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Considerations on electricity storage regulation in Brazil: a comparative study with the European model regarding energy transition*

Considerações sobre a regulação do armazenamento de eletricidade no Brasil: estudo comparado com o modelo europeu visando a transição energética

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ABSTRACT

The article examines the energy transition from the perspective of the legal framework for electrical energy storage in Brazil, focusing on the need to develop a specific regulatory approach, taking the European Union model in general and the Portuguese model in particular as a reference. To this end, a doctrinal and comparative law study is conducted, analyzing the normative structure of the Brazilian electricity sector and the pathways for storage regulation in Brazil, according to the established European model, where both behind-the-meter storage and autonomous storage (as a sectoral agent) coexist. It was identified that the figure of behind-the-meter storage already exists in the Brazilian legal system, and that the established guidelines are similar to those in EU Directive No. 2019/944. On the other hand, recognizing the absence of a legal framework for autonomous storage in Brazil, legislative proposals aiming at its creation were identified, which are broadly aligned with the European model, except for the prohibition of vertical integration of electrical services in distribution. It is concluded that regulating the storage activity in Brazil is necessary to accelerate the energy transition objectives, ensuring greater security and environmental sustainability.

KEYWORDS

sustainability — electric energy — energy storage — comparative law — energy transition

RESUMO

O artigo examina a transição energética sob a ótica do enquadramento jurídico do armazenamento de energia elétrica no Brasil, com enfoque na necessidade de se construir uma abordagem regulatória específica, tomando como referência o modelo da União Europeia em geral e o de Portugal em particular. Para tanto, um estudo dogmático e de direito comparado é realizado, sendo analisadas a estrutura normativa do setor elétrico brasileiro e os caminhos para a regulação do armazenamento no Brasil, segundo o modelo europeu estabelecido, abrangendo tanto o armazenamento associado (*behind-the-meter*) quanto o armazenamento autônomo (como agente setorial). Identificou-se que já existe a figura do armazenamento associado presente no ordenamento jurídico brasileiro, e que as diretrizes

fixadas são semelhantes às existentes na Diretiva UE nº 2019/944. Por sua vez, reconhecida a inexistência de figura jurídica para o armazenamento autônomo no Brasil, identificaram-se propostas legislativas visando sua criação, que a grosso modo estão alinhadas com o modelo europeu, exceto pela vedação à verticalização de serviços elétricos na distribuição. Conclui-se que a regulação da atividade de armazenamento no Brasil é necessária para acelerar os objetivos de transição energética, assegurando maior segurança e sustentabilidade ambiental.

PALAVRAS-CHAVE

sustentabilidade — energia elétrica — armazenamento de energia — direito comparado — transição energética

1. Introduction

The myth of Prometheus, the Titan who brought fire to humanity and in consequence received eternal punishment, chained to a rock by Zeus, is an appropriate metaphor for the modern challenges faced in the energy transition process, especially in terms of electricity storage. Prometheus was an agent of change, condemned for his generosity, in offering fire, a new energy source, to humanity. Today, the question is: how can we promote energy transition, to meet existing demand in a controlled, resilient, safe and, fundamentally, clean way? Many commentators point to energy storage as one of the fundamental technologies.[1]

In simple terms, energy storage refers to capturing energy produced at one moment for use at a later time. This practice makes it possible to balance energy supply and demand, and contributes, in the electricity sector, to a stable grid, ensuring standards of quality in terms of electricity delivered.[2] Storage technologies range widely, including, for example, lithium-ion

1 IRENA. Electricity storage and renewables: costs and markets to 2030. Abu Dhabi: International Renewable Energy Agency, 2017.

2 DUNN, Bruce; KAMATH, Haresh; TARASCON, Jean-Marie. Electrical energy storage for the grid: a battery of choices. Science, 334.6058, p. 928-935, 2011.

batteries, compressed air energy storage (CAES) systems, thermal storage and supercapacitors.[3]-[4] This is, currently, a thriving field of research.

Electrical energy storage technology has advanced significantly due to improvements in both electrochemical components and management systems,[5]-[6] while the development of Battery Energy Storage Systems (Bess) and implementation of advanced battery management systems (BMS) have driven these advances.[7]-[8] These systems allow real-time monitoring of battery status, optimizing efficiency and extending the lifespan of devices,[9] which implies that advancement in the field does not occur only in respect of the storage object, in itself. Technological evolution and the reduction of production costs have made energy storage a viable and attractive solution only in the last two decades,[10] and in 2016 pumped hydro storage (PHES) still accounted for 94% of the world's energy storage capacity (equivalent to 9,000 GWh).[11]-[12]

Expansion of the use of intermittent renewable sources, such as solar and wind power,[13]-[14] presents greater challenges in terms of energy security, since the potential of such renewable sources is considered non-dispatchable,[15] dependent on effective

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3 BEARD, KW Linden's handbook of batteries. 5. ed. McGraw Hill, 2019.

4 POONPUN, Piyasak; JEWELL, Ward T. Analysis of the cost per kilowatt hour to store electricity. IEEE Transactions on Energy Conversion, v. 23, No. 2, p. 529-534, 2008.

5 ZAKERI, Behnam; SYRI, Sanna. Electrical energy storage systems: a comparative life cycle cost analysis. Renewable and Sustainable Energy Reviews, v. 42(C), p. 569-596, 2015.

6 DIVYA, Kurthakoti C.; ØSTERGAARD, Jacob. Battery energy storage technology for power systems—an overview. Electric Power Systems Research, v. 79, No. 4, p. 511-520, 2009.

7 ECKER, Madeleine et al. Calendar and cycle life study of Li (NiMnCo) O2-based 18650 lithium-ion batteries. Journal of Power Sources, v. 248, p. 839-851, 2014.

