

HyLAW

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1. Introduction and Summary

1.1. HyLAW Summary and Methodology

HyLaw (www.hylaw.eu) stands for Hydrogen Law and removal of legal barriers to the deployment of fuel cells and hydrogen applications. It is a flagship project aimed at boosting the market uptake of hydrogen and fuel cell technologies providing market developers with a clear view of the applicable regulations whilst calling the attention of policy makers on legal barriers to be removed.

The project brings together 23 partners from 18 EU and associated Countries¹ and is coordinated by Hydrogen Europe.

Through extensive research, interviews and legal analysis, the HyLaw partners have identified the legislation and regulations relevant to fuel cell and hydrogen applications and legal barriers to their commercialization.

This Policy Paper provides EU level actors with summarised findings and recommendations on how to remove or alleviate the impact of these barriers.

The focus of this paper is on aspects that can or should be treated at EU level (e.g. because they are connected with the implementation of existing EU legislation or are best addressed through actions taken at EU level). Matters which deal exclusively with eliminating barriers or supporting practical implementation at national or local level are treated separately as part of National Policy Papers² published for each country researched.

1.2. Executive Summary

Hydrogen – at the core of a decarbonised energy system

Energy is one of the core needs of our societies. We use energy to, inter-alia, heat our homes, drive our cars, cook our food and shed light at night. However, the current sources of energy are harming our society and new ways of continuing our economic growth while decoupling it from harmful emissions are continuously being developed.

Hydrogen can fulfil a systemic function for integrating all energy consuming sectors and increasing the efficiency of the overall energy infrastructure. Hydrogen can help increase the penetration and integration of decarbonised and renewable energy within our energy mix, reducing our reliance on fossil fuels and helping Europe meet its environmental and climate goals. Hydrogen can be highly efficiently stored, transported and distributed at low cost, making it the ideal energy carrier of a decarbonised, sustainable society.

As **the industry sector** is looking at ways to decarbonise its “hard-to-abate” branches, interest in decarbonised and renewable hydrogen is growing rapidly. Following the results of successful demonstration projects, energy intensive and/or hydrogen consuming industries (e.g. Petro-chemical; steel and fertilizer production) have been given an immense opportunity to use hydrogen technology to reduce their harmful emissions and minimise the carbon footprint of their products.

All branches of the **mobility sector** enjoy similar opportunities to seize the potential of Hydrogen as a fuel and contribute to reducing overall carbon emissions and other pollutants into the atmosphere. Zero-Emission Fuel Cell and Hydrogen (FCH) Road and Rail applications are commercially available and only need the right industrial and regulatory policies to become an every-day, mass market reality. While Maritime and Aviation applications still require additional research and development (R&D) work to scale up existing technologies to fit the specific requirements of the two sectors, demonstration projects have proved the feasibility and potential of HFC technologies for decarbonising these “hard-to-electrify” parts of our transport needs.

The **heating and cooling sector** is entering a new paradigm shift, realising that hydrogen can be a solution to a future, clean gas industry that continues to make use of existing infrastructure to bring energy to millions of private and commercial users across the EU.

¹ Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Norway, Poland, Romania, Spain, Sweden, Portugal, the Netherlands and United Kingdom

² See: <https://www.hylaw.eu/info-centre>

Hydrogen and Fuel Cells: an environmental necessity and economic opportunity.

Estimates of the **total global production value** of key components and systems associated with the FCH sector vary **from €4 bn to €40 bn** while the **EU share** of this market varies between **€1.5 bn and €10.7 bn**³.

EU companies are commercialising equipment to produce hydrogen without emissions (e.g.: global leadership in electrolysis technology), specific storage systems for hydrogen, fuel cells, hydrogen refuelling stations and many other components and sub-components. European companies remain world leaders in some of the areas of the hydrogen supply chain, creating jobs and investment. In the EU, more than 300 companies are active in key FCH sectors⁴ and more exist in other supply chain areas. Even more with latent capabilities exist, who could strengthen Europe's position. These suppliers are supported further by more than 250 identified knowledge-based actors across different domains of expertise such a research centres and universities.

If the world is committed to keep climate change below 2 degrees, **by 2050, hydrogen will represent 18% of the total worldwide energy consumption a figure reaching 24% in the EU**. This would decrease the amount of CO₂ released in the atmosphere by 6 gigatons per year and, at the same time, create 30 million of jobs within an industry worth 2.5 trillion dollars annually⁵. These estimations, although ambitious, have already began to be implemented in different nations: 400 Hydrogen Refuelling Stations (HRS) are planned in Germany by 2023⁶, in Japan, hydrogen is being seen as the main energy vector of the future with the Olympic games in Tokyo putting hydrogen on the main stage (e.g.: Toyota provide 100 hydrogen fuel cell buses)⁷. In France, the national "Plan Hydrogène" proposes to use hydrogen as a key solution for the energy transition of the country⁸, in the US major fleets of hydrogen trucks and a large infrastructure of refuelling stations are under development⁹. In the Netherlands, plans of converting large-scale power stations (>1.3 GW) to run on 100% hydrogen are in the making¹⁰. Leeds (UK) is looking to completely decarbonise its gas infrastructure using Hydrogen. These are just a few examples that show that the world is starting to move towards the hydrogen economy.

The recently published Hydrogen Roadmap for Europe¹¹ estimates that 5 million vehicles and 13 million households could be using hydrogen by 2030 while 600kt of hydrogen would be used to provide high grade heat for industrial uses. In this scenario, by 2030 hydrogen would be abating 80Mt CO₂ annually and account for an accumulated overall investment of 52B€ and 850,000 new jobs within the EU alone, while by 2050, the industry would reach 820 Bn EUR in annual revenue, would account for the abatement of 560Mt CO₂ annually and directly employ 5.4 million people.

Existing policies and legislation affecting hydrogen deployment

As a result of growing interest, **hydrogen has been introduced in a number of EU policies and legislative acts** in the past few years and will continue to fall under the scope of a number of major legislative initiatives in the near future.

Indeed, with the European Commission's Clean Energy and Mobility Plans, the EU is setting its eye on decarbonised, fully integrated and smart energy and transport systems where hydrogen will have a key role to play. For example, in the mobility sector, renewably-produced hydrogen & hydrogen-based fuels (i.e. for maritime and aviation) put on the market will have a twofold impact: increase the share of and integrate renewable energy in our current fuel infrastructure while enabling the deployment of zero-emission vehicles throughout Europe.

The deployment of FCEVs will also be achieved through clean public procurement and new incentives for CO₂ emissions standards for cars, light and heavy duty vehicles as well as the increased refuelling infrastructure through the Connecting Europe Facility and its related Trans-European Networks.

As mentioned above, the European Institutions and the gas sector are looking at the future role of gas in the EU and how we can use the existing interconnected and far-reaching gas infrastructure (e.g.: in the past 10 years, the gas industry has

³ *Study on Value Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cells Technologies* - E4tech (UK) Ltd for FCH 2 JU in partnership with Ecorys and Strategic Analysis Inc. - October 2018

⁴ FCEV's; Electrolysis, HRSs and CHP's

⁵ Hydrogen Council, 2017

⁶ [Germany targets 400 HRS stations by 2023](#)

⁷ [Tokyo Aims to Realise "Hydrogen Society" by 2020](#)

⁸ [Plan hydrogène - Ministère de la Transition écologique et solidaire](#)

⁹ [Hydrogen Refuelling Station, US](#)

¹⁰ [Magnum project](#)

¹¹ <https://www.hydrogeneurope.eu/news/hydrogen-roadmap-europe-has-been-published>

deployed more than 400,000 kilometres of pipelines across the EU¹²) to transport vast amounts of decarbonised/renewable gases such as hydrogen to consumption centres.

The economic impact of hydrogen and fuel cells in Europe is becoming increasingly important for the European economy. This is why the European Commission is looking at how to ensure that such a significant value chain remains in European soil. The recently started **Important Project of Common European Interest (IPCEI)** Strategic Forum¹³ is looking at how to enable such a value chain to thrive in Europe. The creation of such supply/value chain in Europe is one of the many results achieved through the Hydrogen and Fuel Cells Joint Undertaking (FCH) and associated funding which have been instrumental in bridging the gap between innovation and market deployment in the past 10 years and will, hopefully, continue to play a key role in the future.

