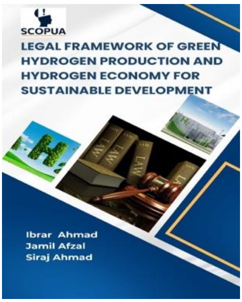
CHAPTER FOUR

REGULATORY ANALYSIS OF ENERGY LAW AND HYDROGEN ECONOMY

IBRAR AHMAD [1], JAMIL AFZAL [2]* AND SIRAJ AHMAD [3]



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[1]Southwest university of political science and Law, China
[2]International Islamic University, Malaysia
[3]Tianjin University, Tianjin, China
*Corresponding: sirjamilafzal@gmail.com (Afzal, J.)

Abstract

This chapter focuses on the Regulatory Analysis of Energy Law and the Hydrogen Economy. The recent rise of hydrogen as a fundamental component of the world's energy transition has demanded a significant change in energy law. Based on regulating fossil fuels, electricity markets, and grid infrastructure, energy law is in a transitional state as it seeks to accommodate hydrogen. This energy transmitter poses opportunities and challenges for current legal regimes. As countries transition towards decarbonising their energy systems, energy law must facilitate the incorporation of hydrogen into domestic energy systems and the efficient, safe, and sustainable production of hydrogen, its transmission, and distribution. This transition is integral to meeting wider environmental, economic, and geopolitical goals, such as energy security and carbon neutrality, and driving the innovation of clean technology. Energy theory broadly controls the production, transmission, distribution, and use of energy.

Keywords: *Hydrogen Law; Hydrogen Economy; Regulatory Analysis of Hydrogen; Regulatory Analysis of Energy Law*

4.1. Overview of Energy Law in the Context of Hydrogen

Adaptation of the existing regulatory framework to cover the variety of applications of hydrogen is one of the key challenges of energy law [1]. Because hydrogen has a dual function as an energy carrier and storage medium, it has a place in many parts of the energy system, reaching across electricity, gas, and even water management [2]. Regulatory matters, including grid access, priority dispatch for renewable electricity, and grid cost allocation, are essential to facilitate that transition. In addition, legal frameworks will need to contend with regulatory uncertainty in regions where there exists no energy law addressing hydrogen [1]. Unaddressed legal uncertainties hang over the production and transportation of hydrogen, making investment in the industry difficult [3]. Those gaps tend to result in a patchwork of regulations," and that in turn can hamper efforts to get hydrogen technologies to scale. New hydrogen-focused legislation will be central if we are to make a smooth transition to hydrogen in our energy system and create the right investment climate [4]. An important issue for the role of hydrogen in decarbonization is the linkage of its production to renewable energy. Legal frameworks, such as PPAs, are the key to enabling this coupling. PPAs are crucial for the realization of electrolysis projects, as they guarantee a stable supply of renewable electricity, a prerequisite for economical feasibility as well as for guaranteeing that emissions targets are met [5]. The European Union is leading the way in creating the regulatory framework to connect hydrogen production to renewable power [6]. According to the EU's Renewable Energy Directive (RED II) and its proposed revisions, renewable-electrolysis hydrogen does have to fulfil strict criteria regarding additionality, temporal relevance, and geographic proximity [7]. Both of these standards are in place to ensure that renewable energy is not displaced from other applications, such as grid balancing, at the expense of the wider decarbonization effort.

