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Clean or renewable – hydrogen and power-to-gas in EU energy law

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Interest in hydrogen as a carbon-neutral energy carrier is on the rise around the globe, including in Europe. In particular, power-to-gas as a technology to transform electricity to hydrogen is receiving ample attention. This article scrutinises current updates in the energy law framework of the EU to explain the legal pre-conditions for the various possible applications of power-to-gas technology. It highlights the influence of both electricity and gas legislation on conversion, storage and transmission of hydrogen and demonstrates why 'green' hydrogen might come with certain legal privileges under the Renewable Energy Directive attached to it, as opposed to the European Commission's so-called 'clean' hydrogen. The article concludes by advocating for legal system integration in EU energy law, namely merging the currently distinct EU electricity and gas law frameworks into one unified EU Energy Act.

Keywords: power-to-gas; hydrogen; 'green' hydrogen; hydrogen regulation; EU energy law; legal system integration

1. Introduction

What is renewable energy?[1] Energy that may be renewed within the lifespan of a generation, within the span of a human life, within two, three or four generations? Energy that does not harm the climate? Although political and philosophical debates wage on (nuclear being just one example), from a legal point of view the Renewable Energy Directive[2] and national laws concerning subsidies put an end to this debate. They feature a clear definition.[3]

1 The author would like to gratefully acknowledge that this article benefitted from prior work and research conducted by Gijs Kreeft, legal consultant in energy and environmental law at Royal HaskoningDHV.

2 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 renewble sources [2018] OJ L 328/82 (hereinafter RED).

3 RED, art 2.

However, there is a similar 'war' in the making at the moment about what ways of storing energy may be considered renewable. Power-to-gas and hydrogen are becoming prominent topics in debates on the design of future energy systems. The technology is gaining popularity amongst the energy industry and energy regulators alike, as highlighted by the increasing policy research in this field.[4] The reason for this popularity is the flexible and versatile way in which the technology could facilitate the ongoing energy transition.

Power-to-gas could be used for a number of purposes,[5] but one of the most promising is the storage of surplus electricity from renewable energy installations. In this way renewable energy could be stored and the time of use can be inferred. This would be helpful to counter the naturally intermittent production pattern of renewable energy installations, which do not produce (and thus do not feed electricity into the system) when the sun does not shine and the wind does not blow. In these situations the electricity has to be balanced, which at the moment means that coal and gas-fired power plants have to make up for temporary shortages in renewable energy generation. Storing electricity via power-to-gas could be a long-term option to counterbalance seasonal differences (e.g. strong winds in autumn, but not in summer). The current article will specifically focus on this promising potential of power-to-gas as a means to store electricity to counter this intermittence issue.

There are several ways to produce hydrogen and even more ways to use it. In many countries of the world, the differences between 'grey', 'blue' and 'green' hydrogen are well established. According to numbers of the International Energy Agency in 2019, a total of 76 per cent of world hydrogen was produced from gas and 22 per cent from coal. This means fossil fuels (for instance, by a process called steam reforming or partial oxidation, or by a combination of both) account for virtually all hydrogen produced in the world today.[6] The resulting product is called 'grey' hydrogen. This process generates greenhouse gases in significant quantities.[7] By contrast, only around 2 per cent of hydrogen is derived from renewable sources via electrolysis.[8] This hydrogen, produced from renewable energy sources, is referred to as 'green hydrogen'.[9] A further, as yet neglected, method is to produce hydrogen from fossil fuels, but to utilise or capture the resulting CO_2.[10] This is called 'blue' hydrogen.

4 Examples are the HyLAW project which identifies legal and regulatory barriers on hydrogen in the European Union www.hylaw.eu and Task 38 of the International Energy Agency 'Hydrogen Implementing Agreement', which includes an analysis of legal and regulatory conditions regarding Power-to-X http://ieahydrogen.org/Activities/Task-38.aspx.

5 Ruven Fleming, 'Regulating Power-to-Gas in the Energy Union' (2018) 16(4) OGEL 1.

6 International Energy Agency, 'The Future of Hydrogen' (2019) 38 www.iea.org/reports/the-future-of-hydrogen accessed 10 October 2019.

7 Joseph Romm, 'The Hype about Hydrogen: Fact and Fiction in the Race to Save the Climate' (2004) 3.

8 IEA Hydrogen (n 6), 38.

9 Michael Ball, 'Why Hydrogen?' in Michael Ball and Martin Wietschel (eds), *The Hydrogen Economy: Opportunities and Challenges* (Cambridge University Press 2009) 38–9.

10 Michael Ball, Werner Weindorf, and Ulrich Bünger, 'Hydrogen Production' in Michael Ball and Martin Wietschel (eds), *The Hydrogen Economy: Opportunities and Challenges* (Cambridge University Press 2009) 279; International Energy Agency, 'Energy Technology Essentials Hydrogen Production & Distribution' (2007) 4, table 1 www.iea.org/publications/freepublications/publication/essentials5.pdf accessed 10 October 2019.

Despite its insignificance in world production numbers, 'green' hydrogen is the focus of all hydrogen strategies that are discussed in this article. Notwithstanding its insignificance for current markets, 'green' hydrogen is being tipped to become 'the next big thing'.[11]

In Europe we witnessed a quite controversial debate on whether or not 'blue' hydrogen should be included in efforts to decarbonise modern societies. This will be discussed below.

When zooming in on 'green' hydrogen, we can see that it has two main sources: first, biomass-based production, and second, water-electrolysis based on electricity from renewable sources, also known under the term 'power-to-gas'.[12] According to Ball and colleagues, offshore wind via electrolysis/power-to-gas could play a very important role in hydrogen production after 2020 and become its main source.[13] This, however, will depend on technical advances as well as a clear legal framework for the technology.

This article focusses on the energy law framework at the EU level and how it applies to the storage of renewable energy via power-to-gas. It scrutinises the existing legal framework of the EU and outlines the current regulatory developments for power-to-gas as a storage option.

As a starting point, it is important to explain that the applicable energy law framework for power-to-gas at the EU level is currently in transition. The European Commission created a new legal framework for the European energy system, with the aim to take technical developments like power-to-gas better into account. By the end of 2016 the European Commission had launched a legislative package called 'Clean Energy for All Europeans'.[14] The package consists of a number of legislative instruments,[15] but at its heart are two recast directives, the recast Renewables Directive[16] and the recast Electricity Directive,[17] which are both relevant for the storage of electricity via hydrogen.

They are contrasted with the existing regulations of a third Directive, the Gas Directive,[18] the revision of which is not part of the Clean Energy for all Europeans Package. Although the Gas Directive was amended in 2019, the sole purpose of the amendment was to integrate a new approach of the Commission towards the

11 Jason Dein GTM, 'So, What Exactly Is Green Hydrogen?' www.greentechmedia.com/articles/read/green-hydrogen-explained accessed 7 July 2020.

12 Michael Ball and others in Michael Ball and Martin Wietschel (eds), *The Hydrogen Economy: Opportunities and Challenges*' (Cambridge University Press 2009) 399.

13 *Ibid*, 418.

14 European Commission, 'Clean Energy for All Europeans – Unlocking Europe's Growth Potential' http://europa.eu/rapid/press-release_IP-16-4009_en.htm accessed 10 October 2019.

15 European Commission, 'European Commission Proposes New Rules for Consumer Centred Clean Energy Transition' https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition accessed 10 October 2019.

16 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 (Recast) OJ L 328/82 (hereinafter: Recast RED).

