CHAPTER 5

The Hydrogen Revolution and Natural Gas: A New Dawn in the European Union?

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5.1 Introduction

Hydrogen is a key enabler of the energy transition in the gas sector and attempts to introduce it on a large scale in that sector and beyond are particularly prominent in the European Union (EU). Hydrogen can be produced from fossil sources, like natural gas, as well as from renewable sources (so-called green hydrogen). The technicalities for doing so will be discussed further in this chapter. Green hydrogen, in particular, is slated to be a fundamental part of the energy transition. But what exactly is green hydrogen from a legal standpoint, and how is its categorization reflected in current policy strategies and legal frameworks?

This chapter takes an in-depth look at hydrogen policy and law at the EU level. It assesses the EU hydrogen strategy that has been currently released and then benchmarks those ambitions against the realities of the current EU energy law framework. The chapter describes the EU hydrogen strategy as the underlying policy road map for hydrogen development and the ultimate implementation into law. It is interesting to look at hydrogen in the EU, because this particular part of the world, Europe, has some of the most ambitious plans for hydrogen globally, in addition to experience with renewable energy, electricity

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and gas infrastructure. This and the technical know-how that exists there could be fertile ground for a massive transition to a “hydrogen economy.” Moreover, the legislative discretion of big EU member states is curtailed, to some extent, by EU law. Accordingly, any meaningful discussion about the implementation of hydrogen plans into concrete laws and implementation at the member state level requires examining both the EU legal framework and its underlying policy road maps.

This chapter aims to assess the essential sectors of the European economy that will be transitioning to an increasingly hydrogen-fuelled scenario according to the European Commission. This pertains to sectors as diverse as energy, industry, transport, energy infrastructure and construction. It starts with a discussion of the different types of hydrogen in use, including green hydrogen, and provides the technical background on their production. This is followed by an examination of current policy plans for hydrogen in Europe in Sect. 5.2. Given the fact that the EU hydrogen strategy was only released quite recently, Sect. 5.3 examines that strategy (political ambitions) and goes on to explain the existing legal framework for hydrogen in the most relevant sectors, as identified by European policy makers. Section 5.4 discusses the underlying structural changes concerning the interplay of EU policy and EU energy law that will be required for the further implementation of hydrogen solutions in member states, and Sect. 5.5 presents the conclusions.

## 5.2 The Production of Hydrogen

There are several ways to produce hydrogen and even more ways to use it. Many countries have long distinguished between “grey,” “blue” and “green” hydrogen. According to the International Energy Agency (IEA), a total of 76 per cent of the world’s hydrogen in 2019 was produced from gas and 22 per cent from coal. Fossil fuels, especially natural gas, thus account for virtually all the hydrogen produced today. The resulting product is called “grey” hydrogen. Another, as of yet neglected, method for producing hydrogen from fossil fuels actually utilizes the CO₂ that is emitted and captured when burning gas or coal. This is called “blue” hydrogen. Meanwhile, a mere 2 per cent of hydrogen is derived from renewable sources through electrolysis or from biomass. In the production of this so-called green hydrogen, renewable energy is converted to hydrogen using electrolysis, which can then either be stored and later re-converted to electricity or used as hydrogen in numerous applications. Electrolysis involves using electricity to decompose water (H₂O) into its

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1 Vedder et al. (2016), para. 4.08–4.18.
2 Treaty on the Functioning of the European Union (hereinafter: TFEU), art. 194.
4 Ball and Wietzschel (2009), p. 279; International Energy Agency (2007), Table 1.
5 International Energy Agency (2019), p. 38; because electrolysis is the focus of the hydrogen strategies discussed below, the following explanations will focus on it.
elementary components, hydrogen (H\(_2\)) and oxygen (O\(_2\)), in an electrolyzer. The oxygen (O\(_2\)) can be released into the atmosphere or used in industrial production processes. The gaseous hydrogen (H\(_2\)) can be used for various applications since it can be stored and/or transported as pure hydrogen or admixed in limited volumes to natural gas flows. Such hydrogen produced from renewable energy sources (RESs) is referred to as “green hydrogen.”

Despite its quantitative insignificance, green hydrogen is the focus of the hydrogen strategy discussed in this chapter because it is slated to become “the next big thing,” for reasons that will be discussed below.

