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The Regulation of Hydrogen Storage as End Use

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19.1 INTRODUCTION

Limiting global warming to 1.5 °C and reaching net zero around the middle of the century, as stipulated by the Paris Agreement, will require a swift and radical decarbonisation of energy production and consumption.[1] Achieving this goal will entail an unprecedented uptake of renewable energy sources. A progressive increase in renewable energy production is already underway, and this trajectory is expected to continue.[2] However, an increase in the share of intermittent energy sources in the overall energy mix introduces new technological and commercial challenges, which will vary depending on the sector in question.[3] While intermittent production on a small scale is not an issue, large-scale penetration of intermittent renewable energy poses technological and economic challenges that urge new types of governance approaches.[4]

In the electricity sector, a radical shift to intermittent renewable energy sources – predominantly wind and solar – means that electricity systems will need to be adjusted to take into account the increasing variability in production to ensure a reliable supply when renewable energy sources are not available.[5] While there are relatively developed technologies, such as batteries,

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[1] IPCC, H.-O. Pörtner et al. (eds.), Summary for Policymakers. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press 2022), 9–11, 31.

[2] Matthew A. Pellow and others, 'Hydrogen or batteries for grid storage? A net energy analysis', 8 *Energy & Environmental Science* (2015) 1938–1952.

[3] Elizabeth Côté and Sarah Salm, 'Risk-adjusted preferences of utility companies and institutional investors for battery storage and green hydrogen investment', 163 *Energy Policy* (2022) 112821 (hereinafter: Côté and Salm); Ahmed M. Elberry and others, 'Large-scale compressed hydrogen storage as part of renewable electricity storage systems', 46 *International Journal of Hydrogen Energy* (2021) 15671–15690 (hereinafter: Elberry et al.).

[4] Don C. Smith, 'Developing and deploying energy storage technologies: A "holy grail" effort on which the world cannot afford to fail', 39(2) *Journal of Energy & Natural Resources Law* (2021) 131–136 (hereinafter: Smith); Dennis Anderson and Matthew Leach, 'Harvesting and redistributing renewable energy: On the role of gas and electricity grids to overcome intermittency through the generation and storage of hydrogen', 32 *Energy Policy* (2004) 1603–1614 (hereinafter: Anderson and Leach).

[5] Anderson and Leach.

that can store electricity for short periods of time, medium- and long-term storage continues to be a challenge.[6]

Hydrogen storage has been presented as a potential solution to this obstacle.[7] The gas can be stored for days, weeks and even months depending on the need, and can therefore provide seasonal storage where batteries cannot.[8] The storage options are also diverse: it can be stored in pressurised gaseous or liquified forms; in tanks or as part of a chemical structure;[9] or in salt caverns, water aquifers or depleted natural gas and oil reservoirs.[10] If upscaled sufficiently, hydrogen storage could be a technological solution to remedy the material and temporal shortcomings[11] of battery technologies as well as an economic solution to flatten energy price peaks by providing supply-side flexibility.[12] In practice, hydrogen would be produced and stored when renewable electricity generation is abundant and therefore cheap, and used to supply energy when renewable sources are unavailable or scarce and therefore more expensive.[13] Moreover, producing hydrogen from renewable electricity and storing it in tanks or trailers would allow the transportation of renewable energy to places that are inaccessible by transmission or distribution lines.[14]

The promise of hydrogen storage was recognised in research nearly four decades ago,[15] and its potential in balancing the intermittency of renewables-based energy systems has been discussed for quite some time in energy research.[16] Not surprisingly, given the urgency of the low-carbon transition, hydrogen storage has recently gained significant traction in energy research across disciplines. Its potential has been investigated in the context of microgrids,[17] profitability and economic rationale,[18] different jurisdictions,[19] different economic sectors[20] and different hydrogen storage technologies,[21] as well as in comparison to other energy storage technologies.[22] This

[6] Smith, 131–136; Evan Gray and others, 'Hydrogen storage for off-grid power supply', 36 *International Journal of Hydrogen Energy* (2011) 654–663 (hereinafter: Gray et al.).

[7] Côté and Salm; Anderson and Leach, 1604; Elberry et al.; Thijs Van de Graaf and others, 'The new oil? The geopolitics and international governance of hydrogen', 70 *Energy Research & Social Science* (2020) 101667.

[8] Matthew Little, Murray Thomson and David Infield, 'Electrical integration of renewable energy into stand-alone power supplies incorporating hydrogen storage', 32 *International Journal of Hydrogen Energy* (2007) 1582–1588 (hereinafter: Little, Thomson and Infield).

[9] Anderson and Leach, 1604; Elberry et al.

[10] Naser A. Al-Mufachi and Nilay Shah, 'The role of hydrogen and fuel cell technology in providing security for the UK energy system', 171 *Energy Policy* (2022) 113286 (hereinafter: Al-Mufachi and Shah); Anderson and Leach, 1604.

[11] Elberry et al.

[12] Little, Thomson and Infield.

[13] Eduardo López González and others, 'Energy evaluation of a solar hydrogen storage facility: Comparison with other electrical energy storage technologies', 40 *International Journal of Hydrogen Energy* (2015) 5518–5525 (hereinafter: González et al.); Little, Thomson and Infield.

[14] Elberry et al.

[15] Eduard W. Justi, A *Solar-Hydrogen Energy System* (Springer 1987); Joan M. Ogden, 'Prospects for building a hydrogen energy infrastructure', 24 *Annual Review of Energy and the Environment* (1999) 227–229.

