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NUCLEAR DEVELOPMENT IN BRAZIL AND INDIA: A COMPARISON OF THE NATIONAL PROGRAMS[1]

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ABSTRACT

This article covers the historical and current similarities between Brazil and India regarding the non-war uses of nuclear energy. Considering the information highlighted in the analysis of their trajectory, this study then investigates whether Brazil could learn from the Indian experience and, if so, what these lessons would be. After the analysis, the conclusion is that given the profound differences between the current Brazilian and the Indian nuclear programs, Brazil's adequacy to a possible "Indian model" does not seem achievable. Among the differences identified, there is the divergence regarding the political interest in prioritizing nuclear energy, something that India does. Without a proper emphasis of a topic on a country's political agenda, no public policies can be designed for the sector. As for nuclear agenda, not covering the issue as a state policy has profound implications since it ultimately compromises the training of human capital and technological advancement.
Keywords: Brazil. India. Nuclear Program.

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INTRODUCTION

The 20th century was largely marked by the discovery of nuclear energy. Of a dual nature, its uses range from medicine to agriculture, passing through industry to its use in the defense and manufacture of both tactical and mass destruction weapons. About the latter, since the U.S. attacks on Hiroshima and Nagasaki in 1945 during World War II, international understanding of nuclear nonproliferation and disarmament has progressed significantly and has been consolidated in the form of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The agreement, which currently has 189 countries, was signed in 1960 and entered into force two years later. Among the states recognized by the United Nations, only Israel, Pakistan, India, South Sudan and North Korea are not part of the instrument.[5] Despite widespread criticism from decision makers, analysts, and academics about the NPT's ability to enforce the objectives of its articles, the treaty inaugurated the international regime of nuclear nonproliferation and disarmament, and in its validity was extended indefinitely.

Far beyond weaponry, the interest of developed and developing countries in nuclear power remains and is justified by the versatility of its uses, among which power generation and fuel production are highlighted. Moreover, the technological complexity associated with nuclear energy attracts the attention of developing countries, which associate the scientific and technological domain in sensitive and dual areas with the idea of modernity. Finally, the possession of nuclear technology, when used only for peaceful purposes, indicates the maturity of the detaining country, providing it with international prestige.

The trajectory of Brazil and India in nuclear matters meets the aforementioned perceptions and interests: modernity, maturity, prestige. Even considering the huge abyss that separates the current nuclear reality of these two countries – with Brazil being a holder of nuclear technology without nuclear weapons and India a holder of nuclear technology with nuclear weapons – these countries share some degree of historical similarity in the area and, from different perspectives, participate in the same commitment to the international agenda of nonproliferation and disarmament. From an economic point of view, Brazil and India are both developing countries with a large domestic market and a young population, sharing the same interest in the use of nuclear energy to generate electricity.

[5] North Korea had acceded to the Treaty in 1985 but withdrew in 2003.

From the military point of view, both maintain interest in the construction of submarines powered by nuclear reactors as a deterrent instrument in defending their maritime boundaries and projecting power.

This study is divided into four parts. The first, dedicated to the Brazilian case, is subdivided into two sections. One, focused on the decades between 1930 and 1960, highlights the first Brazilian interests in nuclear energy, the creation of the main management and research institutions in the area, and the first international agreements to obtain nuclear technology; the other, dedicated from the 1970s to 2005, focuses on the years of defining the main national nuclear objective – the search for technological autonomy – as well as the definition and implementation of strategies that would lead Brazil to develop its own capacity to enrich uranium, namely the 1975 agreement with West Germany and the creation of the Parallel Nuclear Program in 1979. This part emphasizes the resumption of the Brazilian nuclear program from 2005 and the motivations that guided this decision.

Part 2 is dedicated to the Indian case and is equally subdivided into two sections, respecting the same time frame as for the Brazilian case study. In the case of India, the first section emphasizes that country's interest in nuclear power as an alternative source of power generation to boost national economic development. The second section reconstructs the Indian trajectory from the 1974 nuclear test, declared peaceful, to the 1998 tests, which made the Indian condition of war nuclear power official and the consequent abandonment by that country of the moral obstacles that delayed this decision. From 1998, therefore, India becomes part of the select group countries with nuclear weapon in the world, along with Pakistan. Until that time, only the United States of America (USA), Russia[6], England, France and China had tested nuclear weapons.