8 BARRÉ, Anthony et al. A review on lithium-ion battery aging mechanisms and estimations for automotive applications. Journal of Power Sources, v. 241, p. 680-689, 2013.

9 LI, Siguang; ZHANG, Chengning. Study on battery management system and lithium-ion battery. In: 2009 INTERNATIONAL CONFERENCE ON COMPUTER AND AUTOMATION ENGINEERING, 2009. p. 218-222.

10 CHEN, Haisheng et al. Progress in electrical energy storage systems: a critical review. Progress in Natural Science, vol. 19, No. 3, p. 291-312, 2009.

11 BARBOUR, Edward; WILSON, IA Grant; RADCLIFFE, Jonathan; DING, Yulong; LI, Yongliang. A review of pumped hydro energy storage development in significant international electricity markets. Renewable and Sustainable Energy Reviews, 2016.

12 IHA et al. Hydropower status report. London: International Hydropower Association, 2018.

13 Consider the Brazilian case: EMPRESA DE PESQUISA ENERGÉTICA. Balanço energético nacional — relatório síntese 2024. Ano base 2023. Rio de Janeiro: Ministry of Mines and Energy (MME), 2024. Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-819/topico-715/BEN_S%C3%ADntese_2024_PT.pdf. Accessed on: 22 Feb. 2025.

14 DENHOLM, P.; HAND, M. Grid flexibility and storage required to achieve very high penetration of variable renewable electricity. Energy Policy, v. 39, p. 1817, 2011.

15 In other words, they cannot be used only on the command of the operator, as is the case, for example, with a thermoelectric plant.

storage solutions. With the European Union adoption of accelerated electrification and expansion of renewable sources as a decarbonization strategy,[16] the role of storage in promoting the proposed energy transition is recognized as fundamental.

Pirstner-Ebner[17] notes that electricity can also be stored by converting it into another form of energy, but this process should be differentiated from, for example, gas storage.[18] Although electricity can be stored in batteries and accumulators without conversion,[19] it is technologically unfeasible when it comes to large amount of energy. In this regard, several strategies may be employed, such as transforming excess electricity into kinetic energy through a pumped storage plant or into synthetic gas (*power-to-gas technology*).[20] The synthetic gas can then be stored in the gas storage facility and transformed back into electricity when needed.[21]

Making the use of energy storage viable, however, is not a straightforward task, especially in the electricity sector, and goes far beyond any technological development in the area. Public policies need to be developed[22] focused on technological innovation, modernization of network infrastructure, implementation of economic incentives, improvement of technical regulations and standards, as well as the promotion of education and awareness programs on the importance of energy storage and role of renewable energies in combating climate change.[23] Here, our analysis centers on the legal and regulatory

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16 EUROPEAN COMMISSION. COM(2018) 773 final - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN INVESTMENT BANK. A Clean Planet for All: the EU's long-term strategy for a prosperous, modern, competitive and climate-friendly economy. Brussels: [s.n.], 2018.

17 PIRSTNER-EBNER, Renate. European energy law: market system for electricity and gas-energy supply security-green energy system of the future (green smart grid). Nomos Verlag, 2022. p. 146-149.

18 As defined in the Gas Market Directive 2009. EUROPEAN PARLIAMENT AND COUNCIL. 2009. Directive 2009/73/EC on common rules for the internal market in natural gas. Available at: https://eur-lex.europa.eu/legal-content/PT/TXT/?uri=CELEX:32009L0073. Accessed on: 27 Feb. 2025.

19 ANEKE, Mathew; WANG, Meihong. Energy storage technologies and real-life applications–A state of the art review. Applied Energy, v. 179, p. 350-377, 2016.

20 GÖTZ, Manuel et al. Renewable power-to-gas: a technological and economic review. Renewable Energy, v. 85, p. 1,371-1,390, 2016.

21 LUND, Henrik et al. Smart energy and smart energy systems. Energy, v. 137, p. 556-565, 2017.

22 KEAR, Gareth; SHAH, Akeel A.; WALSH, Frank C. Development of the all-vanadium redox flow battery for energy storage: a review of technological, financial and policy aspects. International Journal of Energy Research, v. 36, No. 11, p. 1,105-1,120, 2012.

23 WENNERSTEN, Ronald; SUN, Qie; LI, Hailong. The future potential for carbon capture and storage in climate change mitigation–an overview from perspectives of technology, economy and risk. Journal of Cleaner Production, v. 103, p. 724-736, 2015.

framework for electricity storage, in particular through a comparative study of the European and Brazilian scenarios.

To investigate these issues, we analyze the current energy storage situation, providing a general overview of the technologies available and the global challenges and opportunities, which will benefit the whole energy chain, linking the generation, transmission, distribution, supply and end use of energy.[24]

Methodologically, a juridical-dogmatic approach is used, related to the technique of comparative law.[25] Initially, we present a legal understanding of storage practices within the European and Brazilian contexts, to determine the legal regime associated with each regulatory system. In the second part, we analyze the similarities and differences between the regulatory models in place, outlining possible paths suggested by the European experience that may be adopted in Brazil.

The first section focuses on the legal regime developed in the European Union, in general, and in Portugal, specifically. Then, we discuss the national situation, highlighting the general formula for regulating services associated with electricity in Brazil. Finally, we discuss the current state of storage regulation in Brazil, and the legislative proposals for its establishment, compared with the European model, identifying the regulatory direction, as well as its implications for debates on energy transition, security and environmental sustainability.

2. Legal framework for electricity storage in the European Union

2.1 General situation in the European Union (EU)

The European Union has repeatedly expressed concern about the need for a long-term structural change in the approach to energy systems, so that they are more integrated, intelligent and equipped to manage and balance dynamic patterns of supply and demand at European, national and local levels. This involves building a new energy economy,[26] proposing bold business solutions

[24] EUROPEAN PARLIAMENT. Energy storage: which market designs and regulatory incentives are needed? Committee on Industry, Research and Energy (Itre), 2015. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2015/563469/IPOL_STU(2015)563469_EN.pdf. Accessed on: 22 Feb. 2025.

