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Energy Sustainability: Brazil's Nuclear Transition Potencial and Uruguay's Transconstitutionalism

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Abstract: The present investigation was motivated by the purpose - as a general objective of the research work - to examine the legal scenario of Nuclear Energy between Brazil and Uruguay under the bias of Transconstitutionalism and Energy Transition, based on the analytical coexistence between inspection and State entrepreneurship before the Paradigm of Sustainability and Regional Integration. The methodology used in this work will be qualitative, in which it was decided to search for non-exhaustive sources of the transition process of both countries, taking into account the territorial, geopolitical and technological aspects involved. For this purpose, research, surveys and analysis of texts, articles, constitutional reform projects, legislation, Energy Policies and their strategies, as well as official documents from governments, entities, organizations and international agencies were carried out. The focus of this project is based on historical content, concentrated on the period 2015 - 2020, although the Energy Plans are projected until 2050. In the academic period, complementary themes such as energy transition and public security developed in an antagonistic manner, denoting the need for a triple helix of action between three main development actors: the State, the Academy, and the Production of Services through public policies. It is concluded that the Uruguayan plan sought above all to foster innovation leading to the country's internal energy development and independence, strategically achieving its energy security based on political attractiveness, and that the Brazilian exploration potential is concentrated from the moment in which that it can mitigate stigmas and think of the nuclear resource as a complementary source that makes it possible to meet domestic demand and less dependence on water sources.

Keywords: Nuclear Energy, Transconstitutionalism, Security, Transition, Energy Sustainability

1. Introduction

In the face of a period of great political, economic and even social turbulence and challenges in recent years, we have seen important debates on the international agenda that have become goals for nations to prioritize. Sustainable development and its implications for the energy sector continue to top the list, due to the heavy burden on the environment and the constant climate changes resulting from the economic model in which we live. The prospect of a sustainable future with less emissions of pollutants into the atmosphere makes us question the ways and typologies to reach a development model, which uses energies that allow us to provide satisfactory levels of quality of life for the next generations.

Thinking about this resource, the much feared and misunderstood nuclear energy arises, which, although it is one of the world's main sources of energy and is extracted through the splitting of the uranium atom, has a heated debate around the means - the plants and their risks beyond the threshold of the energy and national security debate - and purposes of their use - peaceful or not. Certainly, any energy source can present its dualities in terms of its use, its purposes and its possible legal and security implications, whether in a broader realm - international security, or in a more intrinsic realm - energy security.

It is proposed, then, to question the legal and constitutional aspects that can be used or even that are already part of the development plan for nuclear energy in Brazil, considering that, although it is a non-renewable source, uranium is part of

one of the riches offered in Brazilian soil, with great potential to assume the role of complementary energy to renewable sources, besides being an option to reduce, in relative terms, the use of fossil sources.

However, the proposal is to use as a model, at least for purposes of inspiration, the case of the South American neighbor, Uruguay, although less in its number of inhabitants and territorial issues, can teach us in large matters, mainly, when we looked for specific issues and were able to extract good practices of application and the potential that can still be explored in terms of growth, technological development and innovation in terms of low carbon emissions.

However, the guiding premise of this work was to assume that the strategies outlined in the Uruguay Energy Plan (PE 2005-2030), which guided Uruguay towards the 'BIG PUSH', could serve as a model to help outline impulses or even inspire Brazil in the development of Nuclear Energy, as an exponential factor, not only of transition but also of energy security [1].

The methodology used in this work will be qualitative, in which it was decided to search for non-exhaustive sources of the transition process of both countries, taking into account the territorial, geopolitical and technological aspects involved. For this purpose, research, surveys and analysis of texts, articles, constitutional reform projects, legislation, Energy Policies and their strategies, as well as official documents from governments, entities, organizations and international agencies were carried out. The focus of this project is based on historical content, concentrated on the period 2015 - 2020, although the Energy Plans are projected until 2050.

This paper was structured in four main sections, besides the introduction and final considerations about the study. In the first section, emphasis was given to introductory concepts: a) of nuclear energy - besides bringing a quick explanation of how the transformation of uranium into energy occurs, which, were widely searched in works and authors such as Jukka Letho (2017) and Dimis Braga (2019); b) about the context of the energy transition, succinctly explained by Jorge Camargo, current vice president of the Brazilian Center for International Relations; and, c) about nuclear energy as a clean energy source and its potential in this transition context, exploring contents brought by the International Energy Agencies (IEA) and Atomic Energy (IAEA).

In the second section, the objective was to explore Nuclear Energy in Brazil with historical contents, including the Brazilian Nuclear Program, and, finally, an approach on the development of the Angra Power Plants, under the aspects of authors such as: Carlo Patti - in his work "Brazil in Global Nuclear Order", even though dated 1983, showed to be very current in his considerations and ponderations - Rafael Brandão (2008) and Dimis da Costa Braga (2019), besides other names.