[16] Anderson and Leach; Little, Thomson and Infield.

[17] Ehsan Haghia, Kaamran Raahemifar and Michael Fowler, 'Investigating the effect of renewable energy incentives and hydrogen storage on advantages of stakeholders in a microgrid', 113 *Energy Policy* (2018) 206–222.

[18] Gunther Glenk and Stefan Reichelstein, 'Economics of converting renewable power to hydrogen', 4 *Nature Energy* (2019) 216–222.

[19] E.g. Francisco Ferrada et al., 'The role of hydrogen for deep decarbonization of energy systems: A Chilean case study', 177 *Energy Policy* (2023) 113536; Little, Thomson and Infield (United Kingdom); Gray et al. (Australia); González et al. (Spain).

[20] E.g. aviation. See Yuekuan Zhou, 'Low-carbon transition in smart city with sustainable airport energy ecosystems and hydrogen-based renewable-grid-storage-flexibility', 1 *Energy Reviews* (2022) 100001.

[21] Elberry et al.

[22] González et al.

range and depth of interest notwithstanding, a host of technological and commercial questions remain unexplored.

This chapter examines the legal governance of hydrogen storage by evaluating the typical legal challenges and opportunities of using hydrogen storage to balance the intermittency of renewable energy sources in the low-carbon energy transition. To demonstrate how these questions can be governed through a transnational legal framework, the analysis focuses on the European Union's (EU) legal solutions for electricity and hydrogen. The EU provides an illustrative case, as its approaches to hydrogen have developed dramatically in recent years. The measures taken or proposed will all change the legislative scenery for hydrogen and hydrogen storage.[23] These include the hydrogen-specific strategy published in 2020;[24] the Fit for 55 package, proposed by the Commission in 2021; the Hydrogen and Decarbonised Gas Market package (Gas Package) proposed later that year; and the legal responses adopted to the Russian invasion of Ukraine in 2022 and 2023. While the earlier EU legal frameworks for hydrogen storage have been discussed in legal scholarship,[25] the literature lacks comprehensive analyses of these more recent legal and policy tools.

The remainder of the chapter is structured as follows. Section 19.2 discusses the legal challenges and opportunities of using hydrogen as energy storage. Here, the analysis takes an end-use-neutral approach; that is, it examines the legal governance of hydrogen storage in the form of power-to-gas irrespective of the purpose for which it is used after storage.[26] Section 19.3 focuses on EU law and policy as a case study to ascertain the applicable legal framework for hydrogen storage. Section 19.4 then identifies the approaches taken through the proposed legislative instruments and probes the gaps that still remain in the existing EU legal framework. Section 19.5 concludes with key insights from the analysis.

19.2 LEGAL CHALLENGES AND OPPORTUNITIES OF USING HYDROGEN AS AN ENERGY STORAGE MEDIUM

Any emerging technological innovation in the energy sector is likely to invite new types of legal questions; these will vary depending on the type of technology and energy carrier and the

[23] European Commission, 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, COM (2021) 550 final and in literature Kaisa Huhta, 'The "Fit for 55"-package in the Context of EU Energy Law and Policy', *OGEL* (2022); European Commission, Proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen, COM(2021) 803 final (hereinafter: proposed Gas Directive); European Commission, Proposal for a Regulation of the European Parliament and of the Council on the internal markets for renewable and natural gases and for hydrogen (recast), COM(2021) 804 final (hereinafter: proposed Gas Regulation).

[24] European Commission, A hydrogen strategy for a climate-neutral Europe, COM(2020) 301 final (hereinafter: Hydrogen Strategy).

[25] Francesco Dolci and others, 'Incentives and legal barriers for power-to-hydrogen pathways: An international snapshot', 44 *International Journal of Hydrogen Energy* (2019) 11394–11401; Moritz Wüstenberg, 'Regulating the future hydrogen trade in the EU: WTO law considerations', 41 *Journal of Energy & Natural Resources Law* (2023) <http://doi.org/10.1080/02646811.2023.2165315>; Ruven Fleming and Gijs Kreeft, 'Power-to-Gas and Hydrogen for Energy Storage under EU Energy Law', in Martha M. Roggenkamp and Catherine Banet (eds.), *European Energy Law Report* (Vol. XIII, Intersentia 2020), pp. 101–124 (hereinafter: Fleming and Kreeft); Ruven Fleming and Joshua P. Fershee, 'The "Hydrogen Economy" in the United States and the European Union Regulating Innovation to Combat Climate Change', in D. Zillman, L. Godden, L. Paddock and M. Roggenkamp (eds.), *Innovation in Energy Law and Technology: Dynamic Solutions for Energy Transitions* (Oxford University Press 2018), pp. 137–153; Ruven Fleming, 'Clean or renewable – Hydrogen and power-to-gas in EU energy law', 39(1) *Journal of Energy & Natural Resources Law* (2021) 43–63 (hereinafter: Fleming 2021).

[26] Similarly in Fleming and Kreeft, 101–124.

jurisdiction in which they are governed. This is particularly true for hydrogen storage, the technologies for which vary,[27] some being more emergent than others.[28] While a detailed analysis of the variety of legal questions that figure in the case of different hydrogen storage technologies[29] is beyond the scope of this chapter, it should be acknowledged that the choice of storage technology naturally influences the legal questions that may arise. For example, for a technology located deep underground the environmental permit processes or the safety requirements are likely to be different compared to those for a hydrogen storage facility sited in a residential area. Similarly, the jurisdiction in which the hydrogen storage is located may well determine the pertinent legal issues to be addressed. A region with an extensive natural gas infrastructure and a commensurately robust legislative framework is likely to encounter legal issues relating to the applicability of the existing legal framework to hydrogen storage whereas a jurisdiction with no natural gas infrastructure and no existing legal framework is likely to deal with very different issues.