The historical sections of both Brazil and India observe a fundamental aspect for the referral given by these countries to their nuclear programs, namely, the nature of the regional relations of each of these countries (CARPES, 2015). In the case of Brazil, although there was some degree of nuclear competition with Argentina, such a dispute never evolved into an arms race in South America. In fact, through the Treaty of Tlatelolco, signed in 1967 and to which Brazil is a signatory, Latin America became the first densely populated region on the globe to be designated

[6] Soviet Union (USSR) at the time of the first tests.

as a Nuclear-Weapons-Free Zone (NWFZ).[7] Later, in the 1990s, Brazil and Argentina succeeded in overcoming the historic nuclear discussion and kept the cooperation commitments made since then. Conversely, the Indian regional experience has never advanced beyond hostilities with either China or Pakistan, making any real attempt at nuclear disarmament impossible.

The third part of the article compares the current nuclear programs of Brazil and India, focusing on the 2000s. In this part, two themes are emphasized: nuclear participation in the energy matrices of these countries and their interest in the development of nuclear submarines through the establishment of international partnerships. In addition, we seek to systematize the comparison between the nuclear programs of the two nations and to understand how each government has dealt with the theme. This study also presents objective aspects of these countries' use of nuclear energy, such as production capacity, their correspondence in their national energy matrices, available uranium reserves and investments to expand their exploration.

Finally, based on historical narratives and on a comparison of the advances that Brazil and India have made in nuclear matters in recent years, some considerations are made in the last part of the article. The conclusion is that, although the Brazilian and Indian cases generally bear some similarities – especially with regard to international narratives regarding nonproliferation, disarmament, and historical associations between energy nuclear power and modernity, and the interest in nuclear submarines – the options nuclear of Brazil and India have radically put these countries far from a common trajectory, to the extent that the lessons that Brazil could draw from the Indian case are few and punctual. As will be clarified at the end of the article, the current stage of the Brazilian nuclear program is not due to the country's inability, but to a political option to keep the current relative weight of nuclear energy on the national public policy agenda. The exception is the Brazilian project for the submarine powered by nuclear reactor, which the country seeks to advance from its current condition.

[7] The following regional treaties currently proscribe nuclear weapons besides Tlatelolco, constituting NWFZ: Treaty of Rarotonga – South Pacific (1985); Bangkok Treaty – Southeast Asia (1995); Pelindaba Treaty – Africa (1996); Treaty of Semipalatinsk – Central Asia (2006). Besides these, there are three other treaties banning nuclear weapons in uninhabited areas: Antarctic Treaty (1959); Outer Space Treaty (1967); and Seabed Arms Control Treaty (1972).

NUCLEAR DEVELOPMENT IN BRAZIL BETWEEN THE 1930S TO 2005

Brazil's nuclear policy was influenced by the objectives traditionally pursued by Brazilian foreign policy during its republican period, namely: autonomy, power projection in terms of influence, and pursuit of prestige (PAUL, 2000, p. 109). Together, these general objectives made the Brazilian nuclear program somewhat ambiguous, as the country's specific objectives for the nuclear area varied significantly, but always in the name of the same interests. If in the early years the focus was on academic studies and, later, on the generation of energy for the supply of an energy matrix that seemed to be running out; in a second moment the Brazilian interest in nuclear energy led the country to consider studies in the area of explosives, whose use, even if declared peaceful, would have placed the country internationally as a pariah state (CARPES, 2006). In all these historical moments, the Brazilian interests in the nuclear area were covered by the same aforementioned arguments. As Kassenova (2013, p. 1) argues, the Brazilian nuclear policy resembles the image of a kaleidoscope; when considering the maintenance of the same elements – search for autonomy, prestige, and power –, the relationship between them has changed over time. Therefore, since the beginning the Brazilian nuclear trajectory has been complex and sometimes discontinuous, like the country's history itself (CARPES, 2015, p. 107).