The regulatory framework around green hydrogen certification is also spreading, with the likes of India and Ireland introducing comparable initiatives. Such mechanisms create tighter monitoring of hydrogen's environmental profile, thereby signalling that the hydrogen produced is in line with national and global sustainability goals. But, on the other hand, this is a challenge for legalisation, especially in regions where, so far, no legal framework has been established for hydrogen production [8]. The integration of hydrogen into traditional energy systems is among the most challenging issues in energy law. In many regions, the natural gas distribution network is being considered as a future possible backbone network for hydrogen distribution, through mixtures blending hydrogen and natural gas or by repurposing the infrastructure to operate with pure hydrogen. However, the unique physical characteristics of hydrogen, including differences in energy density and permeability compared to natural gas, require major investments in adjustments to the pipeline network. There must also be legal frameworks to regulate safety standards, material specifications, and operational procedures to ensure that it is safe and feasible to deliver hydrogen within such systems. Within the European Union, measures are taken to modify existing regulations to facilitate hydrogen infrastructure. The Reform of the Gas Directive and Gas Regulation (part of the EU's 'Fit for 55' package) is to establish a specific regulatory framework for hydrogen networks [9]. These measures are intended to secure non-discriminatory access to hydrogen infrastructure, foster competition, and prevent the monopoly of the new fuel. Meanwhile, regulatory sandboxes and pilot projects were being trialled across a number of EU member states that offered key learnings on the on-the-ground hurdles to the integration of hydrogen. The United States, however, is a different regulatory patchwork. Although both the Bipartisan Infrastructure Law and the Inflation Reduction Act included substantial funding for hydrogen hubs, inconsistent regional permitting and safety oversight, and a fragmented approach to infrastructure planning have prevented a coherent national regulatory framework for hydrogen from emerging [10],[11]. To fix the problems, there needs to be better coordination between federal, state, and local government authorities. In addition, a harmonised legal framework for hydrogen infrastructure needs to be established at the national level in order to enable an effective and efficient integration of hydrogen markets [12].

Hydrogen production in particular from electrolysis avails of dominant cross-sectoral impacts: water for utilisation and land for exploitation [13]. Electrolysis involves massive amounts of water and thus legal questions regarding water rights, appropriation, and use. These issues are even more urgent in areas with a shortage of water. Energy law will therefore need to be melded with water law under legal regimes so as to avoid hydrogen production becoming another source of water stress or creating new environmental threats [14]. Land use is another important factor to consider. Production and storage of hydrogen facilities and transport and infrastructure can require large areas of land and raise concerns about land availability, zoning, and community issues. At the legal level, laws have to find a compromise between the need to facilitate the fast spread of hydrogen distribution infrastructure and the necessity to ensure public interest and protect environmental values. Open and transparent permitting, stakeholder engagement, and thorough environmental reviews are necessary to address these concerns. Legal instruments, like the EU ETS, provide economic incentives for the hydrogen producers' environmental impact. International cooperation is indispensable, too, for the establishment of a global hydrogen market. The International Energy Agency (IEA), International Renewable Energy Agency (IRENA), and International Organisation for Standardisation (ISO) are already cooperating to standardise technical standards, certification schemes, and definitions of hydrogen [15],[16]. These measures will help to enhance cross-border trade, investment, and innovation and to preserve the environmental performance of hydrogen around the world.

4.2. Energy Transition and Hydrogen: A Legal Perspective

Hydrogen has legal importance in the sense that it helps balance renewable energy systems, offsetting the peaks and troughs, aligning with the solar cycle, for example, helping those sectors we struggle with to electrify (deep sea shipping, say) to decarbonise. For instance, the European Union, in its Hydrogen and Decarbonised Gas Package (2024), mandates multimember cross-border infrastructure planning and implements industrial renewable hydrogen quotas for steel and chemicals, among others. The EU targets a share of 20–50% of fossil-based hydrogen to be replaced by renewable hydrogen by 2030, which reflects the increasing role placed on hydrogen in the journey towards climate neutrality [17]. Similarly, India's National Green Hydrogen Mission (2023) sets a legally binding target for 5 MMT of green hydrogen production per annum by 2030, underpinned by a whopping 125 GW of renewable energy capacity [18]. It is one example of a broader push to place hydrogen into countries' energy transition plans, with country-specific targets and mandates to promote decarbonization. This enables us to highlight key features of these legal frameworks, including the requirement for a strong connection between the production of hydrogen and its application in renewable energies. Under the European Union's Renewable Energy Directive (RED III), hydrogen producers would have to prove "additionality," ensuring that the renewable electricity they used for electrolysis came from new, additional renewable capacity, as opposed to simply replacing clean electricity already in the system.