17 Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on Common Rules for the Internal Market for Electricity and Amending Directive 2012/27/EU [2019] OJ L 158/125 (hereinafter: Recast Electricity Directive).

18 Council Directive (EC) 2009/73 of 13 July 2009 Concerning Common Rules for the Internal Market in Natural Gas and Repealing Directive 2003/55/EC [2009] OJ L 211/94 (hereinafter: 2009 Gas Directive).

regulation of gas pipelines coming from third countries to the EU[19] (the 'Nord Stream 2 saga').[20] What is urgently needed is a fundamentally revised and recast Gas Directive, as the focus of the current one on natural gas raises questions about its applicability to hydrogen, as will be discussed below.

After some remarks on the technical aspects in section 2, section 3 highlights the discussions on clean and 'green' hydrogen at the EU level, and discusses the legal categorisation of hydrogen as a form of renewable energy under the new recast Renewable Energy Directive and the repercussions for electricity storage via hydrogen. Section 4 explores the extent to which current EU electricity and gas legislation applies to electricity storage via hydrogen and who, under EU unbundling rules, is allowed to own and/or operate these power-to-gas facilities for the purpose of storing electricity. Section 5 provides some recommendations for further clarification in the legal frameworks before section 6 concludes the article.

2. Power-to-gas technology and applications

Power-to-gas is an energy conversion technology that allows for the transfer of the energy content of electrons to molecules, thereby enabling alternative storage and usage pathways of electricity generated from renewable sources (RES-E). In a first step, electricity is used for a water-electrolysis process which decomposes a water molecule (H_2O) into hydrogen (H_2) and oxygen (O_2).[21] The resulting hydrogen can be stored and/or transported as pure hydrogen or admixed in limited volumes with natural gas flows. In case of electricity storage, a second step is needed (gas-to-power) to reconvert hydrogen molecules into electrons. This is most frequently done using a fuel cell, a technology deployed already today for various purposes, including fuel cell vehicles.

By establishing this link between the electricity and gas sectors, power-to-gas is frequently linked to terms such as 'sectoral integration' or 'sector-coupling'.[22] This coupling of sectors through energy conversion plays an important role in the seasonal storage of renewable energy,[23] but also enables the decarbonisation of end uses such as mobility[24] or heat.[25] Sectoral integration for storage purposes can facilitate

19 Directive (EU) 2019/692 of the European Parliament and of the Council of 17 April 2019 amending Directive 2009/73/EC concerning common rules for the internal market in natural gas [2019] OJ L 117/1.

20 Kim Talus, 'Application of EU Energy and Certain National Laws of Baltic Sea Countries to the Nord Stream 2 Pipeline Project' 10(1) The Journal of World Energy Law & Business 30.

21 See, for a techno-economic analysis of the power-to-gas chain, Manuel Götz and others, 'Renewable Power-to-Gas: A Technological and Economic Review' (2016) 85 Renewable Energy 1371.

22 Asset, 'Sectoral Integration – Long-Term Perspective in the EU Energy System' (2018) https://ec.europa.eu/energy/sites/ener/files/documents/asset_study_2018.pdf accessed 10 October 2019; Maria Olczak and Andris Piebals, 'Sector Coupling: The New EU Climate and Energy Paradigm?', Florence School of Regulation Policy Brief http://fsr.eui.eu/wp-content/uploads/QM-AX-18-017-EN-N.pdf accessed 29 October 2018.

23 Stephen Clegg and Pierluigi Mancarella, 'Storing Renewables in the Gas Network: Modelling of Power-to-Gas Seasonal Storage Flexibility in Low-Carbon Power Systems' (2015) 10(3) IET Generation, Transmission & Distribution 566.

24 Martin Robinius and others, 'Linking the Power and Transport Sectors – Part 1: The Principle of Sector Coupling' (2017) 10(956) Energies 1.

25 Benedetto Nastasi and Gianluigi Lo Basso, 'Power-to-Gas Integration in the Transitions Towards Future Urban Energy Systems' (2017) 42(38) International Journal of Hydrogen Energy 23933.

integrated network planning and operation.[26] The European Union recently decided to establish a EU strategy on energy system integration.[27] Hydrogen, however, received special attention, and a particular EU Hydrogen Strategy has been designed.[28] The European Commission wants to bring these two strategies together and proposes one communication to integrate them into EU energy policy.[29]

3. Clean or renewable – hydrogen strategy and recast renewable energy directive

Hydrogen is viewed by European Union institutions as a key energy carrier to achieve these ambitions.[30] On 8 July 2020 the European Commission proposed a communication for an EU hydrogen strategy, which is part of the 'European Green Deal'.[31] This will be coupled with a broader EU strategy on systems integration, which means linking the various energy carriers – electricity, heat, cold, gas, solid and liquid fuels – with each other and with the end-use sectors, such as buildings, transport or industry.[32]

According to the Commission, the new hydrogen strategy will explore the potential of clean hydrogen to help the process of decarbonising the EU economy in a cost-effective way, in line with the 2050 climate-neutrality goal, set out in the European Green Deal.[33] It should also contribute to recovery from the economic effects of COVID-19.[34] The hydrogen strategy establishes possibilities to support the production and use of clean hydrogen, focusing in particular on the mainstreaming of renewable hydrogen.[35]

Striking is the new 'spin' that the European Commission is trying to give to the debate on hydrogen. The aims of the strategy are to, *inter alia*, explore 'the use of clean hydrogen'. This choice of words is by no means coincidental. While the differentiation between 'green', 'grey' 'blue' and other 'colours' of hydrogen is well established in the member states, the Commission is now trying to frame the debate in a different way by only referring to 'clean' and 'not clean' hydrogen. The idea behind this semantic exercise is to blur the line between 'green' and 'blue' hydrogen, essentially defining both as 'clean'. Given that several major member states have considerable reservations against carbon capture and storage technology (CCS), it is a

26 Stephen Clegg and Pierluigi Mancarella, 'Integrated Modeling and Assessment of the Operational Impact of Power-to-Gas (P2G) on Electrical and Gas Transmission Networks' (2015) 6(4) IEEE Transactions on Sustainable Energy 1234.
27 European Commission, 'EU Strategy on Energy System Integration' https://ec.europa.eu/energy/topics/energy-system-integration/eu-strategy-energy-system-integration_en accessed 7 July 2020.
28 European Commission, 'EU Hydrogen Strategy' https://ec.europa.eu/energy/topics/energy-system-integration/hydrogen_en#eu-hydrogen-strategy accessed 7 July 2020.
29 European Commission, 'EU Strategy on Energy System Integration' (n 27).
30 European Commission, 'Clean Energy – An EU Hydrogen Strategy' https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12407-A-EU-hydrogen-strategy accessed 16 June 2020.
31 Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, 'The European Green Deal' COM/2019/640 final, 6, 8 and 18.
32 European Commission, 'EU Strategy on Energy System Integration' (n 27).
33 *Ibid*.
34 *Ibid*.
35 *Ibid*.

dangerous attempt by the Commission to 'talk away' the debate and equate 'green' with 'blue' hydrogen. Germany is an example of a major EU member state with a long history of objections to CCS; it transposed the EU CCS Directive only with great delay and hesitation.[36] To 'brush over' these considerable differences in appraisal of energy and climate technologies ultimately means that the European Commission is not taking member states' considerations and priorities seriously, and that could harm the public acceptance of hydrogen in some member states.

