UiT The Arctic University of Norway

Faculty of law

Enabling renewable hydrogen development in light of the clean energy transition

How do the existing EU legal framework and State aid rules treat the investment dynamics for renewable hydrogen development?

Marion Revest

Master´s thesis in Joint Nordic Master Programme in Environmental Law (NOMPEL) JUR-3920-1 24V May 2024

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1. Introduction

1.1. Factual background

At the 2023 COP28 in Dubai, the European Union (EU) reaffirmed its steadfast commitment to directing the clean energy transition.[1] With a shift away from fossil fuels towards low-carbon and renewable energy (RE) sources, the EU's ambition is characterised by its pledge to achieve climate neutrality by 2050.[2] Understanding that 75% of the EU's overall greenhouse gas (GHG) emissions stem from the energy sector,[3] decarbonisation emerged as an urgent priority. Within this transformative agenda, renewable hydrogen appears as a cornerstone, prominently featured in EU key policy instruments such as the EU Green Deal,[4] the European Hydrogen Strategy,[5] REPowerEU plan,[6] and the Fit-for-55 package.[7] Renewable hydrogen's significance lies in its potential to decarbonise sectors traditionally reliant on fossil fuels, also known as hard-to-abate sectors, positioning it as essential in Europe's pursuit of climate neutrality.[8] This thesis analyses how the EU's legal framework and State aid rules shape renewable hydrogen development, focusing on the interplay of perceived risk factors that influence investment decisions. By analysing these elements, the study aims to clarify the regulatory landscape, enhancing investor confidence and fostering the financing and realisation of renewable hydrogen projects.

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[1] 'Summary of Global Climate Action at COP 28' (United Nations Framework Convention on Climate Change).
[2] Council Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') [2021] OJ L 243, hereafter referred to as European Climate law.
[3] Agnieszka Widuto, 'Energy Transition in the EU' (European Parliamentary Research Service 2023).
[4] European Commission The European Green Deal, COM (2019) 640 final, hereafter referred to as the European Green Deal.
[5] European Commission, A hydrogen strategy for a climate-neutral Europe, Com (2020) 301 final, 2021, hereafter referred to as Hydrogen strategy for a climate-neutral Europe.
[6] European Commission, REPowerEU Plan, COM (2022) 230 final, 2022, hereafter referred as REPowerEU Plan.
[7] European Commission, 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, COM (2021) 550 final, 2021, hereafter referred to as Fit for 55 package.
[8] Paris Agreement to the United Nations Framework Convention on Climate Change (12 December 2015) U.N. Doc, hereafter referred to as Paris Agreement.

Hydrogen can either be found as a natural resource in the subsoil, as recently discovered in the South of France region,[9] or it can be produced through the physical process of electrolysis, known as Power to Hydrogen.[10] Electrolysis involves splitting water (H2O molecules) into two distinct molecules: 'hydrogen' (H2) and 'oxygen,' (O).[11] Various methods exist for this water-splitting process, resulting in a complex colour-coded system used within the energy industry to differentiate between the types of hydrogen production. These colours are green, grey, black, blue, brown, yellow, turquoise, pink, and white hydrogen.[12] However, this thesis analyses green hydrogen, not obtained through biomass-based production, but through water-electrolysis using renewable electricity sourced from wind or solar power. Its particular focus reflects the potential of water-electrolysis hydrogen obtained through RE sources in energy production, as brought to light by Ball and his colleagues already as far back as 2009.[13] Thus, throughout this thesis, the terms "renewable hydrogen" or "green hydrogen" or "clean hydrogen," which are often found in literature,[14] specifically refer to hydrogen generated through this particular chemical process.

Europe's notable advancements in clean hydrogen technologies position it favourably to capitalise on the global development of clean hydrogen as an energy carrier.[15] Analysts forecast cumulative investments in green hydrogen in Europe, ranging from €180-470 billion by 2050, alongside an additional €3-18 billion projected for low-carbon fossil-based hydrogen.[16] Moreover, the emergence of a hydrogen value chain serving various sectors, such as the transport, industrial, building sectors, and other end uses, has the potential to employ up to 1 million people either directly or indirectly.[17] Analysts also estimate that clean hydrogen

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[9] Jacques Pironon and Philippe de Donato, 'World's Largest White Hydrogen Deposit Found in France' (World Economic Forum, 15 September 2023).
[10] 'Hydrogen in a Nutshell' (Hydrogen Europe).
[11] Mingyong Wang and others, 'The Intensification Technologies to Water Electrolysis for Hydrogen Production – A Review' (2014) 29 Renewable and Sustainable Energy Reviews 573, 574.
[12] 'Hydrogen in a Nutshell' (Hydrogen Europe).
[13] Michael Ball and others, 'Hydrogen-Infrastructure Build-up in Europe', The Hydrogen Economy Opportunities and Challenges (Cambridge University Press 2009), 399.
[14] Henri Roman Dörr and Roman Eric Sieler, 'Certification of Green and Low-Carbon Hydrogen - An Overview of International and National Initiatives' (Adelphi), 8.; Michael Ball, 'Why Hydrogen?', The Hydrogen Economy Opportunities and Challenges (Cambridge University Press), 38-39.; Ruven Fleming, 'Clean or Renewable – Hydrogen and Power-to-Gas in EU Energy Law' (2021) 39 Journal of Energy & Natural Resources Law 43, 44.
[15] 'Hydrogen' (European Commission).
[16] Hydrogen strategy for a climate-neutral Europe, 2.
[17] Ibid.

could satisfy 24% of the world's energy demand by 2050, translating into annual sales in the range of €630 billion.[18] Noting its potential socioeconomic, financial, and environmental benefits, enabling factors are to be addressed urgently. At the EU level, the adoption of renewable hydrogen is facilitated by comprehensive frameworks and policy actions aiming to support its integration across various sectors. The European Hydrogen Strategy,[19] complemented by initiatives like the REPowerEU plan[20] and the Fit-for-55 package,[21] emphasises the necessity of robust investment, regulatory, and infrastructure development, and international collaboration to establish a thriving hydrogen market.[22] Furthermore, the newly revised Renewable Energy Directive[23] (RED III) sets ambitious targets for renewable hydrogen deployment, underscoring its pivotal role in reducing GHG emissions and advancing clean energy integration.[24]

On the same line, analysis of the Clean Hydrogen Monitor 2023 report demonstrates a positive trajectory in the deployment of Power to Hydrogen projects across the EU leading up to 2040.[25] The report's graphical representations demonstrate a consistent annual increase trend in cumulative announced Power to Hydrogen projects expected to be operational by 2030.[26] This trend reflects the steadfast commitments of both national governments and the EU to decarbonise hard-to-abate sectors using Power to Hydrogen technology. Of particular note is the marked rise in announced Power to Hydrogen capacity projected for 2030 compared to figures from 2022, indicating a robust upward trajectory in Power to Hydrogen project development. However, amidst these promising trends, the graphs also reveal a concerning decline in the number of projects estimated to be operational by the end of 2024.[27] This decline aligns with previous findings from the 2022 report, suggesting persistent challenges in the

[18] Ibid.
[19] Ibid.
[20] REPowerEU plan.
[21] Fit-for-55 package.
[22] Hydrogen strategy for a climate-neutral Europe.
[23] Council Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 [2023] OJ L, hereafter referred to as RED III.
[24] RED III, (80), Articles 3 (1), 29a (1).
[25] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 34-36.
[26] Ibid.
[27] Ibid 34.

timely execution and completion of Power to Hydrogen initiatives.[28] Hence, notwithstanding the growing number of project announcements, challenges such as delays and a slow progression rate towards final investment decisions underscore the complexities surrounding investment in renewable hydrogen initiatives.[29] With 146 projects announced to start in 2023, revised timelines suggest a potential shortfall in the actual implementation of these initiatives by the end of 2024 compared to previous projections.[30] Furthermore, an interview with the CEO of Hydrogen Europe, featured in the 'Review Energy' online journal, highlighted a concerning trend: *only 4% of the announced projects in Europe's hydrogen sector are progressing to the final investment decision stage, emphasizing the pressing need for an increased rate of Final Investment Decisions in 2024*.[31] However, the emergence of a clean hydrogen market driven by EU energy transition and decarbonisation policies underscores the critical need for a strong investment climate within the hydrogen sector. Indeed, the apparent investment gap in renewable hydrogen initiatives highlights the imperative need for a deeper understanding of how the legal framework shapes investment decisions.

1.2. Research question and research objectives

In light of the escalating commitments to meet RE targets and the expanding share of renewables in the EU's energy consumption, governments increasingly view investments in RE sources as pragmatic pathways to bolster energy independence and spur economic growth.[32] Despite the emergence of renewable hydrogen as a novel RE carrier with the potential to address pressing energy issues such as fossil fuel dependency, as well as its remarkable energy density, which is estimated to be three times higher than that of fossil fuels, global production of renewable hydrogen remains marginal, accounting for less than 1% in 2022.[33] Consequently,

[28] Ibid.; 'Clean Hydrogen Monitor 2022' (Hydrogen Europe), 58.
[29] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 34-36.
[30] Ibid 34.
[31] Jorgo Chatzimarkakis, 'Challenge of Lack of Hydrogen Regulatory Framework Has Been Overcome: Jorgo Chatzimarkakis (Hydrogen Europe)' (Review Energy, 29 December 2023).
[32] Nurcan Kilinc-Ata and Ilya A Dolmatov, 'Which Factors Influence the Decisions of Renewable Energy Investors? Empirical Evidence from OECD and BRICS Countries' (2023) 30 Environmental Science and Pollution Research 1720, 1720-1736.
[33] 'Global Hydrogen Review 2022' (International Energy Agency).

it becomes imperative to ensure that Europe's hydrogen sector garners the necessary investment to facilitate the region's transition toward a low-carbon and sustainable energy landscape. The EU and several Member States (MS) seem to have taken the right direction regarding green hydrogen ambition by outlining their strategies for renewable hydrogen by 2030. [34] Nevertheless, the pronounced gap between the number of project announcements and their actual implementation cannot be ignored and is worth addressing in a legal paper. Thus, this master thesis seeks to address the research question: *In light of the need to enable and achieve the clean energy transition, how do the existing EU legal framework and State aid rules treat the investment dynamics for renewable hydrogen development?* In this thesis, investment dynamics refer to the complex realm of factors that influence investors' decisions, including economic conditions and regulatory frameworks, as well as perceived risks and uncertainties, which shape the trajectory of investment flows in renewable hydrogen projects. Thus, by investigating the critical interplay between legal and non-legal factors shaping investment dynamics in the emerging clean hydrogen sector, this thesis aims to comprehensively analyse how the EU's legal framework, including the regulatory landscape and State aid rules, influences the investment climate. Clarifying the regulatory landscape can provide investors with the necessary confidence and clarity to navigate complexities, potentially catalysing a greater uptake of projects. This will include, *inter alia*, the financing and successful realisation of clean hydrogen projects crucial for achieving the EU's energy transition objectives.

To define the scope of this research, this thesis exclusively focuses on the deployment of 'green' hydrogen while abstaining from the examination of other colour-coded hydrogen,[35] production methods as it has the most potential in the clean energy transition.[36] Even though it is essential to acknowledge the far-reaching implications of green hydrogen across diverse sectors, including transportation, buildings, industrial, storage, and its end-use applications such as fuels, feedstock, or carbon capture and storage,[37] the primary focus of this thesis will centre on

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[34] 'National Hydrogen Strategy Update - NHS 2023' (The German Federal Government 2023).; 'Spain Green Hydrogen Vision' (Green Hydrogen Organisation).; REPowerEU plan.
[35] Dalia Majumder-Russel, Hydrogen Project: Legal and Regulatory Challenges and Opportunities' (Globe Law and Business Ltd), 36.
[36] Ruven Fleming, 'Clean or Renewable – Hydrogen and Power-to-Gas in EU Energy Law' (2021) 39 Journal of Energy & Natural Resources Law 43, 44.
[37] Haris Ishaq, Ibrahim Dincer and Curran Crawford, 'A Review on Hydrogen Production and Utilization: Challenges and Opportunities' (2022) 47 International Journal of Hydrogen Energy 26238.

the exploration of the production, transportation, and industrial potential of green hydrogen, with particular attention given to the legislative and financial frameworks governing these aspects. This limitation is chosen to provide a focused analysis of the elements of the green hydrogen value chain, which are critical for establishing the robust infrastructure and market presence required to support its broader applications across the other unexplored sectors. Additionally, the research encompasses a review of legal and economic factors influencing the investment climate, intentionally excluding technical and engineering considerations. By delving into specific facets, this research aims to provide insights into the legal feasibility, challenges, and opportunities associated with the widespread adoption of green hydrogen as a clean energy solution, enhancing the current standards of the legal framework.

1.3. Method of research

The thesis will follow a legal doctrinal research methodology to analyse the implications of EU law, particularly within the context of the assessment of the hydrogen legal framework and State aid rules. This approach combines descriptive and normative elements, facilitating a systematic examination of legal provisions and their implications within the renewable hydrogen sector. Drawing from diverse disciplines, including economics and law, normative criteria for evaluating the legal framework will be established in Chapter 2 through a literature review. Indeed, the examination of legal factors aims to define clear normative criteria to assess the impact of the existing regulatory framework on investors' decisions, as examined in Chapter 3. Chapter 3 addresses three major areas facing current challenges in the green hydrogen development chain, namely production, transport, and industry, and the high cost associated with producing and integrating green hydrogen in transport and industry infrastructure makes those areas of particular concern in the need to attract investors.[38] While this paper uses a doctrinal research methodology, it is also supported by a comprehensive review of the economics literature in Chapter 2, which will allow for insights from economic elements. These will serve as measuring rods to establish the economic context for evaluating the legal

[38] Robert Hren and others, 'Hydrogen Production, Storage and Transport for Renewable Energy and Chemicals: An Environmental Footprint Assessment' (2023) 173 Renewable and Sustainable Energy Reviews 113113, 9.

implications of the EU State aid rules in Chapter 4 in terms of a more favourable investment climate. The integration of economic and legal research relevant to energy, RE, and renewable hydrogen will determine the investment climate for the clean energy transition. Similarly to the legal factors, the review of economic factors will lead to the assessment of a normative criterion, which will be used to assess the implications of EU State aid rules on investors' decisions to invest in renewable hydrogen projects within Chapter 4. This approach ensures a thorough analysis of the various factors influencing the development and investment dynamics within the renewable hydrogen sector. In order to assess the implications of the legal frameworks on investors, the last chapter of this thesis, before the conclusion, aims to merge the legal frameworks discussed in Chapters 3 and 4 with the normative criteria impacting the investment dynamics established in Chapter 2, fostering a comprehensive understanding of their interplay. To that end, primary sources, such as EU policies, directives and regulations, and case law, and secondary sources, such as articles, journals, and reports from both the EU and various scholars, will be used to assess and evaluate the renewable hydrogen legal framework and the factors influencing the investment climate.

Investigating the legal framework for green hydrogen in the context of investment dynamics represents an attempt that has not been thoroughly explored previously in the literature. It is important to understand the legal intricacies surrounding this relatively nascent RE carrier in order to facilitate the transition to clean energy systems as envisioned by the EU.[39] To that end, this thesis contributes to the EU energy and State aid fields of law, engaging with ongoing discussions on the possibilities for renewable hydrogen to meet the ambitious EU decarbonisation targets,[40] while adding a new dimension to the discourse, particularly in terms of how legal frameworks can stimulate or hinder investment decisions. While EU energy law and State aid law share some commonalities in their interpretation methods, there are notable differences. EU energy law primarily focuses on 'public supervision of energy markets'[41] and promoting sustainability and clean energy transition,[42] while State aid law emphasises fair competition and preventing market distortions caused by government incentives in the clean

[39] See 'no net emissions of greenhouse gases in 2050' in European Green Deal, 2.
[40] Ibid.
[41] Kim Talus, EU Energy Law and Policy: A Critical Account (Oxford University Press 2013), 4.
[42] Ibid 12.

transition.[43] Additionally, in the EU, energy law is a shared competence[44] between MS and the EU, while State aid law is an exclusive competence.[45] This can have legal implications on how certain legal instruments are interpreted.[46] Overall, the thesis links to discussions on the implications of legal certainty, stability, coherency, and predictability on investment decisions and the role of State aid in supporting nascent renewable technologies. It assesses how the EU's legal instruments can be optimised to support the ambitious goals of the European Green Deal and the REPowerEU plan while maintaining a level playing field for market participants. By shedding light on this underexplored area, this thesis aims to provide valuable insights for policymakers and stakeholders, ultimately fostering a more conducive environment for investment and innovation in the renewable hydrogen sector, thus advancing the EU's ambitious goals for a sustainable energy transition. Through identifying vulnerabilities and weaknesses in the existing legal framework, potential consequences for investment dynamics will be elucidated.

[43] 'Global Forum on Competition: Roundtable on Competition, State Aids and Subsidies.' (Organisation for Economic Co-operation and Development 2011) 112.
[44] The Consolidated version of the Treaty on the Functioning of the European Union, OJ C 326, hereafter referred to as TFEU, Article 194.
[45] Oana Stefan, 'General Principles in EU State Aid Law', *Research Handbook on General Principles in EU Law Constructing Legal Orders in Europe* (Edward Elgar Publishing), 1.
[46] TFEU, Articles 194 and 108.

2. Literature review on renewable energy investment dynamics

Since the beginning of the 21st century, a growing acknowledgement of RE technologies as "survival technologies"[47] for the clean energy transition has catalysed an emerging field of literature focused on identifying barriers to investment.[48] Many empirical studies have investigated various potential factors influencing investors worldwide in their decisions to invest in RE project expansion. These are considered diverse policy frameworks that have taken distinct paths shaped by a country's economic and legal factors, geographic location, and prior experiences with RE investment.[49] Understanding these factors, or, in other words, the investment dynamics, is crucial for policymakers, investors, and other stakeholders involved in the transition to sustainable energy systems in order to manage risks and foster market deployment, including renewable hydrogen.[50] Indeed, it is worth noting that, in the evolving landscape, renewable hydrogen emerges as a novel energy carrier with limited literature and with even less on the investment dynamics surrounding it directly. Green hydrogen has the potential to play a pivotal role in the clean energy transition, both within the EU and globally, given its ability to address pressing energy issues such as fossil fuel dependency and its

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[47] Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28, 28.

[48] Nadine Gatzert and Thomas Kosub, 'Risks and Risk Management of Renewable Energy Projects: The Case of Onshore and Offshore Wind Parks' (2016) 60 Renewable and Sustainable Energy Reviews 982, 239-252.; Sonja Lüthi and Rolf Wüstenhagen, 'The Price of Policy Risk — Empirical Insights from Choice Experiments with European Photovoltaic Project Developers' (2012) 34 Energy Economics 1001, 1001-1011.; Paul Noothout and others (DIA-CORE), 17-55.

[49] Dimitrios Angelopoulos and others, 'Risk-Based Analysis and Policy Implications for Renewable Energy Investments in Greece' (2017) 105 Energy Policy 512.; V Di Dio and others, 'Critical Assessment of Support for the Evolution of Photovoltaics and Feed-in Tariff(s) in Italy' (2015) 9 Sustainable Energy Technologies and Assessments 95.; Ximei Liu and Ming Zeng, 'Renewable Energy Investment Risk Evaluation Model Based on System Dynamics' (2017) 73 Renewable and Sustainable Energy Reviews 782.; Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28.; Ming Yang and others, 'Evaluating the Power Investment Options with Uncertainty in Climate Policy' (2008) 30 Energy Economics 1933.; Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326.

[50] Ximei Liu and Ming Zeng, 'Renewable Energy Investment Risk Evaluation Model Based on System Dynamics' (2017) 73 Renewable and Sustainable Energy Reviews 782, 782.

remarkable energy density, estimated to be three times higher than fossil fuels.[51] However, despite its promising prospects, the significant disparity between project announcements and actual implementation underscores the importance of looking at the investment climate from an investor's point of view.[52] Possible barriers, such as the novelty of renewable hydrogen technologies, their relatively high infrastructure costs, or a fragmented legal framework, could hinder renewable hydrogen development. It is, therefore, essential to integrate, *inter alia*, insights from existing studies on RE investment while also considering the unique attributes and challenges associated with renewable hydrogen investment in order to fully comprehend the factors that influence investors' decisions. The final aim is to define normative criteria to evaluate the EU legal framework and State aid rules for renewable hydrogen development. Significantly, the following sections are differentiated based on the context in which the factors influence RE investment dynamics using joint economic and legal papers. While legal factors refer to the elements of the legal system and regulatory environment that directly impact the operations and decision-making processes of investors in the RE sector, economic factors, on the other hand, pertain to the financial and market conditions that affect the attractiveness of RE investments.

2.1. Legal factors shaping investment dynamics

The influence of regulatory and policy factors on the investment climate in RE sectors has been thoroughly examined within the literature. Indeed, studies consistently highlight the crucial role of governments and regulators in introducing incentives and policies that enhance sustainable investment decisions.[53] The ability of policymakers to directly motivate investment in technology, thereby promoting sustainable energy consumption and supply, is recognised as a

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[51] Giovanni Nicoletti and others, 'A Technical and Environmental Comparison between Hydrogen and Some Fossil Fuels' (2015) 89 Energy Conversion and Management 205, 211.
[52] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 34-36.; 'Clean Hydrogen Monitor 2022' (Hydrogen Europe), 58.
[53] Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326, 55326-55328.; William Blyth, Ming Yang and Richard Bradley, 'Climate Policy Uncertainty and Investment Risk' (International Environmental Agency), 17.; Ximei Liu and Ming Zeng, 'Renewable Energy Investment Risk Evaluation Model Based on System Dynamics' (2017) 73 Renewable and Sustainable Energy Reviews 782, 784.

necessary condition for the attainment of a sustainable energy system.[54] However, the literature reflects a diversity of perspectives regarding the optimal regulatory environment for fostering RE and green initiative investments. While some older studies emphasise the importance of stable policy frameworks and long-term regulatory certainty to attract investments and mitigate detrimental effects,[55] newer research sheds light on the potential benefits of climate policy uncertainty as a driver for environmentally friendly investments.[56] In fact, new studies have shown that investors' inclination to invest positively correlates with an unclear climate policy environment.[57] For example, a study by Bouri et al. 2022 found that investors tend to view policy uncertainty as an opportunity to capitalise on emerging trends and adapt their investment strategies accordingly.[58] Consequently, it can be said that the literature is not unanimous, with varying views on the optimal regulatory environment.[59] Despite the evolving nature of this discourse, a balanced consideration of various perspectives and empirical evidence is essential for informed policy-making and investment decisions in the realm of green hydrogen.