Barriers and legislative and policy gaps remain

Nevertheless, **an integrated vision of the hydrogen infrastructure is in its infancy. In road mobility**, as a result of EU intervention¹⁴, hydrogen is recognised as an alternative fuel at EU and national levels., however, hydrogen “fuelled” Fuel Cell Electric Vehicles (FCEVs) are still more expensive than conventional ones due to lack of economies of scale. The high vehicle purchasing prices and the scarcity of hydrogen refuelling infrastructure (also associated with high capital and operational costs) are the main barriers against a rapid development of emission free FCEVs. Lengthy processes, for example for the construction and operation of a hydrogen refuelling stations – resulting from legal and administrative barriers increase costs and represent a further barrier for the market uptake of hydrogen as energy carrier. **Maritime applications** continue to be developed and rolled-out on a demonstration basis but policies and supporting legislation are not yet ready to kick-off commercial deployment.

In the Gas sector, the existing policy framework has been designed around natural gas and although major players (gas producers, transmission and distribution operators, industrial users) are looking at ways of using decarbonised and renewable hydrogen. Significant, systemic regulatory barriers and gaps stand in the way of the potential of hydrogen to decarbonise EU gas networks and to make use of existing infrastructure to further integrate higher shares of renewables into EU energy systems.

Other parts of the hydrogen value chain, such as production, storage, distribution and other uses (such as for heating and power generation) continue to face (mostly unintended) regulatory and administrative barriers.

But solutions exist and are within grasp

Building on the research conducted within the HyLaw project, **this paper aims to be specific about the legislative acts and administrative processes which hinder or prevent the deployment of hydrogen and hydrogen-based applications within the EU** and provide recommendations on how such barriers can be overcome in the hopes that targeted actions will be taken at EU level to unlock the full potential of hydrogen for achieving EU climate, environmental, energy and mobility goals.

¹² [Km of gas transmission and distribution pipelines, Gas Infrastructure Europe](#)

¹³ [Important Project of Common Europe Interest](#)

¹⁴ Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels

2. Production and Storage of Hydrogen

2.1. Legislative summary

The production of hydrogen is subject to a significant number of requirements. Although enshrined in national legislation following transposition, the source of most of these requirements can be traced to EU Directives in various fields. Nevertheless, while the overall requirements are similar across all partner countries, significant differences in interpretation and implementation exist.

At EU level, the most relevant legislative acts for hydrogen production plants are: the SEVESO Directive (2012/18/EU)¹⁵, the ATEX Directive (2014/34/EU)¹⁶ and Directive 2010/75/EU on industrial emissions¹⁷. These acts apply specifically to the production of Hydrogen and generate important obligations on operators involved in the production of Hydrogen as well as on manufacturers of equipment used in the process.

The obligations prescribed in the SEA¹⁸ and EIA¹⁹ Directives could also apply, subject to national conditions²⁰;

Error! Reference source not found., annexed to this paper, summarises the relevance of these acts for the requirements imposed to hydrogen production plants and presents the main obligations they impose to operators.

The requirements for permitting the operation of a (hydrogen) production plants and storage facilities are well rooted into the intervention logics of the acts mentioned above (i.e. the intent to subject them to certain obligations is evident or would become clear when considering the objectives sought by the intervention). The requirements, while high, are, in general, necessary and proportional in light of the need to protect human life, property and the environment.

That being said, several inconsistencies and potentially unintended consequences of the existing acts are worth mentioning, as they result in high, disproportionate barriers.

2.2. Assessment

The production and storage of hydrogen is subject to a significant number of requirements enshrined in national legislation or administrative practice of Member States. Although national authorities have a significant degree of freedom to design and implement such requirements (and indeed significant differences between MS exist), a number of them can be traced to EU Directives in various fields.

Although most actions for improvement of the situation can and should be taken at national and local level, this paper focuses on conclusions and recommendations at EU level²¹

Barrier 1: No distinction between production methods

While hydrogen has been produced and stored safely for decades, it has been regarded and treated as an industrial gas, therefore, hydrogen production continues to be seen as a traditional chemical or industrial process, without regard to the type of H₂ production. None of the requirements contained in the Directives mentioned above make any distinction between the various methods for hydrogen production, despite the significant differences in terms of the production process, presence of harmful substances and environmental impact. Most notably, the Industrial Emissions Directive includes production of hydrogen within its scope and does not distinguish between production methods. This places a high burden on environmentally friendly production methods, as it subjects them to the same requirements as industrial, emission emitting processes.

¹⁵ 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

¹⁶ Directive 2014/34/EU - covering equipment and protective systems intended for use in potentially explosive atmospheres

¹⁷ Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (IED)

¹⁸ Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (SEA Directive)

¹⁹ Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (EIA Directive)

²⁰ Production and Storage of Hydrogen falls within the projects listed in Annex II (6a and 6c -production of chemicals; and storage facilities for chemical product), for which Member States shall determine whether the project shall be made subject to an assessment or not, they may result in the obligation to prepare an Environmental Impact Assessment (EIA),

²¹ Actions which can be taken at national level are presented in D4.3 (Horizontal Position Paper – Production and Storage of Hydrogen) available at www.hylaw.eu/info-centre . For a more in-depth analysis, please consult deliverable D4.1 “Analysis of commonalities and differences between countries”, available at www.hylaw.eu/info-centre

Barrier 2: Absence of simplified rules and processes for small quantities

The absence of clear thresholds for the application of the above-mentioned requirements means that the implementation of small production units is as complicated as large ones which, in turn, discourages development of environmentally friendly production methods and further exacerbates the (lack of) economies of scale issues faced by smaller units. While this may be inconsequential for centralised production business models, it severely limits the potential for development of localised²² production units, including HRSs with on-site production

Barrier 3: Unintentionally relegating HRS's with on-site production to industrial areas

From a land use perspective, the production of hydrogen is, in many partner countries, regarded as an industrial activity, irrespective of the production method (even when produced from non-emitting methods such as water electrolysis), hence such activity would only be permitted in an area designated as an industrial zone or, in under specific conditions in commercial areas²³.

Traditionally, the production of hydrogen in large quantities (often the case for centralised production) has taken place through industrial processes such as steam methane reforming, the limitation of these activities to industrial zones is understandable. However, current legal and administrative processes would, in certain jurisdictions, also relegate non-emitting production processes such as electrolysis to such zones, thereby unduly limiting the locations where such installations can be built.

Without prejudice to the ability of competent authorities to explicitly limit hydrogen production to industrial zones, the current situation can also be viewed as an unintended outcome resulting from the misunderstanding of the processes involved and/or the lack of clarity on the scope of application of legislation, in particular those stemming from the Directives presented above. The lack of clarity/inadequacy connected with these Directives may contribute to the historical assumption that production of hydrogen (as an industrial gas) is a chemical process involving emissions (which is not the case when hydrogen is produced via *inter alia* electrolysis).

Furthermore, in terms of administrative practice, the determination of whether a certain economic activity is allowed (or not) in a given zone is determined by the NACE²⁴ code under which the activity falls. As currently defined, production of hydrogen, irrespective of production method and irrespective of the quantities involved or environmental impact, falls under NACE code: 20.11 - *Manufacture of industrial gases*. This further increases the likelihood that the production of hydrogen would only be allowed (c.f. by planning authorities) in industrial zone

2.3. Recommendations

- It is important to distinguish and recognise that hydrogen production can take place in different ways and that some of these methods (e.g. electrolysis) have little environmental impact and generate little to no emissions. While zone prohibition may continue to exist even in such situations, it is important that legal and administrative procedures recognise the differences and distinguish between the various methods, thereby incentivizing production of hydrogen from environmentally friendly methods.
- At the same time, procedures should continue to be simplified and streamlined; authorities should act as one-stop-shops to systematically process permitting and zoning in a centralized manner and the duration of the process should be decreased in order to reduce the economic cost borne by economic operators engaged in such activities.
 - For this purpose, guidelines for specific requirements and zone prohibitions when a hydrogen production unit is installed should be developed at a national and/or regional level. The document should *inter alia* propose a list of zones and corresponding activities allowed which include not only hydrogen production through industrial pathways (e.g. SMR), but also from non-emitting, environmentally friendly methods such as electrolysis, biomethane reforming, and SMR with CCS. Differentiated treatment between these pathways could be made on the basis of environmental soundness.