With hydrogen transitioning from idea to application, energy law is rapidly evolving. Economic stimuli or subsidies are critical to bridging the gap between the costs of green hydrogen (USD 4–6/kg) and fossil-based hydrogen (USD 1–2/kg). For example, the U.S. Inflation Reduction Act provides a $3/kg production tax credit for low-carbon hydrogen if it meets emissions levels and wage standards. They aim to speed up the commercial readiness of green hydrogen, bridge the cost gap and illustrate the legal burden of regulating energy technologies that depend largely on financial support in their early years. Japan's Hydrogen Society Promotion Act (2024) also represents a legal innovation, adding Contracts for Difference (CfD) as measures to bring down the market risks to hydrogen producers [19],[20]. While these factors encourage investment, they bring about medium-term market stability. Are such subsidies and price guarantees a world of international competition? And how much will competition in the marketplace matter in the end? Yet U.S. regulatory issuances also point to the piecemeal regulation that hydrogen continues to face. The U.S. also has a single federal coordination authority, causing delays in hydrogen hub deployment. Meanwhile, state and territory differences in regulations and permit processes are hampering progress, highlighting the urgent need for a joined-up approach to regulation and harmonised permitting at a national level for hydrogen infrastructure.

As hydrogen production increases, the question of energy justice and equity is increasingly salient. Projects that aim to produce hydrogen in places like Sub-Saharan Africa (which could help avert energy poverty by giving clean energy to 600 million people in the world who currently lack access to it) often operate under international acquisition laws (such as India's Land Acquisition Act, 2013) that primarily prioritize corporate interests over the rights of those living on or near the land. This has resulted in the displacement of communities living near the mines; these are marginalised, which is causing concerns about the consequences of the projects. Meanwhile, California’s Environmental Justice Equity Principles require local consent for hydrogen projects. We saw it in the rejection of the ARCHES hydrogen hub, which appeared to get public residents onside when their views were poorly managed [21],[22]. The significance of public participation and transparent procedures cannot be overstated, especially when it comes to major infrastructure development projects that have great ramifications for the living conditions of the local population. Second, the Global North-South dynamic on the production of hydrogen adds more equity issues. This initiative encourages revenue-sharing, local resource development, and open governance to help ensure that host countries can benefit from hydrogen production and infrastructure construction. Indigenous rights are also becoming a hot topic on the hydrogen production legal front. One exception is the Hydrogen Valley Initiative in South Africa, which allocates 20% of project revenue to local development [23]. But provisions like these are few and far between, and these should be incorporated into more regulatory frameworks so that hydrogen producers have a type of "equitable" stake.

4.3. Legal Barriers to Hydrogen Integration into Energy Markets

The incorporation of hydrogen into the world's energy markets is subject to intricate, multi-jurisdictional legal challenges preventing its smooth integration into energy systems in many parts of the world. These obstacles are not only technical but also include differences in national regulations, market disintegration, as well as legal uncertainty that challenge the scalability and integration of hydrogen. Related to the above, regulatory fragmentation, a lack of policy coordination, and inconsistent public engagement vehicles create stumbling blocks for the development of a harmonised international hydrogen market. Hydrogen policy and infrastructure development policies of individual countries are considerably based on domestic energy priorities, traditions of regulation on energy, and politics [24]. For example, the French Industrial Emissions Directive requires a high-level environmental impact statement and detailed risk mitigation for hydrogen storage depots of over 1-tonne capacity [25]. Smaller plants are held to less regulatory scrutiny, resulting in inefficiency and uncertainty for developers. In addition, the EU's Hydrogen Backbone project to develop a dedicated hydrogen transport network across Europe has been held back due to incompatible safety standards and national views on how hydrogen can be safely injected into existing pipeline networks. This case study is indicative of the fragmentation of regulation across Europe that prevents a unified and interoperable hydrogen infrastructure.

One of the greatest challenges when it comes to hydrogen deployment is securing the required finance for large-scale projects. The high costs of producing green hydrogen, estimated to be 2-3 times more expensive than hydrogen produced from fossil sources, need large-scale investment. Although there are financial incentives such as subsidies, tax credits, and carbon pricing to help alleviate costs, both policy uncertainty and the absence of long-term regulatory stability are deterrents to investment. In the US, the Inflation Reduction Act (IRA) provides tax benefits for low-carbon hydrogen production; however, changing federal priorities across different administrations results in cyclical policy risk. For instance, tax credits such as 45V are also subject to expiration after 2025, creating uncertainty around longer-term investment returns [26].

