ENERGY TRANSITION, LEGAL CERTAINTY, AND THE NEW ENVIRONMENTAL LICENSING FRAMEWORK: PERSPECTIVES FOR THE GREEN HYDROGEN AND AMMONIA INDUSTRY IN BRAZIL

TRANSIÇÃO ENERGÉTICA, SEGURANÇA JURÍDICA E NOVO MARCO DO LICENCIAMENTO AMBIENTAL: PERSPECTIVAS PARA A INDÚSTRIA DE HIDROGÊNIO E AMÔNIA VERDE NO BRASIL

TRANSICIÓN ENERGÉTICA, SEGURIDAD JURÍDICA Y EL NUEVO MARCO DEL LICENCIAMIENTO AMBIENTAL: PERSPECTIVAS PARA LA INDUSTRIA DEL HIDRÓGENO Y AMONÍACO VERDE EN BRASIL

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ABSTRACT

The energy transition has redefined regulatory and economic priorities in the international scenario, especially with regard to the consolidation of new production chains linked to low-emission sources. In this context, the debate on Brazilian environmental licensing gains strategic relevance in light of the expansion of the green hydrogen and ammonia industry. The research was developed using a qualitative approach, and two research methods were applied: bibliographic research and documentary research. The general objective of this study is to analyze the impacts of the new Brazilian environmental licensing framework on legal certainty and the consolidation of the green hydrogen and ammonia industry within the context of the energy transition, identifying regulatory challenges and institutional opportunities for the sustainable development of the sector. It is concluded that the new environmental licensing framework, by seeking to provide greater predictability and rationality to administrative procedures, may directly influence legal certainty and the investment environment in the green hydrogen and ammonia sector. The consolidation of this industry in Brazil will depend on the institutional capacity to harmonize economic development, energy transition, and environmental protection, ensuring regulatory stability and trust as the basis for sustainable growth.

Keywords: Energy Transition. Environmental Licensing. Legal Certainty. Green Hydrogen.

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RESUMO
A transição energética tem redefinido prioridades regulatórias e econômicas no cenário internacional, especialmente no que se refere à consolidação de novas cadeias produtivas vinculadas a fontes de baixa emissão. Nesse contexto, o debate sobre o licenciamento ambiental brasileiro ganha relevância estratégica diante da expansão da indústria de hidrogênio e amônia verde. A pesquisa foi elaborada com uma abordagem qualitativa e foram utilizados dois métodos de pesquisa: a pesquisa bibliográfica e a pesquisa documental. O objetivo geral desta pesquisa é analisar os impactos do novo marco do licenciamento ambiental brasileiro sobre a segurança jurídica e a consolidação da indústria de hidrogênio e amônia verde no contexto da transição energética, identificando desafios regulatórios e oportunidades institucionais para o desenvolvimento sustentável do setor. Conclui-se que o novo marco do licenciamento ambiental, ao buscar conferir maior previsibilidade e racionalidade aos procedimentos administrativos, pode influenciar diretamente a segurança jurídica e o ambiente de investimentos no setor de hidrogênio e amônia verde. A consolidação dessa indústria no Brasil dependerá da capacidade institucional de harmonizar desenvolvimento econômico, transição energética e proteção ambiental, garantindo estabilidade normativa e confiança regulatória como bases para um crescimento sustentável.

Palavras-chave: Transição Energética. Licenciamento Ambiental. Segurança Jurídica. Hidrogênio Verde.

RESUMEN
La transición energética ha redefinido las prioridades regulatorias y económicas en el escenario internacional, especialmente en lo que respecta a la consolidación de nuevas cadenas productivas vinculadas a fuentes de baja emisión. En este contexto, el debate sobre el licenciamiento ambiental brasileño adquiere relevancia estratégica ante la expansión de la industria del hidrógeno y amoníaco verde. La investigación fue elaborada con un enfoque cualitativo y se utilizaron dos métodos de investigación: la investigación bibliográfica y la investigación documental. El objetivo general de esta investigación es analizar los impactos del nuevo marco del licenciamiento ambiental brasileño sobre la seguridad jurídica y la consolidación de la industria del hidrógeno y amoníaco verde en el contexto de la transición energética, identificando desafíos regulatorios y oportunidades institucionales para el desarrollo sostenible del sector. Se concluye que el nuevo marco del licenciamiento ambiental, al buscar otorgar mayor previsibilidad y racionalidad a los procedimientos administrativos, puede influir directamente en la seguridad jurídica y en el entorno de inversiones en el sector del hidrógeno y amoníaco verde. La consolidación de esta industria en Brasil dependerá de la capacidad institucional para armonizar el desarrollo económico, la transición energética y la protección ambiental, garantizando estabilidad normativa y confianza regulatoria como bases para un crecimiento sostenible.