²² production of hydrogen for a given application on the same location, eliminating the need to transport the hydrogen outside a facility

²³ One particular exception to this can be observed in Belgium (Flanders) where, a hydrogen facility can, in principle, be built in both industrial as well as other areas, if there is a link with the functions in the area, (e.g. if a hydrogen filling station is included)

²⁴ NACE Classification Codes. NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) is a European industry standard classification system similar in function to Standard Industry Classification (SIC) and North American Industry Classification System (NAICS) for classifying business activities. <http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>

- At EU level, permitting requirements applicable to hydrogen production at national level should be identified and studied in detail. The extent to which they represent an operationalization of obligations established at EU level should be studied (e.g. perhaps within the context of a REFIT process). “Gold-plating” (i.e. requirements going beyond those established by the EU acts) in national transposition of requirements should be highlighted and avoided.
 - When a possibility of revision comes up, small scale storage of H₂ for retail refuelling and the small-scale production of hydrogen via electrolysis should be excluded from the scope of the relevant EU acts, or at the very least adapted to consider the specific nature of these activities.
- In the Member States, hydrogen refueling stations (with or without on-site production²⁵) should explicitly be treated as conventional refueling stations from the perspective of land use plans and zone prohibitions. For such a treatment to be possible, direct emission free (e.g. via electrolysis) production of hydrogen should be excluded from the scope of legislative acts (EU and national laws alike) which currently cover the production of hydrogen. At the very least, the concept of “*chemical conversion on an industrial scale*”²⁶ should be defined in a manner which excludes the production of hydrogen via electrolysis in small enough quantities (i.e. those required to supply a HRSS with on-site production) from the obligations stemming from the IED, EIA and SEA Directives.
- Finally, to support practical implementation at local and regional level, the NACE codes should be adapted to reflect the emission free (e.g. via electrolysis) production of hydrogen separately from the manufacture of industrial gases under which hydrogen production currently falls. Furthermore, to further reduce the risk of unequal treatment from a land-use plan perspective, HRS should unequivocally fall under the same NACE code as conventional refueling stations, i.e. 47.30 - *Retail sale of automotive fuel*.

²⁵ Where such a treatment is possible, depending on the additional risk profile of the production method.

²⁶ Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (IED) - (Annex I, point 4.2)

3. Hydrogen as a fuel and Hydrogen Refuelling Stations (HRS)

3.1. Legislative summary

Hydrogen refuelling stations can exist in different configurations: (i) Different size (i.e. amount of H₂ stored); (ii) with or without on-site production of hydrogen; (iii) with various storage and dispensing pressure (e.g. 350 / 700 bars) (iv) the hydrogen can co-exist with other fuels on the same site or not; (v) the hydrogen can be supplied by pipeline or transported to the station in tube trailers; (vi) it can be dispensed in gaseous or liquid form, etc.

As a result of this, a large number of rules can apply in the context of planning, permitting, building and operating of hydrogen refueling stations.

Firstly, it is important to highlight that all considerations presented in chapter 2 on the production and storage of hydrogen apply also to hydrogen refueling stations, therefore, these will not be repeated in this section which will present additional legal and administrative barriers associated with the development of hydrogen as a fuel and other specific considerations associated with hydrogen refueling stations.

The Alternative Fuels Infrastructure Directive²⁷ (AFID) establishes a common framework of measures for the deployment of alternative fuels infrastructure in the Union in order to minimize dependence on oil and mitigate the environmental impact of transport by setting out minimum requirements for the building-up of alternative fuels infrastructure, including refueling points for hydrogen.

The Directive sets out minimum requirements for the building-up of alternative fuels infrastructure, including recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and provides a non-mandatory provision for hydrogen infrastructure to be implemented by means of Member States' national policy frameworks. It also lays down common technical specifications for such recharging and refueling points and user information requirements. The AFID requires Member States which decide to include hydrogen in their national policy frameworks to ensure that an appropriate number of such points are available and to ensure the circulation of hydrogen-powered motor vehicles, including fuel cell vehicles, within networks determined by those Member States, including, where appropriate, cross-border links. Despite the fact that the inclusion of hydrogen within the scope of national policy frameworks was the only technology left optional for Member States, 14 countries²⁸ decided to include hydrogen within their national strategies, however, this is insufficient in light of ensuring a seamless EU transport network.

The most recent version of the Fuels Quality Directive²⁹ introduces a definition³⁰ for renewable transport fuels which would also apply to hydrogen. However, despite national / private initiatives (e.g. DE, DK,) to define “green” / “renewable” hydrogen, there is currently no binding or voluntary, uniform certification of origin system at European level.

The recast **Renewable Energy Directive (RED II)**³¹ requires Member States to set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14 % by 2030 (minimum share)³². This is far more than what can be achieved with advanced bio-fuels alone and will require the use of renewable hydrogen. Importantly, the directive allows fuel suppliers to take into account, when fulfilling this obligation, the use of renewable *liquid and gaseous transport fuels of non-biological origin* (n.b. “renewable hydrogen”) also when they are used as intermediate products for the production of conventional fuels. As a result of these provisions, it becomes abundantly clear that investments in increasing the capacity to produce renewable hydrogen will be needed in the very near future.

²⁷ Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure (AFID)

²⁸ Austria, Belgium, Bulgaria, Czech Republic, Germany, Estonia, Spain, Finland, France, Hungary, Italy, Netherlands, Sweden, and UK

²⁹ Directive (EU) 2015/1513 Of The European Parliament and of The Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources

³⁰ The Fuel Quality Directive defines “renewable liquid and gaseous transport fuels of non-biological origin” as “liquid or gaseous fuels other than biofuels whose energy content comes from renewable energy sources other than biomass, and which are used in transport”.

³¹ Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources

³² Article 25 Recast of the Renewable Energy Directive (Directive (EU) 2018/2001)

The RED II also contains provisions for the establishment of Guarantees of origin schemes that will include hydrogen³³. Article 25.2 of this proposal requires that *the greenhouse gas emission savings from the use of renewable liquid and gaseous transport fuels of non-biological origin excluding recycled carbon fuels shall be at least 70% as of 1 January 2021*. As a consequence, a low-carbon hydrogen definition and tracking and tracing mechanism is required to help demonstrate compliance with the above-mentioned articles.

In this regard, the CertifHy³⁴ Project is currently developing the first EU-wide tracing and tracking scheme for low-carbon and green (low carbon and renewable) hydrogen for the purpose of Guarantee of Origin (GoO) scheme envisioned by the RED II³⁵ as well as Supply Certificates to demonstrate the 14% target of renewables in transport³⁶.

3.2. Assessment

The absence of a common definition of renewable or low-carbon hydrogen could be a major barrier that will slow down the implementation of hydrogen as an alternative fuel. Divergent approaches may jeopardize the free movement of hydrogen across borders. Moreover, the absence of an (EU Wide) Guarantee of Origin (GoO) scheme for renewable and low-carbon hydrogen hinders the development of a hydrogen fuel market. Remaining in this status-quo may encourage the production of hydrogen from hydrocarbons that may reduce the overall environmental benefits of hydrogen in all applications (mobility, energy, industrial feedstock).

The reference to GoO schemes in the recently adopted recast RED, together with the developments in the CertifHy project appear to have pre-empted the emergence of a barrier in this area, however national implementation of RED obligations and the GoO scheme remains to be achieved, meaning that operational barriers may arise in the future.

However, it is unclear whether and how Article 25.2 of the recast RED will impact existing and future tracing and tracking schemes, in particular the labels of “green / low carbon” hydrogen proposed by the CertifHy project: these labels for Supply Certificates will have to be made compliant with Art 25.2 of the RED II (including delegated acts).

In addition to the definition of renewable and low carbon hydrogen, an essential element of any useful GoO scheme (n.b. foreseen by CertifHy) is the ability to separate the renewable character of the hydrogen (proven by the GoO) from the movement of the actual molecules of hydrogen concerned. The recast RED accepts the principle that *A guarantee of origin can be transferred, independently of the energy to which it relates, from one holder to another*³⁷.

In addition to the regulatory barriers / gaps (including the considerations presented in section 2 of this policy paper)³⁸, the deployment of Hydrogen Refueling Stations is negatively affected by a lack of ambitious policies for the development and support for a meaningful hydrogen refueling network. The current version of the AFID allows Member States to ignore hydrogen mobility altogether from their national frameworks which significantly hinders the development of an EU-wide network and severely impacts the development of zero-emission cross-border mobility of European Citizens across the Union.