Although power-to-gas is, thus, not a 'green' technology per se, it is often associated with renewable energy. This perception is mainly rooted in the possibility to use hydrogen to store electricity that has been produced from renewable sources.[37] The 2009 Renewable Energy Directive already included a number of favourable conditions and privileges for renewable energy, compared to conventional energy.[38] The Renewable Energy Directive has been revised recently, and from December 2018 onwards the recast Renewable Energy Directive has been in force (hereafter: RED),[39] which is part of the 'Clean Energy for All Europeans' package.[40] Two legal aspects are crucial for the issue of power-to-gas as a storage option in relation to renewable energy. First, it has to be assessed whether or not hydrogen falls within the definition of 'renewable energy' under the RED; second, renewable energy support mechanisms (broadly defined), particularly the so-called Guarantees of Origin scheme, have to be checked for applicability to hydrogen.

3.1 *Definition of renewable energy*

Regarding the first point, hydrogen is not an energy source in itself, but rather an energy carrier. Similar to electricity, hydrogen is as green as its source – or, more accurately, as green as the source of the electricity used for electrolysis to produce hydrogen for storage. This is also the logic behind the approach of the new recast RED (2018/2001)[41] towards hydrogen. While hydrogen is not explicitly mentioned as 'renewable energy' in its own right in RED Article 2(1), 'green' hydrogen is included indirectly in the scope of RED.[42] This becomes clear from the second sentence of Article 7(1), concerned with calculating the share of energy from renewable sources: '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'. The article thus

36 For more see Ruven Fleming, *Shale Gas, the Environment and Energy Security* (Edward Elgar, 2017) 244, 245

37 See Fleming, 'Regulating Power-to-Gas in the Energy Union' (n 5).

38 More on that can be found at Hans Vedder, Anita Ronne, Martha Roggenkamp and Inigo del Guayo, 'EU Energy Law' in Martha M Roggenkamp and others (eds), *Energy Law in Europe* (3rd edn, Oxford University Press 2016), para 4.406.

39 Recast RED (n 16).

40 European Commission, 'Clean Energy for All Europeans Package' https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans accessed 10 October 2019.

41 Recast RED (n 16).

42 This reference includes only 'green' and not 'grey' hydrogen; see European Parliament 'Briefing EU Legislation in Progress Promoting Renewable Energy Sources in the EU after 2020' www.europarl.europa.eu/RegData/etudes/BRIE/2017/599278/EPRS_BRI(2017)599278_EN.pdf accessed 10 October 2019, 7.

works on the assumption that hydrogen from renewable sources can be considered renewable energy.

With a view to storage, RED Recital 60 establishes that the use of energy storage systems for integrated variable production of energy from renewable sources shall be supported, but no article in the body of RED actually follows up on this. However, there is a different, interesting way in which hydrogen produced from renewable energy, *inter alia* for storage purposes, is being supported by RED: the Guarantees of Origin scheme.

RED Recital 59 acknowledges indirectly that the term 'renewable gas' encompasses hydrogen from renewable energy sources. This means 'grey' hydrogen, derived from fossil fuels, falls outside of this definition and the applicability of the Renewable Energy Directive.

3.2 *Support of hydrogen as renewable gas via the Guarantees of Origin scheme*

As regards Guarantees of Origin, RED Recital 59 and Article 19(7)(b)(ii) together establish that Guarantees of Origin shall now be issued for renewable gases, including 'green' hydrogen. According to RED Article 19(1), each member state must be able to guarantee the origin of energy from renewable sources.[43] Guarantees of origin have the sole function of proving to a final customer that a given share of energy was produced from renewable sources.[44]

However, a guarantee of origin can be transferred independently of the energy to which it relates, from one holder to another – regardless of the energy to which it refers.[45] The underlying rationale is to use guarantees of origin as evidence of 'green supply' in order to allow consumers to differentiate between 'green' and 'grey' energy commodities, but they do not of themselves confer a right to benefit from national support schemes.[46] This system of guarantees of origin was in place for renewable electricity and will now be extended to renewable gases like hydrogen.

4. The classification of power-to-gas and hydrogen storage

The legislative archives of the EU provide no indication that power-to-gas and hydrogen storage were a topic of consideration during the drafting of the 2009 Third Energy Package. The Electricity Directive (2009/72/EC) and Gas Directive (2009/73/EC) both reflect that the energy system was, and is, dominated by 'traditional' actors which can be classified as producers, system operators, gas storage operators, or consumers. It is based on these classifications that the directives prescribe how energy markets need to be organised and what the rights and obligations of the respective entities are. Market integration of 'new' technologies such as power-to-gas for electricity storage via hydrogen thus provokes three questions. First, how does electricity storage via hydrogen fit with recent EU electricity law; second, is electricity storage via hydrogen possible

43 In the new RED of 2018 (n 2), the term 'electricity' has been altered to 'energy' to clarify that renewable gases are included.
44 RED (n 2), recital 59 and art 19 (1).
45 Vedder and others (n 38), para 4.400.
46 *Ibid*, para 4.401.

under current EU gas legislation; and, third, who is actually allowed to own and/or operate a power-to-gas plant for electricity storage under the EU's unbundling provisions?

4.1 *Power-to-gas and hydrogen storage under electricity legislation*

In the old Electricity Directive of 2009, no mention was made of 'electricity storage'.[47] That changed with the introduction of the new recast Electricity Directive (EU) 2019/944[48] (hereinafter: Electricity Directive). Article 2(59) of the recast Electricity Directive defines energy storage as

> in the electricity system, deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy or use as another energy carrier.

While hydrogen and/or power-to-gas are not explicitly mentioned here, the phrasing about the conversion of electrical energy into another, storable, form of energy and subsequent reconversion to electricity suggests that power-to-gas plants – in which, indeed, the hydrogen is re-converted to electrical energy by a fuel cell or gas turbine – would be covered.

This interpretation of the text is bolstered by a Staff Working Document (SWD) of the European Commission, which elaborates upon an earlier proposed version of this article.[49] It explains that 'storage within the electricity system covers all power-to-power solutions, including batteries, pumped hydro and compressed air energy storage. It also covers power-to-hydrogen when the produced hydrogen is used for re-electrification … '.[50]

The wording of Electricity Directive Article 2(59), however, is much more open than that. The last six words 'or use as another energy carrier' indicate that no reconversion of electricity is required for a power-to-gas plant to be recognised as an electricity storage facility. This is a crucial point, as it means that electricity can be converted to hydrogen and stay hydrogen. Although the wording of the cited SWD is stricter and, indeed, only covers hydrogen that is used for re-electrification, this is not a valid argument. The SWD dates from 2017 and is thus not actually interpreting the final law (the Electricity Directive). By the time the SWD was drafted, the European Parliament as well as the European Council and the European Commission had all proposed slightly different versions of a possible wording for Article 2(59). With the coming into force of the recast Electricity Directive in 2019, the European legislator decided on the exact wording and, given the fact that there has been a lively discussion about the exact wording in the drafting phase, it may only be assumed that the legislator made a conscious decision here to also include power-to-hydrogen without re-conversion to

47 Directive 2009/72/EC of the Parliament and of the Council of 13 July 2009 Concerning Common Rules for the Internal Market in Electricity and Repealing Directive 2003/54/EC [2009] OJ L 211/55.