The third section contains the legal point of view of both countries around the nuclear issue, bringing to light aspects of the Constitutions of Brazil and Uruguay and their transconstitutionalism, in addition to the main challenges regarding public safety and energy issues, explored in general terms only for understanding the main theme around Nuclear energy as a sustainable potential. Finally, the last section presents the future perspectives of nuclear energy as a source of clean energy and as an increment to the energy matrix. For this, in the last sections, the approaches of International Energy Agencies (including atomic energy) and authors such as Alexandre Nina (2020), the Brazilian Minister of Mines and Energy, Bento Albuquerque (2020) and Ivo Dorileo (2020) were reviewed, in addition to the researched National Energy Plans and official documents and news directly from the Uruguayan and Brazilian governments.

However, even though the intent is to bring a comparative analysis between the energy models between Brazil and Uruguay, it is emphasized that it is by no means our pretension to compare literal aspects of both countries, incomparable in characteristics and cultures, however, even though different in many aspects, it is believed that the Uruguayan model, containing the guidelines and strategies outlined in the Uruguayan Energy Plan of 2005 - 2030, with which, has drawn in a splendid way its path towards energy transition using renewable energies, besides the market potential and business environment it is directed towards a low carbon economy and the full development and awareness of its population and should be used as an inspiring source or at least seen as a bridge to be followed in strategic terms by Brazil regarding the adoption of Nuclear Energy as a driving source for the transition.

2. Nuclear Energy as a Clean Energy Source

2.1. The Concept of Nuclear Energy

Nuclear Energy can be defined as the energy released from chain reactions that take place in the nucleus of atoms and are converted into electrical energy, either by fission or fusion of radioisotopes [2]. Thus, radioisotopes can be termed as the set of atoms with unstable nuclei involving radiation emission [3]. These radiations occur through these nuclear fissions or fusions, which are basically processes of chemical energy release. However, fission consists of the fission of a radioisotope using free neutrons. Fusion, on the other hand, results from the union of atoms. Thus, in both processes, a new chemical element emerges that generates a massive level of energy [4]. Therefore, this phenomenological conglomerate following nuclear disintegration, due to the instability present in the nucleus of these atoms, results in the production of particles (alpha and beta) or radiation (gamma) defining what can be conceptualized as radioactivity.

The set of sources used to create energy in a given territorial locus can be called energy matrix [5]. The energy matrices are regulated by special rules, which provide for the conduct of natural and legal persons in relation to certain activities involving handling and/or exposure to radioactive materials and products, whether of natural or processed origin [6]. It is this set of rules that configures the field of action of the so-called Nuclear Law.

Thus, nuclear energy performs the work of a force and can

be seen with a set of factors, i.e., in addition to energy, economic and ecological. According to United Nations, sustainable development is linked to meeting the needs of the present without the compromise of future generations [7]. Since, according to Cruz, Bodnar and Ferrer (2012) sustainability consists of a meta-legal paradigm that guides the global society and the actions of the interpreter of law in the third millennium [8]. That is why the figure of transconstitutionalism in this field is so important, since it permeates solutions to legal-constitutional problems that arise simultaneously at different levels [9]. Therefore, the desires pursued in this energetic transition are ennobled.

2.2. The Energy Transition Context

The depletion and overloading of the environment, product of the current global development model and derived from the most diverse economic activities, mainly in the aspect of resource exploration, are only the "faces" derived from the emission of GHG (Greenhouse Gases) as a Reflection of this, alarming concerns about global warming are already showing their features in extreme and increasingly frequent weather events and events [10].

Consequently, discussions about the environment and the types of resources for energy generation that make up the global energy matrix, assume a rising weight in the political agenda of States, especially after the 1990s. Contrary to this sustainable explosion, we find, although disproportionately, the dependence of these same States on the energy sectors, which are firmly supported by the exploitation of fossil fuels, which in turn generate profuse impacts to environmental depletion. In addition to this shock, we must take into account the role of new actors that generate a drastic change, not only in the way in which natural resources are exploited but above all in the form of consumer participation and competitiveness in the energy sector for the world and new forms of generation [11].

Therefore, this scenario presents a new phase of the energy transition, building and contributing to new consumption patterns that involve more advanced technological processes and that essentially meet the Age of Transition, with climate change as the main driver leading to a more sustainable economic development.

The energy transition that we are going through at the moment is the result of other versions that we have been going through over the centuries, with it a significant transmutation of the geopolitical energy paradigm we have experienced so far.

We are witnessing a profound energy transition, both for the supply and demand scenarios, in the form of energy that reaches consumers, as well as for the factors that determine the influence and power relations between nations and regions. [...] The energy transition we are experiencing today, in different forms and at different paces, has unprecedented characteristics. It is the first with climate as a motivating force. It will necessarily have to be more intense and faster than previous transitions if we are to achieve the goals set in 2015 at the United Nations Climate Change Conference in Paris [12].

In this context, the energy transition can be understood as a change of paradox. If before the energy primacy was based on an essentially economic context [13], today we are led to rethink this entire development model and reformulate it. While we have witnessed several phases of transition since the Industrial Revolutions I and II, what we are witnessing today leads us directly to a new vision, whose concern is essentially environmental and sustainable.