3.3. Recommendations

- In the context of the up-coming **revision of the Directive on Alternative Fuels Infrastructure (DAFI)**, A level playing field between the fuels should be ensured. The inclusion of hydrogen should be mandatory.
 - The report of the European Parliament’s on the Deployment Alternative Fuels Infrastructure Directive (2018/2023(INI) goes in this direction (it *“calls on the Commission to create a level playing field between the different alternative fuels ensuring technology neutrality, especially when promoting distribution infrastructure, thus making hydrogen infrastructure mandatory with deployment requirements equal to those for CNG, but adjusting these deployment requirements”*)

³³ Article 27 of the the recast of the Renewable Energy Directive

³⁴ <http://www.certifhy.eu/>

³⁵ Art 19, Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources

³⁶ Directive (EU) 2018/2001, Articles 25, and 27)

³⁷ Preamble (55) Recast of the Renewable Energy Directive (Directive (EU) 2018/2001)

³⁸ To support regulatory improvement, the HyLaw project has distinguished between regulatory barriers (or legal and administrative barriers) and policy / economic barriers. The focus of the project was on the former, however, when relevant absent policy measures / lack of financial incentives are also identified as barriers.

- The distance between Hydrogen Refuelling Stations should be reduced from 300km to 150km to be equal to the current distance between compressed natural gas (CNG) stations.
- Member States should be encouraged to be more ambitious in their national policy frameworks as regards to their plans to deploy hydrogen infrastructure as part of their efforts to decarbonize the transport sector.
 - Member States should establish the level of their national sub-targets for advanced fuels (including hydrogen) and incentives for those targets to be met.
 - Member States should report annually to the European Commission on the implementation of the Directive rather than every 3 years.
- An **EU-wide Hydrogen guarantee of origin scheme** is crucial for both renewable and low-carbon hydrogen.
 - A Guarantee of Origin Scheme (GoO) should be established as a consumer information tool.³⁹
 - According to the proposal for RED II, the extension of the guarantee of origin systems to non-renewable energy sources should be an option for Member States. There must be a clear and unambiguous distinction between renewable GoOs and (non-renewable) low-carbon GoOs, so that stakeholders can be confident in the GoOs system and be willing to pay a certain premium price for Low carbon GoOs and a higher premium price for Green GoOs. Else there would be a major risk for GoOs of being considered as greenwashing, and so the confidence of stakeholders, which is vital for such a system, would be damaged.
- A **tracking and tracking system for renewable and low carbon hydrogen** should be established at EU level (e.g. CertifHy project) as a mechanism for facilitating the compliance of fuel suppliers with the RED II under Article 25⁴⁰.
 - The implementation the Renewable Energy Directive (RED II) should be closely monitored and all schemes should be designed with close attention due to the legal requirements stemming from the RED II and its implementing acts.
 - The certification of hydrogen should include the carbon intensity and other relevant parameters (e.g. renewable origin, greenhouse gas savings, the type of feedstock used and other benefits towards a circular economy) as for electricity in order to encourage the production and use of Hydrogen from low carbon and/or renewable processes.
 - The renewable origin of the hydrogen should be transferrable independently of the molecules to which it relates (within a mass balanced system and to ensure double-counting is not possible).

³⁹ Article 2.12 of the RED II defines a ‘guarantee of origin’ as ‘an electronic document which has the sole function of providing evidence to a final customer that a given share or quantity of energy was produced from renewable sources’

⁴⁰ N.B. The achievement of the Article 3 target of 32% (obligation on Members States to achieve a minimum share of energy from renewable sources) cannot be proved through the use of Certificates of Origin according to Article 9 (2)

4. Fuel Cell Electric Vehicles (Road)

Since 2014, greenhouse gas emissions from the EU-28 transport sector have been increasing. In 2016, transport (including aviation and shipping) contributed 27 % of total greenhouse gas emissions in the EU-28. Within this sector, road transport was responsible for almost 72 % of total greenhouse gas emissions. Of these emissions, 44 % were contributed by passenger cars, while 19 % came from heavy-duty vehicles .

Although the economy-wide greenhouse gas emissions reduction target for 2020 of 20% compared to 1990 levels looks likely to be met, further policy actions are needed to meet the 2030 target of 40% compared to 1990 levels. Moreover, emissions from transport need to fall by 67% by 2050 compared with 1990 levels, in order to meet the long-term 60 % greenhouse gas emission reduction target in this sector as set out in the 2011 Transport White Paper . An interim target aims to reduce transport GHG emissions by 20% below their 2008 levels by 2030, which would still leave them 8% higher than in 1990.

At present, the EU policies that have the largest impact on decarbonisation of transport are CO₂ standards for passenger cars, vans and HDVs, the Clean Vehicles Directive review and policies aimed at increasing the share of renewable energy sources in transport.

For purposes of achieving their climate policy goals in transport for 2020, the majority of EU Member States have adopted policies, national legislative acts and support schemes for stimulating the market of electric or zero-and low-emission vehicles. FCEVs are legally defined as electric driven vehicles or as zero emission vehicles and could benefit to a certain extent from the financial and non-financial incentives provided for these types of vehicles.

Vehicle tax and registration fee reductions or exemptions are the most commonly implemented support measures, whereas the direct purchase grants, green public procurement and toll reductions or exemptions are not widely used support tools. Non-financial incentives like access to the bus lines and free or reduced fee parking in public parking spaces are provided at local level in several countries.

In order to accelerate the transition to net zero emission transport, the current policies have to be revamped and improved, targeting the efficiency of vehicles, the decarbonisation of fuels and the development of charging and refuelling infrastructure for zero-emission vehicles.

Hydrogen powered fuel cell electric vehicles (FCEVs) can contribute to meeting the EU medium- and long-term targets for reduction of greenhouse gas emissions and integration of renewable energies in transport sector. FCEVs emit no emissions at the tail-pipe; the only by-product is water. At the same time, a fuel cell car can cover far greater distances per tank – typically 500 km, and could even reach up to 800 km – with a refuelling time equivalent to that of conventional petrol or diesel cars. Hydrogen is the most promising zero emission alternative for long haul trucks, given its higher energy density compared to batteries. A fuel cell electric bus running on green hydrogen can reduce the global warming potential by up to 85 % compared to an existing diesel bus while providing the same flexibility and productivity.

In this context, it is important that the EU and Member States policies set targets for CO₂ emission reduction for cars, vans, heavy duty vehicles and buses, encouraging the deployment of zero-emission vehicles while ensuring and promoting a level playing field between the solutions and corresponding infrastructure.

4.1. Overview of current legal framework

For achieving the goals for 20% cut in greenhouse gas emissions (from 1990 levels) and 20% renewables in total energy consumption in the EU by 2020, the European Union has adopted a number of legal acts in the energy and transport sectors. The most important of them aimed at creating framework conditions and support mechanisms for clean vehicles are the Alternative Fuel Infrastructure Directive 2014/94/EU (AFID)⁴¹, the Clean Vehicle Directive 2009/33/EC⁴² and Directive 2015/1513/EU (ILUC)⁴³ as well as the two regulations aiming to set CO₂ emission standards for light duty vehicles, light commercial vehicles⁴⁴ and heavy-duty vehicles⁴⁵

⁴¹ Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure

⁴² Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles

⁴³ Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources

⁴⁴ <http://www.europarl.europa.eu/legislative-train/theme-resilient-energy-union-with-a-climate-change-policy/file-jd-co2-emissions-standards-for-cars-and-vans>

⁴⁵ [http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI\(2018\)628268](http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2018)628268)

AFID aims at developing a market for alternative vehicle powertrains, fuel technologies and infrastructure and mandates the Member States to grant direct or tax incentives for the purchase of private and public alternative fuel vehicles (AFVs) and for the building-up of the relevant infrastructure. Each Member State shall submit to the Commission a report on the implementation of its national policy framework by 18 November 2019, and every three years thereafter. Those reports shall include inter alia information about the undertaken policy measures, such as:

- direct incentives for the purchase of AFVs or for building the infrastructure,
- availability of tax incentives to promote AFVs and the relevant infrastructure,
- use of public procurement in support of alternative fuels, including joint procurement,
- demand-side non-financial incentives, for example preferential access to restricted areas, parking policy and dedicated lanes.