As opposed to this well-established differentiation in types of hydrogen by colour, the European Commission has increasingly been using different terminology to differentiate between “clean” and “not clean” hydrogen. The EU hydrogen strategy that will be discussed below, for example, distinguishes between “renewable hydrogen” (effectively, green hydrogen) and “low-carbon hydrogen” (effectively, blue hydrogen), but it also features the term “clean” hydrogen. Confusingly, the strategy defines clean hydrogen as “renewable hydrogen,” but why, then, would an additional term be needed at all? The answer to this lies in a new spin that the European Commission has been trying to give the debate on hydrogen for some time now. While the differentiation between green, grey and blue hydrogen is well established in the member states, the Commission is increasingly trying to frame the debate in a different way by referring to clean versus non-clean hydrogen in its communications with the outside world.

A final further word on terminology is needed. As power-to-gas technology, which creates links between the electricity and gas sectors, has grown, terms such as “sector integration” or “sector coupling” have been increasingly used. Electricity cannot currently be stored for any length of time and needs to be converted to another energy carrier, for instance, gas, to be stored as energy. In our case, electricity is stored in the form of gas, namely hydrogen, and as explained above, later re-converted into electricity. A key element in this is thus the interplay between the electricity and gas sectors, which have to be aligned for a smooth transition process; this is referred to as “sector coupling.” However, given the fact that hydrogen as a gas derived from electricity may also be used directly after the first conversion, for instance, for the decarbonization of end uses such as mobility or heat, “sector coupling” is also a key element of the hydrogen debate.

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8 Dein (2019).
9 European Commission (2020), Communication from the Commission, A hydrogen strategy for a climate-neutral Europe, COM (2020) 301 final; see, for example, pages 2 and following (hereinafter: EU Strategy).
5.3 THE EU

5.3.1 Political Ambition

The EU is committed to ambitious international climate targets, and these have been translated into several policy plans, which will be discussed briefly in this section. EU member states are required to meet legally binding targets by 2020, 2030 and 2050, the overall aim being to progressively reduce the emission of greenhouse gases (GHG), increase the use of renewable energy (RES) and increase energy efficiency. For 2020, under the so-called 20-20-20 targets, the EU needed to reduce its GHG emissions by 20 per cent compared to 1990 levels, achieve an overall share of renewable energy in its energy system of 20 per cent and increase energy efficiency by 20 per cent. For 2030, the climate and energy framework’s original goals were at least a 40 per cent reduction in GHG emissions compared to 1990 levels, an increase in the share of renewable energy to at least 32 per cent and an increase of at least 32.5 per cent in energy efficiency. The 2030 targets for GHG-emissions reductions have recently been amplified after a lengthy debate. The European Council decided in December 2020 to increase the goal to a 55 per cent reduction in GHG emissions by 2030. The long-term strategic vision of the EU is to achieve climate neutrality, defined as no net GHG emissions, by 2050.

5.3.1.1 Hydrogen Policy and Hydrogen Strategy

Hydrogen is viewed by the European Commission as being a key energy carrier for achieving its ambitions. On 8 July 2020, the European Commission released its communication for its EU hydrogen strategy, which is part of the

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15 For example, the United Nations Framework Convention on Climate Change of 1992, which was transposed into clear targets in the Kyoto Protocol of 1997 (COP 3) and more recently the Paris Agreement of 2015 (COP 22).

16 Vedder et al. (2016), para. 4.10.


18 Further specifics include a 43 per cent reduction in GHG emissions in sectors covered by the EU Emission Trading Scheme (EU ETS) and a 50 per cent cut in non-EU ETS sectors.

19 European Council (2020) European Council meeting (10 and 11 December 2020)—Conclusions, EU CO 22/20 COEUR 17 CONCIL 8, p. 4.


22 EU Strategy.
“European Green Deal.” The hydrogen strategy is coupled with an EU strategy on systems integration, which means linking the various energy carriers—electricity, heat, gas and solid and liquid fuels—with each other and with the end-use sectors, such as industry, transport and energy infrastructure, as well as buildings. The use of hydrogen, in particular, green hydrogen, represents an example of the type of integration aspired to, in this case, between the electricity and gas sectors. It may also impact the end users, since hydrogen could potentially replace natural gas and other fossil fuels in the construction sector, replace petroleum in the transport sector and be used in heavy industry to “green” cement and steel production.

