentioned in Art. 90 TFEU.[234] **Art. 100 (2) TFEU** states that the **European Parliament** and the **Council**, acting in accordance with the ordinary legislative procedure, may lay down appropriate provisions for sea and air transport. On EU level the adoption of measures relating to EU Transport lies mainly in the hands of the Council, the Parliament, and the Commission.[235]

### 4.2.1 Policy makers

Policy makers on the European level for the purpose of this study include institutions of the European Union responsible for legislative processes and the standardization body operating within the EU which is considered the most relevant for the transport of dangerous goods in the context of this study.

#### 4.2.1.1 European institutions

The **Council** is politically significant in the field of transport and is principally involved in the adoption of EU transport law and policy.[236] It shares a legislative role with the European Parliament. It is composed of one representative from each Member State that acts on behalf of his or her state. The representatives are originally the Foreign Ministers of the Member States, but the Member States can send other ministers according to the matter in discussion. Thus, for shipping matters the Member States can send Marine or Transport Ministers that can represent the State's interests in the Council on that matter.

The **European Commission** ensures the compliance with the European Treaties and also has the power to initiate legislation.[237] The administration of EU transport law and policy falls within the authority of the European Commission.[238] The Commission operates through 55 **Directorates-General**, some of which are relevant to EU shipping law like Mobility and Transport and Energy; Competition; Climate Action; Economic and Financial Affairs; External Relations; Science, Research and Development, Joint Research Centre; Environment, Consumer Protection and Nuclear Safety; Energy; Trade, and Taxation and Customs. The Directorates-General develop, implement, and manage policy, law, and funding programmes. In addition, service departments deal with administrative issues and Executive agencies manage programmes set up by the Commission. There is an Executive agency for **European Climate, Infrastructure and Environment (CINEA)** whose key role is to support the EU Green Deal through the efficient and effective implementation of its delegated programmes. Its mission is to support stakeholders in delivering the European Green Deal through high-quality programme management that helps to implement projects contributing to decarbonisation and sustainable growth.[239] Overall, the Commission is extremely important for the shipping sector not only in terms of regulation and competition but also stimulation of the sector.[240]

229 RH2INE Consortium, 'RH2INE Program: Sub-Study 1a: Safety Framework Conditions & Sub-Study 1b: Safety and Regulatory Analysis', 18.

230 SGMF, https://www.sgmf.info/shipping-and-the-environment.

231 SGMF, https://www.sgmf.info/shipping-and-the-environment.

232 Vincent Power, EU Shipping Law, Third Edition, vol. Volume I (Oxon: informa law, 2019), 1044.

233 Consolidated Version of the Treaty on the Functioning of the European Union, 26 October 2012, Official Journal of the European Union, C 326/47.

234 Power, EU Shipping Law, Volume I:111.

235 Power, Volume I:112.

236 Power, Volume I:112.

237 Power, Volume I:83.

238 Power, Volume I:112.

239 European Commission, https://ec.europa.eu/info/about-european-commission/organisational-structure/how-commission-organised_en.

240 Power, EU Shipping Law, Volume I:86.

The **European Parliament** has a **legislative** and **advisory function** with a growing role regarding EU shipping law.[241] For example, it influenced the Commission to adopt guidelines on the application of competition law to the maritime transport sector and plays a key role regarding safety and employment issues in shipping as well as environment protection regarding the maritime sector.[242]

#### 4.2.1.2 CESNI

The **European Committee for drawing up Standards in the field of Inland Navigation (CESNI)** is the main European body developing and issuing technical standards in various fields, particularly regarding vessels, crew, and information technology.[243] The European Union, other international organizations, and the Member States of the CCNR or EU Member States may apply these standards by referring to it in their respective legal framework, as they are not directly binding.[244] The **main publication of CESNI is ES-TRIN.**[245] It lays out central standards for **inland navigation**. CESNI has **started to draw up standards for the storage of methanol and hydrogen for fuel use** in the field of inland navigation, which can be expected to be **published in 2024**.[246] In general, drawing up new standards can be expected to take up to five years.