AFID does not oblige Member States to build refuelling infrastructure for hydrogen vehicles, it is up to national policy makers to include hydrogen refuelling points in their national policy frameworks and promote hydrogen powered vehicles. The present version of the directive means that the 14 Member States⁴⁶ which decided to develop refuelling infrastructure for hydrogen powered vehicles are affected by a lack of infrastructure development in other Member States, with possible adverse effects on the functioning of the Internal Market and zero-emission mobility within the EU.

The Clean Vehicles Directive requires contracting authorities to invest in environmentally friendly vehicles and thus to promote and stimulate the market for clean and energy efficient vehicles via clean procurement. An evaluation carried out in 2015 showed that the results have been limited. Public bodies are, on average, not using public procurement well enough to boost the market uptake of clean vehicles. Furthermore, its scope is insufficient and a definition of clean vehicles is lacking. Provisions for vehicles purchase are either vague (technical specifications) or overly complex (monetization of external effects). Therefore, this directive has failed to foster clean public procurements and needs to be revised to achieve its aims.

In November 2017, the European Commission launched a package of proposals with the aim to reinforce EU's leadership in clean vehicles and to achieve the EU's commitments under the Paris Agreement for a binding domestic CO₂ reduction of at least 40% till 2030.

As a part of its Clean Mobility Package, the EU Commission **proposed a revision of the Clean Vehicle Directive (CVD)**⁴⁷. It aims to promote clean mobility solutions in public procurement tenders (purchase, lease, rent or hire-purchase of road transport vehicles, and public service contracts on public passenger transport by road and rail) and thereby raise the demand for and the further deployment of clean vehicles. The proposal's key elements are the following: (i) setting targets for the procurement of clean vehicles per Member States and per vehicles categories by 2025 and by 2030 as well as (ii) provide definitions for clean light-duty vehicles (LDV); clean heavy-duty vehicles and zero emission heavy-duty vehicles.

Specifically, Clean vehicles LDVs (M1, M2 and light commercial vehicles (N1) are defined in the proposal as clean *if they emit less than 50 g CO₂/km at the tailpipe until 2025, and 0 g CO₂/km from 2026*. The Maximum real driving emissions values of PN and NO_x cannot exceed 80% of emissions limit. Clean vehicle HDV (M3, N2 and N3 vehicles) are defined in the proposal as: *vehicles using alternative fuels as defined in the DAFI excluding fuels produced from high indirect land-use change-risk feedstock; in the case of biofuels and synthetic fuels, these shall not be blended with conventional fossil fuels*. A definition of zero emission heavy duty vehicle is also provided: *as a clean vehicle without an internal combustion engine or with a combustion engine that emits less than 1g CO₂/kWh or less than 1g CO₂/km*.

The proposed revision should ensure that all relevant procurement practices are covered, clear, long-term market signals are provided and provisions are simplified and effective. It sets out minimum targets for clean vehicle procurement by 2025 and by 2030 for each category of vehicles and each Member State and a specific target for zero emission buses, this market being seen as more advanced compared to other segments.

The targets laid down in the proposed revision of the CVD are:

- For LDV and LCVs: between 17.6% and 38.5% between 2021⁴⁸ and 2025, and between 17.6% and 38.5% between 2026 and 2030.

⁴⁶ Austria, Belgium, Bulgaria, the Czech Republic, Germany, Estonia, Spain, Finland, France, Hungary, Italy, the Netherlands, Sweden and the UK.

⁴⁷ Proposal for a Directive of the European Parliament and of the Council amending Directive 2009/33/EU on the promotion of clean and energy-efficient road transport vehicles COM (2017) 653

⁴⁸ Assuming the Directive enters into force in 2019

- For buses, the minimum share to be achieved ranges between 24% and 45% by 2025 and between 33% and 65% depending on the GDP and population. Half of the minimum target for the share of clean buses has to be fulfilled by procuring zero-emission buses (defined as a vehicle that emits less than 1g CO₂/kWh or less than 1g CO₂/km).
- With regards to waste collection trucks and other heavy-duty vehicles procured by public authorities, between 6% and 10% of new trucks should be "clean" in 2025, and 7% and 15% in 2030;

One other key element of the Clean Mobility Package is **the proposal for new CO₂ emission standards for passenger cars** and light commercial vehicles (vans) in the European Union for the period after 2020⁴⁹. The proposed targets are set for the EU-wide average emissions of new cars and vans in a given calendar year from 2025 on, with stricter targets applying from 2030. New passenger cars will have to reduce CO₂ emissions by 15% by 2025 and by 37.5% by 2030 relative to a 2021 baseline. As for New LCVs (vans) the CO₂ emissions shall be 15% by 2025 and by 31% by 2030

The proposed framework builds on the current Regulation⁵⁰ setting CO₂ emission targets of 95g CO₂/km for passenger cars and 147g CO₂/km for light commercial vehicles for 2020/2021. In this respect, Zero and low emission vehicles (ZLEV) are defined as vehicles with CO₂ emission values from 0 to up to 50g/km. FCEV fall into this category. Benchmarks for both ZLEV cars and vans are set at 15% for 2025 and 30% for 2030. A "Bonus" is offered for OEMs that exceed the ZLEV targets « ZLEV factor». CO₂ emissions increases are allowed and no malus for OEMs not meeting the ZLEV targets is envisioned. A revision of the directive is planned in 2023 which will fix target for 2035 and 2040.

On 17 May 2018, as a part of its third Mobility Package, the European Commission **presented a legislative proposal setting the first ever CO₂ emission standards for heavy-duty vehicles in the EU**⁵¹. The proposed targets aim to reduce average CO₂ emissions from new heavy-duty vehicles belonging to the regulated categories (> 16t – categorised within sub groups) by 15% in 2025 and 30% in 2030⁵², both relative to a 2019 baseline⁵³.

Within the framework proposed, OEMs investing in ZLEV trucks⁵⁴ will be rewarded as sales of LEV/ZE trucks being accounted multiple times towards meeting the targets while penalties (4,250€/g CO₂/tons km until 2030 and 6,800€/gCO₂/tons km afterwards) are foreseen for OEMs failing to reach the targets.

A revision of the directive is planned in 2022 which will consider *inter alia*: a methodology to develop a life cycle analysis; the value of the targets for 2030 and the extension of the scope to other vehicles including buses, coaches, trailers, etc.

Both proposals, for light- and heavy-duty vehicles include support mechanisms targeted at manufacturers and aimed at incentivising the development and deployment on the Union market of zero- and low-emission light- and heavy-duty vehicles that would complement demand-side instruments, such as the Clean Vehicle Directive, in a technology-neutral way.

Another legislative act with importance for the deployment of FCEVs is **the ILUC Directive** which amended the legislation for biofuels (Renewable Energy Directive and Fuel Quality Directive) and recognised the renewable produced hydrogen as a renewable transport fuel of non-biological origin.

As Part of its Clean Energy Package, the EU Commission recast and revised the Renewable Energy Directive for the period 2021-2030 (RED II⁵⁵). In addition to the new binding renewable energy target of at least 32% of EU final consumption in 2030, one key change is the 14% target for renewable energy in transport by 2030.

RED II considers that renewable fuels of non-biological origin incl. hydrogen are important to increase the share of renewable energies in sectors that are expected to rely on liquid fuels on long term and reduce the greenhouse gas emissions, providing that the electricity used for the fuel production should be of renewable origin.

⁴⁹ Proposal for a Regulation of the European Parliament and of the Council setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO₂ emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast) COM (2017) 676

⁵⁰ Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information

⁵¹ Proposal for a Regulation of the European Parliament and of the Council setting CO₂ emission performance standards for new heavy-duty vehicles COM/2018/284 final

⁵² Subject to a revision in 2022

⁵³ i.e. as compared to new vehicles registered between 1st July 2019 and 30th June 2020 in terms of g of CO₂ per ton Km

⁵⁴ ZE HDV are vehicles without an internal combustion engine, or with an internal combustion engine that emits <1 g CO₂/kWh, or <1 g CO₂/km

⁵⁵ Recast of the Renewable Energy Directive (Directive (EU) 2018/2001)

4.2. Assessment

At present, there are no sufficient support mechanisms at national level to foster the market of FCEVs. The lack of complex and effective support measures is a significant barrier for widespread deployment of FCEVs.

In view of the EU binding target for at least 40% reduction in greenhouse gas emissions by 2030 and the legislative proposals for 14% renewables in transport by 2030 and CO₂ emission reductions of EU fleets of light- and heavy- duty vehicles by 2025 and 2030, new national, investment-friendly policies for clean mobility are needed.