5.3.1.1.1 The Industrial Sector
With a view to the industrial sector, the ambition for hydrogen in the new EU hydrogen strategy is to use it to replace fossil fuels in some of the more carbon-intensive industrial processes, such as steel or chemical plants, to lower GHG emissions and further strengthen the global competitiveness of those industries. The EU’s plan is to place electrolyzers close to big demand centres such as large refineries, steel plants and chemical complexes. These would then ideally be powered directly from local renewable electricity sources. The word “ideally” in that sentence already indicates that the Commission itself is aware that it might be painting a rather rosy picture here. If we take refineries as an example, evidence shows that green hydrogen is not initially able to completely replace grey hydrogen in the refining process. This is due partly to technicalities, but also to the fact that intermittent local renewable electricity sources would require buffering in the form of storage capacity on-site, since refineries require a constant stream of hydrogen.

5.3.1.1.2 The Transport Sector
With a view to the transport sector, green hydrogen can offer solutions for hard-to-abate parts of the transport system. If green hydrogen were to be used as a fuel in vehicles that are currently running on petroleum, GHG emissions could be reduced. However, given the current competition in the alternative vehicles market between electricity and hydrogen, the EU hydrogen strategy foresees the use of green hydrogen as a fuel primarily in the context of heavy-duty vehicles, such as trucks, buses, ships, planes and trains. These vehicles are difficult to run on electricity because of their weight and power,
whereas passenger vehicles can easily be adapted to using electricity as a fuel. This affects the fuelling infrastructure. Hydrogen refuelling stations will be needed for the uptake of hydrogen fuel-cell buses and, at a later stage, trucks. Electrolyzers will thus also be needed to locally supply an increasing number of hydrogen refuelling stations. The EU hydrogen strategy recognizes the need to establish a network of hydrogen refuelling stations. In terms of costs, it provides that establishing as many as 400 small-scale hydrogen refuelling stations (compared to 100 today) could require investments of €850–1000 million.

5.3.1.1.3 Energy Infrastructure and Buildings
With a view to energy infrastructure and buildings, the main issue is the supply of hydrogen to the end consumer. Given its focus on the entire EU, the EU hydrogen strategy mainly addresses larger pipeline infrastructure at the transmission level. One idea under the strategy is to repurpose existing natural gas pipelines and convert them to hydrogen use, either as dedicated hydrogen pipelines or by creating a mingled stream. This could facilitate the supply of hydrogen to a multitude of end customers and purposes, such as refuelling stations, but also the housing sector. The transmission pipelines are owned by the network operators, but the Commission wants to influence the repurposing process by means of the European Network of Transmission System Operators for Gas (ENTSOG) and its Ten-Year Network Development Plans (TYNDPs). ENTSOG comprises 45 transmission system operators and 2 associated partners from 26 European countries and 9 observers. It is charged with some important European-wide planning and operation roles, most notably publishing EU-wide, ten-year development plans. However, the existing natural gas pipelines are owned by network operators that are often not allowed to own, operate and finance hydrogen pipelines.

5.3.1.1.4 Investments and Support Schemes
The explicit focus of the strategy is on green hydrogen, which also becomes clear from the numbers, as the EU Commission estimates that cumulative investments in that area in Europe could be up to €180–470 billion by 2050, whereas investments in low-carbon, fossil-based hydrogen, so-called blue hydrogen, are estimated to be in the range of €3–18 billion. The EC communication sets out a trajectory of aims. By 2024, at least 6 gigawatts of

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30 EU Strategy, p. 5.
31 EU Strategy, p. 7.
32 EU Strategy, p. 8.
33 EU Strategy, pp. 2–3.
34 EU Strategy, p. 15.
36 Vedder et al. (2016), para. 4.45.
37 EU Strategy, p. 15.
38 EU Strategy, p. 5.
39 EU Strategy.
renewable hydrogen electrolyzers are to be installed in the EU and up to one million tons of renewable hydrogen produced. By 2030, at least 40 GW of renewable hydrogen electrolyzers are to be installed and up to ten million tons of renewable hydrogen produced in the EU. By 2050, the hydrogen market should reach “maturity,” but no clear aims in terms of installed capacity are provided.

The above numbers show that, on the one hand, huge investments are required; yet on the other hand, green hydrogen is not price competitive at the moment. It is, thus, important to provide promotional tools for green hydrogen in the intended markets (industry, transport, etc.). Unfortunately, the EU hydrogen strategy is not very bold when it comes to discussing the promotion of hydrogen in the market. One solution that has been suggested and will be looked into is to institute quotas for renewable hydrogen or its derivatives in specific end-use sectors, for instance, such industries as the chemical sector, or in transport applications. Other support mechanisms might be considered. The EU has proposed one support scheme in particular. They suggest creating tendering systems for carbon contracts for difference (CCfD). This would be a long-term contract with a public counterpart to remunerate the investor. In essence, a fixed price for CO₂ would be established between the private company and the state (the so-called CO₂ strike price). Should the actual CO₂ price in the emissions trading scheme (ETS) drop below the strike price, the state would pay the difference between the production price and the market price to the investor. However, it is important to emphasize that the EU’s hydrogen strategy does not include implementing such a scheme; it merely contemplates it as one possible solution, without making any fixed commitments. The same applies to direct and transparent, market-based support schemes for green hydrogen. It is left to the member states to implement these, and should they do so, then they must comply with EU State Aid rules.