Generally speaking, most jurisdictions do not have a legislative framework specific to hydrogen (storage), or such a framework is emergent at best.[30] The applicable legal framework for natural gas is often expected to cover key issues of hydrogen storage, and may present a significant opportunity for finding synergies between natural gas and hydrogen laws.[31] However, in the absence of a gas-specific governance framework applicable to hydrogen, the legislative framework relevant for hydrogen storage is likely to not only draw on legal frameworks for electricity and natural gas but also to tap legal fields beyond energy law, such as environmental law, administrative law or contract law. In what follows, four areas of law are presented which may offer relevant and applicable rules for hydrogen storage yet, at the same time, create challenges: financial incentives, spatial planning, environmental and administrative permitting, ownership and access.

Hydrogen storage requires considerable investments in what are often only nascent technologies and, in most if not all jurisdictions, are not comprehensively governed by legislative frameworks explicitly designed to incentivise investments financially. This being the case, legal and policy frameworks may undermine one another and frustrate efforts to provide a stable and supportive investment environment for hydrogen storage. For example, while a hydrogen policy instrument or a strategy may state that hydrogen storage is a key goal that must be incentivised, the legal framework might in practice disincentivise the pursuit of the very same goal. EU energy policy, for instance, presents hydrogen storage technologies as an important decarbonisation instrument, but under EU energy law hydrogen storage operators are taxed twice: they are taxed when they use electricity to produce hydrogen storage and when they inject power back into the grid.[32] This legislative setting, also referred to as double taxing or double charging, has been cited by industry and in previous energy research as a significant barrier, discouraging investment in hydrogen storage.[33] By the same token, creating optimal legal and policy frameworks to ensure sufficient investment in hydrogen storage has been identified as a key legal issue.[34]

[27] For a detailed examination, see Mehmet Sankir and Nurdan Demirci Sankir, *Hydrogen Storage Technologies* (Wiley 2018).

[28] Elberry et al.

[29] Anderson and Leach, 1604; Elberry et al.; Al-Mufachi and Shah.

[30] Dalia Majumder-Russell, *Hydrogen Projects: Legal and Regulatory Challenges and Opportunities* (Globe Law and Business, 2021) (hereinafter: Majumder-Russell).

[31] *Ibid.*

[32] David Parra and Romain Mauger, 'A new dawn for energy storage: An interdisciplinary legal and techno-economic analysis of the new EU legal framework', 171 *Energy Policy* (2022) 113262 (hereinafter: Parra and Mauger).

[33] Parra and Mauger. The proposed energy tax directive is expected to change this setting, but it had not yet entered into force at the time of writing (1 August 2023). European Commission, Proposal for a Council Directive restructuring the Union framework for the taxation of energy products and electricity (recast), COM(2021) 563 final.

[34] Côté and Salm.

The second challenge is spatial planning. Its effects, again, depend heavily on the particular hydrogen storage technology used and the jurisdiction in which the planning takes place. In any event, land rights must generally be secured to gain access to privately owned land.[35] This might take place through voluntary contracts or through statutory acquisition rules depending on the situation and the jurisdiction. Furthermore, the extent to which land ownership rights reach below ground varies between jurisdictions.[36]

Third, in a consideration inherently connected to spatial planning, environmental and administrative permit processes are likely to influence the attractiveness and feasibility of hydrogen storage projects. These concerns are similar to those affecting any energy technology: its environmental impact, safety and location are subject to legal requirements that may or may not make pursuing the project too costly, too time-consuming, or both.

Finally, ownership and access have been cited as key issues that may create challenges for hydrogen storage.[37] It has been rightly pointed out that the ownership of energy storage facilities is a critical question for the development of hydrogen storage projects.[38] Specifically, the question of who is allowed to own hydrogen storage arises in connection with unbundling rules, which require the separation of network activities from those of production and supply. Robust and clear rules are needed to establish whether it is network operators, energy producers, or both, that are allowed to own hydrogen storage. The following section analyses how these potential opportunities and challenges have played out in the context of the EU legal framework.

19.3 REGULATING HYDROGEN STORAGE IN THE EU

19.3.1 *Applicable Policy and Legal Framework*

The EU's Hydrogen Strategy[39] and the Energy System Integration Strategy[40] view hydrogen energy storage as having several interrelated functions in the European energy system. One is that it stands to increase the flexibility of the energy system. Specifically, it provides an offloading option for renewable energy during times of abundant supply and additional generation capacity during times of scarcity. This in turn accommodates the changing needs of the grid and enables the energy system to manage the variability and uncertainty of demand and supply across all relevant timescales.[41] Furthermore, the two strategies point out that the buffering function of hydrogen has benefits that go beyond mere energy storage. As hydrogen can be stocked and transported, it can be used to transport stored energy across regions. It also makes it possible to connect different energy markets and end-use sectors as well as to reprice energy in specific hydrogen markets.[42] To realise these aspirations, the strategies point towards numerous regulatory issues, ranging from enforcing the implementation of existing energy market legislation to removing regulatory barriers and drafting a dedicated regulatory framework for hydrogen.