48 Recast Electricity Directive (n 17).

49 Commission Staff Working Document, 'Energy Storage – The Role of Electricity' SWD (2017) 61 final.

50 *Ibid*, section 4.1.

electricity in the definition of electricity storage. The will of the legislator needs to be respected during interpretation of the law.[51]

An interesting discussion for future interpretation is the one about intention ('dolus'). In cases where hydrogen is stored and not re-converted to electricity, is there a need for an *intention* to carry out this process with the aim to store electricity? What if someone is using power-to-gas to produce hydrogen and wants to produce hydrogen for the sole purpose of producing hydrogen and with no intention to store electricity? This would most likely not be considered electricity storage. Of course, Article 2(59) of the Electricity Directive actually does not define 'electricity storage', but instead the term 'energy storage' is used. Given that this is broader than only storing electricity, the described constellation would still be likely to fall within the definition, even without a deliberate 'storage' intention.

Moreover, two interesting yet overlooked consequences follow from the wording. First, all types of power-to-gas plants that produce hydrogen for re-conversion are covered. That includes 'green' but also 'grey' and any other hydrogen, as long as it was produced from electrical energy and is being re-converted to that. Power-to-gas can work perfectly well with 'conventional' electricity produced from fossil fuels and is by no means only an option to store renewable electricity. The Electricity Directive clearly applies to any source of the hydrogen, as long as it is electricity.

Second, the wording of Electricity Directive Article 2(59) leaves interesting leeway for discretion and interpretation. It does not clarify what happens when the power-to-gas plant, the hydrogen storage and the plant for re-conversion are not all integrated and build on one premise, but all three are detached from each other and are standalone plants.[52] While the wording seems to assume that all three steps are integrated, this does not have to be the case. What if a power-to-gas plant sells its hydrogen to a variety of customers, e.g. manufacturers of automotive fuels, refineries or fuel-cell plants that convert the purchased hydrogen to electricity? Would the fuel-cell plant still be considered as engaging in the business of energy storage? Or the power-to gas plant?

Article 2(60) of the Electricity Directive provides some answers here. It says that 'energy storage facility' means, in the electricity system, a facility where energy storage occurs. Thus, the place where the energy is stored is considered the storage facility. These considerations might not appear to be of much relevance at the moment, as the market for electricity storage still needs to be developed, but in the future this might change. A further point of interest is the interplay between the storage provisions of the Electricity Directive and the Gas Directive, which will be discussed next.

4.2 *Power-to-gas and hydrogen storage under EU gas legislation*

As power-to-gas is deemed to be a cross-energy vector technology which functions as a linkage between the worlds of electricity and gas, the applicable legal framework for

51 Günter Hager, *Rechtsmethoden in Europa* (Mohr Siebeck, Tübingen 2009) 54; Heiko Sauer, 'Juristische Methodenlehre' in Julian Krüper (ed), *Grundlagen des Rechts* (2nd edn, Nomos 2013), § 9 para 28ff and 34.

52 Gijs Kreeft, 'European Legislative and Regulatory Framework on Power-to-Gas' (2017), STORE&GO Project www.storeandgo.info/fileadmin/downloads/20171030_STOREandGO_D7.2_RUG_submitted.pdf accessed 10 October 2019, 33.

the electricity sector only tells half of the story. When the energy is no longer carried by electrons but by hydrogen molecules in a gaseous state, it becomes necessary to consider the extent to which EU natural gas legislation equally applies. Similarly to natural gas, hydrogen is a gaseous energy carrier which can be compressed and stored in salt caverns, aquifers and depleted oil and gas fields.[53] This similarity to natural gas is what makes hydrogen produced through power-to-gas such an attractive option for the storage of large volumes of renewable energy.[54] Against this background, we will explore in this section the extent to which EU natural gas legislation applies to hydrogen and, subsequently, how power-to-gas and hydrogen storage can be classified from the perspective of EU gas legislation which still stems from 2009.[55]

4.2.1 Applicability of EU natural gas legislation to hydrogen

Our exploration of the applicability of EU natural gas legislation to the power-to-gas and hydrogen sector starts by asking the preliminary question of whether the rules under the 2009 Gas Directive even apply to hydrogen production, storage and transportation.

Similar to its predecessors from 1998 and 2003, the aim of the 2009 Gas Directive is the establishment of a competitive internal market in natural gas. To this end, Article 1 (1) stipulates that the directive 'establishes common rules for the transmission, distribution, supply and storage of *natural gas*' (emphasis added). This does not mean that the drafters of the Gas Directive have ignored the increased attention to and demand for alternative gases such as biogas. It was the European Parliament which suggested, during the negotiations leading up to the 2003 Gas Directive, including biogas and other gas from biomass under the scope of the Gas Directive in order to increase the share of renewable energy in gas consumption.[56] In response, the European Commission expressed its willingness to accept this proposal on the condition that a clause was added emphasising that the directive would only apply to such gases insofar as they can be technically and safely injected into the natural gas system.[57] Finally, it was on the instigation of the Council that the scope of the 2003 Gas Directive (2003/55/EC) also applied to 'other types of gases' than natural gas and biomass-based gases.[58] What specific 'other types of gases' the Council had in mind when it introduced this addition cannot, however, be inferred from the legislative history.

53 See, for a technical analysis of underground hydrogen storage, Netherlands Enterprise Agency, 'The Effects of Hydrogen Injection in Natural Gas Networks for the Dutch Underground Storages' (2017) www.rvo.nl accessed 10 October 2019.

54 See Hans Christian Gils and others, 'Integrated Modelling of Variable Renewable Energy-Based Power Supply in Europe' 123 (2017) Energy 173.

55 A similar exercise in the context of power-to-synthetic natural gas (power-to-SNG) can be found in Kreeft (n 52).

56 European Parliament Committee on Industry, External Trade, Research and Energy, 'Report on the Proposal for a Directive of the European Parliament and of the Council Amending Directives 96/92/EC and 98/30/EC Concerning Common Rules for the Internal Market in Electricity and Natural Gas' (2002), Doc. A5-0077/2002, Amendments 110 and 118.

57 European Commission, 'Amended Proposal for a Directive of the European Parliament and of the Council Amending Directives 96/92/EC and 98/30/EC Concerning Rules for the Internal Markets in Electricity and Natural Gas' (2002), COM 304 final.

58 Council of the European Union, 'Common Position Adopted by the Council on 3 February 2003 with a View to the Adoption of a Directive of the European Parliament and of the Council Concerning

A few years later, during the course of the negotiations resulting in the adoption of the 2009 Gas Directive (2009/73EC), the element of non-discrimination was added to Article 1(2) on the initiative of the European Parliament. This reference to the non-discrimination principle was justified by the statement that 'assuming the technical and chemical safety threshold for the different gases are met, the need for non-discrimination for access between the gases from different sources must be emphasized'. Article 1(2) on the scope of the 2009 Gas Directive now reads:

> [t]he rules established by this Directive for natural gas […] shall also apply in a *non-discriminatory* way to biogas and gas from biomass or *other types of gas* in so far as such gases can technically and safely be injected into, and transported through, the *natural gas system.* (emphasis added)

As it is basic chemistry that hydrogen molecules can constitute a 'gas', and as hydrogen is neither natural gas nor biogas, we can safely state that hydrogen which is produced through the power-to-gas process falls within the category of 'other types of gases'.[59] We thus arrive at our first conclusion on the applicability of the 2009 Gas Directive to hydrogen: the directive applies to hydrogen insofar hydrogen can technically and safely be injected into, and transported through, the natural gas system. Importantly, the extended scope of the Gas Directive only relates to the non-discriminatory treatment of alternative gases in relation to *the natural gas system*. What this means for the classification and treatment of power-to-gas and hydrogen storage will be discussed next.