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[54] Carlo Drago and Andrea Gatto, 'Policy, Regulation Effectiveness, and Sustainability in the Energy Sector: A Worldwide Interval-Based Composite Indicator' (2022) 167 Energy Policy 112889, 7.

[55] Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766.; Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740.; Mengjun Huo, Chao Li and Renhuai Liu, 'Climate Policy Uncertainty and Corporate Green Innovation Performance: From the Perspectives of Organizational Inertia and Management Internal Characteristics' (2024) 45 Managerial and Decision Economics 34.; Anatole Boute, 'The Quest for Regulatory Stability in the EU Energy Market: An Analysis Through the Prism of Legal Certainty' (2012) 6 European Law Review.; Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506.; Kaisa Huhta, 'Anchoring the energy transition with legal certainty in EU law' (2020) 27 Maastricht Journal of European and Comparative.

[56] Khanh Hoang, 'How Does Corporate R&D Investment Respond to Climate Policy Uncertainty? Evidence from Heavy Emitter Firms in the United States' (2022) 29 Corporate Social Responsibility and Environmental Management 936.; Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326, 55327.

[57] Ming Yang and others, 'Evaluating the Power Investment Options with Uncertainty in Climate Policy' (2008) 30 Energy Economics 1933.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766.; Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740, 4.

[58] Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740, 4.

[59] William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766.; Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740.; Mengjun Huo, Chao Li and Renhuai Liu, 'Climate Policy Uncertainty and Corporate Green Innovation Performance: From the Perspectives of Organizational Inertia and Management Internal Characteristics' (2024) 45 Managerial and Decision Economics 34.; Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506.

Firstly, the policy framework is perceived as a potential risk factor for investors *per se*.[60] This perception stems from the dynamic nature of policies, which evolve over time and can introduce uncertainty and instability, consequently impacting the potential profitability of investments.[61] The influence of policy uncertainty on investing in RE sources exhibits conflicting views within the literature. Initially, policy uncertainty was seen as a significant barrier to sustainable investment in RE.[62] The absence of a clear, long-term policy vision exacerbates challenges for investors, underscoring the necessity for predictable policies aimed at reducing negative investment risk, as demonstrated by Leete, Xu, and Wheeler's analysis of policy uncertainty in the UK's marine RE industry.[63] They emphasise the adverse effects of uncertain policies on investor confidence and the need for stability, clarity, consistency, and long-term predictability to attract investors,[64] ensuring that policies do not result in the imposition of additional costs on investors.[65] Therefore, to effectively inform investment decisions, policy risk must be quantitatively assessed, taking into account factors such as price uncertainty, timing uncertainty, and other sources of uncertainty.[66] Yang et al. study emphasises the role of government in reducing investors' risks by implementing rather long-term policy frameworks. This aligns with the findings observed by Masini and Menichetti, who highlighted that constant alterations in policy design pose additional risks to RE investments.[67] They stress the importance of stable policy frameworks with robust financial support,[68] making a preference for long-term stable policy frameworks that enable the successful deployment of RE technologies by providing clear signals to the market.[69] On the same line, Bouri et al. provide

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60 Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28, 30.
61 Ibid.
62 Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326.
63 Simeon Leete , Jingjing Xu and David Wheeler , 'Investment Barriers and Incentives for Marine Renewable Energy in the UK: An Analysis of Investor Preferences' (2013) 60 Energy Policy 866.
64 Ibid 870-871.
65 Ming Yang and others, 'Evaluating the Power Investment Options with Uncertainty in Climate Policy' (2008) 30 Energy Economics 1933, 1936.
66 Ibid 2008.
67 Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28.
68 Ibid 35.
69 Ibid 36.

empirical evidence on the impact of climate policy uncertainty on the price dynamics of green and brown energy stocks, emphasising its negative influence on investor preferences.[70] Indeed, economic growth and policy certainty are intrinsically linked, influencing RE investment decisions.[71] Consequently, any delay in economic growth could slow down the transition to RE sources.

Conversely, Bouri et al. demonstrate that climate policy uncertainty can also positively influence investors to favour more environmentally friendly investments.[72] Their findings suggest that uncertainty may prompt investors, particularly during crisis periods, to reallocate assets from brown energy firms to green energy firms.[73] In fact, another study by Huo et al. challenges the prevailing belief by showing that climate policy uncertainty actually boosts corporate green innovation performance, suggesting that uncertainty may have varying effects on different aspects of RE investment.[74] For example, a study showed that heavy emitter firms in the US increased research and development investment in response to climate policy uncertainty, indicating potential opportunities for firms to gain a competitive edge by investing in green technologies.[75] While some studies emphasise the negative impact of policy uncertainty on RE investment, others suggest potential benefits such as a shift towards environmentally friendly investments and increased corporate innovation. This divergence underscores the complex and multifaceted nature of the relationship between policy uncertainty and RE investment, indicating a need for nuanced approaches to understanding and addressing these dynamics in pursuing sustainable energy transitions. Nonetheless, Kilinc-Ata and Dolmatov emphasise the role of policy certainty in attracting RE investments, stressing the need

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[70] Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740, 4.
[71] Nurcan Kilinc-Ata and Ilya A Dolmatov, 'Which Factors Influence the Decisions of Renewable Energy Investors? Empirical Evidence from OECD and BRICS Countries' (2023) 30 Environmental Science and Pollution Research 1720.
[72] Elie Bouri, Najaf Iqbal and Tony Klein, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740, 1, 4.
[73] Ibid.
[74] Mengjun Huo, Chao Li and Renhuai Liu, 'Climate Policy Uncertainty and Corporate Green Innovation Performance: From the Perspectives of Organizational Inertia and Management Internal Characteristics' (2024) 45 Managerial and Decision Economics 34, 37.
[75] Khanh Hoang, 'How Does Corporate R&D Investment Respond to Climate Policy Uncertainty? Evidence from Heavy Emitter Firms in the United States' (2022) 29 Corporate Social Responsibility and Environmental Management 936.

for stable and long-term public policies on economic growth and research and development to stimulate investments in green hydrogen projects.[76]

Secondly, given the capital-intensive and long-term nature of energy investments towards the green transition, it has been demonstrated that the energy regulatory framework has a significant impact on investment decisions, a consensus not only recognised across the literature but also by the European Court of Justice (ECJ).[77] Scholars have emphasised the critical role of regulatory stability and predictability in mitigating investment risks for private companies engaged in low-carbon energy technologies,[78] including renewable hydrogen, as well as an important pre-requisite of the attractiveness of the energy sector to investors.[79] It has been noted that frequent amendments in the RE market legal architecture tend to expose investors to uncertainty regarding investment conditions,[80] impacting their willingness to invest in RE projects.[81] Similarly, the ECJ has emphasised in case law that rules should be clear and precise and their application predictable[82] in order for economic actors to "ascertain unequivocally what [their] rights and obligations are and [to] take steps accordingly."[83] An

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[76] Nurcan Kilinc-Ata and Ilya A Dolmatov, 'Which Factors Influence the Decisions of Renewable Energy Investors? Empirical Evidence from OECD and BRICS Countries' (2023) 30 Environmental Science and Pollution Research 1720.

[77] See example of case law *Duff and Others v Minister for Agriculture and Food* [1996] C63/93 E.C.R. I-569, para 20.; *Vereniging voor Energie, Milieu en Water and Others v Directeur van de Dienst uitvoering en toezicht energie* (VEMW) [2005] C-17/03 E.C.R. I-4983, para 80.; *Gebroeders van Es Douane Agenten BV v Inspecteur der Invoerrechten en Accijnzen* [1996] C-143/93 E.C.R. I-431, para 27.; *Administration des douanes v Société anonyme Gondrand Frères and Société anonyme Garancini (Gondrand Frères)* [1981] 169/80 E.C.R. 1931.; *Commission v France and United Kingdom* [1989] 92/87 and 93/87 E.C.R. 405.

[78]Anatole Boute, 'The Quest for Regulatory Stability in the EU Energy Market: An Analysis Through the Prism of Legal Certainty' (2012) 6 European Law Review 675, 675.; Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506.; Kaisa Huhta, 'Anchoring the energy transition with legal certainty in EU law' (2020) 27 Maastricht Journal of European and Comparative 425, 432-437,

[79]Ibid 675.

[80] Anatole Boute, 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 509.

[81] Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326, 2.

[82] *Ireland v Commission* [1987] E.C.R. 5041 (325/85), para 18.; *Gebroeders van Es Douane Agenten BV v Inspecteur der Invoerrechten en Accijnzen* [1996] C-143/93 E.C.R. I-431, 27.; *Duff and Others v Minister for Agriculture and Food* [1996] C63/93 E.C.R. I-569, para 20.; *Vereniging voor Energie, Milieu en Water and Others v Directeur van de Dienst uitvoering en toezicht energie* (VEMW) [2005] C-17/03 E.C.R. I-4983, para 80.

[83] *Gebroeders van Es Douane Agenten BV v Inspecteur der Invoerrechten en Accijnzen* [1996] C-143/93 E.C.R. I-431, para 27.; *Administration des douanes v Société anonyme Gondrand Frères and Société anonyme*

example of a regulatory unpredictability challenge was during the period of regulatory ambiguity surrounding the Production Tax Credit in the United States (US), where wind energy investment experienced significant fluctuations.[84] The expiration and subsequent extension of the PTC led to unpredictable investment patterns, causing delays in project development and hindering the growth of the wind energy sector.[85] Nonetheless, Boute underscores in one of his articles the necessity of regulatory changes to achieve ambitious long-term decarbonisation targets while advocating for the implementation of a reasonable transitional regime to avoid unforeseeable disruptions,[86] thus ensuring regulatory certainty,[87] a crucial element in mitigating investment risks in low-carbon technologies. This emphasises the need for long-term regulatory coherence. It should be noted that regulatory certainty and policy certainty are inherently linked, as emphasised by various research.[88] Studies show the importance of long-term regulatory stability in mitigating risks associated with uncertain future climate policies.[89] They demonstrate, using a real options model, that increased climate policy uncertainty can lead to uncertain predictability of the benefits of energy projects, resulting in the postponement of investments in less carbon-intensive technologies.[90] Thus, the consensus in the literature highlights that a coherent and well-designed regulatory framework is essential for mitigating investment risks and attracting capital to RE projects. As a result, addressing the issue of policy uncertainty and instability through regulatory coherence within a legal framework has led to the latter factor being viewed as 'an antidote'[91] to evaluating the effectiveness of policy incentives.

Garancini (Gondrand Frères) [1981] 169/80 E.C.R. 1931.; *Commission v France and United Kingdom* [1989] 92/87 and 93/87 E.C.R. 405.

[84] Merrill Jones Barradale, 'Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit' (2010) 38 Energy Policy 7698.

[85] Ibid 7700.

[86] Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 519.

[87] Blyth et al., 2007, 5766-5773.; Lüthi & Wüstenhagen, 2012, 1001-1011.

[88] Merrill Jones Barradale, 'Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit' (2010) 38 Energy Policy 7698, 17.

[89] Sabine Fuss and others, 'Impact of Climate Policy Uncertainty on the Adoption of Electricity Generating Technologies' (2009) 37 Energy Policy 733, 734.

[90] Ibid.; Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 512.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766, 4.; Karsten Neuhoff and Laurens De Vries, 'Insufficient Incentives for Investment in Electricity Generations' (2004) 12 Utilities Policy 253, 264.

[91] Merrill Jones Barradale, 'Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit' (2010) 38 Energy Policy 7698, 17.

In conclusion, the literature demonstrates a consensus on the role of legal and policy factors in shaping the investment climate for RE, including *inter alia* renewable hydrogen. The role of governments and regulators through incentives and policies is important in motivating sustainable investment decisions, fostering the development of technologies, and promoting energy sustainability. [92] While policy uncertainty and instability introduce risks and complexities, regulatory coherence emerges as a crucial antidote, mitigating uncertainties and fostering investor confidence. Scholars underscore the necessity of clear, long-term policies and stable regulatory frameworks to attract investments towards green energy transitions in the EU. Additionally, the ECJ further emphasises the significance of predictable legal environments for fostering economic activity in the energy sector. Nevertheless, balancing the need for regulatory changes to achieve increasing decarbonisation targets with the imperative of providing a stable climate for investors to invest in renewable hydrogen remains a key challenge. Overall, the literature on legal factors demonstrates the need for sustained efforts to establish and maintain regulatory coherence while ensuring policy certainty and stability in order to enhance the full potential of renewable hydrogen projects to the final investment stage.

2.2. Economic factors influencing the investment climate

Studies on the economic factors impacting investment in RE sectors present a diverse array of perspectives. Earlier studies often highlighted challenges such as economic policy unpredictability and inadequate governmental support. [93] However, recent literature increasingly accentuates the role of economic incentives and supportive policy frameworks.[94] Moreover, there is ongoing debate regarding the role of subsidies from governments,

[92] Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326.

[93] Eva Niesten, Albert Jolink and Maryse Chappin, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies' (2018) 81 Renewable and Sustainable Energy Reviews 2519.; Simeon Leete , Jingjing Xu and David Wheeler , 'Investment Barriers and Incentives for Marine Renewable Energy in the UK: An Analysis of Investor Preferences' (2013) 60 Energy Policy 866.; Aled W Jones, 'Perceived Barriers and Policy Solutions in Clean Energy Infrastructure Investment' (2015) 104 Journal of Cleaner Production 297.

[94] Karim Malik and others, 'Renewable Energy Utilization to Promote Sustainability in GCC Countries: Policies, Drivers, and Barriers' (2019) 26 Environmental Science and Pollution Research 20798.

particularly in relation to the removal of fossil fuel subsidies to promote investment in RE, including in renewable hydrogen.[95] This evolution in the literature shows a shifting perception of the economic drivers behind investments in RE sectors and their roles.

Subsidies and supportive funds stand out as the primary economic drivers incentivizing investment in RE projects.[96] Research by Malik et al. and Lilliestam et al. emphasise the critical role of economic support mechanisms in encouraging private sector investment.[97] Economic incentives play a crucial role in mitigating barriers to RE adoption, particularly given the high initial costs of renewable infrastructure, the prevalence of price distortions associated with external costs, and the availability of cheaper conventional energy sources.[98] It is noteworthy that a study by IRENA highlights a substantial decline in traditional renewable power generation costs over the past decade, propelled by advancements in technology, economies of scale, competitive supply chains, and enhanced developer expertise.[99] However, renewable hydrogen, being a relatively nascent RE carrier, requires further technological development, the establishment of competitive supply chains, and the accumulation of industry experience. Consequently, subsidy schemes play a critical role in offering financial incentives that alleviate initial investment obstacles, thereby enhancing the appeal of RE investments to investors.[100] Nevertheless, the unpredictability of subsidy schemes further compounds these uncertainties, creating risks that are particularly challenging for investors with limited experience and risk estimation capabilities, a scenario exemplified in the case of renewable hydrogen investments. Indeed, with clear European targets, national stakeholders have started moving with their transmission and large-scale storage development plans.[101] However, the novelty of renewable hydrogen and its associated infrastructure, including transmission pipelines and storage

[95] Johan Lilliestam and Anthony Patt, 'Barriers, Risks and Policies for Renewables in the Gulf States' (2015) 8 Energies 8263.
[96] Nina Tura and others, 'Unlocking Circular Business: A Framework of Barriers and Drivers' (2019) 212 Journal of Cleaner Production 90.
[97] Karim Malik and others, 'Renewable Energy Utilization to Promote Sustainability in GCC Countries: Policies, Drivers, and Barriers' (2019) 26 Environmental Science and Pollution Research 20798.; Johan Lilliestam and Anthony Patt, 'Barriers, Risks and Policies for Renewables in the Gulf States' (2015) 8 Energies 8263.
[98] Karim Malik and others, 'Renewable Energy Utilization to Promote Sustainability in GCC Countries: Policies, Drivers, and Barriers' (2019) 26 Environmental Science and Pollution Research 20798.
[99] 'Renewable Power Generation Costs in 2020' (International Renewable Energy Agency (IREA)), 11.
[100] Eva Niesten, Albert Jolink and Maryse Chappin, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies' (2018) 81 Renewable and Sustainable Energy Reviews 2519.
[101] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 59-70.

facilities, introduces uncertainties regarding its intrinsic costs.[102] Thus, ongoing efforts to address these challenges through innovative financing mechanisms, policy reforms, and international cooperation are crucial to unlocking the full potential of RE and driving the transition towards a sustainable energy future.

The **cost of capital**, encompassing financing expenses and broader economic conditions, also plays a pivotal role in shaping investment dynamics within the realm of RE projects.[103] It acts as an indicator of the inherent risk-return balance within investments.[104] Specifically in green hydrogen projects, the uncertainties surrounding market dynamics, market competitivity, and the reliability of offtakers contribute significantly to shaping the cost of capital.[105] Research by Angelopoulos et al. and Frank & Shen underscores the profound impact of financing costs on the feasibility and attractiveness of RE investments.[106] Access to affordable capital stands as a linchpin for project developers, facilitating the financing of construction and operation. Fluctuations in the cost of capital have direct ramifications for project economics and investor returns. Although environmental concerns may motivate investors in RE projects, financial returns invariably remain the primary driver of investment decisions.[107] Additionally, insights from studies by Niesten et al. and Salm et al. emphasise the critical importance of predictable cost structures, revenue streams, and overall returns on investment.[108] Uncertainty in these

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[102] Ibid.
[103] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 37-40.
[104] Simeon Leete , Jingjing Xu and David Wheeler , 'Investment Barriers and Incentives for Marine Renewable Energy in the UK: An Analysis of Investor Preferences' (2013) 60 Energy Policy 866.; Murray Z Frank and Tao Shen, 'Investment and the Weighted Average Cost of Capital' (2016) 119 Journal of Financial Economics 300.; Dominique Finon and Yannick Perez, 'The Social Efficiency of Instruments of Promotion of Renewable Energies: A Transaction-Cost Perspective' (2007) 62 Ecological Economics 77.
[105] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 34.; Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 16 and 29.
[106] Dimitrios Angelopoulos and others, 'Risk-Based Analysis and Policy Implications for Renewable Energy Investments in Greece' (2017) 105 Energy Policy 512.; Murray Z Frank and Tao Shen, 'Investment and the Weighted Average Cost of Capital' (2016) 119 Journal of Financial Economics 300.
[107] Georg Inderst, Christopher Kaminker and Fiona Stewart, 'Defining and Measuring Green Investments: Implications for Institutional Investors' Asset Allocations' (OECD) OECD working papers on finance, insurance and private pensions 24, 17.
[108] Eva Niesten, Albert Jolink and Maryse Chappin, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies' (2018) 81 Renewable and Sustainable Energy Reviews 2519.; Sarah Salm, Stefanie Lena Hille and Rolf Wüstenhagen, 'What Are Retail Investors' Risk-Return Preferences towards Renewable Energy Projects? A Choice Experiment in Germany' (2016) 97 Energy Policy 310.

aspects can escalate perceived investment risks, dissuading potential investors, particularly those who prioritise financial performance, from participation.[109] In the context of green hydrogen projects, uncertainties surrounding market demand, hydrogen pricing, and offtaker reliability amplify perceived risks, consequently influencing the cost of capital.[110] If these risks inflate the cost of capital to prohibitive levels, it could dissuade potential investors from engaging in such projects. Conversely, a reduction in the cost of capital enhances the allure of investments, potentially catalysing increased activity in the sector.[111] For instance, in the case of offshore wind projects, the cost of capital is heavily influenced by factors such as regulatory stability, grid connectivity, and technological advancements.[112] Countries with well-established regulatory frameworks and robust grid infrastructure, like Denmark and the Netherlands, often enjoy lower financing costs for offshore wind projects compared to regions with less developed regulatory environments.[113] Additionally, technological innovations such as larger turbines and improved installation techniques have contributed to reducing the perceived risks associated with offshore wind investments, thus lowering the overall cost of capital for investors.[114]

As emphasised above, subsidies, supportive funds, and the cost of capital are major economic factors influencing the willingness of investors in the energy sector. This is without doubt linked to the capital-intensive and long-term nature of energy investment, which may discourage investors from taking the risk associated with investing in new low-carbon technologies. However, these factors are directly intertwined with the regulatory and policy frameworks in place. In economic literature, the **regulatory and policy environment** also plays a pivotal role in shaping investment decisions within the RE sector, impacting broader economic dynamics. Various studies collectively highlight the profound impact of regulatory instability and policy

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[109] Simeon Leete , Jingjing Xu and David Wheeler , 'Investment Barriers and Incentives for Marine Renewable Energy in the UK: An Analysis of Investor Preferences' (2013) 60 Energy Policy 866.
[110] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 32-42.
[111] Ibid 15.
[112] Srinivasan Santhakumar and others, 'Technological Learning Potential of Offshore Wind Technology and Underlying Cost Drivers' (2023) 60 Sustainable Energy Technologies and Assessments 103545, 12.
[113] European Commission (2012). A systemic Assessment of the European Offshore Wind Innovation.
[114] Srinivasan Santhakumar and others, 'Technological Progress Observed for Fixed-Bottom Offshore Wind in the EU and UK' (2022) 182 Technological Forecasting and Social Change 121856.

uncertainty on investor behaviour.[115] Constant changes in subsidy schemes influence investment levels and affect investor confidence, resulting in a negative impact on the inflow of capital to the sector that undergoes change.[116] Moreover, Jones' study emphasises the importance of long-term and stable policy frameworks for fostering a conducive investment environment,[117] particularly given the capital-intensive and long-term nature of RE investment.[118] As previously stated, the capital associated with renewable hydrogen research and development demonstrates that it is important to ensure stability and a long-term framework. Hence, as Tura et al. maintain, supportive regulatory environments, including directing regulations, taxation policies, and subsidy schemes, are significant in driving investments in RE.[119] Collectively, these studies underscore the intricate relationship between regulatory and policy considerations and economic factors towards positive investment outcomes in the RE sector, emphasising the necessity for coherent regulatory frameworks to incentivise sustainable investments.