[25] KOSZOWSKI, Maciej. Analogical reasoning in law. Cambridge Scholars Publishing, 2019.

[26] RIFKIN, Jeremy. The green new deal: why the fossil fuel civilization will collapse by 2028, and the bold economic plan to save life on earth. Macmillan+ ORM, 2019.

for the new energy era[27] and discussing the dilemmas and solutions for energy security in a changing climate.[28] However, there is currently no specific regulatory framework on energy storage, a topic addressed, in a scattered way, in several official texts, some of the most relevant of which are listed in table 1.

Table 1
European Commission's policy framework on electricity storage

Document	Year	Description
Clean Energy For All Europeans/ COM(860)	2016	In this text, the issue of storage appears closely linked to Europe's decarbonization strategy, focused on the role that storage technologies can play in energy markets and, in particular, the need for them to have the same conditions as other technologies, with respect to flexibility, in particular, as well as the role that distributed technologies can play.
Renewable Energy — Recast to 2030 (RED II) (2018/2001/EU)	2018	Addresses the need to promote storage as fundamental to increasing the penetration of renewables and their connection to energy markets, without penalizing distributed storage systems.
Energy Performance of Buildings Directive (2018/844/EU)	2018	Addresses the development of building intelligence through the Smart Readiness Indicator, which assesses, among other factors, the capacity of buildings to interact with energy systems and energy storage, as well as conditions to foster electric mobility and the promotion of zero-balance buildings, using local energy generation.
Internal Market Directive (2019/944/EU)	2019	Addresses the need to integrate the various entities in the energy markets, including producers-consumers, storage systems, and flexibility agents; the use of these services by system operators and the fact that they should not belong to them; and the need to develop seasonal storage.

Source: Adapted from FERRÃO, P. (Coord.). Armazenamento de energia em Portugal. Adene — Agência para a Energia, Observatório da Energia, Ciências ULisboa, Técnico Lisboa. Available at: https://www.observatoriodaenergia.pt/wp-content/uploads/2021/03/ESTUDO-armazenamento-de-energia_Texto_Final_revisto-OBS-v2.pdf. Accessed on: 22 Feb. 2025.

Reports such as *The future role and challenges of energy storage*[29] and *Energy storage: the role of electricity*,[30] published by the European Commission, presaged

[27] LOVINS, Amory. Reinventing fire: bold business solutions for the new energy era. Chelsea Green Publishing, 2013.

[28] BRADSHAW, Michael J. Global energy dilemmas: a geographical perspective. Geographical Journal, v. 176, No. 4, p. 275-290, 2010.

[29] EUROPEAN COMMISSION. The future role and challenges of energy storage. DG ENER Working Paper, 2013. Available at: http://ec.europa.eu/energy/infrastructure/doc/energystorage/2013/energy_storage.pdf. Accessed on: 22 Feb. 2025. .

[30] EUROPEAN COMMISSION. Commission Staff Working Paper. Energy storage: the role of electricity. 2017.

a move towards an institutional approach to the issue, analyzing the importance of storage in energy systems, identifying barriers and policies for its promotion. The main storage regulation in EU law is perhaps the *Electricity Market Directive* (EU Directive 2019/944),[31] which, in art. 2, 59, defined energy storage as:

> Deferring the end use of electricity to a time after its generation, or the conversion of electrical energy into a form of energy that can be stored, the storage of this energy and its subsequent reconversion into electrical energy or its use as another energy carrier.

For Parra and Mauger,[32] the legal regime resulting from Electricity Market Directive No. 2019/944/EU differentiates energy storage from generation and consumption, identifying an independent legal status. This implies that all technologies should be treated equally by policy makers, allowing market agents to choose the best option for their applications. It concludes that the stacking of benefits, although central to increasing the value of energy storage, still lacks a suitable legal framework in the EU.

With Directive No. 944/2019, Member States now define the criteria for granting authorizations to build production facilities on their territory. To this end, they define several criteria set out in art. 8, 2, such as network security and protection (a), environmental protection (c), land use and location (d). Specifically with regard to storage, the Community legislator determines that alternatives to the construction of new production facilities must be taken into account, such as demand response solutions and energy storage.

Regarding small-scale, distributed storage, the Directive determines that Member States must ensure that active customers who own energy storage facilities have (art. 15, 5): a) the right to connection to the grid within a reasonable time after the application, provided they meet all necessary conditions; b) exemption from paying double charges, including network charges, for maintaining stored electricity or when providing flexibility services to network operators; c) exemption from licensing requirements or disproportionate fees; and d) permission to provide services simultaneously, if technically feasible.

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[31] KREEFT, Gijs; MAUGER, Romain. Developing a regulatory framework for electricity storage. In: Energy law, climate change and the environment. Edward Elgar, 2021. p. 679-693.

[32] PARRA, David; MAUGER, Romain. A new dawn for energy storage: an interdisciplinary legal and techno-economic analysis of the new EU legal framework. Energy Policy, v. 171, 113262, 2022.

As a rule, distributors cannot own, develop, manage or operate energy storage facilities in the European Union (art. 36, 1), with exceptions identified in items 2 and 4, provided they are fully integrated in the network and have regulatory approval from the corresponding Member State entity. The aim of this is, ostensibly, prohibit the verticalization of electricity services, mainly through distribution, but allow for exceptions to ensure the regular, safe and efficient operation of the network.

To initiate and support a structural change in the way energy systems operate, the aforementioned Directive sought to develop a more intelligent and integrated energy system, European-wide and local in scope.