4.2.2 Classification of power-to-gas and hydrogen storage under EU gas legislation

We already discussed the possibility that a power-to-gas installation could fall under the definition of 'energy storage' in the 2019 Electricity Directive.[60] Now, we will perform the same exercise from the perspective of the EU gas legislation. As the Gas Directive and Regulation have not received an update simultaneously with the Electricity Directive and Regulation, the concept of 'energy storage' under Article 2(59) of the Electricity Directive has not yet been mirrored in gas legislation.[61] We may have to wait for the new EU Gas Package, which is expected in 2020 or 2021, for this to happen.[62] Today's EU gas legislation, therefore, still revolves around the activities of gas production, gas storage and transportation of gas. As our focus in this article is on power-to-gas for the storage of electricity, we reflect on the possibility that power-to-gas is classified as being gas production and/or gas storage.[63] As we will illustrate,

Common Rules for the Internal Market in Natural Gas and Repealing Directive 98/30/EC' (2003), C 50 E/36.

59 Although hydrogen can be produced from biomass through gasification, we focus in this article on hydrogen produced from electricity generated from wind and solar energy.

60 See section 4.1.

61 See the Conclusion section for an outlook to the Gas Package 2020.

62 Maria Olczak and Andris Piebalgs, 'What to Expect from the 2020 Gas Package' (2019) 7(1) Politics and Governance 165.

63 We do not reflect on power-to-gas as an activity or asset in the transportation context, although a power-to-gas facility could in the future play a role at the crossroads of electricity and gas infrastructure. See in

the outcome of this exercise may be different depending on the setting in which the power-to-gas plant and hydrogen storage are operated.

First, let us consider a power-to-gas facility for electricity storage which is not connected directly to the natural gas network or indirectly via a hydrogen storage facility which is connected to this network. Instead, the electricity is withdrawn from the electricity grid or generation facility, converted to hydrogen, intermediately stored as hydrogen, reconverted to electricity, and finally fed back into the electricity system. As such a 'closed' power-to-hydrogen-to-power system does not interact at all with the natural gas system, there seems no logic in applying the rules and classifications under the Gas Directive thereto. As we expressed earlier, the subject matter of the 2009 Gas Directive is the functioning of the internal market in *natural gas*. Alternative gases such as biogas and hydrogen only fall under the scope of this Directive insofar they are 'injected into, and transported through, the natural gas system.[64] Where this is not the case, the 2009 Gas Directive is irrelevant for the question how a power-to-gas facility and hydrogen storage facility in such a closed setting should be classified. The answer should, instead, be found solely in the legal regime for energy storage under the Electricity Directive.[65]

If we consider a power-to-gas and hydrogen storage facility in an 'open' setting, whereby the hydrogen is injected and transported through the natural gas system, our exercise becomes more complex.[66] Looking at the power-to-gas process, the first question is how to classify the decomposition of water molecules by electricity into oxygen and hydrogen – a gas. Is this gas production similar to biogas production through the anaerobic digestion of biomass or the extraction of gas from natural reservoirs? Notably, the Gas Directive does not contain a definition of 'gas production'. The Oxford Dictionary defines 'production' as: 'the action of making or manufacturing from components or raw materials, or the process of being so manufactured'. Following this definition, it can be argued that the conversion of water molecules (raw material) through electrolysis (process) into hydrogen (product) is a production process. Also, from a functional perspective, power-to-gas can be considered a 'production' activity as it adds 'new' molecules to the natural gas system.

Another question is whether we can classify a hydrogen storage facility which is connected to the gas network as a gas storage facility. Gas storage facilities are defined in Article 2(9) of the 2009 Gas Directive as 'facilit[ies] used for the stocking of natural gas and owned and/or operated by a natural gas undertaking'.[67] The view has been put forward that hydrogen storage facilities are indeed gas storage facilities, as it is technically and safely possible to inject hydrogen into salt caverns and depleted

this context the combined 2050 outlook by the Dutch gas TSO Gasunie and electricity TSO TenneT: Gasunie and Tennet, 'Infrastructure Outlook 2050' (2019) <www.tennet.nl> accessed 10 October 2019.

64 2009 Gas Directive (n 18), art 1(2).

65 See section 4.1.

66 See section 5 on the access and gas quality conditions for hydrogen injection into the natural gas system.

67 For this see Ruven Fleming and Joshua Fershee 'The "Hydrogen Economy" in the US and the EU – Regulating Innovation to Combat Climate Change' in Donald Zillmann, Lee Godden, LeRoy Paddock, Martha M Roggenkamp (eds.) *Innovation in Energy Law and Technology: Dynamic Solutions for Energy Transitions* (Oxford University Press, 2018) 150/151.

oil and gas fields.[68] The argument is, then, that since storage facilities are part of the *natural gas system*,[69] this triggers the non-discriminatory treatment clause for other gases such as hydrogen under Article 1(2) of the Gas Directive, so that hydrogen storage facilities fall under the same regime as facilities for the stocking of natural gas. Insofar as the hydrogen storage facility is connected to the natural gas network, it can indeed be argued that the storage facility is part of the natural gas system. However, the view that a dedicated hydrogen storage facility falls under the definition of a gas storage facility under Article 2(9) of the 2009 Gas Directive could be seen as being at odds with the function of gas storage in the natural gas system, which is to provide flexibility to the system by withdrawing and injecting natural gas. Although it would be possible to inject hydrogen from the storage facility in the natural gas system, the other way around would not be possible. Furthermore, it could be argued that a hydrogen storage facility fulfils a similar function to storage which is operated in the context of natural gas production and which does not fall under the definition of Article 2(9) of the 2009 Gas Directive.

As is clear from the analysis in this section, there are currently more questions than answers concerning the classification of power-to-gas and hydrogen storage. It will, therefore, be necessary for the European Commission to take these issues into account when drafting the new Gas Package.

4.3 *Unbundling of power-to-gas facilities and hydrogen storage for electricity storage*

After assessing electricity and gas legislation for applicability to power-to-gas and electricity storage via hydrogen, the next question is who is entitled to construct and operate such an energy storage facility. We hereby focus on the 'closed' power-to-gas system where the hydrogen is reconverted to electricity after storage. Given the current market constellation, there are four possible answers to this question: electricity customers, electricity generating companies, Distribution and Transmission System Operators (DSOs/TSOs)[70] and independent companies.

For the first option, electricity customers as owners, a distinction needs to be made. The normal, passive customer of electricity will not be interested in this. For a start, only very large electricity customers would even be able to build and run their own power-to-gas storage facilities. However, even they would have no incentive to do so, since European electricity customers are already supplied with a steady stream of electricity, generated farther up in the energy chain.

However, with the recent emergence of active electricity customers (a new term used by the European Commission) or prosumers (as they were hitherto called in the

68 Fleming, 'Regulating Power-to-Gas in the Energy Union' 11 (n 5). With regard to the technical aspects of hydrogen storage, see Maximilian Fichtner, 'Hydrogen Storage' in Michael Ball and Martin Wietschel, *The Hydrogen Economy* (Cambridge University Press 2009) 318; Netherlands Enterprise Agency (n 53).

69 Fleming, 'Regulating Power-to-Gas in the Energy Union' 12 (n 5). The author points here to the definition of 'system' under the 2009 Gas Directive (n 18), art. 2(13), as meaning 'any transmission networks, distribution networks, LNG [Liquefied Natural Gas] facilities and/or storage facilities'.