2.3. Nuclear Energy as a Clean Energy Source and Potential for the Energy Transition

The perspective of a sustainable future with less emissions of pollutants into the atmosphere makes us question the forms and typologies to reach a development model that uses energies that allow us to provide satisfactory levels of quality of life for future generations.

Thus, authors and several technicians in the area recognize nuclear energy as a powerful source capable of covering needs in an energy matrix, being considered, therefore, a clean source, especially because it emits very low levels of carbon into the atmosphere. In this sense, the IAEA (International Atomic Energy Agency), emphasizes that:

"Nuclear power now provides about 10% of the world's electricity, but it contributes almost 30% of all low carbon electricity. Nuclear power will be essential for achieving the low carbon future which world leaders have agreed to strive for" [14].

From this point of view, ABEN (Brazilian Nuclear Energy Association), reiterates the thought that this energy source not only contributes strongly to the advancement of measures to achieve lower levels of carbon emissions, but also considers that the development of nuclear energy is part of the proven way to create affordable and low-carbon energy, as well as to create jobs and high-value local supply chains in the long term [15].

In addition, due to their capacity and high energy density in installed power (MW) per small and occupied area [16], nuclear power plants can be installed relatively close to urban centers, which leads to greater preservation of sensitive areas and makes this resource the main source of energy. generation with reduced significant environmental and social impacts, even providing the local advance of the space of its installation. Therefore, the adoption of nuclear energy as a generating source and active participant in the global energy matrix, can be seen as a strategy of amplification and national development, besides, of course, highly sustainable.

Therefore, the role of nuclear energy can be understood as an engine of transition and a new approach to think, not only in terms of generation, but as a new horizon that emerges for sustainable economic development, based on new technologies specifically designed for low-carbon bias. Moreover, the resource extracted from uranium can be considered as a driving source that allows to improve the process of burning atoms and to increase safety standards.

In short, the application of this mineral as a natural energy resource, if idealized as an inspiring bridge between the crossroads of global warming and the scarcity of resources for sustainable development, will serve as a stimulus for the formation of new alternatives and complementary, clean. and consistent bases that enable not only the global low-carbon

project, but also promote the promotion of innovation, competitiveness and the emergence of new players in the market, capable of leading to a reformulation of the system, especially in technological, geopolitical aspects and related to the search for energy security.

3. Nuclear Energy in Brazil

3.1. Nuclear Energy in Brazil and Its Historical Context

The decades that followed 1930 were extremely important for the development of modern Brazilian physics, since it would host important events, among them the creation of the Faculty of Philosophy, Sciences and Letters of the University of São Paulo [17], and the secret export and the system. of monazitic sands to the United States [18], which corroborated in a cooperative environment in relation to the Manhattan Project of that country, which, was launched in the responsibility of the construction of an atomic bomb that would use the developments in the technology of nuclear Fission reproduction during the Second World War [19].

In this context, the debate on the possible use and preservation of its own natural resources for the production of atomic energy and the development of official projects began in Brazil in mid-1945. Thus, as a supplier of raw materials to the United States, the country supplied until the 1950s abundant quantities of atomic minerals of which it is rich. And, with the implementation of the principle of specific compensation, for each export of strategic minerals, there was a transfer of useful technology aimed at improving the national nuclear sector [20].

The study by Dimis da Costa Braga (2019) [21] is very timely when he points out that, given the demonstration of the difficulty in obtaining technology abroad, the country sought to follow international advances in the sector. And, therefore, it stopped looking exclusively for the acquisition of indigenous technology from abroad, either for the production of uranium metal, or for the development of its enrichment.

Because, it was in the context of the warlike use of nuclear technology that Brazil sought to establish the first steps towards the creation of a Brazilian space center and, in the late 1960s, this center was renamed INPE (National Institute for Space Research), whose The main objective was to design and execute the construction of a satellite launching rocket [21].

As there was no industry to develop or apply the results of this research conducted at INPE and other agencies until then, according to a Brazilian retrospective elucidated by scholars [17], in 1951 the creation of Brazilian National Council for Scientific and Technological Development (CNPq), and at the proposal of this Council, entered the scene several other research centers dedicated exclusively to nuclear physics. Among them, the rigor of the time is evident, the IEA (Institute of Atomic Energy), located in the state of São Paulo and the IPR (Institute of Radioactive Research) installed next to the Federal University of Minas Gerais, in the state of Minas Gerais, both in the period of 1953. In 1960, the Dosimetry Laboratory was created, later transformed, in 1971, into the Institute of Radioprotection and Dosimetry. In the following years, in 1963, the IEN (Institute of Nuclear Engineering) was created, in the state of Rio de Janeiro, and, finally, this cycle culminated with the institution of CBTN (Companhia Brasileira de Tecnologia Nuclear), incorporating the IPR of Minas Gerais, which would later be called CDTN (Center for Nuclear Technological Development), linked to CNEN, with the Federal University of Minas Gerais, in the state of Minas Gerais. It is crucial to reflect that, at this moment, therefore, the Brazilian nuclear territorial locus has overcome a considerable expansion.