5.3.1.2 European Clean Hydrogen Alliance

Overall, it has to be assessed that the EU left the concrete realization of this ambitious agenda to a new private-public partnership called the European Clean Hydrogen Alliance, in which public authorities, industry and civil society will collaborate. This Alliance (not the EU institutions) will develop an investment agenda and create an inventory of projects.

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40 EU Strategy.
41 EU Strategy, p. 6.
42 EU Strategy, p. 7.
43 EU Strategy, p. 4.
46 EU Strategy, pp. 8–9.
47 EU Strategy, p. 3.
5.3.2 EU Legal Framework

5.3.2.1 EU Primary Law
When discussing the EU-wide and cross-border applications of green hydrogen, it is important to briefly recall the fundamentals of EU law when it comes to cross-border energy activities and trade. The EU aims to create an internal market for energy that encompasses the free movement of goods, services, people and capital. While all these might become relevant for our purposes in some more distant future, EU-wide and cross-border trade in hydrogen is currently very limited in many parts of the Union or even nonexistent. Thus, this chapter focuses on the most imminent and direct freedom of relevance for instigating such a market, the free movement of goods, as defined in Articles 34–36 of the Treaty on the functioning of the European Union (TFEU). Articles 34 and 35 of the TFEU are designed to guarantee the free movement of goods by prohibiting member states from placing quantitative restrictions on imports or exports of goods or instituting any other measures that would have an equivalent effect.

In terms of hydrogen, and green hydrogen in particular, it is thus important to briefly discuss whether it constitutes a “good” and thus falls into the realm of this fundamental freedom. The Court of Justice of the European Union has a long and rich history of defining energy and energy products as “goods.” This applies to natural gas and waste (if intended to be combusted for energy generation) as well as to intangible energy like electricity. The bottom line on what constitutes a good has been defined by the Court in the following terms: “goods” are “products which can be valued in money and which are capable, as such, of forming the subject of commercial transaction.” Following this general definition, green hydrogen can be valued in monetary terms and can form the subject of commercial transactions. Thus, it is a good and protected by the fundamental freedom of free movement of goods.

5.3.2.2 EU Secondary Law
A number of years ago, the EU adopted the “Clean Energy for All Europeans” package. It comprises a number of legislative instruments, and we will briefly discuss those with the greatest relevance for hydrogen and its foreseeable future.

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48 Vedder et al. (2016), para. 4.55.
51 Case 6/64 Flaminio Costa v ENEL (1964) ECR 585; Joined Cases C-204/12 to C-208/12 Essent Belgium ECLI:EU:C:2014:2192 para. 83–87.
52 Case 7-68 Commission v Italy (1968) ECLI:EU:C:1968:51 p. 428.
applications in the EU hydrogen strategy below. These are the Recast Electricity Directive (hereinafter: Recast Electricity Directive), the recast Renewable Energy Directive (RED II), the Gas Directive and finally, with regard to transport use, the Fuel Quality Directive (FQD).

5.3.2.2.1 Electricity Directive

The first challenge is to identify EU legislation that actually takes hydrogen into account. Considering the explanations given above about the fact that green hydrogen could well be part of a system integration plan, both electricity and gas legislation could be of relevance. While the Electricity Directive will be discussed here, the Gas Directive will be discussed below in the context of transport. The old Electricity Directive from 2009 contained no mention of hydrogen. Given the EU’s system integration policies and the versatility of green hydrogen applications, it might have been understood that hydrogen was implicitly included in the context of “electricity storage,” as one of the options for storing electricity. However, the old Electricity Directive did not contain any mention of electricity storage either.