Palabras clave: Transición Energética. Licenciamiento Ambiental. Seguridad Jurídica. Hidrógeno Verde.

1 INTRODUCTION

The energy transition has consolidated itself as one of the main axes of reorganization of contemporary economies, requiring normative responses from States capable of reconciling economic growth, technological innovation, and socio-environmental responsibility. In Brazil, this movement takes on its own contours due to the strategic relevance of renewable sources in the electricity matrix and the country's growing insertion in global low-emission energy chains. In this scenario, the debate on environmental licensing assumes centrality, as it constitutes a structuring instrument of environmental policy and conditions the implementation of large-scale enterprises.

The growing green hydrogen and ammonia industry is accelerating this debate. These energy vectors have been considered as strategic options for the decarbonization of industrial sectors and to increase the competitiveness in the international scenario of countries that have a vast supply of renewable energy. However, the construction of factories, the exploitation of natural resources and the need for an appropriate logistics infrastructure bring regulatory challenges that need clear and stable legal frameworks. Legal certainty, in this sense, is crucial to attract investments and for the development of an integrated production chain.

The new environmental licensing framework, called the General Environmental Licensing Law – LGLA, Law No. 15,190, of August 8, 2025, and which came into force on February 4, 2026 (Brasil, 2025), is part of this environment of institutional transformations. By proposing adjustments in administrative procedures and in the distribution of competences, it seeks to provide greater predictability to state decisions. At the same time, it raises debates about the preservation of environmental principles and the maintenance of adequate control standards. The analysis of this normative reconfiguration becomes, therefore, relevant to understand its effects on the energy transition and on Brazil's position in the international market for green hydrogen and ammonia.

The investigation was conducted with a qualitative focus and employed two types of research: bibliographic and documentary. This research aims, in general, to investigate how the new framework of Brazilian environmental licensing influences the legal certainty and the strengthening of the hydrogen and green ammonia industry within the energy transition, while seeking to identify both the regulatory challenges and the institutional opportunities that can promote sustainable development for the sector. The specific objectives outlined are: To analyze the evolution of the rules on environmental licensing in Brazil in comparison with the principles of legal certainty aimed at renewable energy projects; Investigate the main regulatory and environmental obstacles to the implementation of hydrogen and green

ammonia projects in Brazil; and, finally, to assess how the new legal framework for environmental licensing can affect the attraction of investments, international competitiveness and the consolidation of the hydrogen and green ammonia production chain in Brazil.

The article is divided into four interconnected sections. The Introduction brings the context and the outline of the research problem, placing the reader at the center of the current discussion on energy transition and legal certainty. The Methodology details the theoretical options and the steps followed, ensuring that the research has transparency and scientific rigor. The Theoretical Foundation establishes the analytical axes that support the research, connecting environmental licensing, the regulatory aspects of the hydrogen and green ammonia industry, and the new legal framework, to provide a solid basis for the reflections and conclusions that follow.

2 METHODOLOGY

The research was elaborated with a qualitative approach, which is appropriate for the analysis of legal phenomena that are complex and socially situated. According to Creswell (2014), qualitative research makes it possible to explore meanings, interpretations, and processes within an institution that cannot be quantified. The aforementioned perspective is of special relevance in environmental licensing, since it encompasses the understanding of norms, administrative practices, regulatory conflicts and institutional arrangements that organize the actions of the State and economic agents. By valuing interpretation, qualitative analysis helps in the investigation of how the new legal framework impacts legal certainty and the structuring of the green hydrogen and ammonia industry in Brazil.

Two research methods were used: bibliographic research and documentary research. According to Köche (2011), the detailed description of the methodological procedures guarantees the relationship of scientific rigor and the consonance between what is intended and the techniques used. Bibliographic research is a fundamental stage in academic production, as it enables the recognition of the state of the art, the mapping of different theoretical currents and the placement of the research problem within a broader scientific debate. As Batista and Kumada (2021) point out, its various configurations allow the organization and interpretation of already consolidated contributions, serving as a consistent basis for critical analysis and reasoned propositions.