With the acquisition of 03 (three) centrifuges from Germany, intercepted by British occupation troops at the request of the US government and only released after demonstrating that they would enrich very small amounts of uranium and, with minimal fees [21], academic interests were carried out in conjunction with strategic political actions to leverage the Brazilian atomic sector.

According to the historical scheme of the time, nuclear purposes were not exclusively peaceful in the country, nor in other nations. Thus, in a context of combating the clandestine nature of Brazil's operations abroad, considering the obligation that all commitments in nuclear matters be subject to the scrutiny of the National Congress, and the suspension of exports of uranium, thorium, compounds, minerals or other strategic material, CNEN (National Nuclear Energy Commission) was established [22].

Also, according to Dimis da Costa Braga (2019), it was believed that Nuclear Energy by fission process would come to play, already in the mid-1970s, a leading role in global electricity generation, and great steps were taken in the direction of expanding it [21]. However, after this nuclear optimism, the populations of the most developed and democratic countries emerge a simultaneous distrust tangent to the dangers arising from nuclear activities [23].

As a way to ensure safety, protect the environment, participate in decision-making processes, and institute effective safeguards for nuclear activities on a global scale, the IAEA was born [21].

3.2. Brazilian Nuclear Programme

The bases of the Brazilian Nuclear Program were established during the period of the military government regime, adorned by sensitive and strategic issues. The Program, it is emphasized, had business in the country with the United States and, sequentially, with the Brazil-Germany Nuclear Agreement [24].

Signed in June 1975, the Brazil - Germany Agreement provided for the installation of 08 (eight) nuclear power plants, the creation of uranium prospecting and exploration companies, the manufacture of fuel elements, the manufacture of heavy components for plants and reactors, the reprocessing of irradiated fuel, uranium enrichment, and the creation of a true nuclear industry [24]. However, it was stigmatized for accounting for an economic loss with a natural cost higher than the private sector in the country, subsidized by the new nuclear industry.

Although Brazil suffered the boycotts and the economic and strategic interests of these nations, history has shown that even by following such uncomfortable paths, the nation finally stopped the full nuclear fuel cycle. And, by the way, it happened not only with the development of its own technology, but also with the signing of these international agreements.

From the 1990s onwards, the Programme was made more flexible and dismantled, allowing it to distance itself from the prospect of economic and energy integration with the MERCOSUR (Southern Common Market) countries [24]. Between 1991 and 1994, the country adhered to international nuclear non-proliferation regimes, accepted extensive international safeguards, including those of the IAEA [25], and was followed by a component of the Latin American nuclear-weapon-free area.

3.3. Angra Nuclear Power Plants

The paradigm that was created around the Brazilian nuclear power plants comes from the stigmas used within the Brazilian Nuclear Program itself. The latter, which initially contemplated the development of 08 (eight) nuclear power plants [26], as soon as it was left with an economic sustainability affected by the disturbances occurred in the first constructions.

The construction of the Angra I Nuclear Power Plant, in the state of Rio de Janeiro, marked the first phase of the Program and was licensed to start operations in December 1984. However, it suffered several interruptions, including by court order, and was officially inaugurated in 1985. With a PWR (pressurized water reactor), technology supplied by the American company Westinghouse, it has 657 MW of installed power. However, since the preamble of Angra I operations, there were frequent leaks of radioactive material through the rods that store the fossil fuel inside the nuclear reactor and failures in the handling of the Plant's material [27].

The license for the construction of the Angra II Nuclear Power Plant was granted in 1981, however, a long period of time separated it from its official inauguration. The license to start operations was not granted until March 2000, but it was in the period of July 2011 when the Plant finally started its activities. With a PWR reactor, technology supplied by the German company KWU, it has 1,350 KW of net power [25].

The nuclear program was revitalized in the early 2000s. In 1998, Congress approved the reactivation of projects for the construction of an industrial plant aimed at producing nuclear fuel and encouraged collaboration between the Navy's research centres and the nuclear industry. The management of the Angra I Nuclear Power Plant and subsequent plants was rationalized and a new public company called Eletronuclear was created from the merger of Furnas and Nuclen, a subsidiary of Eletrobrás [25].

Thus, the project for the construction of the Angra III Nuclear Power Plant was definitively established. However, due to the national scenario, it has not yet been completed. But in one way or another, it is an undeniable triumph that Brazil has two very efficient Nuclear Power Plants that are considered national patrimony, since it managed to conquer the domain of enriched uranium technology.

4. Nuclear Energy in Brazil and Uruguay from the Legal and Safety Standpoint

4.1. Brazilian Constitutional Law

The Brazilian legal system grants a role of constitutional centrality in energy matters, in particular, the treatment given by the national legislature to nuclear activities. It can be said, in this diapason, that the law has been the mechanism used to maintain state control over these operations and the dependence of the electricity sector for public financing [28].