The absence of global hydrogen certification standards is harming market consolidation and the creation of a single international hydrogen market. The EU's Renewable Fuels of Non-Biological Origin (RFNBO) standards relating to the certification of renewable hydrogen also have a need for complex details to trace back the renewable electricity source [17]. These regulations put exporters from regions that do not have similar detailed certification systems at a competitive disadvantage. The International Partnership for Hydrogen and Fuel Cells (IPHE) has envisioned the establishment of multilateral arrangements to align carbon footprinting methodology and emissions reporting [27]. As long as these frameworks are not synchronised, we face a risk of market fragmentation and disparate certification standards, which would negate economies of scale and, consequently, would counteract the goal of reducing hydrogen production costs. In Germany, the Hydrogen Acceleration Act (2023) refers to hydrogen projects as 'overriding public interest,' with a fast-tracked approval process, overruling [28],[29]. Although the legislation aims to speed the rollout of hydrogen, it has sparked protests and legal challenges, in particular from communities worried about the environmental and social impact of large schemes. The same problems are occurring in Spain, where shortened environmental approval processes for hydrogen projects in so-called hydrogen valleys are likely to condemn vulnerable communities who rely on the land and water that hydrogen projects consume. The California Hydrogen Highway Initiative provides a good example of broad public participation [30]. It is prescriptive, requiring the consent of a community, and projects incorporate socio-economic factors into the planning process. However, such a model still holds on the margins, and there is a pressing need to encourage the adoption of similarly expansive frameworks that allow for both communities and decarbonization to be pursued. Lack of early and effective stakeholder engagement may result in community alienation and project delays.

4.4. Legal Reforms for Hydrogen Integration

Certain legal reforms are necessary to address the regulatory fragmentation, infrastructure barriers and blocks, and innovation barriers that hamper the role of hydrogen as a key energy vector in the global shift to a low-carbon economy [31]. These reforms, which should fit within an enabling legal framework, need to pave the way for the scaling up and introduction of hydrogen technologies in the market, promote transboundary cooperation, and encourage private investment in green hydrogen production. A harmonised system of certification is necessary to allow cross-border trade to take place and to prevent market fragmentation. Fixing this was a global typology for carbon-intensity thresholds as per the IRENA proposal that might provide a baseline for certifications and limit division of the market [32]. Adopting this global standard would give producers and consumers a legal template, meaning that quality standards could be assured in the same way across the hydrogen trade, lowering the costs of entry for new hydrogen markets. Such multilateral treaties, with the assistance of key global players, would help ensure regulatory convergence across borders. It would take a coordinated effort by both developed and developing nations to reconcile regulatory interests with the imperative to convert economies at scale to hydrogen. A major reform centres around “dynamic” hydrogen project licensing. Models such as the GH_2 Best Practices Legislative Guidance model suggest that hydrogen production licenses should be tied to land use rights and environmental approvals to underpin that production activity will be in line with sustainability targets as well as local regulations [33],[34]. This model that mandates operators to obtain decommissioning financial assurances offers an acceptable trade-off between the scale of operations and safety, a key determinant in the uptake of hydrogen at a large scale. In this respect, the UK’s 2023 Energy Act is an innovative piece of legislation. Expanding this license pipeline to hydrogen, the UK sets out a clear regulatory pathway to blending hydrogen into the existing gas system and helping hydrogen producers integrate their product with the key transport networks. Also innovative is the proposed model for financing hydrogen infrastructure projects through the creation of a Hydrogen Levy Administrator in order to lessen the cost burden for developers.