35 Majumder-Russell, 47.

36 Jean Howell, '"Subterranean land law": Rights below the surface of land', 53 *Northern Ireland Legal Quarterly* (2002) 268. Also see Madeline Taylor's chapter in this book (Chapter 5).

37 Parra and Mauger.

38 *Ibid.*

39 See Hydrogen Strategy.

40 European Commission, Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM (2020) 299 final (hereinafter: Energy System Integration Strategy).

41 Commission Staff Working Document, Energy storage – Underpinning a decarbonised and secure EU energy system, SWD(2023) 57 final, 5 (hereinafter: Commission Staff Working Document).

42 Hydrogen Strategy, 1, 6, 14; Energy System Integration Strategy, 4, 12.

Furthermore, the Hydrogen Strategy notes that the deployment of hydrogen storage will require supportive policies and legislation as well as private and public funding for the required investments.[43]

In the EU electricity legislation, the most important provisions for hydrogen storage are found in the Electricity Directive[44] and Electricity Regulation.[45] These legislative acts lay down rules on who can own and operate energy storage and how grid charges are established. The applicability of these substantive provisions hinges on the definition of energy storage. The Electricity Directive provides the following definitions relating to energy storage:

> Energy storage means, 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.[46] . . .
>
> Energy storage facility means, in the electricity system, a facility where energy storage occurs.[47]

Hydrogen storage fits well within the definition of energy storage when all three phases – conversion of electricity into hydrogen, storing the hydrogen produced and reconverting it into electricity – are carried out within a single facility.[48] However, as hydrogen can be transported and stored, each of these phases can be carried out independently of each other in separate facilities and even by different operators. It is therefore less clear whether facilities that only take part in one or two of these phases should be considered energy storage facilities.[49] In this regard, the Directive is clear only to the extent that reconversion is not necessary for an operation or facility to be classified as energy storage. In other words, a facility where electricity is converted into hydrogen can be classified as an energy storage facility even if the hydrogen is not reconverted later.[50] The Directive provides less guidance for the other possible combinations of these phases. For instance, it is unclear whether a combined hydrogen storage and electricity generation facility would be considered an energy storage facility or a normal electricity generation facility.[51]

There are several groups of actors that may be interested in operating hydrogen storage facilities, such as electricity generators, electricity transmission and distribution system operators (network operators), independent energy storage facility operators and electricity customers. In general, the electricity legislation sees energy storage as a competitive market-based activity, meaning that market participants are generally allowed to own and operate energy storage facilities but electricity network operators are usually prohibited from doing so.[52] Although network operators might be interested in running energy storage facilities to fulfil their tasks under the Directive, the electricity market legislation would prefer that they procure storage

[43] Hydrogen Strategy, 8–9, 15; Energy System Integration Strategy, 12—18.

[44] 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, OJ L 158, 14 June 2019, 125–199 (hereinafter: Electricity Directive).

[45] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity, OJ L 158, 14 June 2019, 54–124 (hereinafter: Electricity Regulation).

[46] Electricity Directive, Article 2(59).

[47] *Ibid.*, Article 2(60).

[48] Fleming 2021, 51; Fleming and Kreeft, 107–108.

[49] Fleming 2021, 51; Fleming and Kreeft, 109.

[50] Fleming 2021, 51; Fleming and Kreeft, 108–109.

[51] Fleming 2021, 51; Fleming and Kreeft, 108–109

[52] Commission Staff Working Document, 19; Fleming 2021, 56–59; Fleming and Kreeft, 114–117.

services from the competitive market.[53] Nevertheless, the Directive provides some exceptions to these prohibitions.[54]

Although the Electricity Regulation lays down the general provisions constituting the framework for establishing grid charges, it does not provide unequivocal guidance as to whether double grid charges should be abolished. What is more, the other relevant legal instruments provide only a few limited clarifications on this issue: the Electricity Directive provides that active customers must not be subject to double charges for stored energy remaining within their premises or when providing flexibility services to the system operator;[55] and the Renewable Energy Directive (RED) has a similar provision pertaining to renewables self-consumers.[56] Beyond these, one finds only a general provision in the Electricity Regulation stipulating that network charges should not discriminate positively or negatively against energy storage.[57] Interestingly, this provision has been interpreted as both justifying the imposition of double charges and abolishing them. Since energy storage operators both consume and produce electricity, potentially using the grid twice, it can be argued that the prohibition of positive discrimination requires charging energy storage operators twice. The opposite view is that the operation of energy storage provides benefits to the grid, and therefore avoiding negative discrimination requires charging the energy storage operator only once.[58] Some Member States have imposed double grid charges whereas others have not, and some have set up special tariff structures to accommodate energy storage.[59]

19.3.2 *Storing Renewable Energy in Hydrogen*

One of the main drivers behind deploying hydrogen storage in the EU is to integrate renewable energy into the energy system. The bulk of the legal framework geared to supporting renewable energy in the EU is set out in the RED.[60] In particular, the Directive provides three main features underpinning the storage of renewable energy with hydrogen technologies: it defines what is considered renewable energy, including renewable hydrogen and renewable electricity; provides basic rules for issuing guarantees of origin; and sets targets for renewable energy consumption.[61] At the time of writing, the Directive is under review, with numerous proposed amendments to its provisions relating to hydrogen and energy storage. The EU's co-legislators have agreed on the text of the amendments, and while not yet formally adopted,[62] the revised Directive (RED III) is discussed where appropriate in what follows.