There is a strong emphasis in this program on fostering innovative approaches to energy storage and supply at a local level.[33] The premise is that the security and resilience of an energy system are best achieved when energy demand is minimized and the remaining peak demand is better managed,[34] which may be achieved through the use of storage. Within the program, Working Group 1: "Energy Supply, Generation and Storage" analyzes various parameters of the electricity sector, with the aim of optimizing the role of storage (including thermal, electrical and hydrogen) in the energy system. The cities leading this initiative are London (United Kingdom), Gothenburg (Sweden), Udine (Italy), Tilburg (Netherlands) and Navarra Nasuvinsa (Spain).

In 2021, the European Union (EU) institutions agreed to set a target of reducing greenhouse gas emissions by 55% by 2030,[35] which will only be possible if high volumes of electricity produced from renewable energy sources are integrated.[36] Soares et al.[37] demonstrate that the dilemma of ensuring a stable supply from intermittent sources creates value for on-demand production or

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[33] Available at: https://futurium.ec.europa.eu/sites/default/files/2021-02/Energy%20transition.pdf. Accessed on: 22 Feb. 2025.

[34] Peak demand is when the combined consumption profile of users in the electricity sector is such that, at a certain time of day, there is maximum requirement, forcing centralized operations to dispatch a sufficient number of power plants. As the name suggests, peak demand does not correspond to the energy requirements generally demanded during other hours of the day, and the dispatch of plants specifically to meet that very specific need tends to cause stress on the system, sometimes involving energy supplied by generation from non-renewable thermoelectric plants, whose dispatch is more agile.

[35] EUROPEAN COMMISSION. European climate law. 2021. Available at: https://climate.ec.europa.eu/eu-action/european-climate-law_en. Accessed on: 22 Feb. 2025.

[36] HANN, Veryan. Transition to decentralized electricity storage: the complexities of consumer decision-making and cost-benefit analyses. Energy Policy, v. 147, 10.101, 2020.

[37] SOARES, Ian Varela; MAUGER, Romain; SANTOS, Thauan. Considerations for benefit stacking policies in the EU electricity storage market. Energy Policy, v. 172, 113333, 2023.

consumption and, therefore, for electricity storage, used to balance energy supply and demand.

On March 14, 2023, Recommendation C/2023/1729 was adopted, focused on the Commission's energy storage—the Decarbonized and secure EU energy system,[38] highlighting the importance of a smarter, more integrated and resilient system, in line with the European Green Deal, whose aim is to reduce greenhouse gas emissions by at least 55% by 2030. In this Recommendation, member states have several obligations. They must consider the dual role of energy storage (as producer and consumer) when defining the applicable regulatory framework and procedures, especially when applying Union legislation in the electricity market. This includes removing unnecessary obstacles, avoiding double taxation and facilitating the granting of licenses. National regulatory authorities should take this role into account when setting network access tariffs and pricing regimes.

Furthermore, Member States must identify the flexibility needs of their energy systems in the short, medium and long term. In national energy and climate plans, they must reinforce objectives, policies and measures that promote the deployment of energy storage and flexibility in a cost-effective manner. It is important that energy system operators fully assess these needs when planning transmission and distribution networks, considering the potential of energy storage as a cost-effective alternative to grid investments.

The Recommendation also points out that Member States should identify opportunities for energy storage and other flexibility instruments, assessing the need for additional resources, to achieve environmental and security objectives. In addition, it is vital to examine whether energy storage services are sufficiently remunerated, especially in terms of flexibility in distribution networks, and whether operators can accrue remuneration for various services. Consideration of competitive tendering may be necessary to achieve a sufficient level of source flexibility, at the same time ensuring supply security and meeting environmental objectives. Capacity mechanisms must be improved, to facilitate the participation of flexible sources such as energy storage.

To remove obstacles to the deployment of demand response and downstream storage, EU countries need to identify specific regulatory and non-regulatory actions. Accelerating the deployment of storage and flexibility to islands, remote

[38] EUROPEAN COMMISSION. Commission recommendation of 14 March 2023 on energy storage: underpinning a decarbonized and secure EU energy system 2023/C 103/01. 2023. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2023_103_R_0001. Accessed on: 22 Feb. 2025.

areas and outlying regions is also necessary, in support of hybrid renewable energy production and storage projects. Releasing detailed data on grid congestion, displacement of renewable generation, market prices, emissions and existing storage facilities is crucial in facilitating investment decisions about new facilities. Finally, member states should continue to support research and innovation in energy storage, especially long-term solutions and the integration of electricity with other energy sources, using risk reduction instruments to support innovative technologies until they reach the market.

Deployment of electricity storage in the EU, in this economic and engineering context, is still hampered by legal obstacles,[39] which incorporation of Directive 944/2019 into the national legislation of EU member states, adapted to their own legal systems, should help remedy.

2.2 The Portuguese Context

Restricting ourselves to a European national legislation whose legal system is close to that of Brazil, we shall focus on the Portuguese case. Decree-Law No. 162/2019, October 25,[40] introduced significant changes to the electricity self-consumption regime in Portugal. According to Art 2.1 of the norm, behind-the-meter storage was provided for the first time.[41] This is defined as electrical energy stored in energy storage devices, including in electrical vehicles where bidirectional EV charging stations are installed. Decree-Law No. 15/2022, of October 20, revised this Law, maintaining, however, local storage as a legal provision in Portuguese law.

Philip Matias Santos[42] observes that the legal provision of self-consumption allows for the association and sharing of various production and consumption facilities, called collective self-consumption. The Decree-Law of 2019,[43] even allowed such an arrangement to be established through use of the public

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[39] EUROPEAN COMMISSION. Study on energy storage: contribution to the security of the electricity supply in Europe. 2020. Available at https://op.europa.eu/en/publication-detail/-/publication/a6eba083-932e-11ea-aac4-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search, accessed February 22, 2025.

