1

Introduction

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1.1 INTRODUCTION

Werner Franz, a fourteen-year-old German cabin attendant, was off to a good start on 6 May 1937. At midday he saw New York passing by beneath his feet – the Big Apple. Despite a detour of three hours to avoid a thunderstorm, the airship embarked on an early evening landing at Lakehurst, New Jersey. Passengers were already able to see friends and relatives on the landing field, awaiting their arrival.[1] But all of a sudden Werner Franz witnessed a 'huge bang and strong vibration in the airship'.[2] As the Hindenburg burst into flames, Werner Franz jumped off the airship from about four or five metres, walked under the ship and ran out the other side.[3] Magically he, together with sixty-one of the ninety-seven people aboard the airship, survived the disaster. But he remained traumatized for months to come. What caused the explosion of the Zeppelin Hindenburg was, most likely, sparks from a static charge that loaded the newly repainted outer cover of the airship. The sparks occurred when the landing rope was dropped, igniting 200,000 cubic metres of hydrogen.[4]

Fast forward eighty-six years: by the end of September 2023, the Director of IRENA, the International Renewable Energy Agency, Francesco La Camera, underlined in a speech on the future of renewables that 'rapid green hydrogen scale-up lies on a systemic innovation approach beyond technology, which means we need innovative regulatory and policy frameworks, finance, and business models'.[5] Be clear about the significance – this is the Director of the World's Agency on renewables strongly advocating for a comprehensive and holistic roll-out of hydrogen – the very substance that lay at the heart of one of the biggest disasters in civil aviation. How did we end up here?

One could have expected a ban on hydrogen after the Hindenburg disaster, but instead, we kept using hydrogen over the following eighty-six years. In the 1970s, a hype around hydrogen as

Parts of this chapter benefited from the research done by Ms. Kelsey Pailman, to whom I am indebted for her help.

[1] Focus 'Am 6. Mai 1937 wird der Zeppelin LZ 129 "Hindenburg" bei einer Landung zerstört' <https://focus.de/wissen/videos/1937-die-katastrophe-der-hindenburg-am-6-mai-1937-wird-der-zeppelin-lz-129-hindenburg-bei-einer-landung-zerstoert_id_5272588.html> accessed 8 February 2024 (hereinafter: Focus).

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] IRENA 'Removing Barriers for Green Hydrogen Development' <https://irena.org/News/articles/2023/Nov/Removing-Barriers-for-Green-Hydrogen-Deployment> accessed 8 February 2024.

the next 'big thing in energy' developed.[6] One tangible result was cars, running on fuel cells, developed with competitive examples like the Kordesch passenger car in 1970 and the Japanese Musashi cars.[7] But until today hydrogen remains hugely important to our daily lives. No refining of crude oil into petroleum, which we need for our cars, planes and many other everyday applications, would be possible without hydrogen.[8] Thus, hydrogen was never gone entirely, but it vanished a bit from the public eye.

This changed significantly during the 2010s, when hydrogen was rediscovered, this time as driver for the decarbonization of our lifestyle.[9] Since the 2020s, arguably, another hype around hydrogen developed and by the time of writing this book it is even possible to (provocatively) conclude (again): a spectre is haunting Europe and the world – the spectre of hydrogen.

Today there are fierce proponents and staunch opponents of hydrogen – people who love and those who loathe the molecule. Some stakeholders view hydrogen as a saviour for the decarbonization of the gas industry and others consider it to be a smoke screen by the gas industry to keep operating for decades to come.[10]

And much like the communist manifesto that was launched 175 years ago, the aim of this book is two-fold: first, it wishes to take away the mist surrounding hydrogen, enabling a clear and sober view of law and regulation concerning this energy carrier. Second, the book also contains an element of appeal and urgency, just as the manifesto did. This book is not neutral. It explains hydrogen regulation from around the globe, but at the same time also makes various concrete suggestions on how to improve the regulatory system and speed up the phase-in of hydrogen as a carrier to be used in our energy systems. The reason for this normative view is simple: hydrogen is important to help with the decarbonization of certain sectors, those (heavy industry, heavy duty transport, and so on) where emissions are hard to abate.[11]