The bibliographic research, which supported the study in question, was based on 15 scientific sources, including books, academic articles and reports published in specialized journals. This set of resources made it possible to analyze both the theoretical foundations of

environmental licensing and the recent discussions on the new legal framework and the energy transition. The diversity of sources ensured a broad understanding of the theme, with the combination of doctrinal perspectives, institutional analyses and positions of the productive sector, which makes the research even more solid from a scientific point of view.

The documentary research, in turn, was supported by the analysis of institutional documents relevant to the understanding of the regulatory and economic context of the sector. According to Piana (2009), documentary research makes it possible to access records produced by official bodies and specialized entities, contributing to the analytical reconstruction of public policies and normative processes. In this sense, the IEA report was examined . *Ammonia Technology Roadmap: Towards More Sustainable Nitrogen* (2021), the IPEA study *Institutional Constraints on the Execution of Investments in Economic Infrastructure in Brazil: Environmental Licensing* (2017), as well as the new regulatory framework for Brazilian environmental licensing, instituted by Law No. 15,190, of August 8, 2025, which provides for environmental licensing and regulates item IV of paragraph 1 of article 225 of the Federal Constitution. These documents offer technical, institutional, and legal subsidies for the analysis of Brazil's insertion in the global green hydrogen and ammonia market, as well as for the understanding of the regulatory challenges inherent to environmental licensing in the context of the energy transition.

3 THEORETICAL FOUNDATION

The theoretical foundation was arranged in an organized way in three axes that are interrelated, aiming to ensure a logical coherence in the analysis that is presented. In the first segment, 3.1 Environmental Licensing, Legal Security and Energy Transition in Brazil, the conceptual and normative elucidation that underlies the discussion is made, aligning environmental principles with legal certainty in the process of transformation of the energy matrix. The second, 3.2 Regulatory and Environmental Aspects of the Green Hydrogen and Ammonia Industry, investigates the technical and legal aspects of these projects in function of territorial and environmental constraints. Finally, item 3.3 New Framework for Environmental Licensing and Environment of investments for Clean Energy makes a critical analysis of recent changes in legislation and their impacts on the predictability of standards, the reduction of legal risks and Brazil's competitiveness in the global market for low-emission energy.

3. 1 ENVIRONMENTAL LICENSING, LEGAL CERTAINTY AND ENERGY TRANSITION IN BRAZIL

Environmental licensing in Brazil has evolved in parallel with the consolidation of Environmental Law as an autonomous and properly structured branch since the 1988 Constitution. According to Antunes (2023), licensing is the most important instrument of the National Environmental Policy, making the principles of legality, prevention, and precaution real. Its normative evolution in recent decades shows a constant effort to reconcile environmental preservation and economic growth, especially in strategic sectors, such as renewable energy. Legal certainty, in this context, gains relevance, as the predictability of rules and the stability of administrative decisions are factors that impact the viability of large enterprises.

The inclusion of the climate variable in the licensing process enriches this discussion and accentuates the urgency of normative coherence. Feldmann (2025) argues that the explicit inclusion of climate impacts in the licensing process not only complies with international environmental commitments, but also strengthens legal certainty by reducing the possibilities of interpretative uncertainty. By incorporating objective criteria regarding emissions and energy transition, the State provides more defined parameters for investors and society, preventing contradictory decisions and prolonged disputes. In this way, regulatory stability is no longer just a market request, but becomes a fundamental component of contemporary environmental governance.

In the current context of constitutionalism focused on environmental issues, the environmental licensing process has been understood in a broader way, not being restricted to a simple administrative procedure. Instead, it is seen as an important legal instrument that plays a key role in the organization and implementation of the National Environmental Policy. This perspective highlights the relevance of licensing for environmental protection and the sustainable management of natural resources, evidencing its structuring function within the normative framework that aims at the conservation of the environment. Within this perspective, the authors Coelho, Silva, and Serafim (2023) argue that the institute in question needs to be understood under the aegis of the constitutional principles that promote the protection of the environment. This is necessary to ensure that there is an appropriate balance between economic progress and the preservation of ecology.

Thus, the interpretation must consider the importance of harmonizing these two aspects. This perception highlights that the validity of the licensing process is directly related to attention to criteria that are technical, legal and also institutional. These criteria play a

fundamental role, as they are capable of providing greater stability and security in the decisions that are made in the administrative sphere.