In conclusion, economic factors do influence investment dynamics in the deployment of renewable hydrogen for the clean energy transition. The availability of subsidies, supportive funds, and cost capital remains crucial for attracting private sector investment in renewable hydrogen infrastructure. However, these economic incentives are intricately linked with the regulatory and policy frameworks set in place by MS and the EU. Indeed, the literature highlights the impact of unpredictability, instability and uncertainty on investor behaviour, emphasising the need for long-term and stable policy frameworks to foster a conducive

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[115] Ibid.; Eva Niesten, Albert Jolink and Maryse Chappin, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies' (2018) 81 Renewable and Sustainable Energy Reviews 2519.; Nina Tura and others, 'Unlocking Circular Business: A Framework of Barriers and Drivers' (2019) 212 Journal of Cleaner Production 90.; Nadine Gatzert and Thomas Kosub, 'Risks and Risk Management of Renewable Energy Projects: The Case of Onshore and Offshore Wind Parks' (2016) 60 Renewable and Sustainable Energy Reviews 982.

[116] Anatole Boute, 'The Quest for Regulatory Stability in the EU Energy Market: An Analysis Through the Prism of Legal Certainty' (2012) 6 European Law Review 675.

[117] Jones, 2015.; Eva Niesten, Albert Jolink and Maryse Chappin, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies' (2018) 81 Renewable and Sustainable Energy Reviews 2519.

[118] Anatole Boute, 'The Quest for Regulatory Stability in the EU Energy Market: An Analysis Through the Prism of Legal Certainty' (2012) 6 European Law Review 675, 680.

[119] Nina Tura and others, 'Unlocking Circular Business: A Framework of Barriers and Drivers' (2019) 212 Journal of Cleaner Production 90.

investment environment, particularly given the capital-intensive and long-term nature of green energy investment projects.[120]

2.3. Normative criteria for evaluating the legal framework

Following the literature reviewed above, it is evident that both legal and economic factors are instrumental in shaping investment dynamics in the deployment of renewable hydrogen. Overall, three normative criteria derived from the literature review for evaluating the legal framework can be identified as impacting investors' investment dynamics and will be used as measuring rods throughout the thesis to answer the research question.

The first normative criterion is **policy stability and certainty** to foster an environment conducive to investment in renewable hydrogen projects. These projects require significant long-term investment due to their significant cost[121] and are sensitive to the policy and regulatory environment. While the literature review above revealed a nuanced debate regarding the impact of policy uncertainty, with some studies suggesting that a certain degree of uncertainty may spur innovation and environmentally friendly investments, the prevailing consensus underscores the importance of stable and certain policy frameworks as a way to increase investor confidence. Indeed, clear, long-term policy directives serve as an incentive for investors, guiding their decisions and reducing the perceived risks associated with the evolving landscape of renewable energy technologies. The second normative criterion is **regulatory coherence**, which is also essential in creating a conducive investment for renewable hydrogen initiatives. It ensures that the legal environment presents a consistent, harmonious, and integrated approach across various policies and regulations, thereby reducing complexities and aligning the regulatory landscape with investor expectations. The literature review demonstrates that frequent shifts in policy design and regulatory frameworks can introduce

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[120] Farhad Taghizadeh-Hesary and others, 'Green Finance and the Economic Feasibility of Hydrogen Projects' (2022) 47 International Journal of Hydrogen Energy 24511, 24519.
[121] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 32-42.

significant risks to RE investments. Such risks stem from the uncertainty that these changes impact the market, potentially undermining the financial viability and long-term sustainability of renewable hydrogen projects. In light of these considerations, regulatory coherence is important in translating policy objectives into tangible investment flows, thereby advancing the deployment of renewable hydrogen to the final investment decision. The last normative criterion is **investment predictability**, which shapes the investment climate, particularly within the renewable hydrogen sector. The literature review on economic factors highlighted the role of economic incentives, such as subsidies and supportive funds, in catalysing private sector investment in renewable hydrogen infrastructure. However, the efficacy of these incentives is intrinsically linked to their predictability. Fluctuating subsidy schemes and the uncertain costs of emerging renewable hydrogen technologies can significantly amplify investment risks, as seen above.[122] Predictability is important for investors to make informed investment decisions, particularly in the context of renewable hydrogen, where the initial costs and evolving market conditions introduce uncertainties.[123] Hence, the availability of subsidies and supportive funds is essential for attracting private sector investment in renewable hydrogen infrastructure. Thus, the stability and coherence of the legal and policy frameworks that underpin these economic instruments are important. Consistent and long-term governmental policies and incentives are crucial in fostering an environment conducive to sustainable investment decisions and in driving the advancement of green energy technologies. By ensuring a predictable investment landscape, policymakers can effectively lower the barriers to entry for investors and advance green energy production.[124]

Given the current context of renewable hydrogen projects being delayed in attaining the final investment decision stage, possible questions about the legal implications of the EU framework for investors can be raised. It is worth noting that the three normative criteria identified, namely policy stability and certainty, regulatory coherence, and investment predictability, are

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[122] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 42-58, 157.
[123] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 32-42.
[124] Godwin Olasehinde-Williams, Oktay Özkan and Seyi Saint Akadiri, 'Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S' (2023) 30 Environmental Science and Pollution Research 55326.; William Blyth, Ming Yang and Richard Bradley, 'Climate Policy Uncertainty and Investment Risk' (International Environmental Agency).

interdependent and collectively form a synergistic framework that shapes investor behaviour and decision-making processes. The interplay between these criteria underscores the complexity of the investment climate and the need for a holistic approach to policy and regulatory design that considers the multifaceted nature of investor confidence and risk assessment in the renewable hydrogen sector. The following two chapters delve deeper into the legal environment surrounding renewable hydrogen projects, shedding light on how regulations that embody policy stability and certainty, regulatory coherence, and investment predictability shape investment dynamics and influence the clean energy transition.

3. The regulatory landscape for renewable hydrogen

As demonstrated in Chapter 2, regulatory coherence and policy framework stability and certainty have a major impact on the investment climate. With new legislation perpetually being finalised, adopted, and revised in the EU, the novelty of the current renewable hydrogen framework is evolving towards a clean energy transition. Nonetheless, it is important to closely examine the current stage of the policy and regulatory framework to understand whether the evolution has brought **certainty**, **stability**, and **coherence** to investors or whether there are still some areas where there is room for improvement.

The European Commission has introduced several key policy documents aimed at advancing the deployment and adoption of renewable hydrogen as a critical component of its climate and energy strategies. These initiatives align with the broader objectives outlined in the 2019 European Green Deal, which seeks to position Europe as the world's first climate-neutral continent by 2050.[125] Within this overarching strategy, the Commission's Hydrogen Strategy for a Climate-Neutral Europe, adopted in 2020, outlines a roadmap for the deployment of clean hydrogen over three distinct phases. Beginning with the establishment of 6 GW of renewable hydrogen electrolysers and the production of 1 million tonnes of renewable hydrogen by 2024, the strategy progresses towards installing 40 GW of electrolysers and producing 10 million tonnes of renewable hydrogen by 2030.[126] The ultimate goal is to achieve maturity and large-scale deployment of renewable hydrogen technologies by 2030 onwards, targeting hard-to-decarbonise sectors and significantly increasing renewable electricity production. To complement this strategy, the Commission presented the Fit-for-55 package[127] in 2021, with 2024 as the year for implementation at the national level, translating the hydrogen strategy into concrete policy frameworks. This includes proposals to set targets for the uptake of renewable hydrogen in industry and transport by 2030. Furthermore, various initiatives have been launched to support funding, research, and innovation projects related to hydrogen, aimed at

[125] European Green Deal, 2.
[126] Hydrogen Strategy for a Climate-Neutral Europe.
[127] Fit-for-55 package.

decarbonising the EU in a cost-effective manner and reducing reliance on imported fossil fuels.[128] Indeed, one year later, the Commission launched the REPowerEU plan,[129] spurred by geopolitical shifts, namely the conflict between Russia and Ukraine, emphasising the urgent need to accelerate the clean energy transition and enhance energy security to diminish the dependence on Russian coal, oil, and gas. To this end, the REPowerEU plan sets a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of renewable hydrogen imports by 2030.[130] Starting in 2025, regular reports on hydrogen uptake will be issued,[131] since efforts are needed to establish hydrogen infrastructure for producing but also importing 20 million tonnes by 2030.[132] Lastly, the introduction of the Green Deal Industrial Plan[133] in 2023 further underscores the Commission's commitment to enhancing Europe's competitiveness in the transition to a net-zero economy by supporting industries to achieve climate neutrality. The plan is based on four pillars, all of which are crucial to the feasibility of the deployment of renewable hydrogen. Firstly, the Commission sets forward a predictable and simplified regulatory framework, which may be very relevant for renewable hydrogen, as will be seen later in this chapter.[134] Secondly, faster access to funding, which will lead to an important revision of the Temporary Crisis and Transition Framework (TCTF),[135] with its extension until the end of 2025, thus allowing renewable hydrogen to benefit from more open State aid rules,[136] to be seen more in-depth in Chapter 4. Thirdly, proper skills for the green transition should be ensured, including upskilling and reskilling in the hydrogen sector.[137] Finally, setting an ambitious trade agenda reflecting the EU's priorities for clean technologies on the international scene.[138]

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[128] REPowerEU plan.; European Commission A Green Deal Industrial Plan for the Net-Zero Age, COM (2023) 62 final, hereafter referred to as Green Deal Industrial Plan for the Net-Zero Age.; Hydrogen Strategy for a Climate-Neutral Europe.
[129] Ibid.
[130] Ibid.
[131] Ibid.
[132] Ibid.
[133] Green Deal Industrial Plan for the Net-Zero Age.
[134] Ibid.
[135] Communication from the Commission amendment to the temporary crisis and transition framework for state aid measures to support the economy following the aggression against Ukraine by Russia [2023] c/2023/1188, hereafter referred to as Temporary Crisis and Transition Framework.
[136] Green Deal Industrial Plan for the Net-Zero Age.
[137] Ibid.
[138] Ibid.

These EU policies recognise renewable hydrogen as a strategic technology pivotal in reducing GHG emissions, diversifying energy sources, and fostering fossil fuel energy independence. Nonetheless, in order to meet the abovementioned objectives, the EU has also developed a regulatory framework on different aspects of renewable hydrogen. The sub-chapters within this framework first elucidate the criteria and mechanisms defining renewable hydrogen, facilitating its production, and ensuring regulatory compliance. Then, once this has been done, the following sub-chapters outline regulatory guidelines governing the integration of production into the transport and industrial sectors, providing insights into the EU's efforts to advance renewable hydrogen as a pivotal carrier.

3.1. Production regulations

3.1.1. Defining renewable hydrogen

In order to achieve the targets outlined in the policy documents and attract investors for the advancement of hydrogen development, stability and certainty in the transition process are paramount.[139] It is, therefore, essential for the EU to establish a clear definition of renewable hydrogen and determine whether it qualifies as a RE carrier.

The revised Renewable Energy Directive, which came into force in November 2023 to accelerate the EU's transition to clean energy, plays a crucial role in shaping the legal framework for hydrogen. This Directive sets a renewable energy target for the Union's gross final consumption in 2030, aiming for at least 42.5%, with a stretch goal of 45%.[140] An important aspect clarified in the Directive is the treatment of renewable fuels of non-biological origin (RFNBOs) as renewable energy, regardless of the sector in which they are consumed, in order to achieve the 42,5% target.[141] Renewable hydrogen, a key component of the hydrogen

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[139] Hydrogen Strategy for a Climate-Neutral Europe, 12.
[140] RED III, Article 3(1).
[141] Ibid (80).

strategy, can be produced through electrolysis, utilising renewable electricity to split water into hydrogen and oxygen, hence, falling under the category of RFNBOs. The Directive defines RFNBOs as liquid and gaseous fuels whose energy content is derived from renewable sources other than biomass.[142] This encompasses hydrogen produced via water-electrolysis using RE sources like wind and solar power, which are favoured within the EU.[143] Furthermore, to ensure that hydrogen production contributes to GHG emissions reduction and the RE target in Article 3(1), the Directive mandates that RFNBOs must achieve at least a 70% reduction in GHG emissions compared to conventional fossil fuels.[144] In order to uphold these standards and provide clarity to investors, the Commission adopted in June 2023 two, 'long-awaited and highly controversial',[145] Delegated Acts. These acts were enacted in accordance with Articles 27(3) and 28(5) of RED II, as they were adopted before RED III came into force.[146]

3.1.2. Facilitating renewable hydrogen production

The Commission's primary objective with the Delegated Acts is to establish detailed requirements for sourcing renewable electricity[147] and the methodology for assessing GHG emissions savings from RFNBOs.[148] Thereby, they facilitate the inclusion of such fuels in the targets of EU countries in internal production, as well as external production.[149] This step attempts to offer certainty to investors, especially as the EU strives to achieve its goal of

[142] Ibid Article 1(36).
[143] Ad Van Wijk and Jorgo Chatzimarkakis, 'Green Hydrogen for a European Green Deal A 2x40 GW Initiative' (Hydrogen Europe), 9.
[144] Ibid Article 29a(1).
[145] 'Renewable Energy: EU Commission Rules for Renewable Hydrogen Enacted' (CMS, 21 July 2023).
[146] RED III, Article 29a(3).
[147] Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels C/2023/1086 [2023] OJ L 157, hereafter referred to as DA on detailed requirements for sourcing renewable electricity.
[148] 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, C/2023/1087 [2023] OJ L 157, hereafter referred to as DA on the methodology for assessing GHG emissions savings from RFNBOs.
[149] DA on detailed requirements for sourcing renewable electricity, Article 1.; DA on the methodology for assessing GHG emissions savings from RFNBOs, Article 1.

producing 10 million tonnes of domestic renewable hydrogen and importing an additional 10 million tonnes of renewable hydrogen by 2030.[150]

Within the Delegated Act on methodology for assessing GHG emissions savings from RFNBOs, a formula has been established to ensure that a minimum of 70% emissions savings compared to fossil fuels have been achieved.[151] In essence, the final aim of the methodology is to assess the emissions within the supply chain step by step and add them up to obtain the overall emissions. The Act establishes a reference point for life-cycle GHG emissions, with a limit of 28.2 g CO2e per MJ for RFNBOs and Recycled Carbon Fuels.[152] It takes into account both direct emissions from fuel combustion and upstream emissions, which include input supply, production processes, and fuel transport and distribution. The methodology specifies how to attribute emissions to each input, such as electricity, purpose-produced materials, or byproducts.[153] Suppliers must now calculate and report the intensity of GHG emissions of each input, facilitating transparency in the production chain. The methodology raised some criticism due to its possible negative consequences for investors as a result of its complexity.[154] However, it is a well-known methodology already used, to some extent, for the calculation of biofuel emissions in RED II, for instance.[155]

In the inaugural Delegated Act on detailed requirements for sourcing renewable electricity,[156] the Commission aimed to establish a comprehensive framework outlining conditions for officially recognising renewable hydrogen as fully renewable.[157] In essence, there are two options for RFNBOs to count as fully renewable, as **Figure 1.** shows either Option I, when there is a direct electricity connection between the RE source plant[158] and the RFNBO plant, or

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[150] 'Renewable Hydrogen Production: New Rules Formally Adopted' (European Commission, 20 June 2023).; REPowerEU plan, 7.
[151] DA on the methodology for assessing GHG emissions savings from RFNBOs, Articles 2 and 3.
[152] Ibid, Annex (B).
[153] DA on the methodology for assessing GHG emissions savings from RFNBOs, Annex.
[154] Jan-Hendrik Scheyl , 'Delegated Acts on Art. 27 and 28 Explained: How They Will Shape the PtX Market Ramp Up'.
[155] RED II, Article 31, Annex V.
[156] DA on detailed requirements for sourcing renewable electricity.
[157] Ibid Article 1.
[158] Ibid Article 3.

Option II, when the RFNBO plant uses different types of electricity from the grid.[159] Looking more closely at **Figure 1.**, the yellow, green, and blue boxes show the DA delineated two distinct sets of criteria that need to be fulfilled on top of the different scenarios to ensure its renewable integrity. Firstly, the Act introduces the concept of *additionality*,[160] which serves as a cornerstone principle to guarantee that the escalation in hydrogen production is accompanied by commensurate advancements in new renewable electricity generation capacities. In essence, this provision seeks to foster a symbiotic relationship between the burgeoning hydrogen sector and the expansion of RE infrastructure.[161] To operationalise this principle, the rules mandate two criteria for hydrogen producers. On the one hand, engage in power purchase agreements exclusively with newly established and unsupported renewable electricity generation projects.[162] By enforcing this requirement, the Commission endeavours to facilitate the simultaneous growth of both the hydrogen and RE sectors, thus reinforcing broader efforts toward decarbonisation. On the other hand, the RE source generation facilities must not have received State aid beforehand, restricting a wide range of subsidies and State support.[163] It is worth noting that these two additional criteria will only apply to both new and existing producers as from January 1, 2028. Secondly, the Act delineates criteria pertaining to *temporal* and *geographic* correlation,[164] reflecting, *inter alia*, the imperative to synchronise hydrogen production with the availability of renewable electricity resources. The *temporal correlation* requirement mandates, on the one hand, that the production of RFNBOs must occur in the same calendar month as the production of electricity from the contracted RE sources until January 1, 2030, and then within the same hourly period after that.[165] Given the inherent variability of RE sources, meeting this requirement may prove impractical or excessively costly for producers, as it necessitates maintaining a large energy capacity consistently available when RFNBO production requires it.[166] The *geographical correlation* requirement, on the other hand, necessitates that the RE source facilities and the RFNBO are both located within the same, or in an interconnected, electricity market bidding zone, where renewable electricity already

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[159] Ibid Article 4.
[160] Ibid Article 5.
[161] Ibid (8).
[162] DA on detailed requirements for sourcing renewable electricity, Article 5(a); 36 months at start-up of the RFNBO facility
[163] Ibid Article 5(b).
[164] Ibid Articles 6 and 7.
[165] Ibid, Article 6.
[166] Dan Feldman and others, 'Europe's Definition of Green Hydrogen (RFNBO) Adopted into EU Law' (King & Spalding, 22 June 2023).

represents the dominant share and adding additional renewable electricity generation capacity would not be necessary or possible.[167] A bidding zone, as defined by EU law,[168] represents the largest geographical area where market participants can trade energy without the need for capacity allocation. [169] The delineation of these zones typically hinges on the unique characteristics of the electricity market within a given region.[170] Bidding zones can vary widely in size, ranging from encompassing entire countries to specific provinces or States, contingent upon factors like market structure, transmission infrastructure, and regulatory frameworks. Consequently, determining the precise configuration of a bidding zone requires a tailored analysis, especially in non-EU countries. This analysis will have to consider a range of factors to ensure that the boundaries of the bidding zone align effectively with the dynamics of the local electricity market.

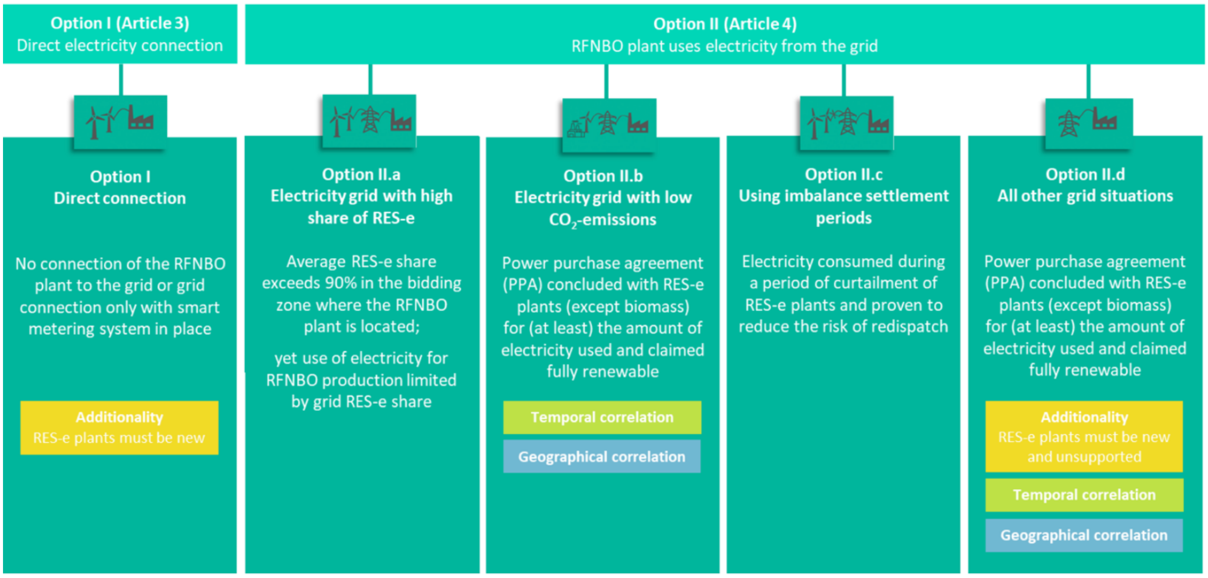

Figure 1. Renewable RFNBOs.[171]

[167] DA on detailed requirements for sourcing renewable electricity, (5).
[168] Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management [2015] OJ L 197, hereafter referred to as CACM Regulation, Articles 32-34.; Council Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity [2019] OJ L 158, hereafter referred to as Electricity Regulation, Article 14.
[169] Electricity Regulation, Article 2(65).
[170] CACM Regulation, Article 15(2).
[171] 'EU requirements for renewable hydrogen and its derivatives: Analysis of the two delegated acts adopted by the European Commission in February 2023 specifying the conditions under which electricity used to produce renewable fuels of non-biological origin (RFNBO) may be counted as fully renewable & the methodology to assess the greenhouse gas emissions savings from RFNBO' (International PtX Hub 2023), 10.