THE BEGINNING OF THE INTEREST FOR NUCLEAR ENERGY: FROM THE 1930S TO THE 1960S

Brazil took its first steps towards the nuclear age in the early 1930, when a research group on cosmic radiation and radioactivity was created in the physics department of the University of São Paulo (USP). In the 1940s, Brazil signed agreements with the USA in the area of prospecting for radioactive minerals (1940) and for rare earth exports to the Manhattan Project (1945). In the 1950s, the National Council for Research (CNPq) – now known as the National Council for Scientific and Technological Development – was created, and its first idealizer and director was Admiral Álvaro Alberto (PATTI, 2012; COMISSÃO NACIONAL DE ENERGIA NUCLEAR, 2017).

In subsequent years, the Getúlio Vargas administration sought to acquire nuclear technology by signing cooperation agreements with developed countries: West Germany – to purchase centrifuges for uranium enrichment; France – to purchase uranium dioxide; the United Kingdom – to purchase uranium hexafluoride; and with the USA – to purchase research reactors (COMISSÃO NACIONAL DE ENERGIA NUCLEAR, 2017). Except for the agreement signed with the US, all others were interrupted with the death of Getúlio Vargas in 1954, and the rise of Café Filho as president and his choice for a more US-aligned foreign policy.

Under Café Filho's administration, Brazil signed four more nuclear agreements with the United States, including the Wheat Agreement in 1954 (KURAMOTO; APPOLONI, 2002, p. 380). This agreement provided for the Brazilian export of five thousand tons of rare earths to the US, in exchange for 100 thousand tons of wheat. In 1956, under Juscelino Kubitschek's administration, the Atomic Energy Institute (IEA – *Instituto de Energia Atômica*) was created to develop research in the area and enable the installation of a research reactor. In the following year, Brazil signed, with the US, an agreement to join the USA Atoms for Peace program. Under the program, Brazil inaugurated its first nuclear research reactor – and the first in Latin America – the IEA-R1 (COMISSÃO NACIONAL DE ENERGIA NUCLEAR, 2017).

During Kubitschek's administration, the Brazilian nuclear policy would again assume more assertive contours. During this period, the National Nuclear Energy Commission (CNEN – *Comissão Nacional de Energia Nuclear*) would be created. In the 1960s, the construction of the first Brazilian research reactor, the Argonauta, with 93% of national components, deserves attention, confirming the Brazilian interest in the development of technologies in the nuclear sector.

THE SEARCH FOR NUCLEAR AUTONOMY: FROM THE 1970S TO 2005

During the military regime, the Brazilian nuclear program acquired a more strategic orientation and experienced years of constancy, both in investments and objectives. In Costa e Silva's administration, a plan contemplating the complete development of nuclear energy in Brazil was elaborated (PAUL, 2000, p. 110). However, the choices made during this period would lead Brazil to maintain a relationship of dependence with

the USA. As noted by Patti (2012), the Brazilian effort in the period was to obtain, through international agreements, the necessary infrastructure to develop the embryo of a national nuclear industry in a short time. In this context, between 1971 and 1972, CNEN and Eletrobras negotiated a nuclear agreement that would give Brazil its first thermonuclear plant. Installed in Angra dos Reis, a municipality of Rio de Janeiro, the plant, named Angra I, would be supplied with enriched uranium, although the agreement did not include the transfer of any technologies to Brazil: neither for reactors nor uranium enrichment. In the short and medium term, the agreement kept Brazil dependent on enriched uranium imported from the USA (KURAMOTO; APPOLONI, 2002, p. 381, 382). This dependence would only begin to break from the 1980s, when Brazil could, for the first time, enrich uranium in national soil.

In contrast, at international level, the Brazilian nuclear policy would adopt an assertive profile. Brazil's engagement with nonproliferation had its first milestone in the signing of the Treaty of Tlatelolco in 1967, which banned nuclear weapons in the Latin American and Caribbean region. Brazil, one of the signatories of the Treaty, deposited its instrument of ratification in the following year.[8] To ensure compliance with its obligations, the Treaty established the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL).[9] From 1970 onwards, in turn, the newly created TNP would be open for signatures. Arguing that the treaty was discriminatory and promoted a freeze on world power, creating a class of countries with the monopoly of most advanced nuclear technologies and another category of countries without the right to develop those technologies, Brazil refused to join to the treaty, a position that would only be revised in the 1990s (ARAÚJO DE CASTRO, 1971).