### 4.2.2 Stakeholders

For the purpose of this analysis, stakeholders at the European level include institutions and associations that are not directly equipped with legislative powers or the competence to draw up technical standards but have primarily consultative or executive functions.

#### 4.2.2.2 ECSA

Founded in 1965, **the European Community Shipowner's Association** (ECSA) is an **inter-trade and industry association representing its members interest mainly to European institutions**, e.g. the European Commission, but also to international institutions, e.g. the UN. Germany and the Netherlands are members.[247]

#### 4.2.2.3 EMSA

The **European Maritime Safety Agency (EMSA)** is a **key player in developing rules** and **guidelines** as well as in **enforcement.**[248] However, the ESMA is a body, that does not have law-making power but works on the **executive side**. It was established to ensure a high, uniform, and effective level of maritime safety, maritime security, prevention of, and response to pollution caused by ships as a response to marine pollution caused by oil and gas installations (Art. 1 [1] of Regulation (EC) 1406/2002[249]).

#### 4.2.2.3 ACER

The European Union Agency for the Cooperation of Energy Regulators (ACER) is an **independent European body** working on the integration and completion of the European Internal Energy Market for electricity and natural gas.[250] In general, European agencies are separate legal bodies with **special knowledge** to support EU institutions and Member States in implementing policies.[251] ACER **works closely with National Regulatory Authorities (NRAs)** to achieve the energy transition within an integrated European Energy Market.[252]

241 Power, Volume I:91.

242 Power, Volume I:91.

243 CESNI, https://www.cesni.eu/en/.

244 'Overview of Documents', CESNI, n.d.

245 European Standard laying down Technical Requirements for Inland Navigation Vessels, edition 2021/1, https://www.cesni.eu/wp-content/uploads/2020/10/ES_TRIN_2021_en.pdf.

246 CESNI, work programme 2022-2014, PT-1.

247 ECSA, https://www.ecsa.eu/index.php/about-us/organisations.

248 Power, *EU Shipping Law*, Volume I:1044.

249 Regulation (EC) No 1406/2002 of the European Parliament and of the Council of 27 June 2002 establishing a European Maritime Safety Agency.

250 ACER, https://www.acer.europa.eu/the-agency/about-acer.

251 ACER, https://www.acer.europa.eu/the-agency/about-acer.

252 ACER, https://www.acer.europa.eu/the-agency/our-mission.

# 05 Summary

## 5.1 Conclusion

The analysis conducted for this study concludes that it is **legally feasible** to import hydrogen from Australia to Germany with the envisaged infrastructure via the hydrogen transport options $LH_2$, ammonia, methanol and LOHC. However, the extent of the feasibility depends on the concrete implementation and the specific stage along the transport route. In certain respects, the regulatory framework presents **high legal hurdles,** such as construction requirements for vessels carrying dangerous goods, safety requirements for import terminals, and route limitations for landside distribution. The construction of import terminals may present the highest hurdle: due to safety distances from adjacent infrastructure, not every port is suitable for the import of all (or any) of the four hydrogen carriers.

> *While the density of relevant regulations makes it necessary to assess the applicable requirements prior to implementing the import structure, it does not pose a fundamental hindrance. This study finds that, while specific considerations vary depending on the substance and the mode of transport, the implementation of a hydrogen bridge between Australia and Germany using the transport options examined here is fundamentally feasible from a legal perspective.*

Regarding the transport of the hydrogen carriers from Australia to mainland Europe, extensive technical requirements must be met, which include regulations on packaging and the equipment of the vessels in question. Under the legal framework for seagoing vessels, there is still some uncertainty regarding the applicability of mass limitations, package requirements and safety obligations to the transport of the LOHCs examined in this analysis.