[40] Decree-Law that significantly amended Decree-Law No. 153/2014, of October 20.

[41] Repealed by Decree-Law No. 15/2022, of January 14, previously established in Decree-Law No. 153/2014, of October 20.

[42] SANTOS, Philip Matias. Tendências recentes do direito administrativo da energia: a regulação das comunidades de energia (e do autoconsumo coletivo) e a descarbonização do setor do gás natural. e-Pública, Lisboa, v. 8, n. 1, p. 271-283, abr. 2021.

[43] Now transposed in Decree-Law No. 15/2022.

grid, modifying measurement requirements and creating entities such as renewable energy communities. This enabled the integration of electricity storage infrastructures, in a framework that now favors sales based on a market regime. In this scenario, there is a clear option to match behind-the-meter storage with a consumption or production facility, adopting the respective rules (for consumption or production) based on the dominant behavior of storage in each quarter-hour period, as per Erse Regulation[44] 373/2021, which establishes special rules for pilot projects in the form of regulatory sandboxes.

The legal framework of the Portuguese Electricity System, approved by Decree-Law 15/2022, established new general rules applicable to the licensing of these facilities, as well as specific provisions for energy storage, for it to exist in two different forms: (i) autonomous storage, when the storage facility has a direct connection to the Public Service Electricity Grid (Resp) and is not associated with an electro-producing center or a Self-Consumption Production Unit (Upac); and (ii) associated storage, when the storage does not have a direct connection to Resp and is associated with an electro-producing center or an Upac.[45]

Erse Regulation No. 815/2023, July 27, which approved the Regulation of Self-Consumption of the Electricity Sector according to the premises of Decree-Law No. 15/2022, established the provisions applicable to the exercise of the activity of self-consumption of renewable energy, individual and collective, when there is a connection to the Public Service Electricity Grid. Furthermore, it regulated renewable energy communities and communities of citizens that carry out the activity of self-consumption of renewable energy. The Regulation includes rules on commercial relationships, measurement, data reading and provision, sharing methods and on the application of tariffs and prices.

In April 2024, Portuguese Prime Minister Luís Montenegro announced that the country plans to create a National Energy Storage Strategy by 2026, to accelerate investments in the sector, including the integration of units in wind and photovoltaic parks, and address the storage of renewable gases.[46] The goal is to achieve carbon neutrality by 2045 and comply with the provisions of *Lei Bases do Clima* ("The Climate Framework Law"), facilitating the Climate Action Council and the preparation of Municipal Climate Action Plans.

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[44] Erse: Entidade Reguladora dos Serviços Energéticos

[45] In other words, by which storage takes place behind the meter.

[46] Available at https://www.jn.pt/7435992254/programa-do-governo-preve-estrategia-para-armazenar-energia-ate-2026/. Accessed on: 22 Feb. 2025.

3 Electricity storage in Brazil

3.1 Regulatory framework of the Brazilian electricity sector

Article 21 of the 1988 Brazilian Constitution states that it is the responsibility of the Federal Government to provide electricity services and installations directly, or through authorization, concession or permits. In addition, dealing with the national economic and financial order, regimes are established for the pursuit of economic activities through free enterprise, according to art. 170, and public services, as per art. 175, analyzed in legal doctrine in terms of their applicability to electricity-related activities.

In turn, what the Federal Constitution did not, nor could not, foresee, are specific determinations for sectoral technologies. It is not the role of the Constitution to detail each specific technology. This would make it overly analytical and subject to obsolescence.[47]-[48] Thus, to incorporate energy storage in the SEB, it is necessary to define whether it will be treated as a new segment of the electricity production chain or as an accessory service, considered in the system as an integral part of another category. To better understand how legal entities are defined within the SEB legal and regulatory framework, we shall consider the legal framework relevant to the case.

In 1995, SEB took the first step towards its present structure. With the enactment of Law No. 9,074/1995,[49] the rules applicable to the granting of sectoral activities were defined, with the establishment of legal categories and regimes of economic law associated with each of the main electricity services. The relevance of this norm is central to the case of storage, as it enables identification of the sectoral legal dynamics and determines the best way to accommodate this new technology.

Taking electricity generation as an example, Law No. 9,074/1995 provided for several entities capable of undertaking the activity, each with its own legal regime. Baptista observes[50] that, depending on the purpose of the generation provision, the activity will be categorized in terms of a public service, independent

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47 SILVA, J. A. Curso de direito constitucional positivo. 45. ed. São Paulo: Malheiros Editores, 2024.

48 MELLO, C. A. B. Curso de direito administrativo. 35. ed. São Paulo: Malheiros Publishers, 2021.

49 Available at: https://www.planalto.gov.br/ccivil_03/Leis/L8666cons.htm. Accessed February 22, 2025.

50 BAPTISTA, David Felice Falivene. Direito da energia elétrica: uma proposta de regulação para microrredes. Thesis (doctorate in electrical energy)—Faculty of Electrical and Computer Engineering, Universidade Estadual de Campinas, Campinas, 2024. p. 175-179.

producer or self-production. Even though each, in practice, generate energy and have the ability to inject power into the grid, the plurality of legal characteristics implies different legal regimes, with their own specific rules, such as the granting method, whether concession, permission or authorization, depending on the installed power of the plants. Electricity generation in Brazil was traditionally a public service but with the acceptance of independent electricity producers in the legal system these agents were permitted to produce and sell electricity at their own risk.[51] Later, Decree No. 2,003/1998 regulated the production of electricity by independent producers and self-producers,[52] currently supplemented by Aneel Normative Resolution (REN) No. 921/2021. Such sub-legal standards are, in sectoral practice, the rules that govern the execution of the activity in a more detailed and operational manner.