The first provision expressed in nuclear matters is contained in Constitutional Amendment No. 1/1969 to the 1967 Constitution, immediately in its article 8, item XVII: "*It is up to the Union: [...] XVII – legislate on: [...] i) water, telecomunictions, postal service and energy (electric, thermal, nuclear or any other*" [29]. The Thematic Subcommittee on Health, Safety and Environment issued normative instructions in its article 70, in which the opinion of the rapporteur tended to restrict the use of Nuclear Energy in the national territory: "*It is forbidden in the National Territory the installation and operation of nuclear reactors, except for scientific purposes. [...] All other nuclear activities shall be carried out under the control of the Public Power, ensuring supplementary oversight by entities representing civil society*." [30].

According to Dimis da Costa Braga [28], it cannot be denied that the democratic framework of 1988 established many precepts aimed at ensuring the maximum participation of society in terms of participatory deliberation in the decision-making process regarding electricity generation. Article 225 of the Magna Carta is timely when it establishes the environment as a fundamental right and principle, requiring in its clause IV, prior preliminary environmental impact study and wide publicity for the installation of works or activities that potentially cause environmental degradation.

In relation to the exploitation of energy sources, most of them were open to the action of both the State and private entities. This can be seen in article 21 of the Federal Constitution of 1988, *"It is incumbent upon the Union: XII - to explore, directly or by means of authorization, concession or permit: [...] b) electric energy services and installations and the energetic exploitation of watercourses, in coordination with the States where the hydro-energetic potential is located"* [29].

However, it is interesting to note that in the nuclear field, unlike the others, it was relegated to dependence on the State. Its use was restricted and placed in a centralized condition in the Union, dependent on state funding and conditioned to the expansion of the sector to the authorization of the Legislative Power, according to the provisions of articles 21 and 22 of the Federal Constitution of 1988:

> *"XXIII - to explore nuclear facilities and services of any kind and to exercise State monopoly over research, development, enrichment and reprocessing, and to to exercise State monopoly over the research, processing,*

enrichment and reprocessing, industrialization and industrialization and trade of nuclear mines and their derivatives, subject to the following principles and conditions: a) all nuclear activity on national territory shall be permitted only for peaceful purposes and only by approval of the National Congress; b) under a permit system, the commercialization and use of nuclear commercialization and use of radioisotopes for research and medical, agricultural and industrial uses; (Amendment given by Constitutional Amendment no. 49, of 2006) c) under the permit regime, the production, commercialization and use of radioisotopes for research and medical, agricultural and industrial uses are authorized the production, commercialization and use of radioisotopes with a half-life equal to or less than two hours. two hours; (Redação dada pela Emenda Constitucional no 49, de 2006) d) a responsabilidade civil por d) a responsabilidade civil por danos nucleares independe da existência de culpa; (Redação dada pela Emenda Constitucional no 49, de 2006)" [29].

The Fundamental Charter is, therefore, the exclusive competence of the Union for the management and development of nuclear activities in all their phases, including legislation. This constitutional rigidity is important and continues to establish the exclusive competence of the National Congress to approve also initiatives of the Executive Power [29]. However, the fear lies in this cloud of ignorance in the Brazilian nuclear field, which may dismiss the thermonuclear option without considering other debates and social institutions.

The role currently occupied by the CNEN as the highest governing body in nuclear management should be viewed with caution, once the competence of the National Congress has been delegated, it has acquired such power with the exclusive responsibility of inspection, planning, supervision, scientific research and national regulatory instruction of the sector. However, it is undeniable that regulatory updating is of utmost importance in this scenario and that infra-constitutional laws continue to dictate the great reservations and urgencies in the nuclear legal context.

One of the major issues to be discussed in the nuclear field is the prioritization of regulatory research within a regulatory agency such as the CNEN. From these premises, more efficient and democratic paths can emerge in the energy field and strengthen the Democratic Rule of Law as a whole [31].

4.2. Uruguayan Transconstitutionalism

The use of nuclear energy in Uruguay is prohibited by Law n. 16.832, enacted in 1997, which regulates the updating of the National Electric System and creates the Energy Regulatory Unit [32]. The present order provides for the prohibition in its Article 27 and stresses that no agent in the wholesale electricity market may enter into electricity supply contracts using nuclear generators or foreign generators, as the plants would pollute the national territory.

Despite the contemporary legislative understanding, the country relied on numerous institutional and regulatory efforts to structure the nuclear sector. The creation of the National Regulatory Authority for Radioprotection, through Law No. 17,930, 2005; the National Atomic Energy Commission and the National Directorate of Nuclear Technology, through Law No. 15,809, 1986; the Centre for Nuclear Researchers, in 1966; and, the granting of a retirement benefit to persons performing work activities exposed to X-ray radiation or handling radioactive elements are initial examples [33].