That changed with the introduction of the Recast Electricity Directive (EU) 2019/944 (hereinafter: Recast Electricity Directive), in which electricity storage features prominently under Article 2 (59). While hydrogen and/or power-to-gas are not explicitly mentioned, the formulation about the conversion of electrical energy into another, storable, form of energy suggests that hydrogen is covered. This only applies, however, to the storage of hydrogen, so the question arises whether conversion from electricity to hydrogen by means of electrolysis is also covered by the Electricity Directive. The short answer is no. If someone is using electrolysis for power-to-gas to produce...
hydrogen and wants to produce hydrogen without having any intention of storing electricity, this would most likely not be considered electricity storage.\footnote{Fleming (2021), p. 51.}

Importantly, all types of power-to-gas plants that produce hydrogen are covered. That includes green as well as grey and blue hydrogen, as long as it is produced from electrical energy. The Recast Electricity Directive thus clearly applies to any type of hydrogen, as long as it is being produced with the help of electricity.\footnote{More details can be found at Fleming and Kreeft (2020), pp. 107–109.} But what, then, are the specific provisions for green hydrogen in secondary EU law? One possibility for covering green hydrogen could be found in the recently revised Renewable Energy Directive (RED II).

5.3.2.2.2 Renewable Energy Directive (RED II)

While hydrogen is not explicitly mentioned as a “renewable energy” in its own right in Article 2 (1) of the RED II, green hydrogen is included indirectly in the scope of the RED II.\footnote{This reference includes only green and not grey hydrogen; see European Parliament (2019), p. 7.} This becomes clear from the second sentence of Article 7 (1) of the RED II about calculating the share of energy from renewable sources. It says “hydrogen from renewable sources shall be considered only once for the purposes of calculating the share of gross final consumption of energy from renewable sources.”\footnote{European Parliament (2019), p. 7.} The Article, thus, is based on the assumption that hydrogen from renewable sources can be considered a renewable energy.

As we have seen before, this does not necessarily have to be the case. If the green hydrogen is produced from biomass, it is considered a renewable energy. Or if an electrolyzer is placed next to a windfarm and uses its electricity exclusively for electrolysis, this is the case as well. While these examples illustrate the ways in which most pilot projects for green hydrogen currently work, challenges will arise in the future if large-scale implementation of green hydrogen in our energy systems becomes a growing reality. Then, the electricity might need to be transported over long distances to more remote electrolyzers via the transmission and/or distribution grids, where the electrons might mingle with those produced by coal-fired power plants or nuclear plants. In such a case, the electrons can no longer be differentiated into “greens” and “greys,” and we just have electricity flowing on a cable.

To cover such situations, hydrogen is now included in the Guarantees of Origin scheme. Recital 59 and Article 19(7)(b)(ii) of the RED II together establish that Guarantees of Origin shall now be issued for renewable gases, including green hydrogen. Guarantees of Origin are certificates that prove to a final customer that a given share of energy was produced from renewable sources.\footnote{RED II, above n 56, recital 59 and art 19 (1).} However, and that is the interesting bit, a Guarantee of Origin can be transferred from one holder to another independently of the energy to

\footnote{Fleming (2021), p. 51.}
\footnote{More details can be found at Fleming and Kreeft (2020), pp. 107–109.}
\footnote{This reference includes only green and not grey hydrogen; see European Parliament (2019), p. 7.}
\footnote{European Parliament (2019), p. 7.}
\footnote{RED II, above n 56, recital 59 and art 19 (1).}
which it relates—and regardless of the energy to which it refers. The Guarantees of Origin function like labels on a bottle. These labels, while originally indicating that this particular bottle has content X, might be removed from the original bottle and attached to a different bottle. The underlying rationale is that the Guarantees of Origin serve as evidence of “green supply,” proving that originally content X (in our case green hydrogen from renewable electricity) was produced. The label of the original product, however, may be attached to another, originally non-green bottle (in our case electricity). In other words, these Guarantees of Origin can be transferred to other forms of electricity. That way, any electricity can be bought for electrolysis as long as the buyer also simultaneously buys an equivalent amount of Certificates of Origin in the market. This system of Guarantees of Origin was in place for renewable electricity and will now be extended to renewable gases like hydrogen.

5.3.2.2.3 Gas Directive

Once hydrogen has been produced, it needs to be transported. Gas is usually transported through pipelines, either in a form mingled with other gases or in dedicated, standalone hydrogen pipelines. Ultimately, the gas will then arrive at the end user, where it is required for purposes in the industrial sector and the building sector, as well as possibly in large buildings, as discussed above. The transport of gas in the EU is covered by the Gas Directive. Given its chemical composition, hydrogen is a “gas” like other gases from a chemical standpoint. However, a somewhat awkward question emerges when looking at the EU Gas Directive—namely whether or not the same logic actually applies in the law. In other words, just because hydrogen is a gas from a chemical point of view does not necessarily mean it is a gas from a legal point of view. The starting point for this thinking is as follows.