Including new technology in the SEB that could become a new sectoral feature is no simple task. As with the generation of electricity in the 1990s, a choice must be made about the legal nature of storage—and its consequent legal regime—so the technology is promoted to the extent that it adds value to the sector as a whole and is incorporated cohesively into the legal system in place. To this end, it is clear that the State must act on different fronts: (i) the Legislative Branch, to elaborate at least the legal form, and regulate the general rules and granting methods; (ii) the Executive Branch as a government entity, to establish public policy through the Ministry of Mines and Energy (MME), guiding its development and its benefits for the electricity sector and energy security; and (iii) the Executive Branch as a State body, prescribing its normative framework via a regulatory agency, as well as its supervision.

To illustrate how the proposed dynamic is already common in the electricity sector, we will consider the case of mini and micro distributed generation (MMGD) in Brazil. At least since 2012, there has been a national policy to encourage adoption of decentralized energy generation, marked by Aneel Normative Resolution No. 482/2012. As the technology was identified as possibly beneficial to consumers and the electricity sector at that time, it was decided that it should be based on generation models which already existed in the sector, thus fulfilling the requirement for State action mentioned in item i above.[53] This normative resolution was fundamental to the implementation of

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[51] TÁCITO, Caio. Produtor independente de energia elétrica. Revista de Direito Administrativo, Rio de Janeiro, v. 242, p. 183-186, 2005.

[52] FAGUNDES, Maria Aparecida. Os novos rumos do direito da eletricidade. Revista de Direito Administrativo, Rio de Janeiro, v. 224, p. 1-30, 2001.

[53] Baptista, Direito da energia elétrica, op. cit.

the technology, since it created, through its rules, a system of energy credits capable of making a previously expensive infrastructure economically viable.[54]

It is important to emphasize that, although this system clearly demonstrates State action, as described in item iii, the material content of its rules is, if not public policy per se—as shown in item ii—[55]is, alternately, an.[56]

Given the rapid growth of MMGD in Brazil,[57] in 2022 the National Congress enacted Law No. 14,300/2022, known as the Legal Framework for Distributed Generation. In this case, not only were the incentives and subsidies hitherto given to MMGD reviewed, but it was legally defined as an autonomous generation entity, treated by Baptista[58] as having a *sui generis* nature in the SEB legal system.[59] REN Aneel No. 1,059/2023 regulated it, amending REN Aneel No. 1,000/2021, again establishing state action on the three fronts described and proposed above.

As explained, the MMGD case, considering both its successes and failures, may serve as a basis for energy storage. Whether storage is considered as analogous to generation,[60] or through creation of an autonomous status for it in the legal system of the sector, the path to creating a distinct legal regime must follow the proposed logic, to guarantee, as far as possible, its adoption in a cohesive and orderly manner, in line with an existing, complex system of rules.

3.2 Ways to regulate storage in Brazil according to the established European model

Carvalho et al.[61] show that the regulatory framework and market structures of the Brazilian electricity sector, established after the last major reform in 2004,

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[54] BAPTISTA, David Felice Falivene; SILVA, Luiz Carlos P. da; FONSECA, Isabel Celeste. A natureza jurídica da geração distribuída de energia elétrica no Brasil. Revista Direito Público, v. 19, n. 104, p. 179-186, 2022. Available at: https://www.portaldeperiodicos.idp.edu.br/direitopublico/article/view/6956. Accessed on: 22 Feb. 2025.

[55] For example, Aneel Normative Resolutions No. 517/2012, No. 687/2015, No. 786/2017, No. 1,000/2021.

[56] ABSOLAR. Energia solar fotovoltaica no Brasil: infográfico Absolar — junho de 2024. São Paulo: Associação Brasileira de Energia Solar Fotovoltaica, 2024. Available at: https://www.absolar.org.br/wp-content/uploads/2024/07/Infografico_junho-724x1024.jpg. Accessed on: 22 Feb. 2025.

[57] Ibidem.

[58] Baptista, Direito da energia elétrica, op. cit., p. 179-186.

[59] Although the subject is controversial, since sector bodies tend to see MMGD as a common consumer, rather than a generator, Felice (Direito da energia elétrica, op. cit.) supports the view of MMGD as a new sector entity, given that it was provided for in Law 14,300/2022.

[60] Como se fez com a MMGD até o advento do seu marco legal específico. Baptista, Silva e Fonseca, A natureza jurídica da geração distribuída de energia elétrica no Brasil, op. cit.

[61] CARVALHO, Priscila; SPATARU, Catalina; SERRÃO, André. Electricity markets and regulatory developments for storage in Brazil. *In*: *Storing energy*. Elsevier, 2022. p. 811-830.

present weaknesses and are subject to increasing economic, environmental, social, legal and regulatory risks. The reduction in water levels stored in hydroelectric plants and increase in intermittent renewable sources, for example, mean that planning and operation of the sector is more complex, as it faces risks of capacity shortages and supply security. The European model, especially that set out in the COM(860) documents and in EU Directive No. 2,018/2001, presents electricity storage as an additional element in this whole equation, which offers balancing capacity to the current complex equilibrium and paves the way towards energy transition and decarbonization.

As established by the European Community regime, and specifically in Portugal in Decree-Law No. 15/2022, Brazil is, it seems, moving towards a dual vision of storage: both in terms of an autonomous sector agent and a behind-the-meter storage system.

3.2.1Associated storage (behind the meter)

Regarding the latter case, the concept is clear in the Brazilian legal system. Law No. 14,300/2022, describing the legal framework for MMGD, also defines what we now call an associated storage facility, which must exist together with a consumer-generator, under the terms of art. 2 of Law No. 14,300/2022:

> Art. 2. Electricity distribution concessionaires or permissionaires must respond to requests for access from consumer units equipped with distributed microgeneration or minigeneration, with or without an energy storage system, as well as hybrid systems, in compliance with the regulations.