70 The function of TSOs and DSOs is explained by Hans Vedder and others, 'EU Energy Law' in Martha M Roggenkamp and others (eds), *Energy Law in Europe* (3rd edn 2016), para 4.10.

literature),[71] this picture can change. With Article 15, the Electricity Directive now features an article dedicated to active electricity customers. Article 15(5) of the Electricity Directive assumes that such customers can own energy storage facilities and provides a number of legal assurances to such customers. As discussed earlier, power-to-gas facilities that are used to produce hydrogen for electricity storage purposes fall within the definition of 'electricity storage'. As a result, an active customer would be allowed to own an energy storage facility. It should be noted that Article 15(5) of the Electricity Directive speaks only of 'owning' an energy storage facility, not operating it. However, as becomes clear from the four assurances provided in Electricity Directive Article 15(5)(a–d), the legislator does assume that such active customers would also often operate the storage facilities. In any case, while this might become important in the future, there are no current examples of this in the EU.

The second option would be for electricity-generating companies to own and operate power-to-gas facilities that work with the purpose of storing electricity. Indeed, there is a real interest in power-to-gas on the part of renewable energy-generation companies.[72] Their aim is to generate a steady stream of electricity before it is fed into the system.[73] The aim for the future could be to receive a reward from the transmission system operator for countering the intermittent feed-in pattern of renewable energy and helping the operator to balance the system.

Running an energy storage facility as an energy producer, however, can conflict with rules on the liberalisation of the European energy market. Under the Gas Directive, for example, producers are not allowed to run a gas storage facility.[74] A prohibition for producers/generators to run storage facilities, similar to the one in the Gas Directive, does not feature in the Electricity Directive. In the absence of an explicit prohibition, it must be assumed that electricity generators could run those facilities. The key point here is the categorisation of hydrogen storage for electricity generation purposes. Is it storage of gas (in which case the Gas Directive and its current ambiguities apply, as discussed above) or storage of electricity in the form of gas (which is possible under the Electricity Directive)? The European legislator should consider this interrelation between the two directives and align them.

The third option would be TSOs and/or DSOs that could also develop an interest in running hydrogen storage facilities. In principle it is perceivable that both kinds of system operators could want to use power-to-gas facilities as electricity storage options to solve congestion and as an alternative to grid expansion. These, however, could only be electricity TSOs/DSOs and not gas TSOs/DSOs for the purpose of the Electricity Directive, which deals with electrical energy. As a starting point, it must be understood that energy storage was designed under European energy market rules

71 Sharon B Jacobs, 'The Energy Prosumer' (2017) 43(3) Ecology Law Quarterly 519.

72 A good example for power-to-gas experiments is the wind turbine and electricity producer Enercon; see Enercon Storage Technology, 'First Pilot Projects for Energy Storage Realised' (2015) Issue 3 Windblatt 10 www.enercon.de/fileadmin/Redakteur/Medien-Portal/windblatt/pdf/en/WB_032015_GB_150dpi.pdf accessed 10 October 2019.

73 *Ibid*.

74 Only natural gas undertakings are, according to 2009 Gas Directive (n 18), art 2(9).

as a competitive activity, which TSOs/DSOs should stay away from.[75] From the point of view of the European Commission, flexibility and ancillary services by energy storage and other technologies are primarily a market activity.[76] Usually, the TSO has contractual relationships with commercial market parties to purchase the flexibility services it needs.[77] The role of DSOs is so far limited on this.

In line with this general rule, Articles 36(1) (dealing with DSOs) and 54(1) (dealing with TSOs) of the Electricity Directive state that neither TSOs nor DSOs shall own, develop, manage or operate energy storage facilities. There are, however, two exceptions to this rule. The member states can allow TSOs and DSOs to engage in electricity storage activities via the power-to-gas technology if (alternatively):

(1) the storage facility is a fully integrated network component and the regulatory authority has granted its approval, or
(2) the following three conditions are met cumulatively:

    (a) other parties, following an open, transparent and non-discriminatory tendering procedure that is subject to review and approval by the regulatory authority, have not been awarded a right to own, develop, manage or operate such facilities, or could not deliver those services at a reasonable cost and in a timely manner;
    (b) such facilities are necessary for the distribution system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the distribution system and the facilities are not used to buy or sell electricity in the electricity markets; and
    (c) the regulatory authority has assessed the necessity of such a derogation and has carried out an assessment of the tendering procedure, including the conditions of the tendering procedure, and has granted its approval.[78]

At least every five years, the relevant regulatory authority of the member state shall hold a public consultation on the existing energy storage facilities in order to assess the potential availability and interest of other parties in investing in such facilities.[79] In the case that these consultations indicate that third parties are able to own, develop, operate or manage such facilities in a cost-effective manner, the regulatory authority shall ensure that the TSOs' or DSOs' activities in this regard are phased out within 18 months.[80] This entire procedure is, thus, in the hands of member states and includes a number of decisions that will entail room for discretion by the regulatory authority in charge. Just think about the

75 European Commission Directorate General Energy, 'Energy Storage – Proposed Policy Principles and Definitions' https://ec.europa.eu/energy/sites/ener/files/documents/Proposed%20definition%20and%20principles%20for%20energy%20storage.pdf accessed 10 October 2019.
76 *Ibid*.
77 Dimitrios Zafirakis and others, 'The Value of Arbitrage for Energy Storage: Evidence from European Electricity Markets' (2016) 184 Applied Energy 971.
78 Recast Electricity Directive (n 17), art 36 (2) and 54(2).
79 *Ibid*, art 36 (3) and 54 (4).
80 *Ibid*.

interpretation of 'cost-effective manner', for example – which costs are included/excluded, how effectiveness is measured, etc. All of this will be subject to the interpretation of regulatory authorities of member states.

And there are even more ambiguous terms. Articles 36(4) and 54(5) of the Electricity Directive allow for derogations from the necessity to have consultations every five years and from the 18-month period for phasing out of energy storage ownership/operation by TSOs and DSOs. These requirements shall not apply to fully integrated network components or for the usual depreciation period of new battery storage facilities with a final investment decision until 4 July 2019, provided that four further conditions are fulfilled.[81]

This wording provides two alternatives: either we are talking about a 'fully integrated network component' or 'new battery storage facilities with a final investment decision until 4 July 2019'. These are alternatives, not cumulative pre-requisites. A power-to-gas plant is not a battery storage facility, so the second alternative does not apply. However, the first option could apply if the power-to-gas facilities are 'fully integrated network components'. According to Article 2(51) of the Electricity Directive, a 'fully integrated network component' means network components that are integrated in the transmission or distribution system, including storage facilities, and that are used for the sole purpose of ensuring a secure and reliable operation of the transmission or distribution system, and not for balancing or congestion management. As mentioned earlier, power-to-gas for electricity storage might be used as a congestion management tool in certain constellations. So, this section would only apply to those facilities not used for congestion management.

Moreover, the question arises what exactly can be deemed the demarcation between a *fully* integrated and a *partly* integrated network component. This wording was introduced into the Directive at the wish of the European Council (as opposed to the proposal of the European Parliament to use the term 'an integral part of the transmission system' instead).[82]

Finally, there is the fourth possibility that independent parties are running power-to-gas plants and hydrogen storage facilities with the aim of reconversion of electricity. Under the current recast Electricity Directive, there is nothing to prohibit such independent parties from engaging in storage activities, and it would also fall in line with the overall rationale of energy market liberalisation in Europe to have different activities assigned to independent parties.

5. Energy storage through hydrogen admixing to natural gas: access and quality issues

The European natural gas system performs a double role in the energy system: (1) it is used for the transportation of large volumes of energy over long distances, and (2) it stores large amounts of energy as the gas travels from point A to point B. Contrary to the electricity system, for which input and output has to be continuously balanced,

81 *Ibid*, art 36 (4) and 54 (5).