[53] Electricity Directive, Articles 31–32, 36(1) 40, and 54(1), and Recital 62.

[54] Ibid., Articles 2(51), 36(2) and 54(2). See also Parra and Mauger, 7–8; Fleming 2021, 56–58; Fleming and Kreeft, 115–117.

[55] Electricity Regulation, Article 15(5).

[56] Article 21(2) of 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, OJ L 328, 21 December 2018, 82–209 (hereinafter: RED).

[57] Electricity Regulation, Article 18(1).

[58] Parra and Mauger, 8.

[59] Commission Staff Working Document, 28; ENTEC, Study on Energy Storage. Publications Office of the European Union, 2023 <https://data.europa.eu/doi/10.2833/333409> accessed 8 November 2024 (hereinafter: ENTEC Study on Energy Storage), 138, 141.

[60] RED, Article 1. For an example of a sub-target, see Article 25 of the Directive.

[61] RED, Articles 2(1) and 2(12). See also Fleming 2021, 47–49.

[62] See European Parliament legislative resolution of 12 September 2023 on the proposal for a directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European

The RED recognises that hydrogen produced from renewable electricity can be considered a form of renewable energy and that its renewable qualities can be certified through guarantees of origin.[63] A guarantee of origin is a document that is used to show the final customer that a given share of the energy supplied to it has been produced from renewable sources. Guarantees of origin can be traded independently of the energy to which they pertain, meaning that they essentially serve as evidence of renewable energy.[64] Indeed, this is the sole function of guarantees of origin, and the system plays no role in calculating the attainment of different renewable energy targets under the RED.[65]

Rather than using guarantees of origin, the attainment of the different renewable energy targets is calculated using the rules provided in the RED. The rules for what are known as 'renewable fuels of non-biological origin' have become particularly important in the case of renewable hydrogen, as they set out how renewable electricity for hydrogen production needs to be sourced if the hydrogen produced is to be considered renewable.[66] The main principles informing these rules are set out in the Directive and further detailed in what is known as the Additionality Regulation.[67] These rules aim to ensure that the electricity used for the production of hydrogen is renewable and that the production of hydrogen leads to emissions reductions and increased deployment of renewable electricity generation.[68] Strictly speaking, the rules only apply to calculating whether the renewable energy targets under the Directive are achieved.[69] However, in practice other instruments, such as state aid guidelines, refer to the calculation rules, widening their actual scope of application.[70]

The RED and the Additionality Regulation provide different calculation rules for different circumstances. The rules frequently use the so-called additionality, temporal correlation and geographical correlation criteria. In brief, additionality criteria require that the electricity for hydrogen production is sourced from new installations.[71] Temporal and geographical correlation criteria stipulate that hydrogen is produced at times and in places where renewable electricity is available.[72]

When the electrolyser and electricity generation facilities are connected by a direct line, the calculation rules allow for the hydrogen produced to be considered renewable if certain additionality criteria are met.[73] Hydrogen produced from grid electricity can be deemed entirely

Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 (hereinafter: RED III).

63 RED, Article 19(7). See also Fleming and Kreeft, 105–106; Ruven Fleming, 'The Hydrogen Revolution and Natural Gas: A New Dawn in the European Union?', in Damilola Olawuyi and Eduardo Pereira (eds.), *The Palgrave Handbook of Natural Gas and Global Energy Transitions* (Palgrave MacMillan 2022) pp. 123–140, 132–133 (hereinafter: Fleming 2022).

64 RED, Article 19(7). See also Fleming and Kreeft, 105–106; Fleming 2022, 132–133.

65 RED, Article 19(2).

66 *Ibid.*, Article 27(3) (Article 27(6) RED III).

67 *Ibid.* Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin, OJ L 157, 20 June 2023, 11–19 (hereinafter: Additionality Regulation).

68 RED, Recital 90.

69 See ibid., Article 27(3) (Article 27(6) RED III).

70 See e.g. paragraph 19(70) in European Commission, Guidelines on state aid for climate, environmental protection and energy 2022, C/2022/481, OJ C 80, 18 February 2022, 1–89 (hereinafter: CEEAG).

71 RED, Article 27(3), subparagraph 5 (Article 27(6), subparagraph 2 RED III); Additionality Regulation, Article 3 subparagraph 2 point b and Article 5.

72 See Additionality Regulation, Recital 8 and Articles 6–7.

73 *Ibid.*, Article 3. The article also applies to co-located renewable electricity and hydrogen production.

renewable if the electricity is sourced from installations generating renewable energy and the additionality, temporal correlation and geographical correlation criteria are met.[74] However, in some circumstances it is not necessary to meet the three sets of criteria for the hydrogen produced to be considered renewable. There are two situations where none of the criteria need to be met and one situation where the additionality criteria do not apply. First, hydrogen produced from grid electricity is considered entirely renewable when it is produced during a period of oversupply of electricity and the energy stored enables the use of renewable electricity to a greater extent than would otherwise be possible.[75] Second, there are specific calculation rules, which are not subject to the three sets of three criteria, for the production of hydrogen from grid electricity in bidding zones where the proportion of renewable energy in the electricity mix exceeds 90 per cent.[76] Finally, it is not necessary to comply with the additionality criteria if the hydrogen is produced in a bidding zone where the emission intensity of electricity is below a certain threshold. In this case, the hydrogen produced is considered fully renewable if the electricity used is sourced from renewable sources and the geographical and temporal correlation criteria are met.[77]