The recent sustainable criteria of RFNBOs within the Delegated Acts is a significant step forward, albeit accompanied by notable legal implications to be further explored in Chapter 5. Yet, this development underscores the urgent need for a comprehensive certification framework, crucial not only for regulatory compliance under RED III but also for fostering growth in the renewable hydrogen sectors, such as transport and industry.[172] A harmonised RFNBO certification scheme is imperative to provide assurance to both producers and consumers that hydrogen labelled as 'RFNBO' adheres faithfully to the production criteria outlined in the Delegated Acts.

3.1.3. Ensuring regulatory compliance

Certification and standardisation are critical components in fostering confidence and certainty among energy investors, particularly in the burgeoning sector of renewable hydrogen.[173] These mechanisms not only ensure transparency and reliability across the supply chain but also serve as powerful tools for promoting renewable hydrogen adoption, especially in sectors historically resistant to renewable gases.[174] Certifications play a role in providing crucial information about the geographic source and renewable origins of energy within the EU and outside. For example, as will be seen in the next section, the European Commission's establishment of quotas for renewable hydrogen in sectors like transport and industry underscores the need for companies to demonstrate compliance through certification, verifying the renewable nature and GHG content of purchased hydrogen.[175] However, despite the urgent need, there is currently no specific EU legislative act outlining certification processes for renewable hydrogen throughout its entire lifecycle. Historically, the absence of Delegated Acts defining RFNBOs has limited the development of a universally recognised certificate, but the recent definition of renewable hydrogen in the Delegated Act, which sets requirements for RFNBOs, highlights the necessity for robust certification mechanisms to ensure regulatory compliance.[176] To understand the

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[172] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 108 and 109.
[173] Ibid.
[174] Alberto Pototschnig and Ilaria Conti, 'Upgrading Guarantees of Origin to Promote the Achievement of the EU Renewable Energy Target at Least Cost' (Florence School of Regulation).
[175] Andris Piebalgs and Christopher Jones, 'A Proposal for a Regulatory Framework for Hydrogen Guarantees of Origin' (Florence School of Regulation).
[176] Jan-Hendrik Scheyl, 'EU Regulatory Framework and Certification in a Nutshell' (2023).

possible legal implications on the investment dynamics, it is essential to examine the current certification and standardisation framework. Within the EU, two main certification types could be applicable for renewable hydrogen:

On the one hand, RED III acknowledges the Guarantee of Origin as a crucial certificate tool for verifying the origin of energy produced from renewable sources,[177] including RFNBOs.[178] These certificates operate under transparent, objective, and non-discriminatory criteria within the EU borders, serving as a simple identifier for end consumers regarding the energy source.[179] They remain valid for 12 months after energy production, expiring automatically after 18 months if not previously cancelled.[180] According to Article 19(6) of RED III, the issuance, transfer, and cancellation of Guarantee of Origin for electricity adhere to the technical standards found in the CEN-EN 16325 standard. While this EU standard has undergone revision over the past 3 years to encompass *inter alia* hydrogen in order to ensure the purity of injected hydrogen into the grid, its updated version is yet to be finalised, impacting the investment dynamics.[181]. Despite the fact that the new standards are not yet in place, which may reveal legal implications, it is crucial for MS or competent bodies to ensure that any requirements they impose in their Guarantee of Origin comply with these forthcoming standards. On the same line, the hydrogen Guarantee of Origin is expected to prioritise high-purity hydrogen, potentially raising both the gas's market value and its corresponding Guarantee of Origin.[182] However, a standardised definition of 'high purity' renewable hydrogen is still pending.[183] In practice, CertifHy,[184] has developed CertifHy H2-GO, a market-based voluntary standard for e-fuels. This certification calculates GHG emissions based on a life cycle assessment, although it may not encompass every aspect of the cycle.[185] While Guarantees of Origin primarily aim to disclose the energy

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[177] See definition in RED III, Article 2(1).
[178] Ibid Article 19.
[179] See what must be mentioned in Guarantee of Origins in RED III, Article 19(7).
[180] RED III, Article 19(3).
[181] Katharina Sailer and others, 'Establishing a National Hydrogen Standard - An Aid to Decide between Developing an Own National Hydrogen Standard or Adopting an International Hydrogen Standard at the National Level' (Deutsche Energie-Agentur GmbH).; Stefan Van Laer and Isabel François, 'Hydrogen and Certification - Position Paper in Relation to the Certification of Hydrogen in Belgium' (Waterstof Industrie Cluster), 12.
[182] Ibid.
[183] Ibid.
[184] 'Certification Schemes' (CertifHy).
[185] Jan-Hendrik Scheyl, 'EU Regulatory Framework and Certification in a Nutshell' (2023).

source, RED III also allows for trading of these certificates. The CertifHy H2-GO initiative adopts a 'book and claim' approach, which facilitates the trading of certificates alongside physical energy flows, creating revenue opportunities.[186] However, this approach does not ensure complete traceability due to the complexity and varying reliability of national tracking systems.[187] Since it is technically infeasible to trace individual electrons back to their original source once they enter the grid, renewable electricity Guarantees of Origin inherently rely on a 'book and claim' approach. Under this framework, the sale of green hydrogen and the associated Guarantee of Origin occurs independently, eliminating the requirement for physical traceability of the hydrogen molecules themselves.[188]

On the other hand, there exists proof of sustainability certifications, a market-based voluntary standards scheme applicable to production sites beyond the EU borders. Unlike Guarantee of Origin, proof of sustainability certificates contribute to RE targets outlined in Article 3 of RED III, aiding companies and countries in demonstrating compliance with mandated quotas such as the RFNBOs sub-quota of 5% in transport and 75% in industry.[189] The establishment of robust standards and certification protocols is crucial within the renewable hydrogen sector to ensure efficacy. A significant stride was made in June 2023 when the European Commission published the RFNBOs standards in Delegated Act RED II Article 27(3) and Delegated Act RED II Article 28(5), laying the foundation for sustainability criteria. This regulatory framework is complemented by the involvement of various actors at both the EU and national levels. Regulatory bodies, such as the Commission, define sustainability criteria, while Voluntary Bodies translate these into actionable schemes and potentially introduce additional criteria. Once recognised as a Voluntary Scheme by the Commission upon Voluntary Bodies request, an independent third party oversees the certification process to ensure transparency and investor confidence.[190] Collaborating closely with certification bodies and auditors, these third parties facilitate thorough verification processes, bolstering the credibility of the certification

[186] Stefan Van Laer and Isabel François, 'Hydrogen and Certification - Position Paper in Relation to the Certification of Hydrogen in Belgium' (Waterstof Industrie Cluster), 5.
[187] Ibid.
[188] Anthony Velazquez Abad and Paul E Dodds, 'Green Hydrogen Characterisation Initiatives: Definitions, Standards, Guarantees of Origin, and Challenges' (2020) 138 Energy Policy 111300, 4.
[189] REPowerEU plan, 7.
[190] Stefan Van Laer and Isabel François, 'Hydrogen and Certification - Position Paper in Relation to the Certification of Hydrogen in Belgium' (Waterstof Industrie Cluster), 8.

journey. Moreover, RED III establishes a publicly available Union database for tracing RFNBOs,[191] enhancing investor confidence. Nonetheless, the Commission retains the authority to adopt further Delegated Acts to clarify the scope of the remaining unclear data. As Delegated Acts are officially published, the Commission's role evolves to recognise Voluntary Schemes for RFNBOs, harmonising investor confidence across the EU. Presently, one company has expressed intent to seek official recognition from the Commission for the CertifHy RFNBO standard, aligning with the aforementioned Delegated Acts requirements. This ongoing recognition process signifies progress toward establishing recognised certification bodies and fortifying the framework for sustainable investment within the EU.

3.2. Integration into the Transport and Industrial sectors

There has been a notable evolution in the regulatory framework regarding the integration of renewable hydrogen within the transport and industrial sectors since both are major hard-to-decarbonise sectors that need clear targets. These targets aim to ensure investors that there will be no chicken and egg problem of green hydrogen, in other words, that they will be guaranteed demand, ensuring substantial production and infrastructure.[192] Indeed, without demand, investment remains too risky to spread wide-scale production that could reduce costs.

On the one hand, aviation and maritime transport are highly subject to the use of renewable hydrogen, as reflected in the FuelEU Maritime[193] and ReFuel EU Aviation regulations,[194] though these have not yet entered into force. Indeed, since aviation and maritime transport are considered hard-to-decarbonise sectors, they aim to decarbonise by encouraging the use of alternative fuels[195] in a cost-effective manner and improving, *inter alia*, energy diversification

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[191] RED III, Article 31(a).
[192] 'Green Hydrogen for Industry a Guide to Policy Making' (International Renewable Energy Agency 2022).
[193] Proposal for Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC, COM (2021) 562 final, hereafter referred to as FuelEU Martime Regulation.
[194] Proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport, COM (2021) 561 final.
[195] See 'sunrise Clause' in FuelEU Martime Regulation, Article 4.

while promoting innovation, economic growth, and jobs in the Union on top of reducing reliance on energy imports.[196] Initially, the focus was on relatively vague targets outlined in the RED I of 2009,[197] where a 10% goal for biofuels adhering to sustainability criteria was set for the transportation sector.[198] Subsequently, in RED II of 2018,[199] the target shifted to a broader 14% mandate for RE sources in transportation, encompassing sustainable biofuels and RFNBOs.[200] Nonetheless, precise regulations were not established as the Delegated Acts had yet to be adopted. However, presently, there are more concrete objectives for RFNBOs, as outlined in RED III, delineating specific sub-goals for both the transportation sector.[201] Article 25 aims to increase the amount of renewable fuels and renewable electricity supplied to the transport sector, targeting a share of renewable energy within the final consumption of energy in the sector of at least 29% by 2030, or a reduction in GHG emissions intensity of at least 14.5%. These two options leave more scope for transport companies to decarbonise. The calculation rules to ensure the referenced reduction in Article 25(1) are detailed in Article 27. Within these RE targets, the new RED III also sets a target concerning the supplied fuel in the transport sectors. In fact, starting in 2025, all fuels must be biofuels or RFNBOs, with a mandatory 1% coming from RFNBOs by 2030. In other words, RFNBOs' impact or contribution to meeting targets in these sectors increases and generates a stronger incentive for their use in aviation and shipping, though not without the legal implications that will be examined in Chapter 5. Additionally, the REPowerEU plan also established a RFNBOs sub-quota of 5% in transport, making it crucial to launch sustainability certification to make progress toward making those targets traceable.[202]

[196] RED III, (11) (72).
[197] 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, hereafter referred to as RED I.
[198] RED I, Article 3(4).
[199] 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, hereafter referred to as REDII.
[200] RED II, Article 25(1).
[201] RED III, Articles 25.
[202] Katharina Sailer and others, 'Establishing a National Hydrogen Standard - An Aid to Decide between Developing an Own National Hydrogen Standard or Adopting an International Hydrogen Standard at the National Level' (Deutsche Energie-Agentur GmbH).

On the other hand, the industrial sector includes energy-intensive industries, such as steel, iron, and chemicals, which account for 25% of the Union's energy consumption.[203] These are considered hard-to-abate sectors since they have been reliant on fossil fuels for many years. It is important that those investment decisions are future-proof and avoid the creation of stranded assets. Therefore, benchmarks should be put in place to provide the industry with incentives to switch to production processes based on renewable energy, which are not only fuelled by renewable energy but also use renewable-based raw materials such as renewable hydrogen.[204] Indeed, in those industries, having concrete targets and objectives is crucial to unlocking the green transition while keeping them local and competitive within the EU.[205] With this in mind, the newly revised RED III has increased its targets for the industrial sectors, such as it did for the same transport sector. In the industrial sector, RED III aims to increase the share of RE sources for end-use and non-energy purposes (energy used in industrial production processes) by an average of 1.6% annually for the periods 2021-2025 and 2026-2030.[206] Additionally, RED III sets a target for RFNBOs in the industry, stipulating that by 2030, at least 42% of the hydrogen used for these purposes should come from renewable sources, increasing to 60% by 2035.[207] Additionally, MS can reduce the contribution of RFNBOs in industrial use by 20% if their national contribution to the overall binding EU target is met and the share of hydrogen from fossil fuels is no higher than 23% in 2030 and 20% in 2035.[208] These targets intend to promote the switch to more environmentally friendly energy sources and should create potential for innovation and demand in the field of renewable fuels and hydrogen-based technologies.

[203] RED III, (59).
[204] Ibid.
[205] 'Green Hydrogen for Industry a Guide to Policy Making' (International Renewable Energy Agency 2022), 30.
[206] RED III, Article 22a (1).
[207] Ibid.
[208] RED III, Article 22b (1)(b).

4. The role of State aid rules in renewable hydrogen

The landscape of renewable energy investment, particularly within the realm of renewable hydrogen, lies at an intersection between economic dynamics and regulatory frameworks. As outlined in the literature review in Chapter 2, the economic factors shaping the investment climate, ranging from the role of subsidies and supportive policies to the impacts of capital costs and market uncertainties, demonstrate the challenges financial incentives aim to address to overcome investor indecision. Consequently, a normative criterion has been established that increases investor confidence, namely **investment predictability**. State aid rules can positively influence investment predictability for RE projects, including renewable hydrogen projects, by providing financial support to offset capital costs and mitigating the deterrent effects of uncertainties surrounding evolving market conditions.[209] In the EU, due to the lack of harmonisation schemes for the deployment of RE,[210] schemes tend to be developed and implemented nationally.[211] Governmental support is the primary means of deploying RE incentive schemes, such as feed-in-tariffs, green certificates, etc., which provide financial guarantees to investors and facilitate the adoption of renewable energy technologies.[212] However, the 27 MS must abide by State aid legislation at the EU level to grant government support for RE projects, including renewable hydrogen projects.

To acknowledge the relevance of State aid rules for renewable hydrogen project investment, it is necessary to examine the role and evolution of State aid rules in the energy sector, which influence the financial viability and market competitiveness of such projects within the EU's

[209] Falk Schöning and Clemens Ziegler, 'What Is State Aid?', *State Aid and the Energy Sector* (Hart Publishing 2018), 4.
[210] Elena Cima and Makane Moïse Mbengue, A Multifaceted Approach to Trade Liberalisation and Investment Protection in the Energy Sector (Brill, 2021), 193.
[211] Ibid.; Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020).; Elisabetta Gasperi and Guendalina Catti De, 'The Application of EU State Aid Law in the Energy Sector' 10 Journal of European Competition Law & Practice 53.' Cecilia Sbrolli and Steven Verschuur, 'The European Green Deal and State Aid: The Guidelines on State Aid for Environmental Protection and Energy Towards the Future' (2020) 19 European State Aid Law Quarterly 284.
[212] Elena Cima and Makane Moïse Mbengue, A Multifaceted Approach to Trade Liberalisation and Investment Protection in the Energy Sector (Brill, 2021), 194.

regulatory framework.[213] The role of State aid in the energy sector has been emphasised by several authors, with a significant increase from when the European Green Deal was adopted by the Commission in 2019.[214] Due to the sharp increase in energy and energy infrastructure prices and the constantly increasing requirements to meet RE and environmental targets, the role of State aid has been recognised to promote an increasing level of environmental protection and energy efficiency.[215] In fact, this aid is necessary to control the internal market's support for energy-related activities while forbidding MS from unfairly favouring businesses.[216] Hence, unless the support aligns with the internal market and has received Commission approval, it is deemed illegal. The energy industry, in particular, frequently faces market failures that call for government intervention, such as addressing natural monopolies, carrying out public service obligations, and funding renewable energy projects.[217] State aid rules are structured to avoid a "race to the bottom," in which MS attempt to outbid one another with subsidies to attract or retain businesses.[218] This could result in an ineffective use of resources and undermine the competitiveness of the EU as a whole. However, the EU recognises that in certain contexts, well-designed State aid is necessary to address market failures, support crucial projects of common European interest, and facilitate the transition towards a more sustainable and resilient economy.[219] Indeed, in the context of renewable hydrogen production, transportation, and industrialisation, EU State aid plays a role in bridging the gap between current market capabilities and the ambitious goals set by the Hydrogen Strategy and the REPowerEU plan. In comparison to conventional production from fossil fuels, hydrogen production is still at a nascent stage, facing significant technological challenges and high costs.[220] It is also less

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[213] Falk Schöning and Clemens Ziegler, 'What Is State Aid?', *State Aid and the Energy Sector* (Hart Publishing 2018), 4.; Guillaume Dezobry and Adrien de Hauteclocque, 'State Aid and Price Regulation in the Energy Sector' *State Aid and the Energy Sector* (Hart Publishing 2018), 31,

[214] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 126.; Falk Schöning and Clemens Ziegler, 'What Is State Aid?', *State Aid and the Energy Sector* (Hart Publishing 2018).

[215] Ibid 14.; Cecilia Sbrolli and Steven Verschuur, 'The European Green Deal and State Aid: The Guidelines on State Aid for Environmental Protection and Energy Towards the Future' (2020) 19 European State Aid Law Quarterly 284, 285, 286.

[216] 'Global Forum on Competition: Roundtable on Competition, State Aids and Subsidies.' (Organisation for Economic Co-operation and Development 2011) 112.; Lena Sandberg, 'State Aid in the Form of Taxation and Emission Costs', *State Aid and the Energy Sector* (Hart Publishing 2018), 78.

[217] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 126.

[218] Setareh Roshanjahromi, 'A Comparative Analysis between EU State Aid and WTO Subsidies ' (Master Thesis, FACULTY OF LAW Lund University 2017), 13.

[219] ClientEarth (2020). *A State Aid Framework for a Green Recovery,* 12.; 'State Aid: Commission Invites Stakeholders to Provide Comments on Revised State Aid Rules on Important Projects of Common European Interest' (European Commission, 23 February 2021).

[220] Hydrogen Europe (2023). *Clean Hydrogen Monitor 2023*, 42-73.; Scita et al., 2020, 9.

economically attractive than other energy sources due to market demand preferences and competition from those sources, which prevents the development of a global clean hydrogen market.[221] As for transport and industry, the primary challenges will be related to the huge infrastructure development required because, at the moment, hydrogen is usually produced and consumed on-site at relatively low costs.[222] Nonetheless, as technology develops regarding renewable energy and electrolysis, studies have been optimistic regarding the price of renewable hydrogen production, paving the way for a global hydrogen market.[223] This positive pathway has been demonstrated by other RE sources. For instance, solar and wind power experienced remarkable cost deflation between 2010 and 2022.[224] According to a study by Wood Mackenzie, in 2040, the average cost of producing green hydrogen will be the same as that of hydrogen derived from fossil fuels, with a 64% reduction in comparison to today.[225]

Nevertheless, by providing access to State aid, the EU currently aims to lower the financial barriers to entry for renewable hydrogen projects, encouraging investment and allowing for more predictability. This support aligns with the EU's strategy to reduce carbon emissions and transition towards a cleaner energy system. State aid for renewable hydrogen projects can help, *inter alia*, accelerate the development of the necessary technologies and infrastructure, reduce the cost of renewable hydrogen over time, and increase its competitiveness in the energy market.[226] State aid for renewable hydrogen is a significant instrument for the EU to meet its environmental objectives, stimulate economic growth in a new green technology sector, and ensure long-term energy security and sustainability, therefore creating a more secure environment for investors to finance RE projects. Thus, it is, *inter alia,* important to emphasise the importance of exploring EU State aid rules and their impact on the legal landscape as a means to unleash the power of renewable hydrogen for the clean energy transition and avoid the risk of European industries shifting to other countries.[227] In the sub-chapters, the

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[221] Rossana Scita, Pier Paolo Raimondi and Michel Noussan, 'Green Hydrogen: The Holy Grail of Decarbonisation? An Analysis of the Technical and Geopolitical Implications of the Future Hydrogen Economy' (Fondazione Eni Enrico Mattei) 13, 9.
[222] Ibid 13.
[223] Ibid.
[224] 'Renewable Power Generation Costs in 2020' (International Renewable Energy Agency (IREA)), 20.
[225] 'Green Hydrogen Costs to Fall by up to 64% by 2040' (WoodMackenzie , 25 August 2020).
[226] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 131.; CEEAG (n. 4), recital 10.
[227] Irina Trichkovska and others, 'The European Commission Loosens State Aid Rules to Foster Energy Transition and Prevent the Flight of Green Technologies from Europe' (White&Case, 27 March 2023).

background and evolution of EU State aid rules are outlined, emphasising their foundational principles and legal basis relevant to renewable hydrogen. Additionally, an overview of *ex-ante* and *ex-post* State aid rules' exemptions for renewable hydrogen is discussed, along with temporary measures introduced to address specific economic challenges within the EU framework applicable to investors in the renewable hydrogen sector.

4.1. Background of EU State aid rules

State aid is defined in Article 107(1) of the Treaty on the Functioning of the European Union (TFEU)[228] as:

> *Any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the internal market.*

In accordance with Article 107(1) TFEU, the Commission has the discretion to determine whether a state's intervention qualifies as State aid.[229] As a result, it should be prohibited if there is a suspicion that it could be viewed as aid granted by a MS or through State resources, distorting or threatening to distort competition and affect trade between MS, making it incompatible with the EU's internal market.[230] For the Commission to regard it as State aid, it must meet five requirements. Firstly, the aid must have a State origin, meaning it must be imputable to the State or a public authority, including aid granted by a public or private body acting under the authority of a public entity,[231] and State resources must be granted. It is crucial

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[228] TFEU.
[229] Ibid, Article 108(2).
[230] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 126.
[231] Commission Notice on the notion of State aid as referred to in Article 107(1) of the Treaty on the Functioning of the European Union C/2016/2946 [2016] OJ C 262, para 39-43.

that both requirements are cumulative for the aid to have a State origin rather than alternatives.[232] Secondly, the aid must be granted to an undertaking, defined as any entity involved in economic activities.[233] Unless the entity is involved in non-profit activities and not engaged in market-based transactions, which is very rarely the case in the energy sector, all entities fall under this condition.[234] Thirdly, the aid must confer an advantage on a specific undertaking or group of undertakings, creating a favourable situation compared to others.[235] Rather than looking at its cause or intention, an advantage is defined by its effects, whether direct or indirect.[236] It includes any lessening of the typical financial burden of an undertaking, including loans, investments, tax breaks, subsidies, and exemptions from fiscal charges.[237] Fourthly, the aid must be selective *per se*. The selectivity condition can be observed either in law (*de jure*) or in practice (*de facto*), materially or regionally, depending on what the MS puts in place.[238] Finally, the aid must have the potential to affect trade between EU MS and distort or threaten to distort competition in the internal market.[239]

State aid is generally forbidden in order to prevent distortion of the EU internal market, provided that the requirements under Article 107(1) TFEU are met. Nevertheless, government interventions are also required to allow for greater flexibility in the area of State aid for a variety of policy objectives due to potential market failures.[240] In the following sub-chapter, an overview of the various EU State aid rules' exemption specifically applicable to renewable hydrogen projects will be examined. These exemptions have the potential to lower the financial barriers to entry, encourage investment, and enhance investment predictability for such projects.