Reclassifying hydrogen infrastructure for what it “is” critical decarbonization assets” and not “hazardous infrastructure” is a critical change that needs to happen to expedite permitting and deployment. This change might contribute to removing the bottlenecks for the deployment of hydrogen infrastructure. California’s Hydrogen Highway Initiative provides a useful test case for how reforms to zoning laws can cut through the molasses of permitting and approvals for electrolyser siting and pipeline retrofits, speeding the movement of infrastructure. In addition, the UK's Future System Operator, which will also oversee planning for the hydrogen network from 2026, demonstrates that coordination at the system level is required for hydrogen infrastructure development [35]. A single coordinating body could oversee the development of a technically efficient and regulatorily compliant hydrogen infrastructure and prevent a patchwork of overlapping infrastructure across different regions. Cross-border interoperability is also a major challenge for H_2 integration, especially for Europe [36]. The European Hydrogen Backbone project to set up a continent-wide network of hydrogen pipelines has been hampered by conflicting national rules on compressor design and pipeline pressure, and the project has been delayed. One possible approach is to standardise safety across borders; at the very least, Poland's legal move to put hydrogen into its gas grid with combined transmission tariffs offers just such an example. This pilot could act as a model for further regional cooperation on hydrogen infrastructure roll-out. Internationally, the shipping of hydrogen by sea is also a challenge. Such a lack of clarity could be clarified by adopting IMO-consistent standards for hydrogen tankers [37]. If such regulations could be harmonised, then safety and predictability would be enhanced, with consequent risk reduction associated with hydrogen transport and encouragement of international trade. There is an important role for focused tax measures that drive the production of green hydrogen. The UK's CCL exemption for electrolysis electricity is a £1.2 billion p.a. cost saving illustrates well how fiscal policy can help reduce the economic barriers to the production of green hydrogen [38]. However, these kinds of incentives are only successful if there are serious financing models to remove the risk for new technologies. One promising tool for this could be carbon contracts-for-difference (CCfDs) as a price stabilisation mechanism for investors in green hydrogen projects [39]. Germany's H_2Global, combining CCfDs with import-export auctions, provides security of pricing for the import and export of hydrogen by limiting exposure to changing market prices, which mitigates risk [40]. The Indian Production-Linked Incentive (PLI) program, offering capital grants and transmission waivers, highlights, moreover, the relevance of hybrid financing models when it comes to de-risking investment in hydrogen technologies [41],[42]. They provide producers with an incentive to expand capacity, no longer propped up by the safety net of long-term financial subsidies that help bridge the price gap between green hydrogen and fossil-based counterparts.

4.5. Environmental Law and Hydrogen Production: Sustainability, Compliance, and Standards

4.5.1. Environmental Law and Hydrogen Production: Frameworks and Standards

Embedding hydrogen production within environmental law regimes is complex and involves the consideration of sustainability criteria, mandatory requirements, and evolving standards. Internationally, the Paris Agreement acts as the cornerstone legal document, pushing national and regional hydrogen policies to carbon-neutral energy use. On policy looking toward hydrogen, a leader in hydrogen policy, the EU nests its frameworks in the Paris Agreement's 1.5°C framework through the likes of the Renewable Energy Directive III (RED III) [43],[44]. This target requires us to use renewable feedstocks for 42.5% of hydrogen production by 2030 [45]. The criteria for RFNBO impose even lower lifecycle emissions thresholds, demanding that hydrogen producers reduce their emissions intensity by at least 70% below that of fossil fuels [46]. These are strict measures to prevent greenwashing and guarantee that the hydrogen projects effectively contribute to decarbonization. But there are still barriers in trying to align carbon-intensity scoring for hydrogen production, with cross-border trade a case in point. The International Partnership for Hydrogen and Fuel Cells (IPHE) is working towards setting a global standard for emissions accounting that could be used to harmonise carbon intensity thresholds worldwide [47]. Regulation of hydrogen at the national level is disparate, in line with differing geopolitical and economic conditions in hydrogen-producing states. In the EU, hydrogen production plants making more than 25 tonnes per day are considered “integrated chemical installations” under the Industrial Emissions Directive (IED), which means they must comply with strict emissions limits and apply Best Available Techniques (BAT) [48],[49]. And that not only helps ensure that larger facilities achieve strict environmental standards, but proposed reforms would exempt smaller (less than 60 TPD) electrolysers from some permitting requirements to lower bureaucratic hurdles for the new hydrogen projects on the horizon. In the United States, environmental regulation is fractured, and air emissions and the storage of hazardous material are regulated by the Clean Air Act Title V and the Environmental Protection Agency’s (EPA) Risk Management Program (RMP), respectively [50],[51]. OSHA establishes workplace safety regulations, but the absence of a national hydrogen policy means many projects are subject to a patchwork of state-level regulations. Germany’s new law for accelerating green hydrogen (Hydrogen Acceleration Act, 2023) has been criticised, and its application was stopped in the courts because of the law waiving community participation [52]. All this suggests a worrisome conjunction between environmental democracy and the requirement for hydrogen infrastructure at the latest notice. The act’s emphasis on quick decision-making with little public participation points to the tension between decarbonization ambitions and principled environmental governance. This problem highlights the requirement for more comprehensive rules that allow space for the communities to partake in the decision-making processes while also facilitating the realization of projects promptly.