The agreement on the CO₂ emission standards for HDVs is excellent news as it may trigger the market, incentivizing and/or forcing OEMs to consider zero and low emission vehicle fleets. The potential of hydrogen in this respect is immense as Fuel Cells are inherently more suitable for HDV's than battery technologies considering the heavy payloads and long distances involved.

FCEVs have the potential to decrease drastically the CO₂ emissions, reduce the dependency on imported fossil fuels and boost the use of renewable energies in transport sector. Therefore, it is important that the policies affecting the market deployment of FCEVs and related refuelling infrastructure as well as the use of hydrogen as a fuel ensure and promote a level playing field for all types of clean vehicles and fuels.

Regulatory stability and reliable support framework are key conditions for public authorities and industry to invest. Sustainable and targeted support mechanisms could accelerate the transition to clean vehicles and fuels, stimulate employment, foster innovations and competitiveness and thus reinforce the EU's leadership in clean mobility.

The Member States have the flexibility to develop new or redesign the existing support measures to incentivize the uptake of zero- and low-emission vehicles in their national context. Such measures could be direct or indirect funding, tax and registration fee exemptions and reductions, zero VAT, energy taxation based on CO₂ emissions, toll exemptions, special fees for parking and privileged access to environmental zones.

Currently, public procurement and captive fleets are considered to be the main drivers for strong market penetration of zero- and low- emission cars. For LDVs, HDVs and Buses, CO₂ emission limits and mandatory shares for zero-emission vehicles have the potential to fundamentally change the make-up of our transport fleets.

Public authorities, through their procurement policy, can establish and support markets for innovative technologies. Setting minimum targets for clean vehicle procurement by 2025 and by 2030 at Member State level will contribute to policy certainty for market players.

The implementation of FCEVs vehicles in large public fleets could create the initial demand for hydrogen refuelling stations which is crucial for making FCEVs more popular among individual car users and private fleet managers. Private fleet operators could drive the uptake of FCEVs in captive vehicle fleets (utilities, taxis, postal operators or delivery companies) since technical or logistical problems of supplying vehicles with hydrogen fuel are easier to solve. Having a captive fleet can provide the critical mass to obtain better prices, cheaper H₂ and underpin a sustainable business case for HRS operators.

In addition, non-financial incentives, such as privileged access right in urban access restriction zones, are important to strengthen the public acceptance and positively influence the purchase decision of the potential users.

4.3. Recommendations

- Consistent and long-term implementation at national level of the Alternative Fuels Infrastructure Directive for all types of alternative fuels including hydrogen
- Establishment of financial and non-financial incentives for the market uptake and deployment of alternative fuel vehicles and building of related infrastructure.
- Development of new supportive technology-neutral policies and regulations for zero - and low-emission vehicles ensuring a level playing field between FCEVs and BEVs
- Ambitious CO₂ emission targets – verified using reliable methodologies (e.g. on-board fuel consumption devices) to avoid another “diesel gate” scenario
- Determination of higher minimum procurement targets for zero- and low-emission light- and heavy-duty vehicles for public bodies. At the very least, bidders providing zero-emission solutions in response to public procurement should be incentivised to do so by meaningful quality criteria which offset the potential increase in costs. “The lowest cost” should be avoided as much as possible, as this public procurement criteria will incentivise fossil fuel solutions.



- Initiation of legislative changes abolishing the toll-charges for zero-and low- emission heavy- duty vehicles and increasing the toll charges for high-emission heavy-duty vehicles
- Supporting national and local actors to incentivize the circulation of zero-emission vehicles in city centers (e.g. by general prohibition of entry for high-emission vehicles or introduction of a city toll).



5. Hydrogen for maritime and inland-waterway transport

According to IMO figures⁵⁶, Maritime transport emits around 1000 mill tons of CO₂ annually, which accounts for about 2.5% of global GHG emissions. With shipping emissions predicted to increase significant (50%-250%) by 2050, the sector is under pressure to take measures to decarbonize and eliminate other pollutants. The commitment by the IMO to reduce CO₂-emissions 50% by 2050 and to establish a 0.50% Sulphur Cap on marine fuel from 2020 are a great opportunity for the sector to search and adopt alternative fuels consistent with environmental and climate action goals.

At the moment, the interest in hydrogen solutions for maritime applications is growing at an accelerated pace. Several projects have demonstrated the feasibility of the technology for a large range of vessels, working in varied environments⁵⁷ and a number of other vessels utilizing either Hydrogen or fuel cells (or both) are planned to be build and placed into commercial operation in the near future.

The appeal of hydrogen as a fuel for the maritime sector is evident, as it produces no emissions (other than clean water) when used in a fuel cell and a very limited amount of nitrogen oxides when combusted in atmospheric air.

Despite the large potential of hydrogen to support the decarbonization goals of the maritime sector, regulatory challenges may delay or prevent its commercial deployment. Given its relative “novelty”, Hydrogen and fuel cell-specific requirements are lacking from regulations overseeing the maritime sector at all jurisdictional levels. A concerted effort at international (IMO) and national (Maritime Authorities and Inland Waterway regulatory bodies) is required to design rules which pave the way for the deployment of the technology beyond demonstration projects.

5.1. Overview of current legal framework

Design/Type approval – a regulatory gap and main barrier

HyLaw has assessed five legal-administrative procedures for hydrogen in ships. Design or type approval is the most substantial requirement, whereby it is certified that a type of vessel, system, component or separate technical unit satisfies the relevant administrative provisions and technical requirements.

At the International level, (i.e. under the scope of the International Maritime Organisation), the *International code for safety of ships using gases or other low-flash point fuels (IGF Code)*⁵⁸ contains mandatory provisions for arrangement; installation; control and monitoring; equipment and systems using low flashpoint fuels.

As Hydrogen has a flashpoint below 60°C, the IGF code generally applies. Nevertheless, Hydrogen as a fuel and Fuel Cells are not specifically addressed in the IGF code (natural gas as fuel is specifically covered). Presently, the use of hydrogen as a fuel and hydrogen fuel cells is not explicitly covered by IMO rules. The regulatory gap applies to both propulsion (main or auxiliary) as well as the use of HFC for heating, cooling and other power generation purposes. Continued work has been agreed under the IGF Code working group. This includes agreeing on the definition of the fuel cell system (n.b. natural gas fuel cells), however this does not include hydrogen powered fuel cells, which are not currently not on the agenda of the IMO.

In the absence of specific provisions, according to the IGF code, the use of other low flashpoint fuels including hydrogen can be **approved based on alternative design**⁵⁹, however, the current procedure for design and type approval of hydrogen and hydrogen fuel cell vessels (i.e. the alternative design) is not the solution to mass deployment. The procedure for approval of **alternative design is lengthy, costly, unpredictable and subject to individual (subjective) interpretation.**

It is estimated that the procedure takes at least one extra year, as compared to gaining final approval for conventional ships. On top of this, there is the need for technology qualification and development of standards. The EMSA Study on the use of Fuel Cells in Shipping notes, in particular, the need to address uncertainty regarding possible failure modes; to

⁵⁶<http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx>

⁵⁷ FellowSHIP and Viking Lady in Norway, Maranda in Finland, the Energy Observer starting in France and travelling the entire globe, the Hydroville in Belgium.

⁵⁸ Resolution MSC.391(95) (adopted on 11 June 2015)

⁵⁹ IGF code chapter 2; 2.3.2 “*Fuels, appliances and arrangements of low-flashpoint fuel systems may either: .1 deviate from those set out in this Code, or .2 be designed for use of a fuel not specifically addressed in this Code. Such fuels, appliances and arrangements can be used provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant chapters*”. The Alternative Design approach is defined in MSC.1/Circ.1455 – “*Guidelines for the approval of alternatives and equivalent*

test materials ductility for the low temperatures of liquid hydrogen; to decide on the possible allowed locations of pressure tanks; and to qualify pressure tanks for maritime use.⁶⁰

While some National Maritime Authorities (e.g. the Norwegian Maritime Authority) are working on a list of minimum documentation requirements, as well as additional documentation requirements for different designs and classification societies have recently issued Class Rules for Fuel Cell Installation, entrepreneurs are left uncertain, as to what the time and cost implications will be as a result of the lack of explicit requirements embedded into the IGF Code.