The construction and operation of import terminals, storage facilities in ports and commercial supply is subject to authorisation and permit procedures, which vary depending on the carrier. The landside distribution in Germany via road, rail and inland waterway is also governed by comprehensive legislation, which provides rules for all participants in transport regarding e.g., packaging and equipment of transport vehicles and vessels. Relevant legal limitations – again depending on the carrier – include restrictions on the route that can be used to transport the substances.

Legal provisions are increasingly facilitating the implementation of pipeline-bound infrastructure for gaseous hydrogen; the same cannot be said, however, for pipeline infrastructure for hydrogen carriers. While, in principle, it is possible to implement long-distance pipeline infrastructure for the carriers assessed in this study, doing so will require comprehensive – and potentially protracted – approval procedures. The ability to obtain the necessary approvals must be assessed on a case-by-case basis.

Use of the four hydrogen transport options as fuel during transport faces the most challenges. Here, the lack of safety standards is a major factor and can lead to non-authorisation. The fuel use of ammonia on gas carriers is currently not permitted under the law.

Establishing a dialogue with the many stakeholders identified above can introduce new possibilities for the scaled-up import and distribution of hydrogen via these storage options opening up a promising path towards the decarbonisation of the economy worldwide. The successful market ramp-up of a global hydrogen economy certainly still faces many challenges, technically as well as legally; however, the import of hydrogen from Australia via the storage options assessed here does not present a substantial barrier to this development.