Over the last 150 years, hydrogen has been produced technically via various methods, but also several types of hydrogen developed. With a view to production there is the traditional method of steam methane reforming,[12] producing hydrogen via electrolysis,[13] the production of hydrogen from biofuels[14] or biomass,[15] to name some of the important

[6] Peter Hoffmann *The Forever Fuel: The Story of Hydrogen* (Westview Press 1981) 1; Jeremy Rifkin The Hydrogen Economy (Tarcher 2002) 9 (hereinafter: Rifkin); John Bockris 'The Origin of Ideas as a Hydrogen Economy and Its Solution to the Decay of the Environment' (2002) 27 International Journal of Hydrogen Energy 731–740; Joseph J Room *The Hype about Hydrogen: Fact and Fiction in the Race to Save the Climate* (Island Press 2004) 3.

[7] Hydrogen Cars Now '1807–1986 Hydrogen Fuel Cars 1807–1986' <https://hydrogencarsnow.com/index.php/1807-1986/> accessed 8 February 2024.

[8] Martha Roggenkamp 'The Use of Power-to-Gas in Refineries: Regulatory Challenges from EU and German Perspective' in Martha M. Roggenkamp, Catherine Banet (eds.) *European Energy Law Report Vol. XII* (Intersentia, Cambridge 2018) 251–269 at 256.

[9] The European Union, for instance, started spending significant amounts of money into hydrogen research projects such as Store & Go <https://storeandgo.info/index.html> accessed 8 February 2024.

[10] Goda Naujokaitytė 'Clean Hydrogen: Smoke Screen or the Future of Energy?' (Science Business 3 September 2021) <https://sciencebusiness.net/news/clean-hydrogen-smoke-screen-or-future-energy> accessed 12 February 2024.

[11] International Energy Agency (IEA) 'Tracking Hydrogen' <https://iea.org/energy-system/low-emission-fuels/hydrogen> accessed 12 February 2024.

[12] Adolfo Iulianelli et al. 'Advances on Methane Steam Reforming to Produce Hydrogen through Membrane Reactors Technology: A Review' Vol. 58 (2016) Catalysis Review 1–35; for Steam Methane Reforming based on renewable feedstocks see: Mahin Basha Syed, 'Technologies for Renewable Hydrogen Production' in Abul Azad, Mohammad Khan (eds.) *Bioenergy Resources and Technologies* (Academic Press 2021) 158.

[13] For more information on this see Chapter 13 by Elena Tissari in this book.

[14] For more information on this see Chapter 7 by Piti Eiamchamroonlarp in this book.

[15] Alexandre Soares dos Santos, Lílian de Araújo Pantoja 'Microbial Conversion of Biomass' in Sabu Thomas et al. (eds.) *Handbook of Biomass* (Springer 2023) at 1–23.

ones.[16] This book touches upon these techniques in different chapters and appraises them from a legal perspective.

1.2 WHICH HYDROGEN ARE WE TALKING ABOUT?

Concerning the diverse types of hydrogen, terminology differs around the globe. Some regions use the 'colour book of hydrogen'[17] for their regulation and legislation. While the details are subject to debate, at least the three fundamental colours 'grey', 'blue' and 'green' hydrogen are distinguished from each other (with many more colours and shades – details can be found in the overview in Chapter 2 of this book). Hydrogen is often considered 'grey' when it is produced using fossil fuels (for example, through steam reforming).[18] When the CO_2 – which is a by-product of hydrogen production from fossil fuels – is captured and permanently stored, the hydrogen is often referred to as 'blue'.[19] Hydrogen that is produced from renewable sources is frequently labelled 'green'.[20]

Others created their own terms, such as low-carbon hydrogen, renewable hydrogen. Since there is no general agreement on terminology around the globe, this book will make the respective terminology used in the individual jurisdiction as transparent as possible. An overview of the different 'types' of hydrogen and terminologies features in Chapter 2 of this book. In any case, a unified approach to terminology is highly desirable and much needed, as meaningful regulation and the interlinkage of different regions of the world is only possible if we have common standards that are referring to the same things.