In this case, the storage system must be located behind-the-meter, and it is considered *associated* since it does not act as an autonomous sector agent, but rather part of the consumer unit equipped with MMGD. In addition, in the area of distributed generation, the associated storage system is a means of classifying as dispatchable a photovoltaic generating plant whose monthly generation capacity is at least 20% installed storage capacity in batteries.[62]

Although there are no specific infra-legal regulations governing the practice of storage, or even its normative definition, the technology, when associated

[62] As defined in art. 1 IX, of Law No. 14.300/2022 and art. 2, IV-A, c, of REN Aneel 1.000/2021.

with MMGD, tends to be on a small scale and, according to our understanding, the installed capacity is also limited to the existing power limits for the MMGD system. In practice, as was the case with distributed generation in 2012, associated storage, since it is not an autonomously defined concept in the legal system, borrows from the MMGD concept, whose entire set of rules applies to it. The form of regulation chosen by the legislator in Law No. 14,300/2022 is very similar to the Portuguese local storage policy, which, as Santos points out,[63] is similar to the generation and consumption regimes, with its own applicable rules.

Further comparing the European and Brazilian models of associated storage, as presented in the corresponding section, EU Directive No. 2019/944 establishes a series of guarantees for active customers who own storage systems. Even though the regime established by Law No. 14,300/2022 and its regulation in REN Aneel No. 1,000/2021 does not specifically mention units with storage systems, we find similar legislative/regulatory concerns in relation to MMGD, which, in this case, includes associated storage.

As for the system connection period, the Brazilian regime defines specific deadlines in art. 91 et seq. of REN Aneel 1,000/2021, which meet the reasonableness criteria established in the European Directive. Furthermore, such deadlines are general, treating all consumers, active or not, equally (art. 655-A, sole paragraph of REN Aneel No. 1,000/2021). Likewise, in terms of tariff policy, Brazilian legislation provides for the same tariff structure applicable to consumption, granting partial exemption/subsidy for some plants classified according to specific criteria, thus avoiding, as established by the European standard, double taxation.

More significant is how Brazil handles the simplification of licensing requirements for such types of units. Linked to the MMGD, the associated storage benefits from the requirement to merely communicate the connection to the local distributor, established as a right under Article 2 of Law No. 14,300/2022. Therefore, no type of authorization from the regulatory agency is required, and its connection depends only on the adequacy of technical and installation safety criteria.

Finally, the European standard also states that local storage facilities are authorized to accumulate several electricity services simultaneously. In Brazil, again due to the association of the system with MMGD, such authorization is a requirement and must be associated with micro and mini generation.[64]

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[63] Santos, Tendências recentes do direito administrativo da energia, op. cit.

[64] We will not discuss here the possibility of characterizing an MMGD system without the generation element, but rather simply consisting of battery banks.

3.2.2 Autonomous storage (as a sectorial entity)

Different from associated storage, there is currently no sectoral arrangement for autonomous storage in the Brazilian electricity sector. However, there is no shortage of discussion and proposals for its creation.

Aneel, after a long data collection process (TS Aneel 11/2020), which resulted in the Regulatory Impact Analysis Report (AIR) 1/2023-SGM-SCE-STD-STE/Aneel, initiated Public Consultation n 39/2023, to prepare proposals for regulatory adjustments required for the introduction of storage systems in the electricity sector, in the context of the energy transition of the Brazilian electricity sector. Among the proposals, are both normative and non-normative solutions, with specific objectives: (i) to adapt the regulation of access to the network through new storage technologies, (ii) to adapt the regulation of concessions to new energy storage solutions and (iii) to evaluate alternative remuneration structures for electricity storage systems.

Furthermore, the MME held a seminar on May 24, 2024, focused on "Perspectives and Challenges for Batteries in *Sistema Nacional Interligado* (SIN)",[65] bringing together experts from *Empresa de Pesquisa Energética* (EPE), *Agência Nacional de Energia Elétrica* (Aneel), *Operador Nacional do Sistema Elétrico* (ONS) and *Associação Brasileira de Soluções de Armazenamento de Energia* (Absae). According to information from the federal government, the growing competitiveness and diverse applications of energy storage were highlighted, emphasizing its importance in energy planning. The Power Capacity Reserve Tender (LRCAP) is aimed at contracting electric power for supply from 2027 and 2028 onwards, and integration of storage technologies were also discussed in this context, as a way of optimizing the national energy matrix.

The creation of Reserve Energy Contracts (CER) in 2008 provided a mechanism for more efficient management of the energy available. In this context, storage has become an auxiliary strategy to guarantee energy reserves, as recognized in the EU in COM(860), which calls for the technology to be treated under the same conditions as other means of promoting flexibility and system security.

In an effort to promote public policy initiatives surrounding the issue of autonomous storage, the National Congress has proposed the creation of provisions in the national legal system by way of legislative amendments.

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[65] Available at: https://www.gov.br/mme/pt-br/assuntos/noticias/mme-debate-perspectivas-e-desafios-para-as-baterias-no-sistema-interligado-nacional-1. Accessed on: 27 April. 2025.

Provisional Measure No. 1,232, June 12, 2024, currently before Congress, which mainly concerns the management and regulation of electricity purchase and sale contracts and their conversion, as well as issues of corporate control and the economic and financial balancing of concessions, has opened up the electricity storage debate.