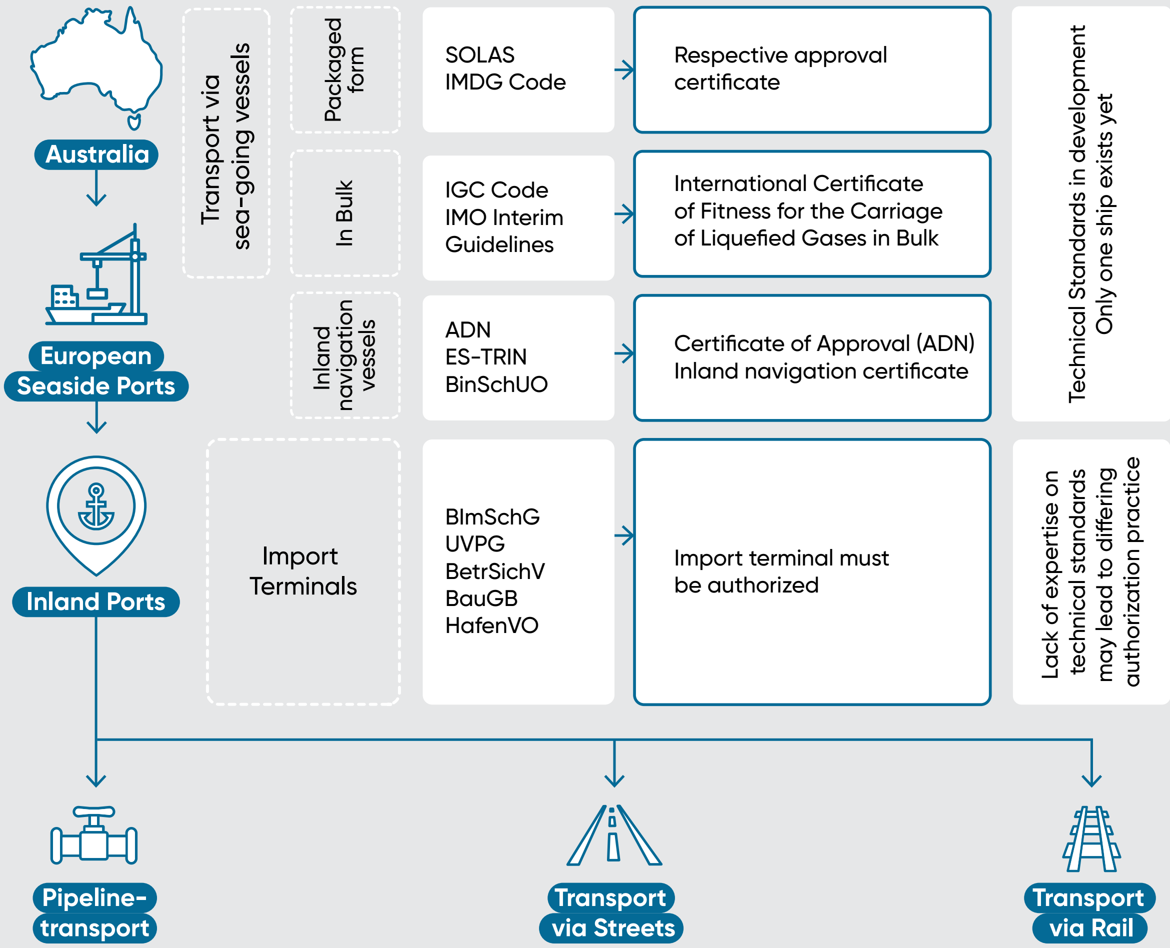
## 5.2 Summary sheets for each carrier



International Classification

**Class 2.1 - flammable refrigerated gas (3F)**
UN-No 1966 | H220
GHS 02, 04

Import is legally feasible. As a new global commodity, the extremely low temperatures present mainly technical challenges. Hazard prevention is a major regulatory aspect due to the flammable characteristics. Extensive safety requirements may limit implementation possibilities. Vessels must comply with construction requirements from the IGC Code. Import terminals are within the scope of Immissions Control Law.