Although clear rules for converting renewable electricity into renewable hydrogen are in place, the RED does not consider electricity generated from renewable hydrogen as renewable energy. According to the Directive's definition, electricity is considered renewable when it is generated from renewable sources; yet even though the energy content of renewable hydrogen is derived from renewable sources, hydrogen is considered an energy carrier rather than an energy source.[78] Consequently, electricity that is produced from renewable hydrogen cannot be considered renewable energy. Furthermore, the provisions on guarantees of origin make no references to energy storage or the option of granting guarantees to electricity produced from renewable hydrogen.[79] However, there have been attempts to circumvent this obstacle in the context of energy storage.[80]

19.3.3 *State Aid for Hydrogen Storage*

Member States may want to facilitate and accelerate the deployment of hydrogen storage by granting financial support from public funds. In the EU, such support is usually considered state aid, which the Member States are generally prohibited from providing, although there are extensive exceptions to this rule.[81] In practice, Member States must notify the Commission of their intention to grant state aid, after which the Commission assesses the measure and approves or prohibits it.[82] Most importantly, the Commission may decide to allow Member States to grant aid that facilitates the development of certain economic activities, including those in the energy sector, provided that the aid does not affect trading conditions in the EU too negatively.[83] The notification of a measure to the Commission by a Member State and subsequent assessment by

74 RED, Article 27(3), subparagraph 6 (Article 27(6), subparagraph 3 RED III); Additionality Regulation, Article 4(4).
75 Additionality Regulation, Article 4(3).
76 *Ibid.*, Article 4(1).
77 *Ibid.*, Article 4(2).
78 See Article 2(1) RED.
79 *Ibid.*, Article 19(7)(a). See also ENTEC Study on Energy Storage, 149–152.
80 E.g. in Austria. See ENTEC Study on Energy Storage, 153–154.
81 Article 107 of the Consolidated version of the Treaty on the Functioning of the European Union, OJ C 326, 26 October 2012, 47–390 (hereinafter: TFEU).
82 *Ibid.*, Article 108(3).
83 *Ibid.*, Article 107(3)(c).

the Commission of the measure take place under the rules provided in the General Block Exemption Regulation (GBER)[84] and the Commission Guidelines on State Aid for Climate, Environmental Protection and Energy (CEEAG).[85] The GBER exempts aid measures from notification and assessment if certain general conditions are met – such as not exceeding the maximum thresholds for the amount of aid provided – and if the measure meets the category-specific criteria laid down in the Regulation. Measures that are not exempted from notification are individually assessed by the Commission under the CEEAG.[86]

The GBER exempts several categories of aid from notification and assessment, including investment aid for projects that are considered energy infrastructure. This category includes aid for large underground hydrogen storage facilities that are subject to tariff regulation and third-party access rules, as well as energy storage facilities owned by electricity network operators.[87] The category also includes aid for hydrogen storage projects that are identified as Projects of Common Interest under the Trans-European Energy Networks Regulation.[88] Also exempt from notification under the GBER is aid for behind-the-meter electricity and hydrogen storage when these are deployed together with renewable electricity generation or renewable hydrogen production.[89]

The catch-all category under which aid for most types of hydrogen energy storage projects is assessed is section 4.1 CEEAG. The section lays down specific rules for assessing aid for the reduction of greenhouse gas emissions. Most importantly, it applies to support schemes for energy storage when their primary objective is to reduce emissions, for example by facilitating the incorporation of a higher share of renewable energy in the energy system.[90] In addition, section 4.1 covers hydrogen storage infrastructure that is combined with energy production or use. Finally, it acts as a fall-back category for 'dedicated infrastructure projects'[91] that are 'built for one or a small group of ex ante identified users and tailored to their needs'[92] and do not fall within the definition of energy infrastructure (assessed under section 4.9 CEEAG).[93] These could include smaller hydrogen storage installations that have a limited number of users. Aid schemes for hydrogen energy storage may also be assessed under section 4.8 CEEAG when the energy storage is primarily used for ensuring the security of electricity supply.[94]

In response to the coronavirus pandemic after 2019 and the escalation of the Russo-Ukrainian war in 2022, the general state aid framework discussed above has been complemented with

[84] Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty Text with EEA relevance OJ L 187, 26 June 2014, 1–78 (hereinafter: GBER).

[85] See CEEAG.

[86] On state aid generally in the energy sector, see Leigh Hancher and Francesco Maria Salerno, 'State Aid in the Energy Sector', in Leigh Hancher and Juan Jorge Piernas López (eds.), *Research Handbook on European State Aid Law* (2nd ed., Edward Elgar 2021) pp. 64–86, especially 79–84.

[87] GBER, Articles 2(130)(c) and 48; CEEAG, points 19(36) and 376 and nn. 27, 28 and 142.

[88] GBER, Article 2(130)(f); CEEAG, para. 19(36)(f). Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No. 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No. 347/2013, OJ L 152, 3 June 2022, 45–102.

[89] GBER, Article 41.

[90] CEEAG, para. 83.

[91] *Ibid.*, para. 84.

[92] *Ibid.*, n. 27.

[93] *Ibid.*, para. 84.