Similarly to natural gas, hydrogen is a gaseous energy carrier that can be compressed, transported through pipelines and stored in salt caverns, aquifers, and depleted oil and gas fields. The 2009 Gas Directive features rules on production, storage and transportation, but these were designed explicitly for natural gas and not for hydrogen. Thus, the question as to whether or not these rules apply to hydrogen production, transportation and storage is fundamental.

According to Article 1 (2) of the 2009 Gas Directive, the directive also applies in a non-discriminatory way to biogas and gas from biomass or other types of gas insofar as such gases can technically and safely be injected into, and transported through, the natural gas system. The question is whether this is the case for hydrogen. The outcome will depend on the individual legal and

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67 Vedder et al. (2016), para. 4400.
68 For a technical analysis of underground hydrogen storage, see Netherlands Enterprise Agency (2017).
70 On this issue, see Gerboni (2016), pp. 283–299.
technical requirements in the country-specific gas systems, an issue that has been discussed in depth elsewhere. This issue is about to be taken up by the European Union. On 15 December 2021 the European Commission presented the ‘Hydrogen and Decarbonised Gas Markets’-package. As the name suggests, once in place, this package, featuring a revised Gas Directive as well as a revised Gas Regulation, will fundamentally change the legal appraisal of EU gas legislation for hydrogen. Details on the package can be found elsewhere (for instance in Ruven Fleming ‘Hydrogen Networks: Networks of the Future?’ in R Fleming, K de Graaf, L Hancher and E Woerdman ‘A Force of Energy - Essays in Energy Law in Honour of Professor Martha Roggenkamp (University of Groningen Press, forthcoming 2022 Open Access)). It is estimated that there will not be new legislation in force before 2023, considering the EU’s internal process that lies ahead for the resolution of the package in the Parliament and by the Council.

5.3.2.2.4 Fuel Quality Directive (FQD) and Calculation Methods Directive

Green hydrogen, while regularly being transported via pipelines, might however also be used in the transport sector as a fuel. As discussed above, the EU is planning for 400 small-scale hydrogen fuelling stations. As assessed in an earlier work, the use of green hydrogen for the transport sector seems to be limited to heavy-duty vehicles, trains and the like whereby the hydrogen would be used as a fuel source. If green hydrogen is used as a fuel, the Fuel Quality Directive (FQD) might be of relevance. According to Article 2 (1)–(3), the Directive specifically covers the quality of gasoline, diesel and gasoil fuels. Article 2(10) also covers “renewable liquid and gaseous transport fuels of non-biological origin,” which means liquid or gaseous fuels other than biofuels whose energy content comes from renewable energy sources other than biomass and which are used in transport. This could partly apply for green hydrogen as long as it is produced in an electrolyzer using electricity from renewable sources, but it would not apply for green hydrogen from biomass, since biomass is explicitly excluded from the scope via Article 2 (10) of the FQD.

According to Article 7a (1) of the FQD, the GHG intensity of a fuel must be monitored, reported and verified by the supplier of that fuel in each member state. The method for calculating and reporting the life-cycle GHG intensity of fuels is laid down in Annex I of an additional Directive, Council Directive (EU)

2015/652,\textsuperscript{76} the Calculation Methods Directive. That Annex I provides a baseline fuel standard for two types of green hydrogen. These are electrolysis fully powered by non-biological renewable energy with the aim of using compressed hydrogen in a fuel cell and a Sabatier reaction of hydrogen from non-biological renewable energy electrolysis with the aim of producing compressed synthetic methane for usage in a spark ignition engine.\textsuperscript{77} In the final step of the latter, synthetic natural gas (SNG) is created with the help of green hydrogen and carbon dioxide, so the green hydrogen becomes part of another fuel.\textsuperscript{78} The calculations thus derived provide the average life-cycle GHG intensity default values for green hydrogen used in or as a fuel, and they must be reported annually by the suppliers of those fuels to the authority designated by the member state.\textsuperscript{79} Numbers will depend on actual usage.