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[232] *PrussenElektra* [2001] C-379/98 E.C.R. I-2099.
[233] *Heiser* [2005] C-172/03 E.C.R. I-1627, para 26.
[234] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020).; *Germany v Commission* [2012] T-347/09 E.C.R. II-0000.; *Germany v Commission* [2013] E.C.R. II-0000, paras 48 and 53.
[235] *Altmark Trans and Regierungsprasidium Magdeburg* [2003] C-280/00 E.C.R. I-7747, para 84.
[236] Commission Notice on the notion of State aid as referred to in Article 107(1) of the Treaty on the Functioning of the European Union C/2016/2946 [2016] OJ C 262, para 67.
[237] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor & Francis Group, 2020), 129.
[238] Ibid 130.
[239] *Unicredito Italiano* [2005] C-148/04 E.C.R. I-11137, para 55.; *Air Liquide Industries Belgium* [2006] C-393/04 E.C.R. I-5293, para 34.
[240] Communication from the Commission on the Guidelines on State aid for climate, environmental protection and energy 2022 C/2022/481 [2022] OJ C 80, hereafter referred to as CEEAG, (9).

4.2. Overview of the EU State aid rules' exemption for renewable hydrogen

4.2.1. *Ex ante* exemption in State aid rules

Within the evolving framework of EU State aid policies, a major EU policy document has strengthened State aid rules within the EU. The Green Deal Industrial Plan, already mentioned in Chapter 3, underlines the relevance of access to finance as one of the key enablers to strengthening and increasing the deployment of strategic clean technologies.[241] In this regard, an important instrument was revised and released on March 9, 2023, expediting the mobilisation of State aid as a significant step toward bolstering the EU's competitiveness and climate ambitions, particularly with regard to the hydrogen sector. Indeed, the General Block Exemption Regulation (GBER), adopted under the Enabling Regulation,[242] was designed to *ex ante* streamline the process for MS in granting aid by allowing aid without requiring the notification obligation and the prior approval of the European Commission, provided that certain conditions are met. This regulatory framework is particularly significant in the realm of environmental protection and energy transition, where it facilitates the implementation of aid measures that align with the EU's ambitious climate goals, including the promotion of RE sources.[243] With the adoption of the Green Deal Industrial Plan, the importance of this framework has been further elevated, particularly in relation to renewable hydrogen. The '2023 Green Deal GBER Amendment'[244] to the General Block Exemption Regulation underscores the essential contribution of renewable hydrogen to the EU's decarbonisation goals, reflecting

[241] 'New State Aid Measures: A Boost for H2 Tech and Deployment' (HydrogenEurope).
[242] Council Regulation (EC) No 994/98 of 7 May 1998 on the application of Articles 92 and 93 of the Treaty establishing the European Community to certain categories of horizontal State aid [1998] OJ L 142.
[243] 'The General Block Exemption Regulation A Revised State Aid Tool to Encourage the Green Transition?' (ClientEarth 2023).
[244] Commission Regulation (EU) 2023/1315 of 23 June 2023 amending Regulation (EU) No 651/2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty and Regulation (EU) 2022/2473 declaring certain categories of aid to undertakings active in the production, processing and marketing of fishery and aquaculture products compatible with the internal market in application of Articles 107 and 108 of the Treaty (Text with EEA relevance) [2023] OJ L 167, hereafter referred to as the GBER.

its heightened significance in the context of the EU's green ambitions.[245] By categorising investment and operating aid for the promotion of energy from renewable sources, including renewable hydrogen, as compatible with the internal market within the meaning of Article 107(3) TFEU, the GBER effectively encourages MS to support the development and deployment of renewable hydrogen projects.[246] Therefore, investment and operating aid falling under GBER are exempted from prior notification to the Commission under Article 108(3) TFEU. This exemption applies as long as the projects comply with specific conditions outlined in the GBER, aimed at ensuring that such aid measures do not unduly distort market competition. Therefore, the 2023 Green Deal GBER Amendment acts as a facilitator for MS to advance their green transition policies, notably in the acceleration and scaling up of renewable hydrogen initiatives, by providing a simplified legal framework that aligns with the broader objectives of the European Green Deal.[247]

4.2.2. *Ex post* exemption in State aid rules

If the aid does not fall within the realm of GBER, it should *prima facie* fall under Article 107(1) TFEU and, therefore, be deemed to be incompatible with the EU internal market. Nevertheless, there are some additional exceptions where the aid pursues positive economic, social, or environmental objectives.[248] Indeed, the principle of incompatibility of State aid with the internal market is not absolute. There are a few circumstances listed in Article 107 (2) and (3) of the TFEU where State aid is still compatible with the internal market. On the one hand, *automatic exceptions* are listed in Article 107(2) TFEU and include aid with a social component and aid to repair damage caused by natural disasters. In this case, the Commission lacks the discretion to determine whether the aid qualifies for an exemption if the conditions are satisfied.[249] As soon as assistance comes under this paragraph's purview, it is, in fact, released from the notification requirement and is therefore considered to be in line with the internal

[245] GBER, Articles 36(1b), 43.
[246] Ibid.
[247] 'The General Block Exemption Regulation A Revised State Aid Tool to Encourage the Green Transition ?' (ClientEarth 2023).
[248] 'A State Aid Framework for a Green Recovery Mainstreaming Climate Protection in EU State Aid Law' (ClientEarth 2020).
[249] Kelyn Bacon, European Union Law of State Aid (3rd Edition, 2017), 91.

market. On the other hand, *discretionary exceptions* can be found under Article 107(3) TFEU, where State aid measures may be compatible with the internal market. In contrast with the automatic exceptions, here, the Commission has the discretion to declare certain types of aid compatible with the internal market. Regarding the applicability of Article 107(3) TFEU for renewable hydrogen projects, two sub-sections should be examined.

Firstly, Article 107(3)(b) TFEU encompasses important projects of common European interests, aiming to foster sustainable economic growth, job creation, competitiveness, and resilience for industry and the economy in the Union by facilitating breakthrough innovation and infrastructure projects through cross-border cooperation, addressing market or systemic failures, and leveraging both public and private sector resources.[250] The relevant question is what exactly falls under an important project of common European interest and whether aid supporting renewable hydrogen projects can be justified under Article 107(3)(b) TFEU. Article 107(3)(b) can be read as follows:

The following may be considered to be compatible with the internal market:

[...]

(b) aid to promote the execution of an important project of common European interest or to remedy a serious disturbance in the economy of a Member State;

The Commission Communication has developed criteria to give guidance on the criteria the Commission will apply for assessing State aid granted to promote the execution of important projects of common European interest in order to determine whether the aid is compatible with the internal market of State aid under important projects of common European interests. Firstly, the Communication defines the scope of what can be encompassed within the important projects of common European interests provision, highlighting that it is applicable to all sectors of

[250] Communication From the Commission Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest [2021] 2021/C 528/02, 1.

economic activity, including energy.[251] Secondly, the Communication provides a list of eligibility criteria that the Commission will apply to the project to see whether it falls under Article 107(3)(b) TFEU.[252] First, the aid must concern either an integrated project or a project with defined goals or implementation guidelines. A project that is integrated is one that is part of a larger program, roadmap, or structure, has a single goal, and is founded on a logical systemic approach. Second, the project per se must make a significant contribution to the EU's objectives or strategies, including sustainable growth. Third, the aid must have a plus value on the market, as the design of the project must be able to overcome market failures. Next, the aid must be beneficial not only to companies but also to the entire EU society through positive spillover effects. Lastly, there must be important co-financing by the beneficiary or beneficiaries, and the project must comply with the principle of 'do not do significant harm' to environmental objectives.[253] Additionally, the Commission has highlighted some projects which are the most likely to be part of the important projects of common European interests. These include; Research and Development and Innovation projects, projects comprising the first industrial deployment that must allow for the development of a new product or service with high research and innovation content or the deployment of a fundamentally innovative production process, as well as infrastructure projects in the environment, energy, transport, health, or digital sectors.[254] The renewable hydrogen projects would fall under the last category. Third, the Communication has developed compatibility criteria, which apply only if a project is deemed to be an important project of common European interest based on eligibility criteria. Accordingly, the Commission will conduct a balancing test to evaluate whether the anticipated benefits of the aid exceed any potential drawbacks. In fact, the aid must be appropriate and necessary in order to support initiatives that would be unfeasible or severely limited otherwise.[255] In order to make sure that aid does not go beyond what is required for project profitability, the counterfactual scenario in which assistance is not provided must be carefully evaluated. The identified funding gap determines the intensity of aid, taking care to prevent overcompensation. Moreover, assistance can be paired with funding from the EU or other State

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[251] Ibid.
[252] Ibid.
[253] See more details on this objective in Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance) [2020] OJ L 198.
[254] 'For the Second Time the European Commission Has Approved State Aid for an Important Project of Common European Interest in the Hydrogen Value Chain' (Simmons Simmons, 29 September 2022).
[255] Communication From the Commission Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest [2021] 2021/C 528/02.

assistance, as long as the total amount of public funding does not exceed the best funding rate. The appropriateness of the aid measure is assessed in comparison to less distorting alternatives in order to prevent excessive distortions of competition. During the assessment process, possible detrimental effects on product market competition are also taken into account.

Secondly, Article 107(3)(c) TFEU encompasses environmental and energy efficiency aid and can be read as follows:

The following may be considered to be compatible with the internal market:

[...]

(c) Aid to facilitate the development of certain economic activities or of certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest;

In 2022, in the process of assessing whether certain aid falls under this provision, the Commission revised its **Guidelines on State Aid for Climate, Environmental Protection and Energy**[256] (CEEAG 2022). These guidelines replace the previous CEEAG that were applicable for the period of 2014 to 2020, in order to pursue European Green Deal objectives. Under CEEAG 2022, 13 categories of aid are covered, with some new ones added since the 2014 version. The category of aid for the reduction and removal of GHG emissions, including through support for renewable energy and energy efficiency, could encompass renewable hydrogen projects, as it is seen as a "catch-all" provision.[257] Nevertheless, there are two conditions for being exempted under Article 107(3)(c) TFEU. A positive condition entails aiding eco-friendly activities within the EU, promoting the green economy's sustainability, and bolstering environmental protection or energy market efficiency.[258] This aid should incentivise

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[256] CEEAG.
[257] 'State Aid in the Energy Sector ' (CMS, 29 June 2023).
[258] CEEAG.

recipients to adopt environmentally friendly practices in line with EU law without imposing restrictions on product or equipment origin. Conversely, a negative condition exists where the aid should not detrimentally impact trading conditions contrary to the Union's interests.[259] To justify State intervention, it must address market failures hindering environmental protection or energy market efficiency.[260] Thus, this aid provision should strike a balance, promoting green initiatives while ensuring fair competition and trade, aligning with the objectives of the GBER.

4.2.3. Temporary State aid rules' exemption

In addition to the *ex-ante* and *ex-post* exceptions of Article 107(1) TFEU, the European Commission has introduced, in response to geopolitical events and economic challenges in Europe, the **TCTF.**[261] This framework is a significant milestone in the EU's efforts to accelerate the transition to a sustainable, low-carbon economy, with a specific emphasis on renewable hydrogen technologies, aiming to loosen State rules to foster energy transition. This financial tool allows MS to provide temporary support schemes until the end of 2025 and aims to facilitate investments in renewable hydrogen production, storage, and utilisation for industrial decarbonisation to enable energy independence from the EU.[262] Notably, the framework introduces more flexible criteria, increased aid scale, and extended completion periods compared to previous initiatives, enabling projects to address pressing energy and environmental challenges effectively.[263] Moreover, the TCTF emphasises the strategic importance of renewable hydrogen by directly supporting investments in manufacturing capacities, advanced materials, and critical raw materials necessary for the scaling-up of

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[259] Ibid.
[260] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 129.
[261] Communication from the Commission on the amendment to the Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia [2023] C/2023/1188.
[262] 'The General Block Exemption Regulation A Revised State Aid Tool to Encourage the Green Transition?' (ClientEarth 2023).; 'New State Aid Measures: A Boost for H2 Tech and Deployment' (HydrogenEurope).
[263] 'New State Aid Measures: A Boost for H2 Tech and Deployment' (HydrogenEurope).

hydrogen technologies by 2030.[264] However, the TCTF also raises certain considerations and potential shortcomings that will be explored in Chapter 5, Section 2.

In conclusion, the overview of EU State aid rules revealed, *prima facie*, a positive environment for investment predictability, influencing the investment dynamic among investors. Overtime, the Commission has developed categories of policy measures that could benefit from State aid without the notification and approval of the Commission. Nonetheless, should a renewable hydrogen project not fall within the realm of GBER, it is not the last option to be exempted from the general prohibition under Article 107(1) TFEU, as the important projects of common European interests, CEEAG 2022, and TCTF showed. Together, these sets of rules form a comprehensive rulebook applicable to the renewable hydrogen sector, which allows for more financial certainty and predictability among investors to reach the final investment stage.

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[264] 'State Aid in the Energy Sector ' (CMS, 29 June 2023).

5. Legal implications of the legal framework on investment dynamics

The small percentage of projects reaching the final investment stage draws attention to the possible gaps, challenges, and complexities of the green hydrogen legal framework analysed in the previous two Chapters for investors. As the EU envisions within its Hydrogen Strategy and is recognised by several authors in Chapter 2, the legal framework's impact on the investment climate is increasingly significant in bringing certainty to investors. In the literature review found in Chapter 2, the paper explored the legal and economic factors influencing the investment climate, concluding on the importance of policy stability and certainty, regulatory coherence, and investment predictability as normative criteria for investor confidence. The literature review demonstrated that even if there is widespread acknowledgement of the need for financial guarantees for investors to reach final investment decisions, the role of the EU is to ensure clear and long-term policy visions. This enhances the need for a coherent, stable, and predictable regulatory environment for the deployment to maturity, as well as final investment decisions for renewable hydrogen projects. Projects that faced delays in the last few years.[265] In the following sub-section, the possible areas of ambiguity within the realm of the green hydrogen legal environment will be linked with the normative criteria impacting the investment dynamics discussed. Both the positive and negative implications of the current regulatory framework for renewable hydrogen and EU State aid rules will be examined.

5.1. Green hydrogen regulatory gaps and challenges

Regulatory coherence and policy stability and certainty have been acknowledged as normative criteria for enhancing investor confidence in renewable hydrogen projects. Within the existing

[265] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 34-36.

regulatory landscape, various gaps and challenges can be identified, yet there has also been positive improvement to highlight.

Firstly, by introducing important policy documents that support the European Green Deal's objective of attaining climate neutrality by 2050, the EU has made great progress towards promoting renewable hydrogen. Adopted in 2020, the Hydrogen Strategy for a Climate-Neutral Europe lays out a phased plan that calls for the construction of 6 GW of renewable hydrogen electrolysers by 2024 and 40 GW by 2030. In addition, the Fit-for-55 package, introduced in 2021, converts these objectives into workable legislative frameworks by establishing precise deadlines for using renewable hydrogen in both transport and industrial sectors by 2030. Furthermore, the REPowerEU plan intends to expedite the shift to clean energy by establishing challenging targets for both domestic production and imports of renewable hydrogen. Lastly, the introduction of the Green Deal Industrial Plan for the Net-Zero Age in 2023 further underscores the EU's commitment by providing a predictable regulatory framework and supporting industries in the transition to a net-zero economy, allowing more certainty among investors. Secondly, for many years, there was no universally agreed definition, as there were no international green hydrogen standards.[266] The legal framework lacked a clear definition of RFNBOs, leading to uncertainty about whether green hydrogen qualified as a renewable energy carrier, in contrast to black and brown hydrogen, which are more uniformly defined as produced from non-renewable sources.[267] Many authors and studies have tried to examine the various definitions of the green criteria that may be applied in future green or renewable hydrogen standards,[268] creating a more fragmented landscape that reduces certainty, as well as coherence and thus undermines investor confidence in the final investment decisions within the EU.[269] Indeed, there is a range of interpretations among authors on green hydrogen. For instance, some

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[266] Anthony Velazquez Abad and Paul E Dodds, 'Green Hydrogen Characterization Initiatives: Definitions, Standards, Guarantees of Origin, and Challenges' (2020) 138 Energy Policy 111300, 2.

[267] Paul Bellaby, Rob Flynn and Miriam Ricci, 'Rapidly Diffusing Innovation: Whether the History of the Internet Points the Way for Hydrogen Energy' (2012) 25 Innovation: The European Journal of Social Science Research 322, 330-331.

[268] Anthony Velazquez Abad and Paul E Dodds, 'Green Hydrogen Characterization Initiatives: Definitions, Standards, Guarantees of Origin, and Challenges' (2020) 138 Energy Policy 111300, 2.

[269] William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766.; Sonja Lüthi and Rolf Wüstenhagen, 'The Price of Policy Risk — Empirical Insights from Choice Experiments with European Photovoltaic Project Developers' (2012) 34 Energy Economics 100.

consider it to be derived solely from renewable sources[270] or some from any other net zero carbon energy through CCS and emissions offsets.[271] Additionally, some interpretations even extend to other sources, including nuclear sources.[272]

However, recent developments, notably the introduction of the associated Delegated Acts under RED II and then the revised RED III, which increased the renewable energy objectives within the EU, represent a significant leap forward for the green hydrogen sector. The following two sub-sections will evaluate the regulatory landscape of renewable hydrogen in light of policy stability and certainty, as well as regulatory coherence, which were assessed in the literature review as major normative criteria influencing investment dynamics.

5.1.1. Policy stability and certainty of the new Delegated Acts?

In the EU, the long overdue adoption of the RED II Delegated Acts by the Commission reflected contentious debate among those involved in green hydrogen deployment. Critics argue that the additionality principle and temporal correlation requirements create unnecessary barriers to hydrogen economy deployment.[273] During the negotiation process, despite opposition from the European Parliament and other enterprises concerned, which rejected the additionality principle, the Commission largely maintained its stance, making only minor changes to transitional provisions at the end.[274] As a result, the Delegated Acts defined RFNBOs and delineated clear production criteria for green hydrogen, as outlined in-depth in Chapter 3. This harmonisation in regulatory standards not only offers investors the clarity they need regarding the production of green hydrogen but also sets forth consistent and foreseeable requirements for offtake agreements, enhancing the attractiveness of investment opportunities. This

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[270] Andreas Poullikkas, ‘Implementation of Distributed Generation Technologies in Isolated Power Systems’ (2007) 11 Renewable and Sustainable Energy Reviews 30.
[271] ‘South Australian Green Hydrogen Study A Report for the Government of South Australia’ (Government of South Australia 2017) A32334.
[272] Greg Naterer and others, ‘Thermochemical Hydrogen Production with a Copper–Chlorine Cycle. I: Oxygen Release from Copper Oxychloride Decomposition’ (2008) 33 International Journal of Hydrogen Energy 5439.
[273] ‘Renewable Energy: EU Commission Rules for Renewable Hydrogen Enacted’ (CMS, 21 July 2023).
[274] Ibid.

development echoes the findings in the literature review addressed in Chapter 2, suggesting that a well-defined concept does provide a clear, consistent, and stable policy framework, which is instrumental in drawing investor confidence.[275] Hence, *prima facie*, the recent RFNBOs clarification can positively treat the investment dynamics in the renewable hydrogen sector, aligning with the policy stability and certainty normative criterion. Nevertheless, although the definition of RFNBOs was long-awaited and allowed to define the eligibility of pathways to renewable sources, there are some legal implications for investors.

The complexity inherent in complying with the criteria outlined in the Delegated Acts presents a significant challenge that could deter investment in renewable hydrogen projects, reflecting concerns about the policy stability and certainty normative criterion on the investment dynamic.[276] One key aspect is the concept of *additionality*, which introduces potential legal implications that may disrupt operations for RFNBO facilities. This requirement mandates that hydrogen producers engage exclusively with newly established and unsupported renewable electricity generation projects for power purchase agreements. This condition could force existing facilities to adjust their energy supply arrangements, possibly entailing costly modifications or renegotiations midway through operations.[277] Moreover, the restriction on subsidies and State support adds another layer of uncertainty, potentially prompting investors to explore opportunities outside the EU where financial benefits may be more attractive.[278] Additionally, the criteria concerning temporal and geographic correlation pose practical challenges for producers. The *temporal correlation* requirement mandates that RFNBO production align with the availability of renewable electricity sources on a monthly basis, transitioning to hourly alignment post-2030. Given the inherent variability of renewable energy sources like wind and solar,[279] maintaining a consistent energy supply to meet this requirement

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[275] Andrea Masini and Emanuela Menichetti, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28, 30.
[276] Merrill Jones Barradale, 'Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit' (2010) 38 Energy Policy 7698.
[277] Dan Feldman and others, 'Europe's Definition of Green Hydrogen (RFNBO) Adopted into EU Law' (King & Spalding, 22 June 2023).
[278] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 104.
[279] Lizica Simona Paraschiv and Spiru Paraschiv, 'Contribution of Renewable Energy (Hydro, Wind, Solar and Biomass) to Decarbonization and Transformation of the Electricity Generation Sector for Sustainable Development' (2023) 9 Energy Reports 535.

could prove impractical and economically burdensome for producers.[280] Furthermore, the *geographic correlation* requirement, which necessitates that RFNBO facilities and renewable energy generation plants are located within the same or interconnected electricity market bidding zones, adds another layer of complexity. Determining the precise boundaries of these zones and ensuring alignment with local market dynamics requires meticulous analysis, further complicating compliance efforts. Therefore, while promoting sustainability, the additionality and correlation criteria introduce a layer of complexity that may inadvertently signal regulatory instability to potential investors. As discussed in Chapter 2, given the importance of policy stability and certainty for fostering a conducive investment environment, particularly for long-term projects like those in the renewable hydrogen sector, these complexities could echo concerns for investors in their final investment decisions.[281] This could potentially lead to investment delays, as investors may adopt a 'wait-and-see' approach to determine the practical implications of these criteria on project feasibility.[282]

5.1.2. Regulatory coherence of the new RED III?

As of April 2024, with the RED III Directive having come into force in November 2023, MS are now in the process of transposing the new renewable energy targets into national legislation, with a 14-month window remaining for compliance. While the future cannot be predicted with absolute certainty, it is crucial that the transposition of the Directive does not introduce additional complexities that could undermine its objectives at the national level.