The production of hydrogen is regulated by a series of pollution control laws that govern emissions, waste, and resource conservation:

- Emissions Monitoring: The Emissions Trading Scheme (ETS) in the European Union mandates that hydrogen plants with production of more than 25 TPD must surrender allowances, encouraging the use of carbon capture technologies. However, the SMR hydrogen production process still has a long way to go to substantially reduce emissions, as it is mainly based on natural gas.
- Waste Management: In the U.S., spent hydrogen production catalysts are also toxic and hazardous and must be disposed of in special facilities at an added cost. This measure relates to the environmental effects of hydrogen production beyond emissions and also includes waste handling.
- Resource Procurement: Governments such as India are tying tax credits on hydrogen production to the purchase of validated renewable power, punishing installations that tap the grid for more than 5% of their power. This policy fosters the development of renewable energy self-sufficiency, but is problematic for fossil-dominant regions. Germany, Community engagement Germany's UVPG mandates a public hearing for projects over 100 MW capacity; this aspect has been criticised, where projects are declared to serve the 'overriding public interest.' Not consulting local communities can result in social unrest, such as the opposition to some hydrogen hubs in Germany. This emphasises the requirement for legal changes to

safeguard representation rights, especially for the communities that might have inherited high risks from the implications of hydrogen production projects.

The GH_2 Standard defines an upper limit for CO_2 of ≤1 kg CO_2e/kg H_2, mandates 100% renewable power for hydrogen production, and covers human rights due diligence and water stewardship. These criteria are essential to prevent an uncontrolled form of greenwashing by which hydrogen producers give the false impression of being green without being held to rigorous sustainability standards. The EU's RFNBO Delegated Acts implement the temporal relationship for grid-connected electrolysers, stipulating that the renewable electricity used for electrolysis is generated in real-time or near electrolysis. This policy is to tie hydrogen production to actual renewable generation, providing that the hydrogen is green. However, there is much disagreement over the question of temporal correlation, particularly for regions with intermittent renewable resources, like wind and solar. A classification system for hydrogen based on carbon intensity has been suggested by the International Renewable Energy Agency (IRENA). For example, those with a carbon intensity of less than 3 kg CO_2e/kg H_2 might qualify as "low carbon" hydrogen, replacing the current use of colour definitions. This classification would deliver a more transparent and less subjective understanding of the environmental impact of hydrogen, e.g., in international trade.

4.5.2. Green Hydrogen and Legal Certification Mechanisms

The certification of green hydrogen is essential for its market access in the world's energy markets in order to demonstrate its environmental performance, market transparency and its compliance with legal requirements. The certification of green hydrogen is commonly hampered by varying tracking systems in different regions. Many jurisdictions, particularly in the EU and Japan, employ mass balance systems to account for the movement of renewable energy attributes related to hydrogen production. Although by enabling certification trading, these arrangements also raise the possibility of double-counting renewable energy attributes, resulting in compromised certification quality. In contrast, book-and-claim systems, which are popular in the voluntary market, separate the purchase of renewable energy from its physical delivery to the hydrogen producer. Although it is more flexible, this approach is problematic in that it is hard to confirm that renewable energy has increased generation capacity, so-called additionality. In response to these concerns, emerging blockchain solutions, such as the ones proposed for the EU Guarantees of Origin (GO) system, are being considered to improve traceability and mitigate the risk of fraudulent behaviour. The Zero Carbon Certification in Australia is one such model that leverages blockchain to record and provide authentic proof of hydrogen production and certification, which would help establish market credibility. Yet the intricacies of cross-national certification schemes continue to present a major obstacle to the global hydrogen economy". Differences in emission standards, matching criteria and renewable policy mean that multinational hydrogen projects face a struggle for compliance. Attempts to fill such gaps include the ISO/TS 19870 international standard accounting for GHGs, which has been adopted in 38 countries. Just as this uniform methodology has the advantage of a more consistent GHG accounting approach, it also poses challenges in harmonising standards across regions with different decarbonisation priorities. Multilateral harmonisation has been progressing slowly in diplomatic circles by the IPHE, but is not moving forward as most nations guard their interests and national economic affairs.