Ship registration – additional documentation requirements anticipated

IMO numbers are mandatory for cargo vessels of at least 300 gross tons and passenger vessels of at least 100 gross tons. Individual registration in international or national ship registers is required also for smaller ships/boats. Beside IMO requirements, a declaration of safety from an approved classification society and a set of qualification requirements are commonly required. Presently, there are no specific requirements for hydrogen-powered ships. Additional documentation requirements may come in, following the anticipated minimum requirements for alternative design, but once the design has been approved, it is not foreseen that there will be any barrier associated with ship registration.

Operations and maintenance – special safety requirements could be a hindrance

When it comes to operations and maintenance, there are no special requirements for hydrogen-powered ships. The additional documentation requirements for alternative designs may be followed by specific operation and maintenance requirements, but due to lack of experience it is difficult to assess to what extent this will be a barrier and what the time and cost implications could be.

Approval of landing/bunkering facilities – need for guidelines

Onshore landing and bunkering installations for hydrogen fall under the same legislation as onshore landing and bunkering facilities for other inflammable gases. The challenges associated with developing a hydrogen refueling infrastructure in ports are similar to those already presented in sections 2 and 3 of this paper.

Onboard hydrogen transport – updating will be required

Generally, transportation of compressed or refrigerated hydrogen in bulk or as packed cargo, is regulated under the *International Maritime Dangerous Goods Code (IMDG Code)*. Here, the requirements for compressed and refrigerated liquid hydrogen are comparable to those for natural gas, and they have the same limitations as packed cargo. However, the *International Gas Carrier Code (IGC Code)* lacks specific requirements for hydrogen.

To address this regulatory gap, IMO adopted a set of interim recommendations for carriage of liquefied hydrogen in bulk (resolution MSC.420(97) under in November 2016. Their application is so far limited to a pilot project where Kawasaki Heavy Industries Ltd got Approval in Principle (AiP) from ClassNK. There is little available documentation of the experience from this project, and it is therefore difficult to assess the impact of the interim recommendations.

Under the IGF Code it is anticipated that initial restrictions regarding storage quantities and locations will be put in place for hydrogen (e.g. storage on top deck). Thus, this is another area where adjustment of legal frameworks is needed, in order to provide clear and predictable conditions for technology and market development.

5.2. Assessment

Deployment of hydrogen in ships is an important step towards a more sustainable transport and energy system. The use of hydrogen as a means for fueling ship propulsion and auxiliary power is needed to meet the ambitious emission reduction target for the maritime sector. It represents a major business opportunity for the maritime industry. Furthermore, increased use of hydrogen and fuel cells in ships will help build an international market of renewable and low-carbon hydrogen which can be produced in regions with high renewable potential such as areas in Northern and Southern Europe.

While some maritime authorities have taken important steps to facilitate development and application of hydrogen solution, significant regulatory barriers remain. Most critical of these is the lack of regulation for design/type approval for hydrogen and fuel cells in ships, which has severe time and cost implications.

Barriers associated with landing and bunkering installations for hydrogen also stand in the way of accelerated deployment and take-up of the technology. For maritime hydrogen solutions to take off, landing and bunkering infrastructure must be put in place.

⁶⁰ DNV GL (2017): European Maritime Safety Agency (EMSA) study on the use of fuel cells in shipping.

For the onboard transport needed to develop a global hydrogen market, interim requirements for liquefied hydrogen have been developed. However, there are remaining regulatory gaps, both under the IGC and the IGF Code.

5.3. Recommendations

- The IMO, National Maritime Authorities, classification societies and other stakeholders within the maritime industry should strengthen international collaboration. They should support the work and quicken the pace of IMO's agenda to develop rules applicable to hydrogen solutions or type approval under the IGF Code.
- Pre-normative research should be encouraged and publicly supported in order to speed up the development of clear regulations in the area.
- At national level, relevant permitting and port authorities should come together to develop clear rules and guidelines that support a rapid development of landing and bunkering installations. The permitting and authorization of such installations should be clear, simple and concluded within a reasonable timeframe.
- On the medium and longer term, as hydrogen becomes a more important piece of the energy mix, the revision of applicable rules related to the transport of hydrogen on board vessels (liquid or gaseous) may become necessary. Such rules should be monitored in order to ensure they do not become a barrier to large scale transport of hydrogen in the future.

6. Gas Grid Issues and Sector Coupling

*“We underline the need for a safe, low carbon and sustainable transformation of the energy sector moving towards an **integrated energy approach**, in which synergies in the operation of electricity, gas and heat networks can be exploited.*

*Accordingly, we **emphasise the role of hydrogen as a promising link** between the electricity, industry and mobility sectors, opening new windows of opportunity in energy flexibility, availability, security, as well as improved efficiency and cost-effectiveness in the energy transition, contributing to the decarbonisation of the economy.*

*We aspire to investigate how to **integrate renewable hydrogen into the gas grids** gradually, which could substantially contribute to “greening” of the gas infrastructure and decarbonisation of the heating and cooling sectors as well as reducing natural gas imports. Additionally, we highlight that injected green hydrogen from electrolysis could improve the efficient use of variable and intermittent renewable energy”*

The words above belong to the Energy Ministers of 26 EU Member States, Iceland and Switzerland who, gathered in Linz, Austria, on the 17th and 18th of September 2018, to sign the “Hydrogen Initiative”⁶¹ and commit to collectively aim to maximise the great potentials of sustainable hydrogen technology for the decarbonisation of multiple sectors.

This powerful political declaration is a recent step (out of many) which stands as further proof that utilizing hydrogen derived from renewable energy sources and blended into natural gas grid networks is increasingly recognized as a means of meeting energy sector decarbonization targets (CO₂ reduction of natural gas-based heating and power), for energy storage, for enhancing the transport and storage capacities of the existing gas network infrastructure, and for indirect electricity transport. Flexibility and adaptability across both e-grids and gas grids across Europe is also acknowledged as vital to allow for future strategic fuel switching and the avoidance of lock-in, ‘stranded asset’ costs for grid infrastructure.

The integration of the power and gas infrastructure requires sector coupling with hydrogen as a coupling agent. Power-to-gas (PtG), in the context of sector coupling, means the conversion, by water electrolysis, of electrical power into a gaseous energy carrier such as hydrogen or synthetic methane, followed by the injection of the hydrogen or the synthetic methane into the gas grid.

Going beyond sector coupling, sectoral integration, i.e. the integration of the power, gas, transport, industries as well as the heating and cooling sectors requires the use of energy carriers such as hydrogen that may be used as an energy vector, a fuel and/or a feedstock. In this context, Power-to-hydrogen (PtH), means the production of hydrogen from electrical power, that may be used as an energy vector, a fuel and/or a feedstock.

The PtG process most typically involves the local gas Distribution Service Operator (DSO) for blending and delivering hydrogen rich natural gas across local network connections and customers, but may also involve use of the national high pressure, long distance, gas grid network managed by a Transmission Service Operator (TSO) and which may have a network interface with international gas grid connections.

In order for PtG to take place, a legal framework covering (among other things):

- (i) gas grid network access;
- (ii) a framework for permission to connect to the gas grid and inject/blend hydrogen into the grid
- (iii) a financial / payments and billing regime for receipt, transport and supply of hydrogen or hydrogen rich natural gas meeting quality requirements to customers.
- (iv) safety regimes for temporary hydrogen storage facilities, and the connection, blending and injection of hydrogen to the gas grid – along with safety regimes for domestic, commercial and other end-user equipment connected to the gas grid.

This paper looks at the current legal framework at EU level in order to identify legal barriers standing in the way of PtG, injection of Hydrogen into the gas grid and (more broadly), sector coupling.

6.1. Overview of current legal framework

European gas grids have been liberalized and opened to market competition over the past 20+ years via Directive 2009/73/EC and three subsequent Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) giving access to gas (and electricity) markets and clear operational and pricing procedures for grid access and operation, but have been based on storage, transmission, distribution and customer-based supply of natural gas. There is no specific legal coverage that allows for, or regulates, hydrogen injection into the gas grid at either a Distribution level or Transmission level across the EU.