Thus, strict compliance with these criteria is essential to ensure that licensing is considered legitimate and reliable, thus avoiding uncertainties and wear and tear in possible future decisions. In the current scenario of the energy transition, which seeks sustainable alternatives and the expansion of new production chains, including the production of hydrogen and green ammonia, the analysis presented here clearly highlights the strategic role that environmental licensing plays.

This licensing becomes essential to intermediate, in a balanced way, the attraction of investments and the protection of the fundamental right of all citizens to an environment that is ecologically balanced and healthy. Thus, this mediation function is crucial to ensure that economic development occurs in harmony with environmental preservation.

According to the institutional perspective, the Ipea study (2017) points out that obstacles in the licensing process are one of the main factors that prevent investments in economic infrastructure in Brazil. The slowness of the processes, the duplicity of competences and the lack of a stable interpretation are indicated as factors that increase costs and increase legal risks.

Particularly in projects linked to the energy transition, such as those focused on the production of hydrogen and green ammonia, such issues become strategic. To harmonize environmental protection, legal certainty and expansion of renewable energies in Brazil, it is crucial to create a stable, coherent and technically grounded regulatory environment.

3. 2 REGULATORY AND ENVIRONMENTAL ASPECTS OF THE GREEN HYDROGEN AND AMMONIA INDUSTRY

The development of the green hydrogen and ammonia industry in Brazil goes beyond the mere availability of renewable sources, involving a cohesive set of technical, socio-environmental and regulatory constraints. According to Ronceros et al. (2025), the generation of green hydrogen requires a significant availability of renewable electricity, an appropriate infrastructure for electrolysis, and well-defined regulatory frameworks on the legal status of the fuel. The lack of clear normative definitions on classification, authorisation and administrative powers tends to increase investor uncertainty and make it difficult to implement large-scale projects.

In technological and environmental terms, green ammonia is positioned as a key element for the storage and transport of hydrogen, especially in logistics chains destined for export. According to Duarte et al. (2025), although ammonia as a hydrogen carrier brings

logistical benefits, it entails challenges in terms of emission control, operational safety, and the need to adjust industrial plants to current environmental regulations. In light of an international perspective, the IEA report (2021) emphasizes that the decarbonization of ammonia production depends on technological updating, integration with renewable energy sources, and stable public policies, elements that directly influence the structure of the environmental licensing of these operations.

In order to systematize the main regulatory and environmental obstacles identified in the literature, Table 1 is presented.

Table 1

Main regulatory and environmental obstacles to the implementation of green hydrogen and ammonia projects in Brazil

Dimension	Obstacles identified	References
Regulatory	Absence of a consolidated regulatory framework and clear definition of administrative competencies	Ronceros et al. (2025)
Technological and industrial	Need for plant modernization and integration with renewable sources	IEA (2021); Duarte et al. (2025)
Environmental	Requirements related to emission control and operational safety	Duarte et al. (2025); IEA (2021)
Infrastructure and natural resources	Dependence on stable renewable energy, intensive use of water and adequacy of logistics and port infrastructure	Ronceros et al. (2025); Kaleem, Zaman and Rajakaruna (2024)

Source: Based on Duarte et al. (2025), IEA (2021), Kaleem, Zaman and Rajakaruna (2024) and Ronceros et al. (2025).

The territorial dimension also deserves attention, especially regarding the use of water resources and the installation of industrial complexes in coastal areas close to organized ports. Kaleem, Zaman, and Rajakaruna (2024) emphasize that the expansion of green hydrogen depends on reliable energy infrastructure and distribution systems adapted to new demands, including in decentralized applications. In the Brazilian context, this reality implies making water use grants, connection to the electricity grid and environmental licenses compatible, in an institutional arrangement that still seeks greater coordination between the federative entities.

3.3 NEW FRAMEWORK FOR ENVIRONMENTAL LICENSING AND ENVIRONMENTAL INVESTMENTS FOR CLEAN ENERGY

The new legal framework for environmental licensing is part of a broader process of restructuring the institutional bases of environmental policy in Brazil. According to Christian (2025), the Senate's approval of the new framework was an attempt to standardize

procedures and bring more clarity to the phases of the licensing process. The aforementioned regulatory reorganization is related to the search for regulatory predictability, especially in areas that require high capital and technology investments, such as the production of green hydrogen and ammonia, whose consolidation depends on consistent and technically grounded administrative decisions.