As diverse as the types of hydrogen and its production are, the academic literature on the subject is just as extensive. There is no shortage of books on hydrogen – the technicalities, physics, chemics and economics behind it have been described well. One of the most notable contributions over recent decades was published by Cambridge University Press[21] and it aptly demonstrates why the current *Handbook of Hydrogen and the Law* is needed. While the book by Ball and Wietschel is a comprehensive scientific publication on hydrogen and its various applications, covering all major aspects related to hydrogen, there is one omission: regulation and law. The lack of regulation and the fact that more needs to be done in that respect is mentioned in various chapters of the book, but it does not feature a chapter solely on hydrogen regulation.

This is characteristic of the regular treatment of hydrogen in recent debates. While technicians have solutions for various hydrogen-related issues, the legal framework is currently still under development, which might be part of the reason it is not frequently discussed. Some notable exceptions to this exist, of course. Particularly over the past few years, there has been a gradual increase in academic discussion and debate regarding the legal implications of a hydrogen economy. Section 1.3 highlights some of these, structured along the hydrogen value

[16] US Department of Energy 'Hydrogen Production and Distribution' <https://afdc.energy.gov/fuels/hydrogen_production.html> accessed 14 February 2024.

[17] More details on that can be found in Chapter 2 of this book.

[18] Grey hydrogen is produced from natural gas, which generates smaller amounts of CO_2 emissions than what is sometimes classified as 'black' or 'brown' hydrogen where coal is used as a source in the production process, see IEA 'The Future of Hydrogen – Seizing Today's Opportunities' (2019) at 34 <https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf> accessed 12 June 2024.

[19] Robert Howarth, Mark Jacobson 'How Green Is Blue Hydrogen?' (2021) 9 Energy Science & Engineering 1676, 1677.

[20] IEA (2007), table 1; IEA (2019), 34.

[21] Michael Ball, Martin Wietschel (eds.) *The Hydrogen Economy Opportunities and Challenges* (Cambridge University Press 2009).

chain, namely production, transportation and supply to end-use customers, which will also serve as a structuring element in general for the organization of this book. The fourth aspect structuring this book, the development of hydrogen markets, will not be considered separately in this overview but is integrated into the discussions on hydrogen transportation.

1.3 CURRENT LEGAL LITERATURE ON HYDROGEN

1.3.1 *Hydrogen Production*

The classification of hydrogen – the 'colour book' of hydrogen[22] – is discussed critically to some extent by the current literature, due to the fact that classification determines the energy production methods which would catalyse the uptake of hydrogen, as Banet argues.[23] Riemer identifies two key challenges for such a classification, in particular with a view to sustainability.[24] First, clarity in legislative frameworks is required when ascertaining which hydrogen production methods (for example, methods for producing green and/or blue hydrogen) would be compatible with a climate-neutral system from a legal and policy perspective.[25] Second, once the forms of hydrogen are selected, the actual content of the sustainability criteria will need to be evaluated, particularly in light of decarbonization targets and lessons learned from certifying biofuels.[26]

Classification plays a significant role in the certification of hydrogen, when produced, but also in the context of certain legal vehicles like guarantees of origin.[27] This can have repercussions for the import of hydrogen into certain regions from other regions. To give an example: for the EU, imports of renewable and low-carbon hydrogen are anticipated to complement domestic production.[28] The balance that, according to the literature, needs to be found here is between allowing flexibility for diverse hydrogen pathways, while considering that certified fuels need to be climate neutral by 2050.[29] Despite certain improvements in defining renewable hydrogen, as noted by Banet, there is a need to ensure consistency across legislative acts, as there remains a risk of divergence in definitions.[30] Such divergence may impact the commodity market, as well as the scale and speed of infrastructure development.[31]

With regard to the second challenge, namely the content of the sustainability criteria for hydrogen, lessons may be drawn from the sustainability of biofuels which preceded that of

[22] Ruven Fleming 'The Hydrogen Revolution and Natural Gas: A New Dawn in the European Union?' in D. Olawuyi, E. Pereira (eds.) *The Palgrave Handbook of Natural Gas and Global Energy Transitions* (Palgrave MacMillan 2022) 123–140 at 125 <https://doi.org/10.1007/978-3-030-91566-7_5> accessed 22 January 2024 (hereinafter: Fleming).