⁶¹ <https://www.eu2018.at/latest-news/news/09-18-Informal-meeting-of-energy-ministers.html>

At EU level, the primary legal instruments setting the legal framework and applying (indirectly and/or directly) to hydrogen and PtG activities (covering financial / payments and billing regime; safety regimes for temporary hydrogen storage; for connection, blending and injection of hydrogen to the gas grid; and safety regimes for domestic, commercial and other end-user equipment connected to / supplied by the gas grid) are as follows:

- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009. This establishes an Agency for the Cooperation of Energy Regulators to assist in various regulatory tasks. Article 8 specifically sets the Agency's "Tasks as regards terms and conditions for access to and operational security of cross border infrastructure" thus making it a relevant stakeholder in the regulatory landscape of hydrogen gas transmission and distribution.
- Regulation (EU) 2015/703 of 30 April 2015 establishing a network code on interoperability and data exchange rules. This aligns the complex technical procedures used by network operators within the EU, and network operators in the Energy Community and other countries neighbouring the EU. This Regulation may also apply at entry points from and exit points to third countries, subject to the decision of the national authorities.
- Commission Regulation (EU) 2017/460 of 16 March 2017 establishing a network code on harmonized transmission tariff structures. The network code enhances tariff transparency and tariff coherency by harmonizing basic principles and definitions used in tariff calculation, and via a mandatory comparison of national tariff-setting methodologies against a benchmark methodology. It also stipulates publication requirements for information on tariffs and revenues of transmission system operators.
- ATEX Directive 2014/34/EU - covering equipment and protective systems intended for use in potentially explosive atmospheres. It defines the essential health and safety requirements and conformity assessment procedures (Article 4) to be applied before products are placed on the EU market and is significant for the engineering of hydrogen production plants. It covers inter alia equipment and protective systems intended for use in potentially explosive atmospheres, such as temporary storage of hydrogen and plant for injection of hydrogen into the grid. The Directive requires employers to classify areas where hazardous explosive atmospheres may occur into zones, related to the likelihood of an explosive atmosphere occurring. It also requires manufacturers to design their equipment to be suitable for use within their customer's explosive atmosphere. Equipment manufacturers thereby rely upon users to provide information about the classification of the zone and the flammable substance(s) within that zone.
- Regulation (EU) 2016/426 of the European Parliament and of the Council of 9 March 2016. This Regulation applies to all appliances burning gaseous fuels used in any domestic, commercial or industrial premises e.g. for cooking, refrigeration, air-conditioning, space heating, hot water production, lighting; and for controlling devices or regulating devices and sub-assemblies thereof, designed to be incorporated into an appliance or to be assembled to constitute an appliance (fittings). All relevant appliances and fittings are obliged to meet technical conformity in design and production (for 10 years); and manufacturers are obliged to monitor and sample test appliances and recall non-conforming appliances and fittings; and to provide instructions for incorporation or assembly, adjustment, operation and maintenance relevant appliances and fittings.

Finally, although not in the same category as the above acts, Directive (EU) 2018/2001 of The European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (RED II) is also relevant, as it establishes a common framework for the promotion of energy from renewable sources. It sets mandatory targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport. It lays down rules relating to statistical transfers between Member States, joint projects between Member States and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources.

At National level, regulations manage network safety and operational procedures for gas grids. Currently, there are differing national limits legally mandated for permissible hydrogen concentration levels within gas flows and differing national approaches to permission to inject hydrogen and payment arrangements for injected hydrogen.

In particular:

- There is considerable variance in rules and procedures where hydrogen injection is allowed (whether to blend down to a legal hydrogen concentration limit or to a safety dictated level) with the consequence that permitting of hydrogen injection is considered on a case by case basis and PtG plant installations are typically operated 'by exception' on a time limited, demonstration basis only;
- All current transport, supply and pricing/billing of natural gas is based on the calorific value of the gas, measured in kWh, as the determinant of the amount of energy involved. The calorific value is measured continually across natural gas networks (at up to 100+ locations for a national network) and the determination of

the calorific value is made in accordance with international standard ISO 6976. The Wobbe Index of natural gas is also calculated under ISO 6976 and this is a critical property in relation to the safe operation of gas burning appliances⁶².

- Acceptable safety threshold levels for hydrogen rich gas blends, for injection and distribution purposes and as limit for safe operation of gas fired appliances, have not been set on a Europe-wide basis. 100% hydrogen is under consideration for some regional networks. A threshold of up to 20% vol.⁶³ hydrogen was considered as potentially acceptable for the UK and the review of gas grid hydrogen composition is underway in Belgium, Bulgaria, Germany, Latvia, and the UK.

6.2. Assessment

The (natural) gas sector legal framework itself is comprehensive. However, the framework has been drawn up around facilitation of natural gas based operational procedures and market related activities for transmission, distribution and supply of natural gas on a utility basis. The regulatory framework does not carry over well or appropriately covers network access for hydrogen injection.

This has caused barriers in four main areas:

- First, the process chain for PtG is complex and there is no clear and unequivocal legal position for PtG. Gas grid network safety and operational procedures are managed at the national level leading to differing approaches to recognition of PtG plants and hydrogen injection at legally acceptable levels. ‘Acceptable’ procedures for hydrogen injection/blending diverge considerably across MS and networks.
- Second, legally mandated national limits apply for hydrogen concentration in the gas grid. These vary from a ‘minimal’ level (reflecting the typical background concentration of hydrogen in natural gas) at 0.1% vol – 0.5% vol.; a ‘low’ level of 1% vol to 4% vol; and a mid to high concentration of 6% vol to 10% vol. Where maximum hydrogen concentrations are not legally mandated, the hydrogen concentration limits are based on accepted (national) safety norms for natural gas and which would limit hydrogen to (considerably) less than 10% vol.
- Third, payment and billing arrangements for natural gas are based on the calorific value of the gas (measured by agreed procedures in kWh). The application of this methodology is not consistent for PtG based hydrogen rich gas flows.
- Fourth, a change to natural gas composition with higher hydrogen concentrations would result in a differing fuel calorific value which impacts the flame and heat characteristics for gas burning appliances – possibly leading to the need for modification or replacement of end-user equipment on an operational safety basis. Uncertainty related to the potential impacts of this aspect represents a major barrier to large scale uptake of PtG.

These four areas collectively represent a substantive barrier to PtG activities and will need to be addressed at a national and Europe wide level via the recommendations set out below.

6.3. Recommendations

- From a broad policy perspective to ensure comparable treatment and a ‘level playing field across the EU, the framework for permitting PtG plant and grid connection / injection requirements between the hydrogen supplier and the gas grid operators should be included within relevant EU regulatory frameworks.
- A common approach to managing gas safety and compliance requirements for grid connection and operation is essential. A coordinated EU wide review is needed to establish a consistent basis for all relevant hydrogen safety and compliance matters (generation sites, blending, connection and injection and related equipment and operations) for hydrogen blends and potentially pure hydrogen flows in the gas grid. Specifically, setting an acceptable upper

⁶² The injection of hydrogen into the gas grid will change the calorific value of the gas flow. Accurate measurement of hydrogen rich natural gas blends is required for billing and payment, to ensure that a hydrogen mix is safe for transport and distribution in pipeline safety terms, and to ensure that concentrations would not unduly impact the safe operation of gas fired appliances

⁶³ UK Health & Safety Executive – Health & Safety Laboratory, 2015: ‘*Injecting hydrogen into the gas network – a literature search.*’ The report concludes that “concentrations of hydrogen in methane of up to 20% by volume are unlikely to increase risk from within the gas network for from gas appliances to consumers or members of the public”.

threshold on hydrogen concentrations is needed to allow for network planning as there is no body of evidence to work with. This would necessarily involve EU nominated safety bodies, together with JRC, Agency for the Cooperation of Energy Regulators (ACER), and both hydrogen and natural gas industry entities.

- There are no pricing principles in place across otherwise regulated EU gas networks for cost allocation and tariff arrangements to support the renewable aspects (via wind and solar energy and electrolysis) of PtG systems. These would need to include incentives for renewable hydrogen and offset costs feed in and connection to the gas grid. A Guarantee of Origin framework and / or tracing scheme is critical.
- Concerns around the safety and operational threshold of end-user gas burner appliances (domestic, commercial, industrial) requires coordination with national initiatives to validate gas grid operation with significantly higher hydrogen thresholds (DE, FR, NL & UK). A supply chain assessment of economic impacts, if modifications are needed, would be key to this. Gas Appliance Regulation revisions to allow (a transition to) higher hydrogen concentrations may therefore need to be implemented.