Finally, in 1964, a small nuclear reactor was purchased from the United States for research and personnel training. However, through the dialectic built by the accidents of Chernobyl (Ukraine), Goiânia and cesium-137 (Brazil), and Fukushima I (Japan), debates were ignited in the Uruguayan political and social sphere [33]. As the government began a phase of evaluation of nuclear energy, specialists were hired to consult the population and evaluate the human resources and technology available. With the growing investment in renewable energies (wind, biomass, solar photovoltaic, solar thermal, hydro and biofuels) and the exploration of the presence of oil in the country, the nuclear debate moved to the background and under a new paradigm of sustainability and peaceful use.

While the arguments against nuclear use overlap in the exhaustive monetization and international safety requirements, it raises important factors for the decarbonization of electricity generation, as it combines with intermittent renewable technologies with ease, as they are not dependent on weather conditions and generate power at all times.

The analysis of high energy performance in Uruguay considers three important factors: the performance and leadership of public companies as service generators, the Uruguayan culture of respect for the environment and the regulatory environment. The materialization of the idea of smart cities comes from a good performance in the generation of services [34].

This probability study also highlights the importance of the State to guide and provide welfare to citizens through public policies aimed at quality of life, and not to favor short-term decisions. That is to say, even if it is tenuous, there must be a limit between the State that supervises and the same State that assumes.

The Uruguayan energy sector has undergone several changes in recent years, energy has become a huge weight in the national accounts, as its consumption has increased exponentially. This also generated a great concern in the regulatory scenario, whose legislation was concerned with establishing a more rational and sustainable use of these energies. A great example of this is the institution of the Energy Efficiency Law n. 18.597, 2009 and the Energy Policy agreed between all political parties [35].

Currently, efficiency is defined by Uruguayan administrative doctrine as the reasonable proportionality between the activity carried out and the means employed in relation to the results pursued and obtained, being a translation of the principle of constitutional roots. The law, therefore, has sought to be reflected in an instrument of impact at the level of energy, economic and environmental policy. In this way, it has

structured and regulated a system of state and non-state actors with different degrees of responsibility, obligations and restrictions to protect the common interest [35].

The analysis of the regulation of the normative institutionality of the energy sector is important to determine whether it is a norm of action (lower normative hierarchy - referring to principles in the strict sense and rules) or a final norm (higher normative hierarchy - referring to the Constitution and the law), and to understand the margin of discretion with which the Administration has to dictate its decisions [35].

As the renowned Uruguayan jurist Héctor Gros Espiell would say, "One cannot realistically describe a social system without referring to the juridical order applicable to it. That is why Georges Burdeau has recently rightly said: 'en voulant demeurer juristes, nous faisons preuve de réalisme'" [36].

4.3. The Challenges of Nuclear Energy as a Public Safety Issue

Thus, as noted by the Brazilian author Guilherme de Souza Nucci (2016) [37] in his work 'Human Rights versus Public Safety', human rights are inherent to human nature and confer a real individuality to the being for the achievement of dignified conditions of survival, and in that way. way they are embraced by the mantle of natural law and also positive. Human dignity, therefore, is intertwined here and it will be up to the State to protect both the individual with regard to life, liberty, dignity and, in particular, public order and security. Such conditions, although specific, are inseparable as a whole and aim to protect the individual even from the actions of the state itself.

Public security, generally seen as antagonistic to human rights, needs to interact with human rights. While it is a duty of the state, it is also a community obligation. Public security, being seen as a common right of all and as public policy, must therefore be pursued by the whole community. Given that the concentration between the state police forces, the Public Prosecutor's Office and the Judiciary for this purpose is fundamental.

4.4. Energy Security and Its Challenges

Despite the challenges observed in the legal and public safety fields, a widely discussed topic called Energy Security is added to the discussion.

This term, although enshrined by the IAEA, is still being discussed in terms of its parameters and, above all, the breadth of its concept, often clashing with the term international security - which leads us to a global legal order - or even as an extension of it.

Created primarily as a protection mechanism for energy-consuming countries that depended on oil supplied by OPEC (World Petroleum Organization), the IAEA instituted the concept of Energy Security, defining it "*as the uninterrupted availability of energy sources at an affordable price*" [38]. This term was solidified at a time when the world had just gone through another phase of energy transition, from coal to oil, and more importantly, with the oil crisis that followed. The Agency still segments this concept into two aspects: long term and short term.

> *"Energy security has many aspects: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance" [38].*

In the first aspect, energy security is assumed when investments manage to follow the evolution of environmental demands, that is, to follow the processes in which it is necessary to carry out the energy transition process and, mainly, the country's economic development. country. The second aspect focuses on the State's capacity to react to domestic energy supply even when there are imbalances, changes and influxes in national supply and demand.