[23] Catherine Banet 'Building Europe's Hydrogen and Renewable Gas Markets' (2023) Centre on Regulation for Europe, 24 (hereinafter: Banet).

[24] Matia Riemer, 'Lessons Learnt from Certifying Biofuels for a Future Hydrogen Certification Scheme' (2022) 18th International Conference on the European Energy Market (EEM), Ljubljana, Slovenia, 1–7 <https://doi.org/10.1109/EEM54602.2022.9921171> accessed 19 January 2024 (hereinafter: Riemer).

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] European Commission 'Directive (EU) 2023/2413 of the European Parliament and of the Council amending Directive (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652' OJ L, 2023/2413, Recital 9(B).

[29] Banet 38.

[30] Ibid. 25.

[31] Ibid.

renewable gases in areas like the EU.[32] In this regard, biofuel certification has had more than a decade of practical experience which can serve as a guideline for certification of hydrogen. This topic will be discussed further in various chapters of the current book.[33] The regulation of hydrogen production as such depends very much on national law and has been investigated from a legal perspective in particular jurisdictions.[34] However, there are no legal assessments as yet concerning other jurisdictions or offshore production of hydrogen, which is why some chapters of the current book are dedicated to these aspects.

1.3.2 *Hydrogen Transmission and Distribution*

The next step in the hydrogen value chain after production is the transport of hydrogen, namely transmission and distribution.[35] As noted by Tanase and Herrera Anchustegui, there are, depending on the regional context, regulatory principles applicable to hydrogen in the context of, for example, the transmission of hydrogen through pipelines.[36] These principles have mostly been adapted from existing frameworks within the natural gas and electricity sectors.[37]

Scheibe and Poudineh opine that the system of hydrogen transmission through pipelines possesses characteristics akin to natural monopolies, particularly due to the high costs of developing and repurposing infrastructure.[38] With the experience of the electricity and natural gas sectors in mind, the importance of ensuring a competitive market through unbundling measures as well as ensuring non-discriminatory third-party access to pipeline networks is emphasized.[39] At the same time, exceptions to these rules are required to stimulate more private investments in the sector.[40] Barnes highlights a chicken-and-egg dilemma: regulation of competition will only become practically effective upon the development of a hydrogen market and associated infrastructure.[41] Yet it is essential for the regulatory framework to be in place, so as to facilitate this development.[42]

[32] European Council Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC art 17 and 18.

[33] For example, in Chapter 10 by Mauger, Villavicencio Calzadilla and Fleming as well as in Chapter 5 by Taylor.

[34] For the United Kingdom see Dalia Majumder-Russell 'Hydrogen Projects: Legal and Regulatory Challenges and Opportunities' (2021, Globe Law and Business Ltd); for Germany see Marlon Koralewicz et al. 'PORTAL GREEN – Genehmigungsrechtlicher Leitfaden für Power-to-Gas-Anlagen' <https://dvgw.de/medien/dvgw/forschung/berichte/g201735-portalgreen-finaler-genehmigungsleitfaden-bd1.pdf> accessed 15 February 2024.

[35] Fleming 125–126.

[36] Lavinia Tanase, Ignacio Herrera Anchustegui 'EU Hydrogen and Decarbonised Gas Market Package: Unbundling, Third-Party Access, Tariffs and Discounts Rules at the Core of Transport of Hydrogen' in Íñigo del Guayo Castiella, Lorenzo Mellado Ruiz (eds.) *Retos Regulatorios de los Gases Renovables en la Economía Circular* (Marcial Pons 2023) at 8 (hereinafter: Tanase and Herrera Anchustegui).