[94] *Ibid.*, para. 326.

temporary crisis measures.[95] Specifically, the Commission's state aid guidance now includes the Temporary Crisis and Transformation Framework,[96] which was adopted in March 2022 and has been amended several times.[97] The latest version of the Framework includes specific sections on accelerating the rollout of renewable energy, expanding electricity storage and promoting storage of renewable hydrogen. These sections provide assessment criteria for investments and operating aid for electricity that are simpler and less stringent than those under the CEEAG. The Framework is applicable to aid measures granted by the end of 2025 and implemented by the end of 2028.[98]

19.4 GAPS AND FUTURE DIRECTIONS IN THE EU

As seen above, while the current EU legislative framework addresses numerous regulatory issues that affect hydrogen electricity storage, it still has unclear provisions and gaps and can be described as emergent. Many of the gaps and issues will be addressed by the ongoing legislative projects, which are expected to enter into force in the coming years. Most importantly, the Gas Package will provide a specific regulatory framework for hydrogen infrastructure and mark a complete overhaul of major legislative instruments.[99] Planning and permitting issues have recently become a key theme in the EU's energy policy debate and RED III will amend the Renewable Energy Directive to address these concerns.[100] What follows gives a brief overview of how these developments stand to affect hydrogen storage.

The questions of whether, how and to what extent the current EU gas legislation applies to hydrogen storage have been discussed in the literature.[101] The main consequence of applying gas legislation to hydrogen storage would be having to decide whether ownership unbundling and third-party access rules apply to facilities storing hydrogen.[102] To summarise this discussion, the scope of application of gas legislation to hydrogen energy storage is unclear, and depends on the specifics of the storage facility and the interpretation of the gas legislation.[103] The proposed recast Gas Directive[104] and Regulation[105] aim to improve this situation by establishing separate

[95] European Commission, State aid: Commission sets out future of Temporary Framework to support economic recovery in context of coronavirus outbreak, 18 November 2021 <https://ec.europa.eu/commission/presscorner/detail/en/ip_21_6092> accessed 8 November 2024; European Commission, State aid: Commission adopts Temporary Crisis Framework to support the economy in context of Russia's invasion of Ukraine, 23 March 2022 <https://ec.europa.eu/commission/presscorner/detail/en/statement_22_1949> accessed 8 November 2024.

[96] European Commission, Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia, 2023/C 101/03, OJ C 101, 17 March 2023, 3–46 (hereinafter: TCTF).

[97] European Commission, State aid: Commission adopts Temporary Crisis and Transition Framework to further support transition towards net-zero economy, 9 March 2023 <https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1563> accessed 8 November 2024.

[98] TCTF, section 2.5 and n. 107.

[99] In general, see European Commission, Hydrogen and decarbonised gas market package <https://energy.ec.europa.eu/topics/markets-and-consumers/market-legislation/hydrogen-and-decarbonised-gas-market-package_en> accessed 8 November 2024.

[100] In general, see European Commission, Enabling framework for renewables <https://energy.ec.europa.eu/topics/renewable-energy/enabling-framework-renewables_en> accessed 8 November 2024.

[101] See Fleming and Fershee, 147–150; Fleming 2021, 51–53; Fleming and Kreeft, 109–114; Fleming 2022, 133–134.

[102] See Articles 15, 26, and 31–33 of Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, OJ L 211, 14 August 2009, 94–136.

[103] Fleming and Fershee, 147–150; Fleming 2021, 51–53; Fleming and Kreeft, 109–114; Fleming 2022, 133–134.

[104] See proposed Gas Directive.

[105] *Ibid.*

legal frameworks for hydrogen and natural gas, clarifying which rules apply to hydrogen infrastructure and which apply to mainly methane-based natural gas infrastructure.[106]

The proposed gas legislation aims to apply third-party access rules to large underground hydrogen storage facilities.[107] This reflects the current situation, in which storage in salt caverns is the only proven technology for large-scale hydrogen storage. Yet only a limited number of appropriate geological formations exist and they are located unevenly among the Member States, resulting in a need to regulate access to the storage sites.[108] The proposed Gas Directive defines a 'hydrogen storage facility' as a large facility stocking hydrogen at a high grade of purity. According to the definition, the qualifier 'large' refers in particular to large-scale underground storage and excludes smaller, easily replaceable storage installations.[109] Read together with the proposal's background, the definition encompasses large-scale underground storage and excludes all other types of storage installations. After the Directive enters into force, Member States will be required to ensure that a strict system of regulated third-party access to hydrogen storage facilities is applied.[110] This differs from the regulation of natural gas storage facilities, which gives Member States a choice between applying a negotiated or a regulated third-party access regime.[111] However, the proposed gas legislation also includes several exemptions to third-party access rules.[112]

The proposed Gas Directive would also lay down horizontal and vertical unbundling rules for hydrogen storage and network operators. The proposed directive does not consider hydrogen storage facilities to be part of hydrogen networks and therefore sets out separate sets of rules for hydrogen storage operators and hydrogen network operators.[113] The vertical unbundling rules are intended to separate operating hydrogen storage from hydrogen production and network operations. Most importantly, hydrogen storage operators that are part of a vertically integrated undertaking would need to be independent of unrelated activities, including the production of hydrogen. As a result, operators of large-scale hydrogen facilities could not operate hydrogen production facilities.[114] In turn, horizontal unbundling rules restrict hydrogen network operators from operating electricity and natural gas networks. However, only account unbundling rules would apply to hydrogen storage facilities; that is, hydrogen and natural gas undertakings would need to keep separate accounts for hydrogen storage and other activities as if these were being carried out by separate undertakings.[115]