5.3.2.2.5 Revised Clean Vehicles Directive

The Clean Vehicle Directive was first put into place in 2009 and was revised ten years later. The result is the current Revised Clean Vehicles Directive.\textsuperscript{80} It concerns public procurement and is intended to promote use of low- and zero-emission vehicles by giving them priority over other vehicles whenever public institutions (government, authorities, etc.) engage in transport-related purchases, leases, rentals and relevant service contracts.\textsuperscript{81} It sets national targets for the public procurement processes of each member state and must be transposed into national law by 2 August 2021.\textsuperscript{82}

Article 4 (4) of the Revised Clean Vehicles Directive differentiates between clean light-duty vehicles, clean heavy-duty vehicles and zero-emission vehicles. It defines a clean light-duty vehicle as any car or van meeting the following emission thresholds: until 31 December 2025, no more than 50g/km CO\textsubscript{2} and up to 80 per cent of applicable real driving emission (RDE) limits for NOx and PN; from 1 January 2026, only zero-emission vehicles. Clean heavy-duty vehicles are defined as any truck or bus using one of the following alternative fuels: hydrogen, battery, electric (including plug-in hybrids), natural gas (both CNG and LNG, including biomethane), liquid biofuels, synthetic and


\textsuperscript{77}Calculation Methods Directive, above n 75, Annex I Part 2, para. 5.

\textsuperscript{78}More on synthetic natural gas can be found at the Deliverables of the Horizon 2020 project “Store & Go” at www.storeandgo.info. Accessed 27 January 2021.

\textsuperscript{79}Fuel Quality Directive, Article 7a (1).


\textsuperscript{81}Revised Clean Vehicles Directive, art. 3.

\textsuperscript{82}Revised Clean Vehicles Directive, art. 5 in conjunction with Annex Tables 3 and 4.
paraffinic fuels or LPG.\textsuperscript{83} The directive also sets a separate definition for “zero-emission heavy-duty vehicles” as a sub-category of clean heavy-duty vehicles.\textsuperscript{84}

As can be seen from the list, hydrogen is explicitly considered an acceptable fuel for heavy-duty vehicles, which is in line with the overall EU hydrogen strategy. However, hydrogen may also be used as a fuel for light-duty vehicles, since it does not produce end-of-the-exhaust emissions. Given the costs involved, though, it is unlikely, from a practical standpoint, that hydrogen will play a major role in this latter vehicle category. Still, it could be relevant for heavy-duty vehicles. This mainly depends on the national implementation.

5.4 RECOMMENDATIONS

Key to the future is the interlinkage between the hydrogen policy goals, as discussed in Sect. 5.3.1, and the legal framework, as discussed in Sect. 5.3.2. In other words, interlinked policies and laws are required for a successful uptake of hydrogen in Europe. This section provides recommendations for improving the situation and facilitating the translation of policy ambitions into the applicable European legal framework. The recommendations focus on two areas in particular that are critical for large-scale uptake of hydrogen and have been addressed earlier in this chapter. The first is industry and energy infrastructure and the second is the transport sector.

5.4.1 Industry and Energy Infrastructure

Hydrogen needs to be transported to all consumers, in smaller amounts for smaller consumers and larger amounts for bigger consumers, such as industry. Gas pipelines and the energy infrastructure are key elements here, even if some electrolyzers could be placed next to large facilities, as overall demand will quickly overtake supply. Thus, what is still needed in the “new” energy world is a reliable network of gas pipelines spanning Europe from one country to another, from production to consumption centres.

From a technical point of view, it is possible to admix hydrogen into the existing natural gas pipeline system and create a mingled stream.\textsuperscript{85} Problematic in that respect, however, is the fact that each EU member state allows a different amount of hydrogen admixture. The maximum level of hydrogen allowed in the natural gas stream in the Netherlands, for instance, is set at 0.02 per cent mol, while in Germany, it is 10 per cent mol.\textsuperscript{86} National gas quality standards have been of a heterogeneous nature because the parameters defined therein

\textsuperscript{83} European Council (2009) Council Directive 2009/33/EC of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles, OJL 120/5, Annex Table 1 in conjunction with preamble 28.

\textsuperscript{84} Revised Clean Vehicles Directive, Article 4 (5).

\textsuperscript{85} For details see Fleming and Kreeft (2020), pp. 118–119.

\textsuperscript{86} Dolci (2019), pp. 11394–11397.
were based on the chemical composition of locally produced or supplied natural gas. Since the 2009 Gas Directive does not lay out minimum or maximum values for the various chemical components present in natural gas, there was no regulatory pressure on member states to bring their gas quality specifications in conformity with a European norm.