[37] Ibid.

[38] Alexander Scheibe, Rahmatallah Poudineh, 'Regulating the Future European Hydrogen Supply Industry: A Balancing Act between Liberalization, Sustainability, and Security of Supply?' (2023) OIES Paper: ET, No. 26, ISBN 978-1-78467-218-8, Oxford Institute for Energy Studies, Oxford at 1 (hereinafter: Scheibe and Poudineh).

[39] Tanase and Herrera Anchustegui 7.

[40] Ibid.

[41] Alex Barnes 'The EU Hydrogen and Gas Package: Help or Hindrance for the Development of a European Hydrogen Market?' (2023) OIES Paper ET22, Oxford Institute for Energy Studies at 21 <https://oxfordenergy.org/wpcms/wp-content/uploads/2023/03/The-EU-Hydrogen-and-Gas-Decarbonisation-Package-ET22.pdf> accessed 23 January 2024.

[42] Ibid.

In the development of a hydrogen market, questions arise as to who will own and operate hydrogen distribution and transmission networks. This might be different regarding distribution networks and transmission networks.[43]

According to Barnes, a strict ownership unbundled model for the regulation of hydrogen transmission, but also in particular distribution, can dissuade further private investment.[44] Barnes provides an example in this regard that the strict ownership unbundling model prevents the risk sharing that was common in the gas pipeline and liquid natural gas (LNG) markets, where producers and purchasers of gas took equity stakes in common infrastructure for the purposes of sharing risks related to the development of a market.[45]

Baumgart and Lavrijssen note that where a hydrogen transmission network operator is part of an undertaking active in transmission or distribution of natural gas or electricity, it should undergo at least legal unbundling, as well as accounting unbundling.[46] Horizontal unbundling has been subject to the criticism that it may hamper synergies between gas and hydrogen networks, and may also result in an inefficient duplication of structures.[47] Tanase and Herrera Anchustegui, however, note that a lighter version of unbundling can be employed, given that the risks of conflicts of interests stemming from combined operatorship is less likely than in vertical integration.[48] Any remaining risks could, in their opinion, be mitigated through monitoring and approval by regulatory authorities.[49]

Further to unbundling, another key component of the legislative landscape for hydrogen transport is the third-party access regime for hydrogen pipelines. As noted by Tanase and Herrera Anchustegui, third-party access implies that states must ensure non-discriminatory third-party access to transport infrastructure.[50] The rationale for providing third-party access is that hydrogen networks are capital intensive to build and risk becoming natural monopolies. De Wildt notes that two types of third-party access to hydrogen pipelines can be accommodated: regulated and negotiated third-party access.[51] These and other aspects will be dealt with in this book with a view to the transmission,[52] but also the distribution[53] level of hydrogen networks and in particular legal conditions for making investments into both will be discussed.[54]

1.3.3 *Hydrogen End Use*

Hydrogen consumption is currently low all around the globe, but how to regulate the end use of hydrogen has been the topic of some discussion in literature, particularly about the key themes of customer protection, hydrogen end-use sectors as well as hydrogen blending.

[43] For an example from the EU context see rGD, art. 42.
[44] Barnes 16.
[45] Ibid.
[46] Max Baumgart, Saskia Lavrijssen 'Exploring Regulatory Strategies for Accelerating the Development of Sustainable Hydrogen Markets in the European Union' (2023) Journal of Energy and Natural Resources Law <https://doi.org/10.1080/02646811.2023.2257528> accessed 20 January 2024.
[47] Ibid.
[48] Tanase and Herrera Anchustegui 11.
[49] Ibid.
[50] Ibid. 8.
[51] Bo de Wildt, Adriaan van der Welle, Marcel Weeda, Sebastiaan Hers 'Towards Decarbonised Gas Markets: An Analysis of the Current and Future Market Design for Gaseous Fuels Based on EU Legislation' (2022) at 8 <https://repository.tno.nl/SingleDoc?find=UID%20ea2d301f-a8ee-4654-8902-a8e13b728cb9> accessed 12 June 2024.
[52] For example, Chapter 15 by Jansen in this book.
[53] For example, Chapter 17 by Broersma, Holwerda and Jaeger in this book.
[54] For example, Chapter 16 by Zerde in this book.