From a dogmatic perspective, Farias (2025, p. 26) recalls that environmental licensing is a preventive instrument aimed at making economic activity compatible with environmental protection. The legislative update, in this sense, cannot be understood only as a measure of procedural simplification, but as a redefinition of the legal guidelines that guide state action. Kassmayer (2025) problematizes precisely this point when inquiring about the concrete effects of the new framework on administrative practice, highlighting that the reduction of interpretative uncertainties can contribute to mitigating legal risks, as long as the technical and constitutional parameters that structure the environmental system are preserved. In order to systematize the main effects of the new legal framework on the environment of investments in clean energy, Table 2 is presented.

Table 2

Reflections of the new environmental licensing framework on the environment of investments in hydrogen and green ammonia

Aspect analyzed	Legislative change or identified effect	Expected impact on investments and competitiveness	References
Regulatory predictability	Standardization of procedures and definition of clearer steps	Reduced uncertainties and greater legal certainty for large-scale projects	Christian (2025); Nigris (2025)
Legal risks	Search for objective criteria and delimitation of competencies	Litigation mitigation and increased institutional trust	Kassmayer (2025); Farias (2025)
Economic environment	Positive signal to the productive sector and industry	Expansion of investments and strengthening of the clean energy chain	Barollo and Seixas (2025)
International insertion	Regulatory compliance with environmental governance standards	Brazil's greater competitiveness in the global hydrogen and green ammonia market	Christian (2025); Nigris (2025)

Source: Source: Based on Christian (2025), Barollo and Seixas (2025), Kassmayer (2025), Farias (2025) and Nigris (2025).

The economic repercussion of the legislative changes has also been emphasized by representatives of the productive sector. Barollo and Seixas (2025) report that industrial entities evaluate the approval of the project as a measure capable of expanding investments and favoring sustainable development. In a similar vein, Nigris (2025) points out that the new framework seeks to establish more objective criteria for the classification of enterprises, which tends to positively impact the perception of legal certainty in the business environment. In the

specific case of the hydrogen and green ammonia production chain, such a scenario can influence Brazil's international competitiveness, especially in the face of the growing global demand for low-emission fuels.

4 FINAL CONSIDERATIONS

The energy transition places the Brazilian State in front of the challenge of harmonizing economic growth, technological innovation, and environmental conservation, all in an increasingly complex regulatory environment. In this sense, the new environmental licensing framework is crucial, especially when considering the strengthening of the green hydrogen and ammonia industry as a means of positioning itself on the international scene and transforming Brazil's energy matrix. The investigation carried out in this study sought to understand how this new normative arrangement can impact legal certainty and the investment climate in Brazil.

The study managed to achieve all the goals and objectives that were proposed at the beginning. It was possible to carry out a detailed study on the evolution of the rules that govern environmental licensing in Brazil and its relationship with the principles of legal certainty applicable to renewable energy projects. This connection is crucial to understand how guidelines and regulations have evolved over time, demonstrating the need to ensure not only the protection of the environment, but also the stability and legal predictability for enterprises in the sector. Thorough studies were also conducted on the regulatory hurdles and environmental issues surrounding the implementation of green hydrogen and ammonia projects. In addition, a thorough analysis was carried out on how the new legal framework can impact the ability to attract investments, international competitiveness, and the consolidation of the production chain of these sustainable fuels.

The results showed that regulatory stability and clarity in procedures are crucial factors for reducing legal risks in industries that depend heavily on capital and technology. It was shown that the lack of firm definitions, the overlapping of attributions and interpretative doubts tend to impair the predictability of regulation. It was also found that legislative adjustments, guided by technical criteria and respecting environmental constitutional principles, can help create a more consistent and reliable institutional environment.

The investigation also revealed that the expansion of the hydrogen and green ammonia industry in Brazil depends on a consistent articulation between energy policy, natural resource management and environmental governance. Environmental licensing, far from representing a mere bureaucratic obstacle, is an instrument for the organization of the territory and mediation between public and private interests. When structured in a balanced

way, it can favor the country's insertion in the global market for low-emission energy, without removing the requirements of environmental control and responsibility.

As a future agenda, it is recommended the development of empirical studies aimed at the analysis of concrete cases of licensing of hydrogen and green ammonia projects, focusing on the practical application of the General Environmental Licensing Law. Comparative research that examines regulatory experiences in other countries and investigations that evaluate the regional socioeconomic impacts resulting from the installation of these projects are also relevant.

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