However, according to the author Alexandre Nina (2020), the challenge of Energy Security sets precedents and complexities beyond the expected, in which, by "uninterrupted availability", it is possible to understand possible interruptions in supply and may be causes of countless variables, intentional or not, that affect the energy infrastructure, such as climatic events. Therefore, from this context of complexity of the term and collective understanding of energy security, a new approach to risk mitigation emerges, incorporating to the concept, indicators that allow to "visualize", in more practical terms, the progress or threat, to security. vulnerability of countries, which we highlight here as: diversification rates of the energy matrix; the relationship between import and domestic demand [39]; the ability to use alternative sources available instead of relying on other sources; or even the ability to develop strategic plans that aim to minimize the rate of energy interdependence.

5. Prospects for Nuclear Energy in Brazil and the Uruguayan Model of Energy Transition and Security

5.1. Nuclear Perspectives as a Potential Factor for Brazilian Energy Transition and Security

The Brazilian energy matrix is considered one of the most diversified in the world and has abundant and completely diverse natural resources in its territory, although the primary base of the whole is based mainly on hydroelectric power plants. Although, after the water crisis that occurred in Brazil in 2014, its energy model has expanded somewhat, it also highlights the need for investment and focus on other alternative and complementary energy sources.

Faced with this and the challenges posed by the scenario of environmental depletion and constant climate change, a broad model of uncertainties is composed for the issue of water, since, then, the need for a strategic diversification of the matrix arises, in which this work suggests as a perspective to consider, nuclear energy, in has highlighted its potential in a sublime way:

> *"Its high capacity, in the order of 90%, translates into a firm*

base generation that provides the confidence and security of supply necessary for the expressive use of variable renewable sources, such as solar and wind. It is also important to highlight that [...] nuclear turbogenerators contribute significantly to the stability of the system, compensating transient oscillations of the network, keeping the frequency within adequate standards" [16].

The concern, however, relates to nuclear exploitation set in a model that is able to overcome the stigma inherited from negativism and enter into the use of this source as a growing potential for transition and energy security factors. While this stigma does not end, the country focuses on the strategy of expansion through its external influence, starting with the export of uranium in the form of commodities.

However, Brazil, which ranks 09 (nine) among the largest uranium reserves in the world, has mapped only 30% of the national territory, with a forecast to resume geological prospecting operations by the end of 2020 [40]. According to the Minister of Mines and Energy, Bento Albuquerque (2020), "*the resumption is the first phase to consolidate our proposal to make Brazil self-sufficient and a uranium exporter"* [40]. It should also be noted that, according to Reis (2015), Brazil, besides having one of the largest uranium reserves and possessing technological mastery of the entire enrichment cycle of this source, the country has only 1.9 GW of energy generation. energy and only 1.3% of the entire energy matrix is occupied by nuclear energy, which has operations concentrated in the Angra 1 and 2 plants, with the expectation of expanding this matrix to 3.39 GW with the Angra 3 plant [10].

This argument becomes valid, assuming that the country uses its influence in the export of primary products to become self-sufficient and expand its exporting credentials, with the objective of better exploring the available and accessible sources in the national territory, including contributing to the formation of prices. on the international scene, given its dimension of wealth - explored and yet to be explored - of this mineral.

In this aspect and, based on the future prospects of the Brazilian Nuclear Program, the manufacture of components that complement the fuel cycle and the regulation and strengthening of its actions, in addition to self-sufficiency in the production of radioisotopes and radioactive. sources, stands out. Therefore, a strategic investment scenario is revealed to increase the Brazilian participation in the fuel cycle domain, meeting the domestic demand and the resumption of exports [13].

When we broaden the scope of the prospects of nuclear energy, comparing it with other energy sources, we can understand the predominance of other markets superimposed on the expansion of thermoelectric plants, this happens, basically because the focus is on expanding the renewable market while, theoretically, it operates. in the development of nuclear technologies, effective and safe that allow this relative expansion. Therefore, the model of expansion and focus on "*markets associated with nuclear technology, such as nuclear medicine, radioisotopes, pest control, food irradiation, erosion markers, defense (nuclear-powered submarine), desalination, generation, generation, hydrogen, etc., is currently being applied"* [41].

5.2. The Uruguayan Case as a Model for Energy Transition and Security

The need to produce a diversified energy plan that converges with its objectives, makes the State focus on the best use of internal resources and promote the offer of a bottom-up development model and create favorable conditions for a paradigm shift, incorporating new energy means to make compatible a convergent evolution with the new environmental challenges. It can clarify that the Strategic Energy Plan should:

"create conditions for the change of the current energy model favoring a greater contribution of renewable energies, water, wind, solar, biomass, nuclear energy, biofuels and hydrogen, in order to make development compatible with environmental protection and the reduction of greenhouse gas emissions" [11].

Additionally, Nina (2020) it is necessary to highlight the need to look at the challenges and opportunities through this strategic plan, considering that the elaboration of these policies has the main scope of avoiding the exposure of the State to risks and must, necessarily, take into account essential aspects and essential, if not intuitive, "*the convenience of diversifying the origin of the resources, the sources of energy acquired, the routes and modes of transport, or even the spatial distribution of the internal energy infrastructure*" [39].