82 See, for a comparison of the proposals by the EU institutions, Council of the European Union, 'Proposal for a Directive of the European Parliament and of the Council on Common Rules for the Internal Market in Electricity (Recast)', 2016/0380(COD), 7506/4/18 REV 4.

the gas system has a buffer which can be used for so-called 'line pack storage'.[83] Similarly, the hydrogen produced through power-to-gas can be stored in the natural gas system by admixing with the natural gas in the European gas system.[84] In this section, therefore, we focus on the gas system access regime relevant for the admixing of hydrogen with natural gas.

5.1 *Technical and safety issues of admixing hydrogen into the natural gas system*

It was concluded under section 4.2 that hydrogen is only entitled to the same treatment as natural gas under the 2009 Gas Directive when it can 'technically and safely be injected into, and transported through, the natural gas system'.[85] The question is, then, whether this is the case.[86]

Concerns related to hydrogen injection exist because of the different physical properties of hydrogen (H_2) compared to methane (CH_4), which is the main component of natural gas.[87] First, due to what is known as 'hydrogen embrittlement', hydrogen volumes of more than 2% may result in crack propagation in steel, which may affect the durability and integrity of transmission and distribution pipelines and compressed natural gas steel tanks. Second, higher hydrogen volumes may have a negative effect on the efficiency and emissions of end-use appliances. Both industrial and household appliances are adjusted to operate on a particular bandwidth of gas quality parameters, which historically differ from member state to member state. In particular, gas turbines such as those found in gas-fired power plants are highly sensitive to variations in the gas quality and higher hydrogen volumes. Third, although on an energy-to-weight ratio, hydrogen contains more energy than methane (1 kg of hydrogen contains 2 to 4 times more energy than methane), hydrogen has the lowest volumetric energy density of all fuels. As a result, admixing hydrogen into the natural gas flow will lower the energy content of the gas mixture and have a downward effect on the Wobbe Index thereof.[88] As calorific value is heat, and heat is economic value, changes in the hydrogen content in natural gas networks may also require a commercial revaluation of the gas supplied to consumers. From the above it is clear that the introduction of hydrogen into the natural gas system presents potential technical and safety

83 The 2009 Gas Directive (n 18), art 1(15), defines 'linepack' as: 'the storage of gas by compression in gas transmission and distribution systems, but not including facilities reserved for transmission system operators carrying out their functions'.

84 Dries Haeseldonckx and William D'haeseleer, 'The Use of the Natural-Gas Pipeline Infrastructure for Hydrogen Transport in a Changing Market Structure' (2007) 32(10–11) International Journal of Hydrogen Energy 1381.

85 See the discussion in section 4.2 on the 2009 Gas Directive (n 18), art 1(2)

86 See, on this issue, Rafaella Gerboni, 'Introduction to Hydrogen Transportation' in Ram B. Gupta, Angelo Basile and T. Nejat Veziroğlu, *Compendium of Hydrogen Energy, Volume 2: Hydrogen Storage, Distribution and Infrastructure* (Woodhead Publishing Series in Energy 2015) 283

87 Klaus Altfeld and Dave Pinchbeck, 'Admissible Hydrogen Concentrations in Natural Gas Systems, Gas for Energy No. 3' (2013) *GERG Study* 36 www.gerg.eu/media-centre/publications/#hips-hydrogen-in-pipeline-systems-project-final-report-admissible-hydrogen-concentrations-in-natural-gas-systems accessed 11 August 2018.

88 See, on the impact of hydrogen admixing to natural gas on the caloric value thereof, J. Leslie Zachariah-Wolff, Tineke M. Egyedi and Kas Hemmes 'From Natural Gas to Hydrogen via the Wobbe Index: The Role of Standardized Gateways in Sustainable Infrastructure Transitions' (2007) 32 International Journal of Hydrogen Energy 1235– 1245 at 1242.

challenges. The next question is, then: Who decides what levels of hydrogen in the natural gas system are acceptable?

5.2 *Determination of safety and technical conditions for the injection and transportation of hydrogen through the natural gas system*

Rules on the technically possible and safe injection of gas into the natural gas system can relate to either ‘access’ or ‘connection’ to the system.[89] On the difference between these two terms, the European Court of Justice in the *Sabatauskas* case ruled that ‘access to the system includes the right to use [electricity] systems and that connection corresponds to physical connection to the system’.[90] A crucial technical safety criterion which is decisive as to whether or not access to, and thus the use of, the natural gas network is granted is the issue of gas quality.

A gas quality standard prescribes the maximum and minimum acceptable limits of individual parameters and components of a gas.[91] Historically, national gas quality standards have been of a heterogeneous nature as the parameters defined therein were based on the chemical composition of locally produced or supplied natural gas. As the 2009 Gas Directive does not lay out the minimum and/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 into conformity with a European norm.[92] This lack of an EU approach to gas quality changed when a collection of European Commissioners collectively came to the conclusion that ‘[t]he interoperability of gas systems requires greater harmonization including co-ordination of the gas quality specifications at the EU entry points and within the EU to facilitate the development of a liberalized and competitive European gas market’.[93]

The European Commission acted by issuing two mandates directed to the European Committee for standardisation (CEN). The first was mandate M/400 (issued in 2007), which requests the CEN to draw up a European standard that defines the gas quality characteristics and parameters, and their limits, for gases classified as group H that are to be transmitted, injected into and withdrawn from storages, distributed and utilised.[94] As legal justification for issuing such a mandate, the Commission points to Article 6 of the 2003 Gas Directive (now Article 8 of the 2009 Gas Directive),

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89 Hannah Kruimer, *The Non-discrimination Obligation of Energy Network Operators: European Rules and Regulatory Practice* (Intersentia, 2014) 142/143.

90 European Court of Justice, C-239/07 *Julius Sabatauskas and Others* [2007] ECR II-7253, para 41–42. With regard to the physical connection, the 2009 Gas Directive (n 18), art 8, determines that member states need to ensure that objective and non-discriminatory technical rules are defined for the connection to the system of liquefied natural gas facilities, storage facilities and networks.

91 Daisy Tempelman, ‘Harmonising Gas Quality: Obstacles and Challenges in an Internal Market’ in Martha Roggenkamp and Henrik Bjornebye (eds), *European Energy Law Report X* (Intersentia 2014) 88–89.

92 See, however, *ibid*, 105 on the effort by the ‘European Association for the Streamlining of Energy Exchange – gas (EASEE-gas) to adopt a common business practice on gas quality.

93 *First Report of the High Level Group on Competitiveness, Energy and the Environment, Contributing to an Integrated Approach on Competitiveness, Energy and Environment Policies*, 2 June 2006 http://ec.europa.eu/enterprise/environment/hlg/doc_06/first_report_02_06_06.pdf accessed 10 October 2019.

94 H-gases are those gases which at 15°C and 1013.25 mbar have a gross Wobbe Index between 45.7 and 54.7 MJ/m^3.

which requires member states to ensure that technical rules are defined that ensure the interoperability of transmission, distribution, Liquefied Natural Gas (LNG) and storage systems. As CEN standards are voluntary by nature, the Commission intended to elevate the status of the standard through a binding reference thereto in the Network Code on Interoperability and Data Exchange Rules.[95]

Notably, hydrogen was explicitly excluded from the scope of the work of CEN under mandate M/400 as, 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 eventually adopted CEN standard EN 16726:2015 contains an annex – of a merely informative nature – covering the admissible concentration of hydrogen in natural gas systems.[96] Also, on the adoption of another parameter which may influence how much hydrogen can be added to natural gas, the Wobbe Index, the representatives of the member states in the CEN technical commission failed to reach consensus. A second mandate, M/475, presented CEN with the task to adopt a standard for the use of biomethane as a transport fuel and injection into natural gas pipelines. As 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 the legal foundation. Again, the determination of a common maximum hydrogen limit was considered to be premature.[97] The adopted CEN standard EN 16723-1 only contains a reference to the informative Annex E to EN standard EN 16726:2015.