**Pipeline-transport:** Infrastructure for exclusively gaseous hydrogen ($LH_2$ pipelines not part of analysis): EnWG: Transitory national legislation offers opt-in possibility for network operators regarding market related regulation; Facilitated procedures in particular for the repurposing of existing natural gas pipelines

**Transport via Streets:** GGVSEB, ADR
- Tunnel restrictions
- Route limitations

**Transport via Rail:** GGVSEB, RID

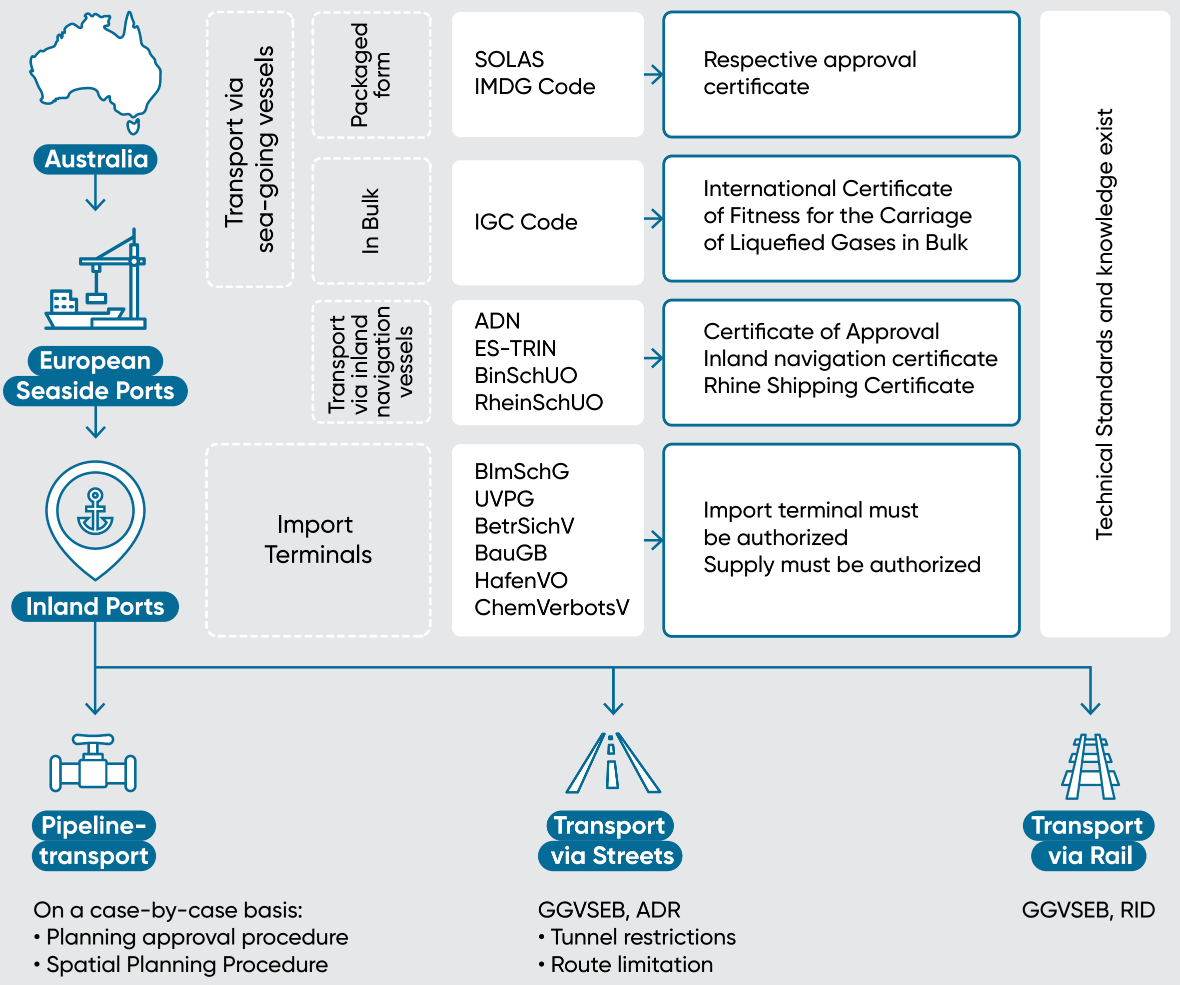
**Fuel use:** **Authorization** through the **alternative design approach** (IGC Code, ES-TRIN) necessary. Technical standards are lacking.