We can mention in this case Uruguay, which recently underwent intense investments to carry out the transition process after a severe period of collapse in the energy sector, in which there were several interruptions in the national energy supply. This process of developing a cleaner matrix was due to Uruguay's quest for energy security.

This required several stages and massive developments included in its Strategic Plan for 'Energy Policy 2005-2030'. Which used the concepts and aspects previously highlighted on strengthening the long-term vision, projecting a predictable future on its model, complementing and converging with plans to implement a new institutional and regulatory framework consistent with the establishment of strategic, operational and above all inclusive guidelines that meet its national demand potential [42]. As a result of this transition policy, based on achieving its own growth and achieving its energy emancipation, Uruguay achieved not only the title of country with "*the highest percentage of wind energy generated in America, occupying the 3rd position in the world"*, but also reversed the role of an excellent buyer and became an exporter [42].

Consequently, the Uruguayan model can be seen as a starting point or even the crossing of the bridge to reduce its internal and energy vulnerability, which has transformed its unavailability into opportunities for evolution towards an energy policy based on the maximization of its independence and the implementation. of investments with new parameters in terms of the use of wind technology that includes supply, the energy transformation process and the satisfaction of internal and external demand.

In view of this, when we look at it from this perspective, we achieve a better vision to evaluate and understand the nuclear potential as any other energy source - as the example of the Uruguayan case and its expansion with focus on wind energy - which, can be seen as an additional and complementary resource to the matrix of countries, in which the concern regarding the use of domestic energy sources goes beyond the approach of fear and enters the thresholds of energy security, especially regarding its support for a new phase of transition.

Therefore, when we explain the Uruguayan transition plan, we understand the specifics of each resource, however, we do not limit ourselves to that. We seek to analyze and approach the debate to observe to what extent Brazil advances in its strategies and the natural potential it has internally, which is currently untapped due to lack of technological development, lack of strategic resources or even a certain 'preconception' due to lack of understanding and fear of misuse of this source. In this way, the contribution of the Uruguayan Energy Plan allows us to rethink new ways of internally exploring the content of our true potential, which until now had been latent.

In this way, it is worth proposing a diagnosis based on the lessons learned from the Uruguayan transition model, such as the articulation of governance instruments, in addition to an institutional alliance in the environmental, legislative, regulatory and regulatory fields, as well as enabling and expanding access to information by the population, so that they can benefit from this range of possibilities assumed when we treat uranium as an indispensable source for the transition and a resource as expressive as other sources, including renewable ones (solar and wind, specifically).

6. Conclusion

Faced with a world in constant transition, due to new environmental and climatic needs, here it was intended to raise the debates on uranium, its functionalities and its challenges in the legal and security field, however, it is worth noting the discovery of a new awareness of the potential of this resource, highlighting that this source, as well as other energy resources, including renewable ones, incorporates in its scope transition uncertainties caused basically by its technological process and adaptation to its matrix. However, this is considered a natural resource with a high growth potential, being fundamental for the process of development and energy generation.

Thus, we believe that it is necessary for the development of this work to consider not only the agility, but the Brazilian energy transition process, its historical context and its development over time, focusing on the level of development of nuclear energy and its prospects based on a current scenario, governed by uncertainties and major inconsistencies in different areas, whether economic, sustainable or environmental.

With that, we realized that, although transition and energy security are practically complementary issues, these at a certain point, become, in a way, antagonistic to each other. That is to say, at the same time that the environmental factor is a face that proposes a transition emergency, this same factor can be a point of attention if it is observed from the angle of (in) availability of resources, which are cleaner and more accessible as well as being sustainable and efficient to provide the supply in satisfactory terms of local demand.

However, the importance of weighting is necessary for us to be able to perform a critical analysis in order to improve the results in relation to public and energy security, which are placed as the main spectre that haunts the management of nuclear energy as a whole.

In sum, in addition to the factors that overlap the use of nuclear energy, we sought to observe Uruguay's transition plan, described in the Energy Plan document (EP, 2005 - 2030), which, in a short period of time, became the world giant of energy transition, implementing decrees and resolutions in its internal system that would allow it the title of global leadership and, above all, the role of pioneer in renewable issues. This study contributed to a vision of good practices of conciliation, governance and interconnected management that leveraged the process and succeeded in this new stage of the energy transition and especially in the areas of security and integration of the population and expansion of the business environment.

Implemented in a socially inclusive manner, the Uruguayan plan sought above all to promote innovation, leading to the internal energy development and independence of the country, strategically achieving its energy security based on political, fiscal and economic attractiveness, getting rid of fossil sources and abandoning, consequently, the relative volatility of their prices. Based on these parameters, the current case of Brazil was analyzed, reaching a brief conclusion that, although the country has the potential to leverage the use of uranium, there are still internal needs to be addressed, such as support for investment, the integration society and the government entities themselves.

In short, there is a potential for exploration in relation to Brazil from the moment it manages to mitigate the stigmas and think of the nuclear resource as a complementary source that allows to meet domestic demand and less dependence on water sources, thus ensuring consequent energy security.

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