Recent developments have heightened the importance of addressing planning and permitting issues at the EU level. The escalation of the Russo-Ukrainian War in 2022 prompted the EU to quickly reduce its dependence on Russian energy imports and accelerate the energy transition. As a follow-up, the EU institutions adopted several emergency measures to expedite and

[106] *Ibid.*, Articles 1 and 2(1). See also Ruven Fleming, 'Hydrogen Networks: Networks of the Future?', in Ruven Fleming and others (eds.), *A Force of Energy – Essays in Energy Law in Honour of Professor Martha Roggenkamp* (University of Groening Press 2022), pp. 121–130, 124–128.
[107] Proposed Gas Directive, Article 33.
[108] *Ibid.*, Recital 72. See also pp. 10, 38, Table 35 in SWD(2021) 455 final.
[109] Proposed Gas Directive, Article 2(6).
[110] *Ibid.*, Article 33.
[111] See *Ibid.*, Articles 29 and 33.
[112] E.g. *Ibid.*, Article 60.
[113] *Ibid.*, Articles 2(6), 2(20), 2(22), 42, 56, 62–65, 67, and 69.
[114] *Ibid.*, Articles 2(37), 56 and 67.
[115] *Ibid.*, Articles 63–64 and 69. For further detail, Lavinia Tanase and Ignacio Herrera Anchustegui, 'EU Hydrogen and the Decarbonized Gas Market Package: Unbundling, Third-Party Access, Tariffs and Discounts Rules at the Core of Transport of Hydrogen', 11–12 <https://ssrn.com/abstract=4431113> accessed 8 November 2024.

streamline the permitting of renewable energy projects.[116] The Commission then went on to propose amending the RED to include stronger rules on spatial planning and permitting for renewable energy projects. These amendments have been incorporated into RED III. Under the Directive, Member States will have to identify and designate areas well suited for renewable energy projects as 'renewables acceleration areas'.[117] The provisions on such areas also apply to what is known as co-located energy storage, which is defined as 'an energy storage facility combined with a facility producing renewable energy and connected to the same grid access point'.[118] To support and complement renewables acceleration areas, Member States may also designate dedicated infrastructure areas for the development of grid and storage projects that are necessary to integrate renewable energy into the electricity system.[119] These areas are selected with environmental considerations in mind to enable a simplified environmental assessment when considering individual projects in them.[120]

RED III will also require Member States to streamline permitting procedures. They will have to establish maximum limits on the duration of the permitting procedures and designate contact points to facilitate the permit-granting process and guide applicants. The rules on streamlining procedures will apply to projects located in the renewables acceleration areas and elsewhere, but the Directive will impose stricter time limits and other requirements for projects within acceleration areas.[121] Finally, RED III includes an article on the principle of overriding public interest. The principle provides that when balancing legal interests in individual cases, renewable energy projects, including storage assets, are presumed to be in the overriding public interest and to serve public health and safety. This presumption enables the projects to benefit from derogations under certain instruments of EU environmental legislation.[122]

19.5 CONCLUSIONS

This chapter has analysed the legal approaches to hydrogen storage with particular reference to electricity and renewable electricity. It has reviewed the legal challenges and opportunities of using hydrogen as an energy storage medium and examined the definition of end use in this context; the focus throughout has been on the legal questions that emerge in using hydrogen as a storage medium to balance the intermittency of renewable energy sources in the low-carbon energy transition. To concretise the analysis with examples from a specific jurisdiction, the chapter explored the EU legal frameworks for electricity and hydrogen storage and demonstrated how the EU legal framework handles financial incentives, spatial planning, environmental and administrative permitting, as well as ownership and access issues.

The analysis has revealed that many of the issues in the existing legislative framework for hydrogen are often definitional: they hinge on whether or not, or to what extent, the existing

116 European Commission, Recommendation on speeding up permit-granting procedures for renewable energy projects and facilitating Power Purchase Agreements, C/2022/3219 final, especially paras. 2–7; European Commission, Guidance to Member States on good practices to speed up permit-granting procedures for renewable energy projects and on facilitating Power Purchase Agreement, SWD(2022) 149 final, especially Section 6(b). Council Regulation (EU) 2022/2577 of 22 December 2022 laying down a framework to accelerate the deployment of renewable energy, OJ L 335, 29 December 2022, 36–44.
117 RED III, Article 15c.
118 *Ibid.*, Article 2(44d).
119 *Ibid.*, Article 15e.
120 *Ibid.*, Articles 15b, 15c, 15e and 16a.
121 *Ibid.*, Articles 16, 16a–16d.
122 *Ibid.*, Article 16f.

rules on natural gas, electricity and renewable energy apply to hydrogen storage. It is clear that the EU legal framework still suffers from a number of gaps and challenges posing obstacles to effectively advancing the uptake of hydrogen storage. However, the analysis on the future directions clearly shows that the EU policy instruments widely recognise these shortcomings and that recent or upcoming legal instruments are likely to bridge many of the gaps identified or at least clarify the status quo. Nevertheless, the interpretation of the recent, and especially the proposed, pieces of legislation has not yet been tested in EU courts, whereby it will take years before the interpretation of the new legislative framework can be considered settled.

Overall, it is clear that the increasing ambition of EU climate measures and the proposed Gas Package alone have placed unprecedented pressures on hydrogen storage to serve as a storage medium in a low-carbon energy system. This fundamental change, combined with the legislative changes brought about by the COVID-19 pandemic and the Russo-Ukrainian war, has further increased the pressure to develop the EU legislative framework to adequately govern hydrogen energy storage.

FURTHER READING

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