Heidecke and others note that emphasis on consumer protection rules, concerning for example supplier switching, price comparisons and obtaining accurate data on consumption, is crucial.[55] With regard to supplier switching, customers could be equipped with an inherent right to change suppliers for natural gas and hydrogen, and protective caps on pricing could be set.[56]

With a view to relevant sectors for hydrogen use, some parts of the world identified early adopter sectors in which a 'switch' to renewable or low-carbon hydrogen may take place soon.[57] These sectors include the industrial sector involving hydrogen in the production of ammonia, methanol and steel making to replace fossil fuels.[58] Another early adopter of renewable or low-carbon hydrogen is the heavy-duty transportation sector, including road, rail, maritime and aviation.[59]

As noted by Scheibe and Poudineh, however, the debate on usage of hydrogen in the heating sector, in particular for heating in buildings, is quite fierce.[60] The primary reservation to the use of hydrogen in the heating sector is based on the assertion that hydrogen is comparatively inefficient compared to its use in other sectors, and will only be available in low quantities at high cost.[61] As a result, Scheibe and Poudineh noted that hydrogen strategies across member states differ in respect of their treatment of heating in buildings.[62] The topic will be discussed in more depth in a separate chapter of this book.[63]

Lastly the percentage of hydrogen allowed for blending in the natural gas system, both for those customers connected directly to the transmission system and those connected to the distribution system, has also increasingly become a point of discussion regarding hydrogen and consumers. At a transmission level, gas transmission networks transmit gas from border interconnection points to gas distribution networks as well as large (for example, industrial) consumers connected directly to the transmission network. It has been argued that a cap, rather than a fixed blending target, would give room for discrepancies in blending percentages at interconnection points between different countries.[64] Furthermore, Zemite and others note that, in any case, there should be harmonization of standards between interconnected countries.[65]

Most customers, such as household customers, are supplied currently via the gas distribution network. Tests are currently underway to ensure hydrogen compatibility with certain appliances. For example, in 2023 a German blending trial was conducted to test whether households could

[55] L. Heidecke et al. 'The Revision of the Third Energy Package for Gas' (2022) Publication for the Committee on Industry, Research and Energy (ITRE) at 26 <https://europarl.europa.eu/RegData/etudes/STUD/2022/734009/IPOL_STU(2022)734009_EN.pdf> accessed 17 January 2024.

[56] Ibid.

[57] For the example of the EU see European Commission, 'EU Strategy on Hydrogen' COM (2020) 301 final, 17 (hereinafter: EU Hydrogen Strategy).

[58] Ibid. at 10.

[59] Ibid.

[60] Scheibe and Poudineh 2–3.

[61] Hydrogen Europe Position Papers 'Hydrogen Technologies Can Boost the Energy Performance of Buildings' (May 2022) 6 <https://hydrogeneurope.eu/wp-content/uploads/2022/05/220516-EPBD_hydrogen-Europe-Position-paper-1.pdf> accessed 6 June 2024.

[62] Scheibe and Poudineh 2–4.

[63] See Chapter 20 by Jansen and Reins.

[64] Ruven Fleming 'Green Hydrogen Developments in the EU: Cross-Border Cooperation between Germany and the Netherlands' in Martha Roggenkamp, Catherine Banet *European Energy Law Report Volume XIV* (Intersentia, Cambridge 2021) 267–293 at 291.