In the past decade, there have been several attempts to remedy the situation and enable the interoperability of the gas systems. The European Commission issued two mandates to the European Committee for Standardization (CEN). The first, mandate M/400, was issued in 2007, and it requests the CEN to draw up a European standard that defines gas quality characteristics and parameters and their limits. However, since CEN standards are voluntary by nature, the Commission intended to elevate the status of the standards through a binding reference to them in the Network Code on interoperability and data exchange rules (INT NC). Notably, hydrogen was explicitly excluded from the scope of the work of CEN under mandate M/400 because, according to the European Commission, “current gas flows do not contain hydrogen and it is not an issue yet in the gas market, i.e. production, transport or appliance-use.” For this reason, the CEN standard EN 16726:2015 that was eventually adopted contains an annex of a mere informative nature covering the admissible concentration of hydrogen in natural gas systems.

A second mandate, M/475, presented CEN with the task of adopting a standard for the use of biomethane as a transport fuel and its injection into natural gas pipelines. Since the aim of the mandate is the promotion of biomass-based gases, the Commission refers inter alia to Article 16 of the 2009 Renewable Energy Directive as a legal foundation. Again, the determination of a common maximum hydrogen limit was considered to be premature. The CEN standard EN 16723-1 that was adopted only contains a reference to the earlier, purely informative, Annex E of EN 16726:2015. That annex, titled “Hydrogen—Admissible concentrations in natural gas systems,” refers to a study by the European Gas Research Group which found that admixing hydrogen into natural gas in volumes of up to 10 per cent is an option for certain sections of the natural gas system. When determining the specific percentage of hydrogen allowed for a certain region, member states are advised to take into account the effect of hydrogen on underground porous rock storage, steel tanks in CNG vehicles, gas turbines and gas engines.

However, there is no unified number for hydrogen admixture in the EU. This needs to be changed if the market uptake of hydrogen is to increase. If no transport of a mingled stream from one country to another is possible without the need for changing the stream, it could result in hydrogen-enriched

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88 European Committee for Standardization (2015).
89 Dubost (2018).
90 For the report to which Annex E refers, see Altfeld and Pinchbeck (2013), p. 3.
natural gas from one member state being rejected by a neighbouring state. This can become a crucial hindrance to cross-border activities, and the EU should act on this matter.

5.4.2 Transport

When it comes to hydrogen as a fuel for vehicles, we have seen that under Article 2 (10) of the FQD not all types of hydrogen are being recognized and accepted as fuel. In particular, green hydrogen from biomass is excluded. It seems likely that when this Directive was drafted, hydrogen from biomass was not an option that was available as a gaseous fuel in the vehicles sector and that this is the main reason why it was implicitly excluded. However, given that green hydrogen has the lowest environmental footprint of all types of hydrogen, it is incoherent to accept other coloured hydrogen as fuel but not green hydrogen from biomass. Article 2 (10) of the FQD should therefore be amended.

A further aspect that is relevant for the transport sector is that of “leading by example.” Due to the high cost of hydrogen-fuelled vehicles, public entities, in particular, could purchase them more readily than normal citizens. The Revised Clean Vehicles Directive is based on that idea. It makes sense from a technological standpoint, as explained above, to procure heavy-duty vehicles that run on hydrogen. However, while this Directive has recently been revised at the EU level in a more hydrogen-friendly manner, the next step is the transposition of the new Directive into national law. It is still early days, but it will be important to keep a close eye on the national implementation of the Directive to ensure that member states are not, maybe even without any bad intent, overlooking the possibilities that this Revised Clean Vehicles Directive offers for hydrogen. The devil lies in the details.

5.5 Conclusion

Overall, it might be assessed from this overview that the EU’s legal framework on hydrogen is patchy, based on minimum harmonization, and leaves many crucial points to the member states. In addition, hydrogen is a rather new topic for the EU, but its integration into the EU’s legal framework, albeit initiated, is far from being complete. This leaves member states with considerable freedom to devise their respective hydrogen frameworks, but it also runs the risk of causing such regimes and hydrogen strategies to differ widely from one another. This could become a particular issue in terms of the cross-border trade of hydrogen, which will become a real possibility in the foreseeable future.

The proper approach is a mix of top-down and bottom-up measures. First, as a top-down measure, the EU should elaborate and impose a unified, EU-wide number on admissible hydrogen admixture in gas grids. This must be supported, however, by a set of bottom-up approaches. Particularly in the area of transport and the use of hydrogen as a transport fuel, the member states need
to ensure proper implementation of the applicable new and revised EU Directives to make the most of the possibilities these have to offer and to remove remaining barriers for hydrogen. Only if these two approaches go hand in hand can the required large-scale changes to our gas infrastructure succeed.

REFERENCES