RED III sets forth ambitious targets for renewable energy across various sectors, notably aiming to increase the share of RFNBOs, in particular green hydrogen. On the one hand, for the

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[280] 'Impact Assessment of the RED II Delegated Acts on RFNBO and GHG Accounting March 2023 ' (Hydrogen Europe), 12.
[281] Ibid.; Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 512.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766, 4.; Karsten Neuhoff and Laurens De Vries, 'Insufficient Incentives for Investment in Electricity Generations' (2004) 12 Utilities Policy 253, 264.
[282] Matthew Doyle, 'Informational Externalities, Strategic Delay, and Optimal Investment Subsidies' (2010) 43 Canadian Journal of Economics/Revue canadienne d'économique 941, 942.

Industrial sector, the Directive's goals of achieving 42% renewable hydrogen by 2030 and 60% by 2035 provide policy certainty that can bolster investor confidence on the demand side. However, the negotiation of RED III has led to the inclusion of a 'nuclear gap' provision, as outlined in Article 22b (1), which permits MS to count hydrogen produced using nuclear energy towards their renewable hydrogen targets,[283] subject to two specific conditions.[284] Firstly, if each MS is on track to contribute at least as much as its expected national contribution to the binding overall Union target set in Article 3(1), first subparagraph.[285] Secondly, the share of hydrogen, or its derivatives, produced from fossil fuels which is consumed in that MS is not more than 23 % in 2030 and not more than 20 % in 2035.[286] The latter condition, resulting from French legislative advocacy,[287] introduces a degree of flexibility that could allow for the use of hydrogen in projects that do not strictly adhere to the EU's definition of renewable sources, such as those involving nuclear power. This 'nuclear gap' could have significant implications for the hydrogen market, potentially affecting the coherent trajectory of investments in renewable hydrogen projects. Indeed, it could potentially lead to a diversification of the hydrogen supply chain, influencing market dynamics and possibly shifting investor focus from strictly renewable sources to include nuclear-derived hydrogen. On the other hand, for the Transport sector, there is a combined sub-target of 5.5% for advanced fuels and RFNBOs by 2030, with a minimum requirement of 1% for RFNBOs, aiming to bolster the hydrogen economy. However, a study by Transport and Environment has highlighted that the actual impact of these targets is less ambitious than it appears to be,[288] possibly bringing doubts about the coherence amongst investors. In fact, only about one-third of the 1% target of RFNBOs will be delivered due to provisions permitting double counting and multipliers. Firstly, due to the higher cost of renewables and the additional renewable capacity needed to produce these RFNBOs, the law allows for every 1 MegaJoule (MJ) of RFNBOs used, to be counted as 2 MJ, resulting in double counting.[289] Secondly, a factor known as a 'multiplier' is used to incentivise the use of RFNBOs in the aviation and shipping sectors, with 1 MJ counted as 1.5 MJ toward

[283] RED III, Article 22a (1).
[284] 'Is Nuclear Green? European Union Is Splitting on Hydrogen From Nuclear Power | Cleary Gottlieb' (Cleary Gottlieb, 27 June 2023).; 'EU's 2030 Targets for Green Hydrogen Use in Industry and Transport Become Law with Publication in Official Journal' (HydrogenInsight, 31 October 2023).
[285] RED III, Article 22b (1)(a).
[286] Ibid Article 22b (1)(b).
[287] Paul Messad, 'France Finally Satisfied with EU Deal on Renewables Directive' (*euroactiv*, 19 June 2023).
[288] Geert Decock, 'First Binding Target to Supply Green H2 and E-Fuels to the Transport Sector' (Transport and Environment).
[289] RED III, Article 27 (2)(c).

the target, 0.3 MJ more than previously.[290] Consequently, there is a need to double the RFNBO target to 2% in order to reflect the growth in renewable energy production capacity more accurately.[291]

While RED III's introduction of ambitious RE targets, as well as specific targets for RFNBOs, is a positive step toward more certainty for investors, the possible 'nuclear gap' provision and the nuanced application of RFNBO targets introduce elements that may challenge the regulatory coherence of RED III. These two elements risk leading to varied implementation across MS, which could compromise the uniformity and predictability that are central to regulatory coherence. As regulatory coherence is an important criterion for creating an investment climate conducive to renewable hydrogen projects reaching the final investment decision stage, it is imperative that the EU ensures a consistent, harmonious, and integrated approach in the implementation of RED III provisions.

5.1.3. Certification gap for investor confidence

The evolving certification landscape for renewable hydrogen in the EU, characterised by the development of voluntary schemes like CertifHy and the pending harmonisation of standards, presents a complex picture for investors, intersecting with the three normative criteria of investment predictability, policy stability and certainty, and regulatory coherence. The current transitional phase, while signalling progress, introduces legal uncertainties that affect investment predictability.[292] Investors are faced with the challenge of navigating a certification system that is not yet fully interconnected across MS, which can lead to hesitancy and a more cautious approach to capital allocation. This caution is particularly pronounced given the potential variability in how different EU countries might implement and recognise these voluntary schemes, as well as how they might integrate them with existing national

[290] Ibid Article 27 (2)(e).
[291] Geert Decock, 'First Binding Target to Supply Green H2 and E-Fuels to the Transport Sector' (Transport and Environment).
[292] 'Decarbonising End-Use Sectors: Green Hydrogen Certification' (IRENA Coalition for Action 2022), 12.

regulations.[293] Nevertheless, the certification framework must operate consistently across the EU, ensuring enforceability for both domestically produced and imported RFNBO volumes. This variability in national implementations challenges policy stability, and the lack of a harmonised regulatory framework across MS disrupts regulatory coherence, all of which are crucial for investor confidence in renewable hydrogen projects. Indeed, the gap linked to the lack of a finalised EU-wide certification standard for the entire lifecycle of green hydrogen means that investors cannot yet rely on a consistent framework to validate the sustainability and origin of their hydrogen investments. This incoherence can complicate efforts to secure financing, as investors require clear and stable regulatory environments to mitigate the risk of investing in low-carbon technologies.[294] Furthermore, while facilitating the trade of certificates and potentially generating revenue, the 'book and claim' approach does not provide full traceability of the hydrogen's renewable origins, which could be a critical factor for investors prioritising sustainability credentials.[295] Overall, the pressing need for certification is driven by the aim of upholding the integrity of the renewable hydrogen sector while safeguarding against adverse environmental and economic repercussions, such as inadvertently incentivising increased reliance on fossil electricity generation.[296]

It is worth noting that the anticipated recognition of voluntary schemes by the European Commission is a positive step towards regulatory coherence. However, investors may remain cautious until these schemes are officially recognised and integrated into a unified EU database for tracing RFNBOs. The possibility of future Delegated Acts that could alter the scope of data included in the database or change the criteria for certification adds another layer of unpredictability, potentially delaying investment as stakeholders await further regulatory guidance. This absence of clarity complicates the process of reaching a consensus on key factors such as GHG emissions thresholds, the precise definition of "renewable electricity," and the establishment of robust tracking models, with the challenge compounded by the diverse market

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[293] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 108.
[294] Sabine Fuss and others, 'Impact of Climate Policy Uncertainty on the Adoption of Electricity Generating Technologies' (2009) 37 Energy Policy 733, 734.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766, 4. Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 519. Blyth et al., 2007, 5766-5773.; Lüthi & Wüstenhagen, 2012, 1001-1011.
[295] Stefan Van Laer and Isabel François, 'Hydrogen and Certification - Position Paper in Relation to the Certification of Hydrogen in Belgium' (Waterstof Industrie Cluster), 5.
[296] REPowerEU plan.

requirements, value systems, and political landscapes across the EU.[297] Hence, it introduces uncertainty regarding the compliance and sustainability credentials of hydrogen investments, which is a critical consideration for investors aiming to meet EU mandates and benefit from associated incentives.[298]

5.2. A path into investment predictability?

As seen in the literature review outlined in Chapter 2, different economic factors influence the willingness of investors to capitalise on a new RE energy carrier project. Having subsidies and supportive funds and the cost of capital are crucial economic factors that may render investors reluctant to capitalise on big infrastructure projects that renewable hydrogen necessitates, knowing that in their absence, there is no financial guarantee. Nevertheless, economic incentives to reach the final investment stage in the EU can also take place upstream by implementing a stable and predictable legal framework, which is essential for investment predictability. This predictability allows investors to forecast potential returns and assess risks with greater accuracy, thereby guaranteeing monetary funds while not distorting the internal market. Indeed, as seen in the last Chapter, MS may want to facilitate and accelerate renewable hydrogen deployment by granting public funds financial support,[299] enhancing the investment predictability criterion. While the aid, as described, are designed to stimulate investment and reduce risk, it can also be noted that they introduce a range of challenges that can complicate the investment landscape.

5.2.1. Renewable hydrogen projects: from theory to practice

[297] Ibid 48.
[298] 'Decarbonising End-Use Sectors: Green Hydrogen Certification' (IRENA Coalition for Action 2022), 12.
[299] Kaisa Huhta and Markus Sairanen, ' The Regulation of Hydrogen in the Context of Energy Storage as End-Use ', *Cambridge Handbook of Hydrogen and the Law* (Cambridge University Press, forthcoming in 2024).

In theory, the EU has developed many different ways for MS to be exempted from the general prohibitions in order to offer specific aid under Article 107(1) TFEU. This has an impact on investors, increasing financial guarantee and, thus, certainty to invest in costly renewable hydrogen projects. By providing clear guidelines and exemptions in particular, instruments like the GBER enhance predictability and stability for investors. In practice, this instrument approves more than 95% of energy-related aid to be exempted.[300] This clarity is decisive for long-term investments in capital-intensive renewable hydrogen infrastructure, as it delineates the conditions under which State aid is permissible, reducing unpredictability. In addition to the GBER, the TCTF, being part of the EU's State aid framework applicable to renewable hydrogen projects, is strategically designed to lower entry barriers. In this way, it facilitates investment and reduces financial risks for investors.[301] This aid renders renewable hydrogen projects more attractive and financially viable, contributing to the EU's broader environmental protection and energy efficiency objectives as outlined in the European Green Deal and the CEEAG 2022 mentioned earlier. Furthermore, State aid rules are crafted to prevent competitive imbalances within the internal market, avoiding a 'race to the bottom' where MS might compete to offer the most lucrative subsidies.[302] By ensuring that aid does not unduly distort competition, the EU fosters a level playing field, which is crucial for fair competition and resource efficiency, avoiding 'picking winners and losers in a given market.'[303]

In practice, over the last few years, there has been an increase in the amount of national aid approved by the Commission, providing a predictable framework for investment. In fact, investors can rely on the EU's support for large-scale renewable hydrogen projects through these mechanisms, signalling a long-term commitment to the sector. Firstly, in 2022, the European Commission approved two important projects of common European interest waves, Hy2Tech and Hy2Use, under Article 107(3)(b) TFEU. The focus on important projects of common European interest under Article 107(3)(b) TFEU stimulates cross-border cooperation,

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[300] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 139.
[301] 'State Aid: Commission Adopts Temporary Crisis and Transition Framework to Further Support Transition towards Net-Zero Economy' (European Commission, 9 March 2023).
[302] Setareh Roshanjahromi, 'A Comparative Analysis between EU State Aid and WTO Subsidies ' (Master Thesis, FACULTY OF LAW Lund University 2017), 13.
[303] Ignacio Herrera Anchustegui and Christian Bergqvist, 'The Role of State Aid Law in Energy', Routledge Handbook of Energy Law (Taylor&Francis Group, 2020), 133.

encouraging large-scale projects with significant EU-wide impact that are likely to appeal to investors due to their potential for higher returns and strategic value. On the one hand, the Hy2Tech wave, with a budget of €5.4 billion, focuses on supporting breakthrough technologies for renewable hydrogen production, expected to unlock €8.8 billion.[304] On the other hand, Hy2Use, with a budget of €5.2 billion, aims to support hydrogen offtake in industry, and it is expected to mobilise €7 billion in investments.[305] Combined, these important projects of common European interest waves allocate more than €10 billion, with an additional €15 billion expected from private investments. Nearly 80 hydrogen projects, submitted by 13 EU MS plus Norway, were approved by the European Commission under the Hy2Use, reflecting collaboration between the public and private sectors to achieve Europe's climate goals.[306] Indeed, by encouraging collaboration between the public and private sectors and sharing technological advancements, it aims to mitigate financial and technological risks while ensuring that State aid remains proportionate and does not unduly distort competition. This initiative underscores the flexibility of State aid rules in supporting large-scale investments to achieve climate goals, paving the way for significant progress in deploying hydrogen at a scale necessary for meeting ambitious emissions reduction targets. Under the TCTF, the European Commission authorised a €450 million scheme by Italy aimed at bolstering renewable hydrogen production as part of efforts to transition towards a net-zero economy, consistent with the Green Deal Industrial Plan.[307] This scheme will support investments in renewable hydrogen and electricity production in industrial areas. Open to all sectors except financial institutions, the aid will be allocated through competitive bidding, with a cap of €20 million per project.[308] Under the same framework, the Commission approved in November 2023 a €1.1 billion Spanish State aid scheme to support investments in equipment necessary to foster the transition to a net-zero economy.[309] In July 2023, the Commission approved a €246 million Dutch scheme under Article 107(3)(c) TFEU and the CEEAG mentioned above.[310] This scheme, part of the Netherlands' efforts to expand electrolysis capacity, will fund at least 60 MW of new

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[304] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 133.
[305] Ibid.
[306] Ibid.
[307] 'State Aid: Commission Approves €450 Million Italian Scheme to Support the Production of Renewable Hydrogen to Foster the Transition to a Net-Zero Economy' (European Commission).
[308] Ibid,
[309] 'Commission Approves €1.1 Billion Spanish State Aid Scheme to Support Investments in Equipment Necessary to Foster the Transition to a Net-Zero Economy' (European Commission, 28 November 2023).
[310] 'State Aid: Commission Approves €246 Million Dutch Scheme to Support Renewable Hydrogen Production' (European Commission, 28 July 2023).

installations through a competitive bidding process open to EEA companies.[311] Beneficiaries will receive direct grants for 7 to 15 years, contingent on compliance with EU criteria for RFNBOs. The Commission's assessment confirmed the scheme's necessity, appropriateness, and limited impact on competition, endorsing it as a positive environmental step that outweighs potential competition distortions.[312] In conclusion, these recent approvals by the Commission are a stride towards achieving the EU's increased renewable energy targets, reducing reliance on Russian fossil fuels as outlined in the REPowerEU plan, and giving investors more confidence. The exemption of more and more schemes from Article 107(1) TFEU to support renewable hydrogen initiatives enhances investment predictability by providing a clearer forecast of potential returns and a more accurate assessment of risks. This predictability is crucial for investors facing the high initial costs and evolving market conditions characteristic of renewable hydrogen projects.[313] By ensuring the stability and coherence of legal and policy frameworks, the EU effectively reduces the unpredictability of subsidy schemes and decreases the cost of capital,[314] thereby attracting private sector investment and increasing the likelihood of green hydrogen projects advancing to the final investment stage.

5.2.2. EU State aid rules: economic complexities

Nevertheless, uncertainties persist in the EU State aid landscape for renewable hydrogen projects, leading to possible complexities undermining the sector's growth and investment predictability. The reliance on State aid introduces the risk of market distortions, particularly if aid is not distributed evenly across MS, leading to an unbalanced investment climate.[315] This imbalance is exacerbated by the varying financial capabilities of MS, which could result in unequal development and support for renewable hydrogen initiatives within the EU. Such disparities are detrimental to the creation of a cohesive and competitive internal market for

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[311] Ibid.
[312] Ibid.
[313] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 24-27.
[314] Ibid 16.
[315] 'Prolonging Eased State-Aid Rules Raises Risk of Territorial Imbalances in Europe, Local Leaders Warn ' (*Europees Comité van de Regio's*, 29 November 2023).

renewable energy technologies and hinder the ability of investors to forecast potential profits and returns and assess risks with greater accuracy.[316] An example of this is the approval process for important projects of common European interest, as seen in the delay in notification for the Hy2Move wave until 2024.[317] Indeed, industrial development is severely hampered by the long delays in important projects of common European interest, which are caused by inefficiencies in both the European and national bureaucracies.[318] In addition to forcing investors to withdraw because of extensive waiting times, these delays increase the likelihood that projects will relocate to countries like the USA, which have more efficient administrative systems, as pointed out by the CEO of Hydrogen Europe.[319]

The aforementioned uncertainties intensify the gradual process of deindustrialisation and highlight the pressing necessity of overcoming bureaucratic obstacles to guarantee the prompt progress of projects essential for the hydrogen economy and funding for innovation. Moreover, the temporary nature of aid frameworks such as the TCTF can lead to a short-term focus, potentially overshadowing the need for sustainable, market-driven solutions. The impermanent nature of these frameworks raises critical questions about the continuity of support for renewable hydrogen projects and whether they can maintain viability without ongoing public funding. This creates a precarious situation for investors, who must weigh the immediate benefits of State aid against the potential for future regulatory and market changes, affecting investment predictability. Indeed, while it provides a mechanism for unlocking investments in renewable hydrogen and increasing investors' confidence, there is a risk of uneven implementation across MS. This could lead to disparities in support and development within the EU since not all MS have the same financial resources.[320] Additionally, the reliance on State aid may temporarily overshadow market-driven solutions, potentially creating dependencies on public funding. Indeed, the temporary nature of the framework raises questions about its long-term effectiveness in catalysing a sustainable hydrogen economy.[321]

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[316] Ibid 24.
[317] 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 133.
[318] Polly Martin, 'European Green Hydrogen Projects Are Being Delayed Due to Torturously Slow EU Subsidy Processes, Say Developers' (HydrogenInsight, 7 July 2023).
[319] Interview with Jorgo Chatzimarkakis, 'Frustration over Continuing Uncertainties' (7 March 2024).
[320] Irina Trichkovska and others, 'The European Commission Loosens State Aid Rules to Foster Energy Transition and Prevent the Flight of Green Technologies from Europe' (White&Case, 27 March 2023).
[321] Ibid.

Despite these challenges, the mentioned EU State aid rules' exemptions present a crucial opportunity for businesses, investors, and policymakers to drive forward the EU's energy transition agenda, particularly in the realm of renewable hydrogen.[322] Concretely, the recent increase in the amount of national aid approved by the Commission under one of the exemption rules is a positive step in boosting renewable hydrogen development. With substantial financial support available for eligible projects, companies across various sectors stand to benefit from incentives to innovate and invest in clean technologies aligned with the objectives of the Green Deal Industrial Plan. In conclusion, while steering through the complexities of EU State aid rules and maximising their benefits, investors must balance the immediate advantages of financial support against the potential for long-term market shifts, ensuring that their contributions to the renewable hydrogen sector align with the overarching vision of a sustainable and resilient European energy future. The legal and policy frameworks' coherence and stability within which these economic instruments operate are equally critical for enhancing investment predictability and motivating sustainable investment decisions that foster the development of technologies advancing green energy production.

[322] Ibid.

6. Conclusion

Throughout this thesis, the potential of renewable hydrogen in contributing to EU decarbonisation objectives has been emphasised, highlighting the need for a strong and confident regulatory environment to deploy the potential of this energy carrier. The significance of renewable hydrogen lies in its potential to decarbonise sectors traditionally reliant on fossil fuels, also known as hard-to-abate sectors, positioning it as essential in Europe's pursuit of climate neutrality.[323] However, amidst the promising initiatives at the EU level, reports' graphs also reveal a concerning decline in the number of projects estimated to be operational by the end of 2024, as compared to the initial projections.[324] This divergence prompted the focus of this thesis, exploring the potential factors influencing these shifts in investors' final decisions. Hence, the research question posed at the outset of the thesis is, "*In light of the need to enable and achieve the clean energy transition, how do the existing EU legal framework and State aid rules treat the investment dynamics for renewable hydrogen development?*" Indeed, for renewable hydrogen development to reach its full potential, the literature review revealed that investors, more generally, require a stable, certain, coherent, and economically predictable regulatory environment that minimises uncertainties and aligns with the long-term sustainability goals of the EU. Based on these factors, three normative criteria, namely policy stability and certainty, regulatory coherence, and investment predictability, were defined to analyse the existing EU renewable hydrogen legal framework and State aid rules. The thesis argued that these criteria are crucial in shaping the investment dynamics for renewable hydrogen development and, thus, were thoroughly analysed to understand their impact on the regulatory environment for green hydrogen and subsequent investment decisions. Therefore, the EU legal framework and State aid rules were examined through the lens of these three normative criteria, assessing their interplay and influence on fostering or hindering investment in renewable hydrogen projects.

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[323] Paris Agreement to the United Nations Framework Convention on Climate Change (12 December 2015) U.N. Doc, hereafter referred to as Paris Agreement.
[324] Ibid 34.