[65] L. Zemite et al. 'Blending Hydrogen with Natural Gas/Biomethane and Transportation in Existing Gas Networks' (2023) 60 Latvian Journal of Physics and Technical Sciences 33–45 at 34–35.

be supplied 20 per cent of blended hydrogen as opposed to the 10 per cent currently provided by German law.[66] After sampling 100 households, the trial showed that following six months of the test, the households in the sample did not experience any technical difficulties in respect of the 20 per cent hydrogen blend.[67] Allowed blending levels of hydrogen at a household level differ in accordance with different technical standards in different countries. But they also depend on the individual end-use purposes, as demonstrated by some chapters in this book.[68]

1.4 CONCLUSION

Having sketched the legal debate on hydrogen, the observed immature status and currently underdeveloped knowledge on hydrogen regulation can wreak havoc on business cases and new hydrogen projects. The hydrogen economies of the future depend on the development of clear legal frameworks, but also on comprehensible explanations about the current situation. Remember the speech by Francesco La Camera? He mentioned 'innovative regulatory and policy frameworks' as the first of several preconditions for rapid green hydrogen scale-up.

This *Handbook* takes the reader along on its mission to fill the knowledge gap on hydrogen and the law. It is the first comprehensive book on hydrogen regulation, not only featuring an overview of the status quo on all permanently inhabited continents, but also looking in-depth at regulatory issues for the four most important aspects of hydrogen economies from a legal perspective: market creation, production, transport and end use. Accordingly, the book features a range of chapters discussing the topic of hydrogen regulation in breadth and depth. This is necessary as, on the one hand, it is the first to provide a truly global overview of hydrogen regulation from the most relevant regions for hydrogen in the world. On the other hand, there are many countries and regional organizations that may provide best-practice examples for certain elements of the hydrogen chain, the knowledge about which can be beneficial for other countries. Finding and discussing these best practices constitutes a particular focal point of this book.

The book addresses several questions, both systematic and pragmatic. Systematic questions include (but are not limited to): if hydrogen is an energy carrier that couples the gas and electricity sectors, how much legal system integration is required to follow up? How can natural gas exporting countries transition to hydrogen? Which types of hydrogen are desired in these transitions and how does law currently steer decisions on that? What are the regulatory criteria to establish sustainability of hydrogen supplies? Should a support mechanism be designed (subsidies, blending quotas or other means) and can/should it be done in such a way as not to distort nascent markets? Which stakeholder perspectives are covered by current law and where are possibilities for improvement?

Besides these issues there are also practical questions that need to be answered. How can current natural gas infrastructure be repurposed for hydrogen and which authorizations are required for that? How may gas quality standards for hydrogen be harmonized to facilitate cross-border trade and export/import of hydrogen? How should permitting regimes for electrolyzers be designed and could proper design provide efficiency gains in the process? Moreover, what are the possibilities for people to participate and have their say in the hydrogen transition? And with

[66] DVGW 'Gasgeräte bereit für 20% Wasserstoff' <https://dvgw.de/medien/dvgw/leistungen/publikationen/gasgeraete-bereit-fuer-20_-h2-factsheet-dvgw-avacon.pdf> accessed 15 February 2024.
[67] Ibid. 4.
[68] See for example Chapter 18 by Cocciolo and Chapter 19 by Huhta and Sairanen in this book.

a view to end use, where should we first focus efforts, as hydrogen will not be readily available in the required quantities and qualities anytime soon? Should, e.g., the transport sector or the housing/heating sector be decarbonized first? Is energy storage the solution for the future?

The chapters have all been specially commissioned for this book and written by leading experts in the field of energy regulation. This includes academics, industry lawyers, lawyers working for non-governmental organizations (NGOs), as well as those working for international institutions. The result is a multitude of perspectives on 'hydrogen and the law', not only (but also) from an academic perspective. All experts obtained knowledge on hydrogen regulation via research projects, daily work, previous publication projects or involvement in commercial hydrogen projects and they all are experts on a particular region or a particular element of the hydrogen value chain. The central idea behind producing this *Handbook* as an open-access publication is to provide everyone with access to the knowledge encapsulated in this reference work. That way, all actors and stakeholders of the 'hydrogen revolution' can gain crucial insights – citizens, the private sector, investors, law firms, but also regulators and governmental and non-governmental organizations. Having said all of that: let the fun begin!