At least two parliamentary amendments are emphatic in this regard. Amendment 32, led by deputy Marcelo Moraes (PL-RS), is aimed at creating a new category, justifying the initiative by the increased use of energy storage systems globally, due to the modernization of the electricity sector and significant reduction in the cost of these technologies. It also highlights the great diversity of storage applications, for both isolated and interconnected systems, proposing an amendment to Law No. 9,427/96[66] to include regulation and supervision of electricity storage among Aneel's powers, in accordance with federal government policies and guidelines. The amendment to create the autonomous storage entity is explicit, in the following terms:

> Art. X, Law No. 9,427, of December 26, 1996, which shall come into force with the following amendments: […] Art. 2 […] Sole paragraph: The electrical energy storage system was developed in the same way as any technology or resource capable of converting electrical energy into potential energy, able to store and reconvert it into electrical energy, which can be used in all the activities of the electrical energy industry: generation, transmission, distribution, commercialization and consumption.

The legislative proposal defines the entity as a transversal sector, as shown in table 2.

Although it does not go so far as to propose the creation of the storage model,[67] Amendment No. 37, authored by Senator Wilder Morais (PL-GO), suggests its incorporation as a sectoral activity of the SEB, providing for: (i) positive implementation of the principle of technological neutrality, tariff modality and decarbonization in capacity-power reserve tenders, including storage as a viable contracting arrangement; (ii) the explicit authority of Aneel to regulate and monitor electricity storage activities; (iii) inclusion of guidelines for reducing energy losses, including in hydroelectric and renewable generation activities

[66] Law which establishes Aneel's regulatory powers.
[67] Possibly due to the fact that the proposal had already been advanced in Amendment 32.

and in terms of the inefficiency of fossil fuels, with storage solutions advanced for this purpose; (iv) the determination of the National Energy Policy Council to propose a specific national policy for energy storage; and (v) consideration of investments in electricity storage as infrastructure projects for qualification under the Special Incentive Regime for Infrastructure Development (Reidi) and as priority infrastructure projects for issuance of debentures and access to public credit.

Table 2
Legal model of Brazilian Battery Energy Storage Systems (Saeb), according to Amendment 32 of Provisional Measure No. 1,232, June 12, 2024.

Storer Profile	Description
Autonomous storage	Legal entity or consortium that owns storage resources, connected to the electric transmission or distribution grid, with or without a generation, transmission, distribution or commercialization concession, providing services to the national electric system, remunerated fairly.
Storage with generation functions	Legal entity or consortium that owns storage resources, connected to the electrical transmission or distribution grid, associated with a concession or grant for the generation of electrical energy, with fair remuneration for services rendered.
Storage with transmission functions	Legal entity or consortium that owns storage resources, which belong to an electricity transmission service concession, with fair remuneration for services rendered.
Storage with distribution functions	Legal entity or consortium that owns storage resources, belonging to an electricity distribution service concession, with fair remuneration for services rendered.
Storage with marketing functions	Legal entity or consortium that owns storage resources and carries out commercial operations remunerated fairly.

Source: Prepared by the authors.

The highlighted amendments demonstrate the interest in including electricity storage as a new sector resource, in line with the European vision of decarbonization (COM(860)), and its capacity to regulate an electricity system which is increasingly permeated by intermittent and distributed sources (EU Directive 2018/2001). Technological neutrality, which according to Parra and Mauger[68] is a premise of EU Directive 2019/944, also features in the Brazilian proposal, in two respects: (i) in relation to the technology itself, since the arrangement proposed by Amendment No. 32 does not specifically establish how storage will operate (by batteries, for example, or another method); (ii)

[68] Parra e Mauger, A new dawn for energy storage, op. cit.

and in relation to the sector as a whole, with Amendment No. 37 emphatically advancing storage as a viable arrangement to be used in the most diverse SEB processes, such as capacity reservation tenders, in line with the MME.

Despite the similarities in the proposals, the model put forward in Brazil, especially in Amendment 32, differs on one crucial point from the European determination: the prohibition, as a rule, of distributors from practicing storage activities. If the concern of EU Directive 2019/944 is to guarantee the de-verticalization of the electricity system, a perspective echoed in Brazilian law, since art. 4, § 5 of Law 9,074/1995 precludes distributors carrying out varied sectoral activities, the Amendment clearly allows such cumulation, in creating a storage profile with distribution functions. Since the justification for the amendment does not include the reasons that led the author to disregard, for storage, the de-verticalization of the distribution sector, it is difficult to identify reasons for not following the model already established in the national legal system, as well as the European recommendation.

4 Conclusion

Given the decarbonization strategy adopted by the European Union, which promotes accelerated electrification and expansion of renewable sources, the centrality of energy storage in advancing energy transition is clear: to facilitate the integration of intermittent renewable sources and improve grid resilience. In the European context, energy storage is regulated such that it encourages both the action of autonomous sectoral entities and implementation of behind-the-meter solutions. In Portugal, in particular, Decree-Law No. 15/2022 exemplifies how regulation can promote the widespread adoption of storage technologies to implement the energy transition agreed in the European context.

In contrast, the Brazilian electricity sector faces significant challenges in increasing energy transition, in terms of regulatory and operational weaknesses, with a high proportion of hydroelectric sources and increasing participation of intermittent renewable energies. Reduction in water levels in hydroelectric plants resulting from climate change, combined with the increased complexity of system operation caused by the introduction of new energy matrices, have increased the urgency to find effective energy storage solutions, to mitigate these risks and consolidate supply security.

Adoption of practices and regulations inspired by the European model can provide Brazil with an effective strategy to overcome these challenges. Integrating

energy storage, as an autonomous sectoral arrangement and in an associated manner, can stimulate the energy transition which is so vital for the country, ensuring greater security and environmental sustainability. Furthermore, by promoting incentive policies and investment in storage technologies, we can foster the development of a more competitive and innovative energy market, to achieve decarbonization goals and ensure a resilient and sustainable energy supply for future generations.

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