Initially, the research has highlighted that while the EU's Hydrogen Strategy, REPowerEU plan, Green Deal Industrial Plan, and associated policy instruments do provide a strategic direction for the role of green hydrogen in the clean energy transition, gaps, and complexities within the regulatory landscape impact investor confidence. The introduction of the Delegated Acts under RED II and the ambitious targets set by RED III both mark significant strides towards policy stability and certainty and support for renewable hydrogen production, transport, and industry, as well as other areas that had not been addressed, such as storage.[325] They establish a crucial framework that paves the way for future investment in the production of RFNBOs, which was absent in the legal environment a year ago. However, the complexity of the compliance criteria set forth by these acts introduces a degree of uncertainty that resonates with the policy certainty and stability criterion concerns discussed in Chapter 2. This complexity poses a challenge for investors as they attempt to navigate the intricate regulatory landscape, potentially leading to hesitancy in investing in renewable hydrogen projects, which could slow down the EU's progress towards its clean energy ambitions. Additionally, the absence of harmonised standards and certifications for the entire lifecycle of green hydrogen means that investors are currently without a consistent framework to ensure that their investments comply with EU mandates and qualify for associated incentives. However, it has been said that investors need regulatory coherence to create a conducive investment climate for renewable hydrogen initiatives. The development of voluntary schemes like CertifHy and the anticipation of their recognition by the European Commission are positive steps toward regulatory coherence, ensuring consistent, harmonious, and integrated recognition for investors. However, investors may remain cautious until these schemes are fully established and integrated into a unified EU database for tracing RFNBOs.

In addition, State aid rules, particularly through frameworks like the TCTF and important projects of common European interest as well as CEEAG, offer financial support to foster the growth of renewable hydrogen projects. The approval of large-scale projects under these frameworks, as shown in Chapter 5, demonstrates the EU's increasing commitment to reducing reliance on fossil fuels and advancing renewable hydrogen as a key energy carrier in the last

[325] See book chapter from Huhta and Sairanen for more information on the regulation of green hydrogen storage. Kaisa Huhta and Markus Sairanen, ' The Regulation of Hydrogen in the Context of Energy Storage as End-Use ', Cambridge Handbook of Hydrogen and the Law (Cambridge University Press, forthcoming in 2024).

two years. Yet, the investment predictability criterion is triggered by the temporary nature of such frameworks and the risk of uneven implementation across MS, which necessitates a careful balance between short-term incentives and long-term market viability. Studies discussed in Chapter 2 showed that long-term predictability is a crucial factor influencing the willingness of investors to reach the final investment decision stage. In essence, EU State aid mechanisms play an important role in mitigating investment risks associated with renewable hydrogen, such as technological uncertainties and substantial upfront costs.[326] Such mechanisms are crucial in attracting investment into this burgeoning sector and advancing the transition to a sustainable energy system. However, the complexities and delays in the approval process of such costly projects highlight the need for more efficient administrative systems to maintain Europe's competitive edge in the renewable hydrogen sector. The risk is that failing to address the uncertainty in funding could impede strategic European sectors such as steel, aviation, and shipping, which may rely increasingly on renewable hydrogen, to modernise and become more competitive globally. Investments will then relocate where the investment case is better outside of Europe. Hence, to prevent investors from seeking opportunities in growing markets like the US,[327] the EU must improve investment predictability, *inter alia* through the harmonisation of State aid rules, the establishment of long-term aid frameworks for renewable hydrogen, and the streamlining of approval processes to ensure consistent application across all MS.

To conclude on a positive note, there are signs of hope for the European energy transition. Green hydrogen is still an emerging RE carrier within the EU, characterised by an actively evolving legal landscape. That said, given the complexities of the renewable hydrogen regulatory environment and the challenges in securing funding, it is understandable that investors have been reluctant to commit to the final investment decision stage in recent years, established by the interplay of the normative criteria identified as impacting investment decisions and the legal framework.[328] Nonetheless, this thesis also argues that the path to

[326] Moongyung Lee and Deger Saygin, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227, 24-27.
[327] See US Hydrogen Strategy as a key player in the global hydrogen market 'Clean Hydrogen Monitor 2023' (Hydrogen Europe), 104.
[328] Ibid.

greater certainty, stability, coherence, and predictability for investors lies ahead. Given the relatively recent introduction of the mentioned regulatory instruments, such as the amended RED III and the new RED II Delegated Acts, there is a lack of established precedent in their application to renewable hydrogen projects. However, a coherent and consistent application of rules reassures investors, providing investors with a more stable, certain, and predictable investment environment in the future.[329] While this thesis concludes that some complexities in the renewable hydrogen legal landscape will be solved over time, the EU can foster investment dynamics in the renewable energy sector by addressing the identified legal and policy challenges and gaps in the regulatory framework, such as the lack of certification schemes, and ensuring the effective and long-term implementation of State aid rules. Such proactive measures would address the normative criteria identified as barriers for investors, *inter alia*, bringing more confidence in the investment dynamics, thereby expediting the deployment of renewable hydrogen projects and advancing a more resilient and clean energy transition.

[329] Anatole Boute , 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506, 512.; William Blyth and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766, 4.; Karsten Neuhoff and Laurens De Vries, 'Insufficient Incentives for Investment in Electricity Generations' (2004) 12 Utilities Policy 253, 264.

7. Bibliography

Primary sources

International legislations

Paris Agreement to the United Nations Framework Convention on Climate Change (12 December 2015) U.N. Doc

EU legislations

Council Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') [2021] OJ L 243

Council Regulation (EC) No 994/98 of 7 May 1998 on the application of Articles 92 and 93 of the Treaty establishing the European Community to certain categories of horizontal State aid [1998] OJ L 142.

Council Directive (EU) 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

Council 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

Council Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 [2023] OJ L

Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels C/2023/1086 [2023] OJ L 157

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, C/2023/1087 [2023] OJ L 157

Council Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance) [2020] OJ L 198

Council Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity [2019] OJ L 158

Consolidated version of the Treaty on the Functioning of the European Union OJ C 326, hereafter referred as TFEU.

Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management [2015] OJ L 197

Case law

Administration des douanes v Société anonyme Gondrand Frères and Société anonyme Garancini (Gondrand Frères) [1981] 169/80 E.C.R. 1931

Air Liquide Industries Belgium [2006] C-393/04 E.C.R. I-5293

Altmark Trans and Regierungsprasidium Magdeburg [2003] C-280/00 E.C.R. I-7747

Commission v France and United Kingdom [1989] 92/87 and 93/87 E.C.R. 405

Duff and Others v Minister for Agriculture and Food [1996] C63/93 E.C.R. I-569

Gebroeders van Es Douane Agenten BV v Inspecteur der Invoerrechten en Accijnzen [1996] C-143/93 E.C.R. I-431

Germany v Commission [2012] T-347/09 E.C.R. II-0000

Germany v Commission [2013] E.C.R. II-0000

Heiser [2005] C-172/03 E.C.R. I-1627

Ireland v Commission [1987] E.C.R. 5041 (325/85)

PrussenElektra [2001] C-379/98 E.C.R. I-2099

Unicredito Italiano [2005] C-148/04 E.C.R. I-11137

Vereniging voor Energie, Milieu en Water and Others v Directeur van de Dienst uitvoering en toezicht energie (VEMW) [2005] C-17/03 E.C.R. I-4983

Secondary sources

EU Policy instruments

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, C/2023/1087 [2023] OJ L 157

Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels C/2023/1086 [2023] OJ L 157

Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management [2015] OJ L 197

Consolidated version of the Treaty on the Functioning of the European Union OJ C 326, hereafter referred as TFEU.

Council Directive (EU) 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

Council 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

Council Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 [2023] OJ L

Council Regulation (EC) No 994/98 of 7 May 1998 on the application of Articles 92 and 93 of the Treaty establishing the European Community to certain categories of horizontal State aid [1998] OJ L 142.

Council Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity [2019] OJ L 158

Council Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance) [2020] OJ L 198

Council Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (‘European Climate Law’) [2021] OJ L 243

Journal Articles

Ajanovic A and Haas R, ‘Economic Prospects and Policy Framework for Hydrogen as Fuel in the Transport Sector’ (2018) 123 Energy Policy 280 <https://www.sciencedirect.com/science/article/pii/S0301421518305925> accessed 29 March 2024

Ajanovic A, Sayer M and Haas R, ‘On the Future Relevance of Green Hydrogen in Europe’ (2024) 358 Applied Energy 122586 <https://www.sciencedirect.com/science/article/pii/S0306261923019505> accessed 29 March 2024

Anchustegui IH and Bergqvist C, ‘The Role of State Aid Law in Energy’, Routledge Handbook of Energy Law (Taylor&Francis Group, 2020)

Angelopoulos D and others, ‘Risk-Based Analysis and Policy Implications for Renewable Energy Investments in Greece’ (2017) 105 Energy Policy 512 <https://www.sciencedirect.com/science/article/pii/S0301421517301325> accessed 29 March 2024

Ballo A and others, ‘Law and Policy Review on Green Hydrogen Potential in ECOWAS Countries’ (2022) 15 Energies 2304 <https://www.mdpi.com/1996-1073/15/7/2304> accessed 29 March 2024

Barradale MJ, ‘Impact of Public Policy Uncertainty on Renewable Energy Investment: Wind Power and the Production Tax Credit’ (2010) 38 Energy Policy 7698 <https://www.sciencedirect.com/science/article/pii/S0301421510006361> accessed 30 March 2024

Bellaby P, Flynn R and Ricci M, ‘Rapidly Diffusing Innovation: Whether the History of the Internet Points the Way for Hydrogen Energy’ (2012) 25 Innovation: The European Journal of Social Science Research 322

<http://www.tandfonline.com/doi/abs/10.1080/13511610.2012.685381> accessed 5 April 2024

Blyth W and others, 'Investment Risks under Uncertain Climate Change Policy' (2007) 35 Energy Policy 5766 <https://linkinghub.elsevier.com/retrieve/pii/S0301421507002170> accessed 29 March 2024

Bouri E, Iqbal N and Klein T, 'Climate Policy Uncertainty and the Price Dynamics of Green and Brown Energy Stocks' (2022) 47 Finance Research Letters 102740 <https://linkinghub.elsevier.com/retrieve/pii/S1544612322000629> accessed 29 March 2024

Boute A, 'Regulatory Stability under Russian and EU Energy Law' (2015) 22 Maastricht Journal of European and Comparative Law 506 <http://journals.sagepub.com/doi/10.1177/1023263X1502200403> accessed 29 March 2024

Boute A, 'The Quest for Regulatory Stability in the EU Energy Market: An Analysis Through the Prism of Legal Certainty' (2012) 6 <https://papers.ssrn.com/abstract=2193904> accessed 29 March 2024

Capurso T and others, 'Perspective of the Role of Hydrogen in the 21st Century Energy Transition' (2022) 251 Energy Conversion and Management 114898 <https://www.sciencedirect.com/science/article/pii/S0196890421010748> accessed 29 March 2024

De Jongh D, Ghoorah D and Makina A, 'South African Renewable Energy Investment Barriers: An Investor Perspective' (2014) 25 Journal of Energy in Southern Africa 15 <https://energyjournal.africa/article/view/2665> accessed 29 March 2024

Di Dio V and others, ‘Critical Assessment of Support for the Evolution of Photovoltaics and Feed-in Tariff(s) in Italy’ (2015) 9 Sustainable Energy Technologies and Assessments 95 <https://linkinghub.elsevier.com/retrieve/pii/S2213138814001015> accessed 29 March 2024

Dolci F and others, ‘Incentives and Legal Barriers for Power-to-Hydrogen Pathways: An International Snapshot’ (2019) 44 International Journal of Hydrogen Energy 11394 <https://www.sciencedirect.com/science/article/pii/S0360319919309693> accessed 29 March 2024

Doyle M, ‘Informational Externalities, Strategic Delay, and Optimal Investment Subsidies’ (2010) 43 Canadian Journal of Economics/Revue canadienne d’économique 941 <https://onlinelibrary.wiley.com/doi/10.1111/j.1540-5982.2010.01601.x> accessed 8 May 2024

Drago C and Gatto A, ‘Policy, Regulation Effectiveness, and Sustainability in the Energy Sector: A Worldwide Interval-Based Composite Indicator’ (2022) 167 Energy Policy 112889 <https://www.sciencedirect.com/science/article/pii/S0301421522001148> accessed 29 March 2024

Fazeli R, Beck FJ and Stocks M, ‘Recognizing the Role of Uncertainties in the Transition to Renewable Hydrogen’ (2022) 47 International Journal of Hydrogen Energy 27896 <https://www.sciencedirect.com/science/article/pii/S0360319922027549> accessed 29 March 2024

Feldman D and others, ‘Europe’s Definition of Green Hydrogen (RFNBO) Adopted into EU Law’ (King & Spalding, 22 June 2023) <https://www.jdsupra.com/legalnews/europe-s-definition-of-green-hydrogen-6926790/>

Finon D and Perez Y, ‘The Social Efficiency of Instruments of Promotion of Renewable Energies: A Transaction-Cost Perspective’ (2007) 62 Ecological Economics 77 <https://www.sciencedirect.com/science/article/pii/S0921800906002862> accessed 29 March 2024

Fleming R, ‘Clean or Renewable – Hydrogen and Power-to-Gas in EU Energy Law’ (2021) 39 Journal of Energy & Natural Resources Law 43 <https://www.tandfonline.com/doi/full/10.1080/02646811.2020.1795382> accessed 29 March 2024

Frank MZ and Shen T, ‘Investment and the Weighted Average Cost of Capital’ (2016) 119 Journal of Financial Economics 300 <https://www.sciencedirect.com/science/article/pii/S0304405X15001683> accessed 29 March 2024

Fuss S and others, ‘Impact of Climate Policy Uncertainty on the Adoption of Electricity Generating Technologies’ (2009) 37 Energy Policy 733 <https://www.sciencedirect.com/science/article/pii/S0301421508005818> accessed 29 March 2024

Gale F and others, ‘Renewable Hydrogen Standards, Certifications, and Labels: A State-of-the-Art Review from a Sustainability Systems Governance Perspective’ (2024) 59 International Journal of Hydrogen Energy 654 <https://linkinghub.elsevier.com/retrieve/pii/S0360319924004488> accessed 29 March 2024

Gasperi E and Catti De G, ‘The Application of EU State Aid Law in the Energy Sector’ 10 Journal of European Competition Law & Practice 53 <https://academic-oup-com.mime.uit.no/jeclap/article/10/1/53/5281302>

Gatzert N and Kosub T, ‘Risks and Risk Management of Renewable Energy Projects: The Case of Onshore and Offshore Wind Parks’ (2016) 60 Renewable and Sustainable Energy Reviews 982 <https://www.sciencedirect.com/science/article/pii/S1364032116001337> accessed 29 March 2024

Gatzert N and Vogl N, ‘Evaluating Investments in Renewable Energy under Policy Risks’ (2016) 95 Energy Policy 238 <https://linkinghub.elsevier.com/retrieve/pii/S0301421516301951> accessed 29 March 2024

Hassan Q and others, ‘Renewable Energy-to-Green Hydrogen: A Review of Main Resources Routes, Processes and Evaluation’ (2023) 48 International Journal of Hydrogen Energy 17383 <https://www.sciencedirect.com/science/article/pii/S0360319923003397> accessed 29 March 2024

Hoang K, ‘How Does Corporate R&D Investment Respond to Climate Policy Uncertainty? Evidence from Heavy Emitter Firms in the United States’ (2022) 29 Corporate Social Responsibility and Environmental Management 936 <https://onlinelibrary.wiley.com/doi/10.1002/csr.2246 > accessed 29 March 2024

Hosseini SE and Wahid MA, ‘Hydrogen Production from Renewable and Sustainable Energy Resources: Promising Green Energy Carrier for Clean Development’ (2016) 57

Renewable and Sustainable Energy Reviews 850 <https://www.sciencedirect.com/science/article/pii/S1364032115014951> accessed 29 March 2024

Hren R and others, 'Hydrogen Production, Storage and Transport for Renewable Energy and Chemicals: An Environmental Footprint Assessment' (2023) 173 Renewable and Sustainable Energy Reviews 113113 <https://www.sciencedirect.com/science/article/pii/S1364032122009947> accessed 29 March 2024

Huo M, Li C and Liu R, 'Climate Policy Uncertainty and Corporate Green Innovation Performance: From the Perspectives of Organizational Inertia and Management Internal Characteristics' (2024) 45 Managerial and Decision Economics 34 <https://onlinelibrary.wiley.com/doi/10.1002/mde.3981> accessed 29 March 2024

Ishaq H, Dincer I and Crawford C, 'A Review on Hydrogen Production and Utilization: Challenges and Opportunities' (2022) 47 International Journal of Hydrogen Energy 26238 <https://www.sciencedirect.com/science/article/pii/S0360319921045377> accessed 30 March 2024

Jones AW, 'Perceived Barriers and Policy Solutions in Clean Energy Infrastructure Investment' (2015) 104 Journal of Cleaner Production 297 <https://www.sciencedirect.com/science/article/pii/S0959652615006277> accessed 29 March 2024

Kilinc-Ata N and Dolmatov IA, 'Which Factors Influence the Decisions of Renewable Energy Investors? Empirical Evidence from OECD and BRICS Countries' (2023) 30

Environmental Science and Pollution Research 1720 <https://link.springer.com/10.1007/s11356-022-22274-8> accessed 29 March 2024

Kovač A, Paranos M and Marciuš D, 'Hydrogen in Energy Transition: A Review' (2021) 46 International Journal of Hydrogen Energy 10016 <https://www.sciencedirect.com/science/article/pii/S0360319920345079> accessed 29 March 2024

Lagioia G, Spinelli MP and Amicarelli V, 'Blue and Green Hydrogen Energy to Meet European Union Decarbonisation Objectives. An Overview of Perspectives and the Current State of Affairs' (2023) 48 International Journal of Hydrogen Energy 1304 <https://www.sciencedirect.com/science/article/pii/S0360319922046675> accessed 29 March 2024

Lebeau A and others, 'Long-Term Issues with the Energy-Only Market Design in the Context of Deep Decarbonization' (2024) 132 Energy Economics 107418 <https://www.sciencedirect.com/science/article/pii/S0140988324001269> accessed 30 March 2024

Lee M and Saygin D, 'Financing Cost Impacts on Cost Competitiveness of Green Hydrogen in Emerging and Developing Economies' (Organization for Economic Co-operation and Development 2023) 227

Lee Y and others, 'Policy Agenda toward a Hydrogen Economy: Institutional and Technological Perspectives' (2024) 54 International Journal of Hydrogen Energy 1521 <https://www.sciencedirect.com/science/article/pii/S0360319923064297> accessed 29 March 2024

Leete S, Xu J and Wheeler D, ‘Investment Barriers and Incentives for Marine Renewable Energy in the UK: An Analysis of Investor Preferences’ (2013) 60 Energy Policy 866 <https://www.sciencedirect.com/science/article/pii/S0301421513003431> accessed 29 March 2024

Lilliestam J and Patt A, ‘Barriers, Risks and Policies for Renewables in the Gulf States’ (2015) 8 Energies 8263 <http://www.mdpi.com/1996-1073/8/8/8263> accessed 29 March 2024

Liu X and Zeng M, ‘Renewable Energy Investment Risk Evaluation Model Based on System Dynamics’ (2017) 73 Renewable and Sustainable Energy Reviews 782 <https://www.sciencedirect.com/science/article/pii/S1364032117302228> accessed 29 March 2024

Lüthi S and Wüstenhagen R, ‘The Price of Policy Risk — Empirical Insights from Choice Experiments with European Photovoltaic Project Developers’ (2012) 34 Energy Economics 1001 <https://www.sciencedirect.com/science/article/pii/S0140988311001678> accessed 29 March 2024

Malik K and others, ‘Renewable Energy Utilization to Promote Sustainability in GCC Countries: Policies, Drivers, and Barriers’ (2019) 26 Environmental Science and Pollution Research 20798 <https://doi.org/10.1007/s11356-019-05337-1> accessed 29 March 2024

Masini A and Menichetti E, ‘Investment Decisions in the Renewable Energy Sector: An Analysis of Non-Financial Drivers’ (2012) 80 Technological Forecasting and Social Change 510 <https://papers.ssrn.com/abstract=2247461> accessed 30 March 2024

Masini A and Menichetti E, 'The Impact of Behavioural Factors in the Renewable Energy Investment Decision Making Process: Conceptual Framework and Empirical Findings' (2012) 40 Energy Policy 28 <https://linkinghub.elsevier.com/retrieve/pii/S030142151000532X> accessed 30 March 2024

Naterer G and others, 'Thermochemical Hydrogen Production with a Copper–Chlorine Cycle. I: Oxygen Release from Copper Oxychloride Decomposition' (2008) 33 International Journal of Hydrogen Energy 5439 <https://linkinghub.elsevier.com/retrieve/pii/S0360319908005478> accessed 5 April 2024

Neuhoff K and De Vries L, 'Insufficient Incentives for Investment in Electricity Generations' (2004) 12 Utilities Policy 253 <https://www.sciencedirect.com/science/article/pii/S0957178704000682> accessed 30 March 2024

Ngwakwe CC and Moyo T, 'Green Investment Behavior in Climate Policy Uncertainty: A Suggested Adjusted Profit Estimation Model' (2017) 5 Environmental Economics <https://www.businessperspectives.org/index.php/journals/environmental-economics/issue-223/green-investment-behavior-in-climate-policy-uncertainty-a-suggested-adjusted-profit-estimation-model> accessed 29 March 2024

Nicoletti G and others, 'A Technical and Environmental Comparison between Hydrogen and Some Fossil Fuels' (2015) 89 Energy Conversion and Management 205 <https://www.sciencedirect.com/science/article/pii/S0196890414008589> accessed 26 April 2024

Niesten E, Jolink A and Chappin M, 'Investments in the Dutch Onshore Wind Energy Industry: A Review of Investor Profiles and the Impact of Renewable Energy Subsidies'

(2018) 81 Renewable and Sustainable Energy Reviews 2519 <https://linkinghub.elsevier.com/retrieve/pii/S1364032117310031> accessed 29 March 2024

Olasehinde-Williams G, Özkan O and Akadiri SS, ‘Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis for the U.S’ (2023) 30 Environmental Science and Pollution Research 55326 <https://link.springer.com/10.1007/s11356-023-26257-1> accessed 29 March 2024

Paraschiv LS and Paraschiv S, ‘Contribution of Renewable Energy (Hydro, Wind, Solar and Biomass) to Decarbonization and Transformation of the Electricity Generation Sector for Sustainable Development’ (2023) 9 Energy Reports 535 <https://www.sciencedirect.com/science/article/pii/S2352484723011022> accessed 10 April 2024