The mislabeling of hydrogen as "green" has serious legal implications for producers and the market more broadly. In the EU, non-compliant manufacturers also stand to be excluded from the quotas of the Renewable Energy Directive (RED), prerequisites for being granted subsidies and market drivers. The fines for mislabeling can reach fines worth 200% of the revenue derived from selling mislabeled hydrogen, the EU said, showing it's serious about thwarting greenwashing and will not back down on strict environmental standards for hydrogen. In the U.S., characterising hydrogen as ‘green’ if it isn’t might breach the Federal Trade Commission (FTC) Green Guides, which regulate environmental claims in advertising. Greenwashing hydrogen as a low-carbon product could result in fines under environmental laws, such as the Clean Air Act, and Securities and Exchange Commission (SEC) disclosure rules. The hazards of misbranding do not stop at financial sanctions; additional civil exposures and litigation may stem from consumers or competitors damaged by false representations. It is illustrated by the H2Global v. NRG case in New Zealand, which saw a producer ordered to pay US$2.78m for misleadingly selling hydrogen as green. Instances like this remind us how important certification and market transparency are to avoid legal disputes. Hydrogen certification legal structures will also need strong anti-fraud measures. Authorised audits by accredited organisations such as DNV or Bureau Veritas are essential to enable verification of the sustainability requirements.

4.6. Future of Hydrogen in Environmental and Energy Law

The future of hydrogen energy and environmental law will not simply require incremental regulatory tweaking; it will require a substantive transformation of the law in a coherent and comprehensive fashion. The emergence of hydrogen as a key energy carrier towards climate neutrality and as a central component in the decarbonisation of hard-to-abate sectors, to date resistant to electrification raises complex challenges that cut across traditional legal categories and necessitate original governance models. There is also an issue of balance to contend with, between separating hydrogen infrastructure from traditional fossil gas systems to foster competition while making sure the system remains reliable. And coordinating rules between different levels of national governments, regional entities, and the E.U. can result in confusion and overlap. Global cooperation is essential but fraught because countries have differing priorities and legal traditions. So, we need strong international agreements to align standards, clarify responsibilities, and work through disagreements.

The future of hydrogen law must inspire confidence among investors through clear, stable, and predictable rules. Licensing frameworks, financial protections, and oversight should be consistent from one area to another to prevent companies from exploiting regulatory loopholes. Mechanisms such as Contracts for Difference (CfDs) and carbon contracts-for-difference (CCfDs), as seen in Germany’s H2Global program and the EU Hydrogen Bank, illustrate how the law can mitigate risk for investors in nascent hydrogen technologies. Hydrogen production should be thoroughly incorporated into integrated environmental management in future legal structures. This includes applying strict emissions standards, pollution control, and resource conservation laws while incentivising green hydrogen through carbon pricing, subsidies, and certification regimes such as the EU's RFNBO and the GH2 Standard. Further, law should lend to the flexibility and promotion of emerging technologies and circular economy theory, such as waste-to-hydrogen generation and resilient water stewardship systems, in order to increase resource productivity and mitigate environmental degradation. Legal flexibility will be key, having regulatory sandboxes and pilot projects serving as learning laboratories for emerging technologies and new business models.

4.7. Conclusion

This chapter has made clear that energy and environmental law contribute significantly to the advancement of the hydrogen economy. It mapped how changing legal frameworks are dealing with challenging technical, environmental, and market requirements for scaling hydrogen as a sustainable carrier of energy. At the heart of that transition is the need for a common, adaptive policy that takes into consideration the nuanced nature of hydrogen and aligns with worldwide climate ambitions. Energy statutes are adopting more and more hydrogen-specific provisions like customised licensing frameworks, priority grid access rights, or hydrogen infrastructure status as a critical decarbonisation asset, while environmental laws establish stringent emissions measures as well as lifecycle carbon accounting and conservation of resources. Certification standards such as the EU's RFNBO and the GH2 Standard guarantee the environmental robustness of green hydrogen, supported by economic instruments that promote low-carbon production. Going forward, legal regimes should emphasise international harmonisation not only of standards and emissions accounting, support innovation with adaptive permitting, and reconcile the rapid deployment of infrastructure with social equity and environmental justice. New fields, liability regimes and standards, water governance, social and economic impacts, and integration into carbon markets are in need of targeted research and policy shaping.

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