**Bunkering:** Separate **authorization** by the port authority necessary. Not permitted in the Port of Rotterdam. Technical standards are lacking.

International Classification

**Class 2.3 – toxic, corrosive gas (2TC)**
UN-No 1005 | H221, H331, H314, H400
Low Flashpoint | GHS 04, 05, 06, 09

Import is legally feasible. The toxic and corrosive characteristics present the biggest challenges for an ammonia import infrastructure: hazard prevention is the main regulatory aspect throughout all transport steps and modes necessitating extensive safety measures and may limit implementation possibilities. Vessels must comply with construction requirements from the IGC Code. Import terminals are within the scope of Immissions Control Law. Establishing a pipeline infrastructure must be scrutinized on a case-by-case-basis.



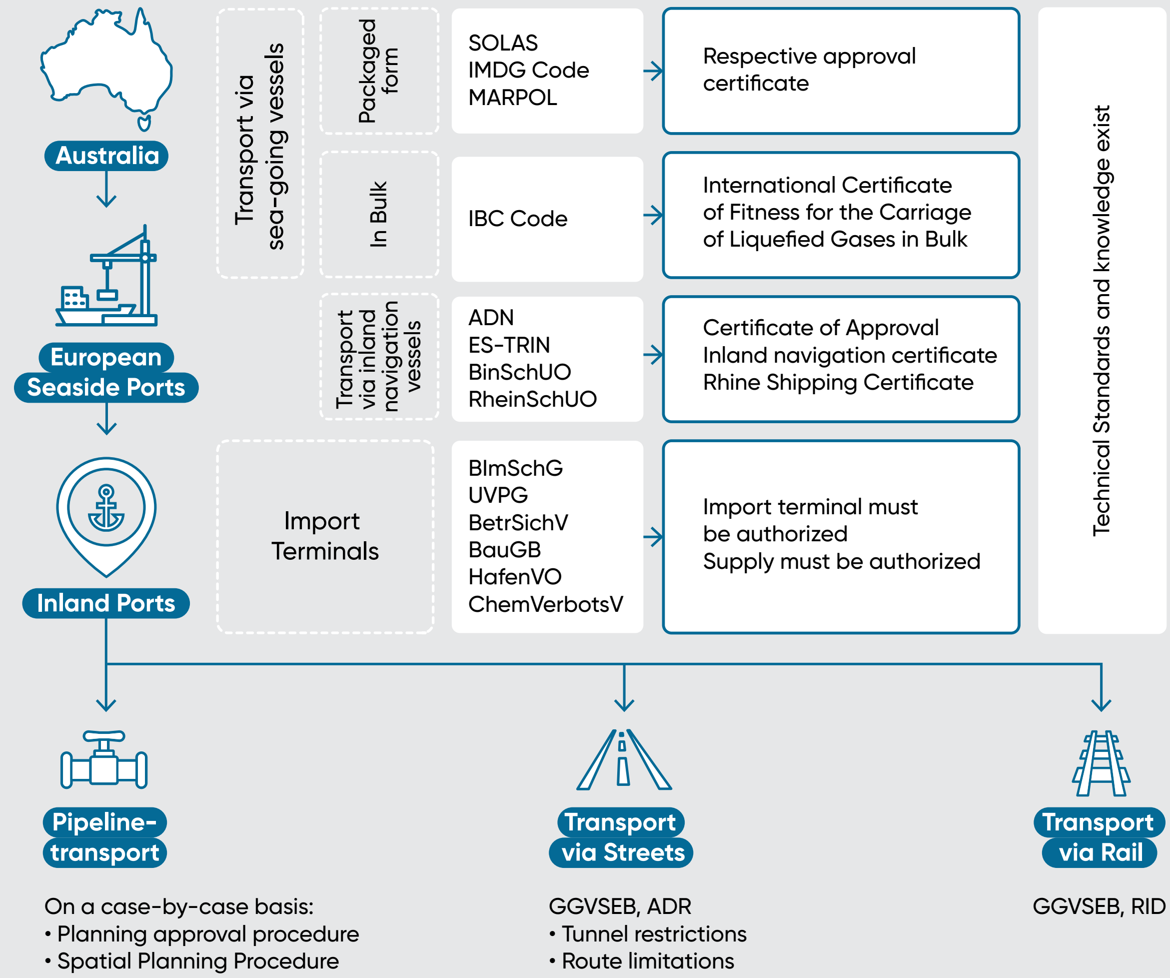

**Fuel use:** **Authorization** through the **alternative design approach** (IGC Code, ES-TRIN) necessary. Simultaneous use as cargo and fuel on ships within the scope of the IGC Code not permitted.

**Bunkering:** Separate **authorization** by the port authority necessary. Not permitted in the Port of Rotterdam.

International Classification

**Class 3 – flammable and toxic liquid (FT1)**
UN-No 1230 | H225, H331, H311, H301, H370
Low flashpoint | GHS 02, 06, 08

Import is legally feasible. Classified as a toxic chemical, extensive safety requirements apply to the transport of methanol. Hazard prevention is the main regulatory aspect throughout all transport steps and modes. Vessels must comply with construction requirements from the IBC Code. As a liquid, storage options are more flexible with regard to quantity and technical requirements but are within the scope of Immissions Control Law. Establishing a pipeline infrastructure must be scrutinized on a case-by-case-basis.