The informative Annex E, titled 'Hydrogen – Admissible Concentrations in Natural Gas Systems', refers to a study by the European Gas Research Group which found that the admixing of hydrogen up to 10% by volume of hydrogen to natural gas is an option for certain sections of the natural gas system.[98] When determining the specific allowed percentage of hydrogen for a certain region, member states are advised to take into account the effect of hydrogen on underground porous rock storage, steel tanks in Compressed Natural Gas (CNG) vehicles, gas turbines and gas engines.

In conclusion, in the absence of a common and binding norm on a hydrogen limit at the EU level, member state regulation remains determinative of what is considered to be safe and technically possible.

5.3 *Determination of national hydrogen limits in the absence of harmonisation*

In absence of a standard for hydrogen levels in natural gas at the EU level, member states have discretion to set the hydrogen limit at the national level, including for gas interconnection points. This explains why, for example, the maximum level of

95 A 'standard' is defined under Article 2(1) of the Regulation on European Standardization (Regulation (EU) No 1025/2012 as 'a technical specification, adopted by a recognized standardization body, for repeated or continuous application, *with which compliance is not compulsory* … ' (emphasis added).

96 European Committee for Standardization, 'Gas Infrastructure – Quality of Gas – Group H' (2015), EN 16726:2015, available in CEN shop.

97 Jacques Dubost, 'Injection/Admixture of H_2 to the NG system: Compatibility, Interoperability and Safety', presentation at the 'Putting Science into Standards: Power-to-Hydrogen and HCNG' workshop of the Joint Research Center of the European Commission, 22 October 2018 https://ec.europa.eu/jrc/sites/jrcsh/files/hcng-2014-s2-dubost.pdf accessed 10 October 2019.

98 For the report to which Annex E refers, see Altfeld and Pinchbeck (n 87).

hydrogen allowed in the natural gas stream in the Netherlands is set at 0.02% mol, while in Germany it is 10% mol.[99] This may result in hydrogen-enriched natural gas from one member state being rejected by a neighbouring state. In this section, we will review what types of actions are open to those entities whose gas is rejected due to a difference in allowed hydrogen content between two countries.

A first mechanism for resolving trade barriers arising from different quality standards between two adjacent TSOs of different countries is the Network Code on Interoperability and Data Exchange Rules, which has been adopted as a Commission Regulation.[100] The Network Code prescribes the terms and conditions which adjacent transmission system operators need to cover in an interconnection agreement in respect of an interconnection point.[101] Although the list of issues which need to be addressed includes 'measurement principles for gas quantities and quality', the code emphasises that its content is without prejudice to the competence of member states to set gas quality standards and the then-ongoing work under mandate M/400.[102] In this same spirit, Article 15, dealing with cross-border trade restrictions due to gas quality differences, points to the national system operators to find a solution to such a restriction by way of, for example, swapping and co-mingling. Similarly, when the adjacent system operators fail to find a practical solution for overcoming the restriction caused by gas quality, is it for the *national* regulatory authorities to demand action.[103] This demand requires the involved system operators to cooperate and develop a cost–benefit analysis of technically feasible options, without changing the gas quality specifications, which may include flow commitments and gas treatment. The duration of these procedures may not, however, provide much relief to the shipper of a natural gas–hydrogen blend in the short term.

In conclusion to this section, in the absence of an EU norm prescribing what levels of hydrogen member states need to accept in their natural gas flows, these states maintain a high degree of discretion to set national limits. The differences between the allowed hydrogen levels in the natural gas system between countries could form an important barrier for the storage of hydrogen from renewable sources in the European gas system.

5.4 *Access to the system for hydrogen as renewable gas*

As far as access conditions to the gas system for 'green' or 'renewable' hydrogen are concerned, the 2018 successor of the 2009 Renewable Energy Directive (RED), known as REDII, establishes under Article 20(2) that member states need to require TSOs as well as DSOs to publish technical rules for network connection, including on gas quality, odorisation and pressure requirements. However, the TSOs and DSOs are regulated by the Member states. The ball would, hence, be passed back to the member states.

99 Francesco Dolci and others, 'Incentives and Legal Barriers for Power-To-Hydrogen Pathways: An International Snapshot' (2019) 44(23) International Journal of Hydrogen Energy 11394.
100 Commission Regulation (EU) 2015/703 of 20 April 2015 Establishing a Network Code on Interoperability and Data Exchange Rules, OJ L 113/12.
101 *Ibid*, art 3.
102 *Ibid*, recital 4 and 5.
103 *Ibid*, art 15(2).

As a result, REDII does very little for the establishment of an EU-wide standard for access conditions of green hydrogen to the gas system.

6. Conclusion

Clean or renewable – at the end of the day the question is not the most significant one when it comes to EU regulation on hydrogen and power-to-gas. What is more important is the interplay of legislative proposals like the new Hydrogen Strategy with the systems integration approach, and the implementation of these into EU and member state laws.

The key component here is the interplay between gas and electricity legislation. By showing the new possibilities that emerged for power-to-gas in the recast Electricity Directive and contrasting those with the uncertainties of the 'old' gas directive, it can be concluded that the EU approach of having two different legislative instruments for electricity and gas legislation, and two different paces of law-making, can no longer be sustained. At the end of the day, the use of power-to-gas as electricity storage option as part of a 'hydrogen economy' depends not only on technical innovation, but also on innovative adaptions in law.

If power-to-gas plants shall be operated with the aim to store electricity, there is the issue of overlap, namely that both the Gas Directive and the Electricity Directive govern the storage of hydrogen created by power-to-gas. This can be problematic if the rules differ from one to the other, for instance with regard to who is allowed to operate an electricity and/or gas storage facility. By reconciling and aligning provisions of the Gas Directive and the recast Electricity Directive, the EU could work towards an increased interlinkage between gas and electricity legislation.

The core energy law challenges that need to be overcome, alongside the technical challenges in the EU regulatory framework on gas, are mainly concerned with the definitions of storage and the feeding of hydrogen into the gas system. A key outcome of this research is the uncertainty that currently exists with regard to the applicability of natural gas legislation to hydrogen. Although neither the Gas Directive nor its 2019 amendment mentions the term 'hydrogen' even once, the wording of Article 1(2) of this directive is sufficiently open and ambiguous for different views on its scope.

From a hydrogen perspective, this is all calling for a bold step by the European legislator: the (system) integration of electricity and gas legislation into one unified EU energy law framework. This is not entirely alien to the fundamentals of EU energy law, as experiences in some member states show. While a number of member states still have one electricity act and one distinct gas act, some member states have taken a different approach for quite some time already. Germany, for instance, only has one Energy Industry Act (*Energiewirtschaftsgesetz*), covering both electricity and gas. While this comes at a price (an extensive number of ordinances and decrees is unavoidable in German energy law) and the complexity of such a unified future EU Energy Directive/Regulation will increase, it may be the best way forward for the EU legislator to react to our changing energy landscape. The energy transition is a task for society as a whole, and the EU legislator is no exception in this.

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