Pique S and others, ‘Comparative Study of Regulations, Codes and Standards and Practices on Hydrogen Fuelling Stations’ (2017) 42 International Journal of Hydrogen Energy 7429 <https://linkinghub.elsevier.com/retrieve/pii/S0360319916300271> accessed 29 March 2024

Poullikkas A, ‘Implementation of Distributed Generation Technologies in Isolated Power Systems’ (2007) 11 Renewable and Sustainable Energy Reviews 30 <https://linkinghub.elsevier.com/retrieve/pii/S136403210600027X> accessed 5 April 2024

Saccani C, Pellegrini M and Guzzini A, ‘Analysis of the Existing Barriers for the Market Development of Power to Hydrogen (P2H) in Italy’ (2020) 13 Energies 4835 <https://www.mdpi.com/1996-1073/13/18/4835> accessed 29 March 2024

Salm S, Hille SL and Wüstenhagen R, ‘What Are Retail Investors’ Risk-Return Preferences towards Renewable Energy Projects? A Choice Experiment in Germany’ (2016) 97 Energy Policy 310 <https://www.sciencedirect.com/science/article/pii/S0301421516304037> accessed 29 March 2024

Santhakumar S and others, ‘Technological Learning Potential of Offshore Wind Technology and Underlying Cost Drivers’ (2023) 60 Sustainable Energy Technologies and Assessments 103545 <https://www.sciencedirect.com/science/article/pii/S2213138823005386> accessed 29 March 2024

Santhakumar S and others, ‘Technological Progress Observed for Fixed-Bottom Offshore Wind in the EU and UK’ (2022) 182 Technological Forecasting and Social Change 121856 <https://www.sciencedirect.com/science/article/pii/S0040162522003808> accessed 29 March 2024

Sbrolli C and Verschuur S, ‘The European Green Deal and State Aid: The Guidelines on State Aid for Environmental Protection and Energy Towards the Future’ (2020) 19 European State Aid Law Quarterly 284 <https://www.jstor.org/stable/48685810>

Taghizadeh-Hesary F and others, ‘Green Finance and the Economic Feasibility of Hydrogen Projects’ (2022) 47 International Journal of Hydrogen Energy 24511 <https://www.sciencedirect.com/science/article/pii/S0360319922002038> accessed 5 April 2024

Tarhan C and Çil MA, ‘A Study on Hydrogen, the Clean Energy of the Future: Hydrogen Storage Methods’ (2021) 40 Journal of Energy Storage 102676

<https://www.sciencedirect.com/science/article/pii/S2352152X21004151> accessed 29 March 2024

Tura N and others, 'Unlocking Circular Business: A Framework of Barriers and Drivers' (2019) 212 Journal of Cleaner Production 90 <https://www.sciencedirect.com/science/article/pii/S0959652618336059> accessed 29 March 2024

Velazquez Abad A and Dodds PE, 'Green Hydrogen Characterisation Initiatives: Definitions, Standards, Guarantees of Origin, and Challenges' (2020) 138 Energy Policy 111300 <https://www.sciencedirect.com/science/article/pii/S0301421520300586> accessed 29 March 2024

Wang M and others, 'The Intensification Technologies to Water Electrolysis for Hydrogen Production – A Review' (2014) 29 Renewable and Sustainable Energy Reviews 573 <https://www.sciencedirect.com/science/article/pii/S1364032113006308> accessed 30 March 2024

White LV and others, 'Towards Emissions Certification Systems for International Trade in Hydrogen: The Policy Challenge of Defining Boundaries for Emissions Accounting' (2021) 215 Energy 119139 <https://www.sciencedirect.com/science/article/pii/S0360544220322465> accessed 29 March 2024

Yang J and others, 'Investment Dynamics in the Energy Sector under Carbon Price Uncertainty and Risk Aversion' (2023) 4 Energy and Climate Change 100110 <https://www.sciencedirect.com/science/article/pii/S266627872300017X> accessed 29 March 2024

Yang M and others, ‘Evaluating the Power Investment Options with Uncertainty in Climate Policy’ (2008) 30 Energy Economics 1933 <https://linkinghub.elsevier.com/retrieve/pii/S0140988307000801> accessed 29 March 2024

Zhang F and others, ‘The Survey of Key Technologies in Hydrogen Energy Storage’ (2016) 41 International Journal of Hydrogen Energy 14535 <https://www.sciencedirect.com/science/article/pii/S0360319916318171> accessed 29 March 2024

Reports

‘A State Aid Framework for a Green Recovery Mainstreaming Climate Protection in EU State Aid Law’ (ClientEarth 2020) <https://www.clientearth.org/media/c45naoms/2020-09-30-a-state-aid-framework-for-a-green-recovery-coll-en.pdf>

‘Clean Hydrogen Monitor 2022’ (Hydrogen Europe) <https://hydrogeneurope.eu/wp-content/uploads/2022/10/Clean_Hydrogen_Monitor_10-2022_DIGITAL.pdf>

‘Clean Hydrogen Monitor 2023’ (Hydrogen Europe) <https://hydrogeneurope.eu/wp-content/uploads/2023/10/Clean_Hydrogen_Monitor_11-2023_DIGITAL.pdf>

‘Decarbonising End-Use Sectors: Green Hydrogen Certification’ (IRENA Coalition for Action 2022)

Decock G, ‘First Binding Target to Supply Green H2 and E-Fuels to the Transport Sector’ (Transport and Environment) <https://www.transportenvironment.org/wp-content/uploads/2023/09/RED-III-Fact-sheet-hydrogen-efuels-RFNBO-1.pdf>

‘EU requirements for renewable hydrogen and its derivatives: Analysis of the two delegated acts adopted by the European Commission in February 2023 specifying the conditions under which electricity used to produce renewable fuels of non-biological origin (RFNBO) may be counted as fully renewable & the methodology to assess the greenhouse gas emissions savings from RFNBO’ (International PtX Hub 2023) < https://ptx-hub.org/wp-content/uploads/2023/04/International-PtX-Hub_EU-Requirements-for-green-hydrogen-and-PtX.pdf>

‘Global Forum on Competition: Roundtable on Competition, State Aids and Subsidies. ’ (Organisation for Economic Co-operation and Development 2011) <https://www.oecd.org/daf/competition/48070736.pdf>

‘Global Hydrogen Review 2022’ (International Energy Agency) <https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf>

‘Green Hydrogen Contracting - Policy and Regulatory Developments’ (Green Hydrogen Organisation) <https://gh2.org/sites/default/files/2022-05/1.%20Brief%20on%20Policy%20and%20regulatory%20developments%20-%20reviewed%20by%20HSF%20and%20GH2%20-%20for%20final%20WG%20comment_0.pdf>

‘Green Hydrogen for Industry a Guide to Policy Making’ (International Renewable Energy Agency 2022) <https://www.irena.org/-

/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Industry_2022_.pdf?rev=720f138dbfc44e30a2224b476b6dfb77>

'Impact Assessment of the RED II Delegated Acts on RFNBO and GHG Accounting March 2023 ' (Hydrogen Europe) <https://hydrogeneurope.eu/wp-content/uploads/2023/07/Impact-Assessment-on-the-RED-II-DAs.pdf>

Inderst G, Kaminker C and Stewart F, 'Defining and Measuring Green Investments: Implications for Institutional Investors' Asset Allocations' (OECD) Oecd working papers on finance, insurance and private pensions 24

'Innovation Landscape Brief: Renewable Power-to-Hydrogen, International Renewable Energy Agency' (International Renewable Energy Agency) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Power-to-Hydrogen_Innovation_2019.pdf?la=en&hash=C166B06F4B4D95AA05C67DAB4DE8E2934C79858D>

'National Hydrogen Strategy Update - NHS 2023' (The German Federal Government 2023) <https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/national-hydrogen-strategy-update.pdf?__blob=publicationFile&v=2>

Noothout P and others (DIA-CORE) <https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/dia-core/D3-4_diacore_2016_impact_of_risk_in_res_investments.pdf>

Piebalgs A and Jones C, 'A Proposal for a Regulatory Framework for Hydrogen Guarantees of Origin' (Florence School of Regulation)

<https://cadmus.eui.eu/bitstream/handle/1814/68779/PB_2020_37_FSR.pdf?sequence=1&isAllowed=y>

Pototschnig A and Conti I, 'Upgrading Guarantees of Origin to Promote the Achievement of the EU Renewable Energy Target at Least Cost' (Florence School of Regulation) <https://cadmus.eui.eu/bitstream/handle/1814/69776/QM-03-21-034-EN-N.pdf?sequence=3&isAllowed=y>

Quitzow R and others, 'Mobilizing Europe's Full Hydrogen Potential: Entry-Points for Action by the EU and Its Member States' (HYPAT H2 Potential) <https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2023/Hypat%20Discussion%20Paper%2005_2023%20Mobilizing%20Europe%E2%80%99s%20Full%20Hydrogen%20Potential%20v01.pdf>

'Renewable Power Generation Costs in 2020' (International Renewable Energy Agency (IREA)) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf?rev=c9e8dfcd1b2048e2b4d30fef671a5b84>

'Renewables 2022 - Analysis and Forecast to 2027' (International Energy Agency) <https://iea.blob.core.windows.net/assets/ada7af90-e280-46c4-a577-df2e4fb44254/Renewables2022.pdf>

Roman Dörr H and Eric Sieler R, 'Certification of Green and Low-Carbon Hydrogen - An Overview of International and National Initiatives' (Adelphi) <https://www.energypartnership.jp/fileadmin/user_upload/japan/media_elements/adelphi_-_International_Overview_-_Certification_of_Clean_and_Green_Hydrogen.pdf>

Sailer K and others, ‘Establishing a National Hydrogen Standard - An Aid to Decide between Developing an Own National Hydrogen Standard or Adopting an International Hydrogen Standard at the National Level’ (Deutsche Energie-Agentur GmbH) <https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2023/STUDY_Establishing_a_National_Hydrogen_Standard.pdf>

Scita R, Paolo Raimondi P and Noussan M, ‘Green Hydrogen: The Holy Grail of Decarbonisation? An Analysis of the Technical and Geopolitical Implications of the Future Hydrogen Economy’ (Fondazione Eni Enrico Mattei) 13 <https://www.econstor.eu/bitstream/10419/228789/1/ndl2020-013.pdf>

‘South Australian Green Hydrogen Study A Report for the Government of South Australia’ (Government of South Australia 2017) A32334 <https://www.energymining.sa.gov.au/industry/modern-energy/hydrogen-in-south-australia/hydrogen-files/green-h2-study-report-8-sept-2017.pdf>

‘Summary of Global Climate Action at COP 28’ (United Nations Framework Convention on Climate Change) <https://unfccc.int/sites/default/files/resource/Summary_GCA_COP28.pdf>.

‘The General Block Exemption Regulation A Revised State Aid Tool to Encourage the Green Transition ?’ (ClientEarth 2023) <https://www.clientearth.org/media/xmhcr2y2/clientearth-legal-briefing-on-the-general-block-exemption-regulation-2023.pdf>

Van Laer S and François I, ‘Hydrogen and Certification - Position Paper in Relation to the Certification of Hydrogen in Belgium’ (Waterstof Industrie Cluster) <https://www.waterstofnet.eu/_asset/_public/publicaties/WIC_Position-paper_Certification_Final_PDF.pdf>

Van Wijk A and Chatzimarkakis J, ‘Green Hydrogen for a European Green Deal A 2x40 GW Initiative’ (Hydrogen Europe) <https://hydrogeneurope.eu/wp-content/uploads/2021/11/Hydrogen-Europe_2x40-GW-Green-H2-Initative-Paper.pdf>

Widuto A, ‘Energy Transition in the EU’ (European Parliamentary ResearchService 2023) <https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754623/EPRS_BRI(2023)754623_EN.pdf>

Books

Bacon K, European Union Law of State Aid (3rd Edition, 2017)

Ball M and others, ‘Hydrogen-Infrastructure Build-up in Europe’, The Hydrogen Economy Opportunities and Challenges (Cambridge University Press 2009)

Ball M and Wietschel M, The Hydrogen Economy: Opportunities and Challenges (Cambridge University Press 2009)

Ball M, ‘Why Hydrogen?’, The Hydrogen Economy Opportunities and Challenges (Cambridge University Press)

Blyth W, Yang M and Bradley R, 'Climate Policy Uncertainty and Investment Risk' (International Environmental Agency) <https://www.iea.org/reports/climate-policy-uncertainty-and-investment-risk>

Cima E and Moïse Mbengue M, A Multifaceted Approach to Trade Liberalisation and Investment Protection in the Energy Sector (Brill, 2021) <https://ebookcentral-proquest-com.mime.uit.no/lib/tromsoub-ebooks/detail.action?docID=6690516>

Dezobry E and de Hauteclocque A, 'State Aid and Price Regulation in the Energy Sector' *State Aid and the Energy Sector* (Hart Publishing 2018)

Huhta K and Sairanen M, ' The Regulation of Hydrogen in the Context of Energy Storage as End-Use ', Cambridge Handbook of Hydrogen and the Law (Cambridge University Press, forthcoming in 2024)

Majumder-Russel D, Hydrogen Project: Legal and Regulatory Challenges and Opportunities' (Globe Law and Business Ltd)

Sandberg L, 'State Aid in the Form of Taxation and Emission Costs', *State Aid and the Energy Sector* (Hart Publishing 2018)

Schöning F and Ziegler C, 'What Is State Aid?', *State Aid and the Energy Sector* (Hart Publishing 2018)

Stefan O, 'General Principles in EU State Aid Law', Research Handbook on General Principles in EU Law Constructing Legal Orders in Europe (Edward Elgar Publishing)

Talus K, EU Energy Law and Policy: A Critical Account (Oxford University Press 2013)

Websites

‘Certification Schemes’ (CertifHy) <https://www.certifhy.eu/go-definition/>

Chatzimarkakis J, ‘Challenge of Lack of Hydrogen Regulatory Framework Has Been Overcome: Jorgo Chatzimarkakis (Hydrogen Europe)’ (Review Energy, 29 December 2023) <https://www.review-energy.com/hidrogeno/challenge-of-lack-of-hydrogen-regulatory-framework-has-been-overcome-jorgo-chatzimarkakis-hydrogen-europe>

‘Commission Approves €1.1 Billion Spanish State Aid Scheme to Support Investments in Equipment Necessary to Foster the Transition to a Net-Zero Economy’ (European Commission, 28 November 2023) <https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5727>

‘EU’s 2030 Targets for Green Hydrogen Use in Industry and Transport Become Law with Publication in Official Journal’ (HydrogenInsight, 31 October 2023) <https://www.hydrogeninsight.com/policy/eus-2030-targets-for-green-hydrogen-use-in-industry-and-transport-become-law-with-publication-in-official-journal/2-1-1545432>

‘For the Second Time the European Commission Has Approved State Aid for an Important Project of Common European Interest in the Hydrogen Value Chain’ (Simmons Simmons, 29 September 2022) <https://www.simmons-simmons.com/en/publications/cl8mu1ctx5ido0a560mzarcxq/state-aid-to-boost-supply-of-renewable-and-low-carbon-hydrogen>

Gielen D and others, ‘Unleashing the Power of Hydrogen for the Clean Energy Transition’ (worldbank, 21 April 2023) <https://blogs.worldbank.org/energy/unleashing-power-hydrogen-clean-energy-transition>

‘Green Hydrogen Costs to Fall by up to 64% by 2040’ (WoodMackenzie , 25 August 2020) <https://www.woodmac.com/press-releases/green-hydrogen-costs-to-fall-by-up-to-64-by-2040/>

‘H2 Is Key Pillar of Green Deal Industrial Plan’ (Hydrogen Europe, 2 February 2023) <https://hydrogeneurope.eu/h2-is-key-pillar-of-green-deal-industrial-plan/>

Hritsyshyna M, ‘Possible Impact of the Delegated Acts on Import of Hydrogen in the EU’ (energypost.eu, 15 June 2022) <https://energypost.eu/possible-impact-of-the-delegated-acts-on-import-of-hydrogen-in-the-eu/>

‘Hydrogen’ (European Commission) <https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en>

‘Hydrogen and Decarbonised Gas Market Package’ (European Commission) <https://energy.ec.europa.eu/topics/markets-and-consumers/market-legislation/hydrogen-and-decarbonised-gas-market-package_en>

‘Hydrogen in a Nutshell’ (Hydrogen Europe) <https://hydrogeneurope.eu/in-a-nutshell/ >

Interview with Jorgo Chatzimarkakis, ‘Frustration over Continuing Uncertainties’ (7 March 2024) <https://h2-international.com/2024/03/07/frustration-over-continuing-uncertainties/>

‘Is Nuclear Green? European Union Is Splitting on Hydrogen From Nuclear Power | Cleary Gottlieb’ (Cleary Gottlieb , 27 June 2023) <https://www.clearygottlieb.com/news-and-insights/publication-listing/is-nuclear-green-european-union-is-splitting-on-hydrogen-from-nuclear-power> accessed 5 April 2024

Kurmayer NJ, ‘EU Agrees New Rules for Investments into Hydrogen Infrastructure’ (Euroactiv, November 2023) <https://www.euractiv.com/section/energy-environment/news/eu-agrees-new-rules-for-investments-into-hydrogen-infrastructure/?utm_source=Euractiv&utm_campaign=79d6d6c500-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_24f4b280c0-2cec83e693-%5BLIST_EMAIL_ID%5D>

Kurmayer NJ, ‘EU’s Future Hydrogen Grid Takes Shape after Parliament Vote’ (Euroactiv, February 2023) <https://www.euractiv.com/section/energy-environment/news/eus-future-hydrogen-grid-takes-shape-after-parliament-vote/>

Martin Polly , ‘European Green Hydrogen Projects Are Being Delayed Due to Torturously Slow EU Subsidy Processes, Say Developers’ (HydrogenInsight, 7 July 2023) <https://www.hydrogeninsight.com/policy/european-green-hydrogen-projects-are-being-delayed-due-to-torturously-slow-eu-subsidy-processes-say-developers/2-1-1483308>

Messad P, ‘France Finally Satisfied with EU Deal on Renewables Directive’ (*euroactiv*, 19 June 2023) <https://www.euractiv.com/section/energy-environment/news/france-finally-satisfied-with-eu-deal-on-renewables-directive/>

‘New State Aid Measures: A Boost for H2 Tech and Deployment’ (HydrogenEurope) <https://hydrogeneurope.eu/new-state-aid-measures-a-boost-for-h2-tech-and-deployment/>

Pironon J and de Donato P, ‘World’s Largest White Hydrogen Deposit Found in France’ (World Economic Forum, 15 September 2023) <https://www.weforum.org/agenda/2023/09/white-hydrogen-deposit-france/>

‘Prolonging Eased State-Aid Rules Raises Risk of Territorial Imbalances in Europe, Local Leaders Warn ’ (*Europees Comité van de Regio’s*, 29 November 2023) <https://cor.europa.eu/nl/news/Pages/prolonging-eased-state-aid-rules-raises-risk-of-territorial-imbalances-in-europe-.aspx>

‘Renewable Energy: EU Commission Rules for Renewable Hydrogen Enacted’ (CMS, 21 July 2023) <https://cms-lawnow.com/en/ealerts/2023/03/renewable-energies-eu-rules-for-renewable-hydrogen>

‘Renewable Hydrogen Production: New Rules Formally Adopted’ (European Commission, 20 June 2023) <https://energy.ec.europa.eu/news/renewable-hydrogen-production-new-rules-formally-adopted-2023-06-20_en>

‘REPowerEU’ (European Commission) <https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en>

Scheyl J-H, ‘Delegated Acts on Art. 27 and 28 Explained: How They Will Shape the PtX Market Ramp Up’ <https://ptx-hub.org/delegated-acts-on-art-27-and-28-explained/>

Scheyl J-H, ‘EU Regulatory Framework and Certification in a Nutshell’ (2023)

Simon F, ‘Grid Fees Remain Key Sticking Point as EU Finalises Hydrogen Rules’ (Euroactiv, 28 September 2023) <https://www.euractiv.com/section/energy-environment/news/grid-fees-remain-key-sticking-point-as-eu-finalises-hydrogen-rules/>

Simon F, ‘Hydrogen under the Spotlight, CCS Back in Fashion’ (Euroactiv, 29 November 2023) <https://www.euractiv.com/section/energy-environment/news/hydrogen-under-the-spotlight-ccs-back-in-fashion/?utm_source=Euractiv&utm_campaign=79d6d6c500-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_24f4b280c0-2cec83e693-%5BLIST_EMAIL_ID%5D>

‘Spain Green Hydrogen Vision’ (Green Hydrogen Organisation) <https://gh2.org/countries/spain>

‘State Aid: Commission Adopts Temporary Crisis and Transition Framework to Further Support Transition towards Net-Zero Economy’ (European Commission, 9 March 2023) <https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1563>

‘State Aid: Commission Approves €246 Million Dutch Scheme to Support Renewable Hydrogen Production’ (European Commission, 28 July 2023) <https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3967>

‘State Aid: Commission Approves €450 Million Italian Scheme to Support the Production of Renewable Hydrogen to Foster the Transition to a Net-Zero Economy’ (European Commission) <https://ec.europa.eu/commission/presscorner/home/en> accessed 10 April 2024

‘State Aid: Commission Invites Stakeholders to Provide Comments on Revised State Aid Rules on Important Projects of Common European Interest’ (European Commission, 23 February 2021) <https://ec.europa.eu/commission/presscorner/detail/en/ip_21_689>

‘State Aid in the Energy Sector ’ (CMS, 29 June 2023) <https://cms.law/en/int/expert-guides/expert-guide-for-state-aid/state-aid-in-the-energy-sector>

Trichkovska I and others, ‘The European Commission Loosens State Aid Rules to Foster Energy Transition and Prevent the Flight of Green Technologies from Europe’ (White&Case, 27 March 2023) <https://www.whitecase.com/insight-alert/european-commission-loosens-state-aid-rules-foster-energy-transition-and-prevent>

Master Thesis

Roshanjahromi S, ‘A Comparative Analysis between EU State Aid and WTO Subsidies’ (Master Thesis, FACULTY OF LAW Lund University 2017) <https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8916234&fileOId=8916236>