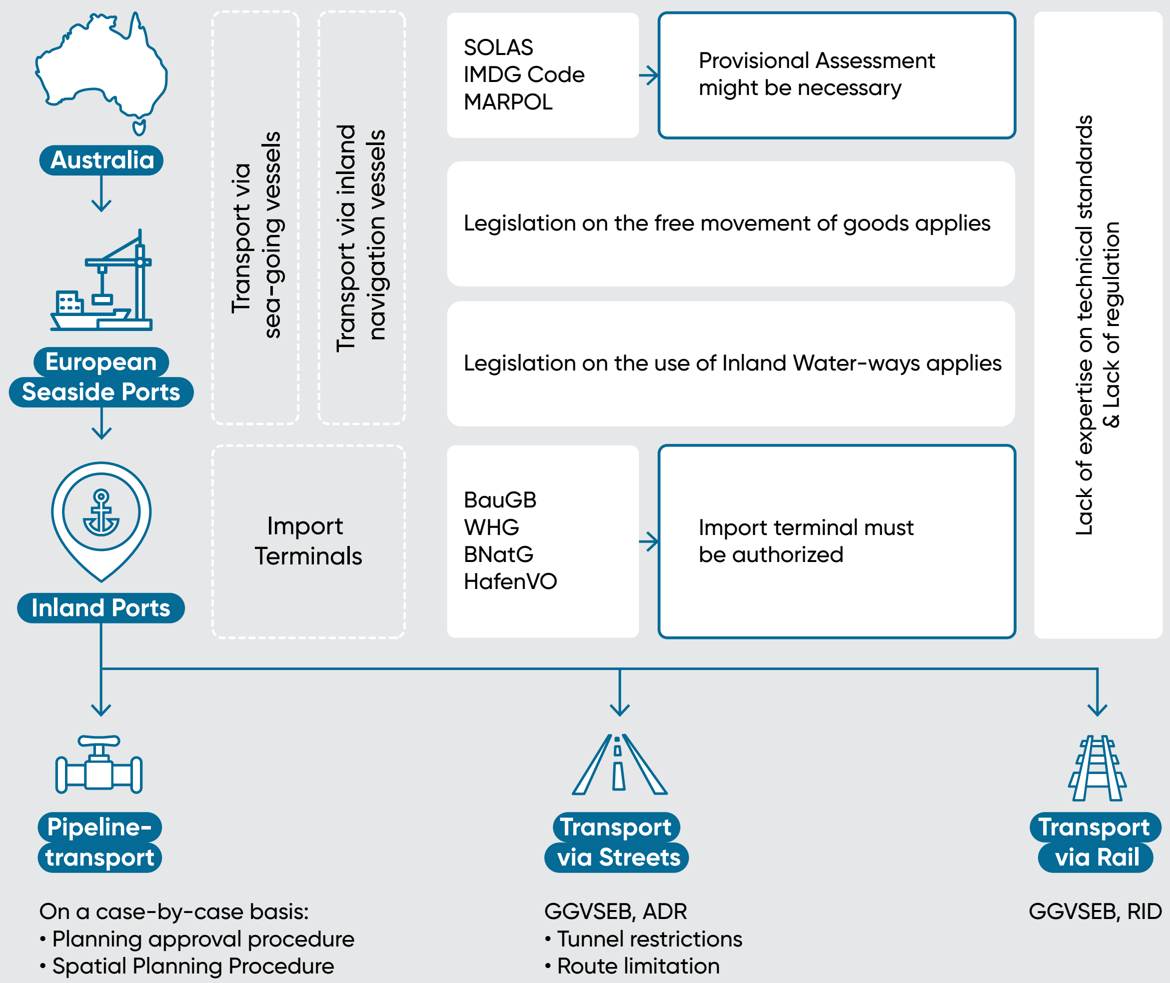

**Fuel use:** **Authorization** through the **alternative design approach** (SOLAS, ES-TRIN) necessary. Technical standards in development.

**Bunkering:** Separate **authorization** by the port authority necessary. Not permitted in the Port of Rotterdam. Technical standards in development.

International Classification

**Not yet classified as dangerous good**
Hazardous to water and potentially health hazard (H304)

Import is legally feasible. Not being classified as dangerous goods, the transport of LOHC meets the least challenges from a legal perspective. To current knowledge, vessels must not comply with special construction requirements and import terminals are not within the scope of Immissions Control Law. Establishing a pipeline infrastructure must be scrutinized on a case-by-case-basis.




**Fuel use:** **Authorization** through the **alternative design method** necessary. Technical standards are lacking.

**Bunkering:** Separate **authorization** by the port authority necessary. Technical standards are lacking.

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