With the first oil shock of 1973 and the first Indian test with nuclear explosives in 1974, Brazil felt the impacts of its choice to maintain nuclear dependency. At that time, and because of the events cited, the US Atomic Energy Commission announced that it would not be able to comply with agreements with Brazil to supply the research and energy reactors with enriched uranium (COSTA, 20016). This context prompted Brazil, already in the Ernesto Geisel's administration, to resume its search

[8] The Treaty of Tlatelolco entered into force in Brazil only in 1994, when the deposit of the Declaration of Discharge set for in the instrument was filed. However, since its signature, the country has made a political commitment to follow the provisions of the instrument.

[9] All 33 Latin American and Caribbean states have signed the Treaty and, consequently, they are part of OPANAL.

for autonomy in the nuclear area, which culminated in the signature of the nuclear agreement with West Germany (FRG) in 1975 (LOHBAUER 2000).

To execute the agreement, the state-owned company Nuclebrás Equipamentos Pesados S/A (Nuclep) was created on the Brazilian side. The undertaking in this sector implied, according to Kuramoto and Apolloni (2002), the attempt by the military government to provide Brazil with advances equivalent to those of the modern countries. To this end, nuclear power would be the most viable solution to the problem of dependence on electricity, since, at that time, the depletion of energy-generating water potential in Brazil was already calculated (CARPES 2006). Moreover, nuclear energy would relativize Brazil's dependence on coal and oil exports.

The agreement with the FRG provided for the construction of eight thermonuclear plants and the transfer of technologies – including that of uranium enrichment – to Brazil (LOHBAUER 2000: 67; ADLER 1987: 282). In the years following the agreement, both Brazil and Germany would face international pressure – especially from the US – to break the agreement. The main argument used by the US was the concern about the transfer of nuclear technology to a country under military government (LIMA, 1986). Although Brazil and Germany remained firm in maintaining the agreed commitment, the terms of the agreement have changed significantly, boosting Brazil towards an independent pursuit of autonomy in the sector.

In 1979, Brazil opted for the development of an autonomous nuclear program, also called the Parallel Nuclear Program, under which the desired technology for uranium enrichment could be developed without external interference (PATTI, 2012). The program integrated the three Armed Forces in a shared effort of scientific studies to obtain their own nuclear technology. Each of the Forces assumed a research hypothesis for uranium enrichment: the Air Force conducted the laser studies; the Army about graffiti; and the Navy, about ultracentrifugation – the latter being the most successful line of research and which gave rise to the Brazilian uranium enrichment technology. Besides the development of uranium enrichment technology, the Parallel Program also included studies on power generation and explosives, as well as the construction of nuclear reactors for submarine powering and thermonuclear power plants. Despite the dual component of the studies, official documents advocated for the Brazilian right to develop nuclear technology in all its peaceful modalities (CARPES, 2015, p. 123).

An important step in the development of these priorities was the achievement of the first experiments with the ultracentrifuge capable of separating uranium in isotopic form (enrichment process) in 1982 and the mini cascades of nine centrifuge machines put into operation in 1984. In the following years, until 1989, there were many delays due to the problems related to the new ultracentrifuges, but at the same time, there was a range of up to 5% enrichment of national uranium (BARLETTA, 1997), all produced from efforts of the agencies created by the Brazilian Navy: the Coordination for Special Projects (COPESP – *Comando de Operações Especiais*), and the Aramar Experimental Center (CEA – *Centro Experimental de Aramar*), both in the state of São Paulo. These factors emphasized how important the development of technology was to the Brazilian government of the time.

In the context of the Brazilian search for technological autonomy in the nuclear area, it is important to emphasize the relations with Argentina. Since the 1960s, the two neighbors have developed a relationship that simultaneously involved competition and intermittent attempts at cooperation in the nuclear area. Despite the competition, the Brazilian-Argentine relationship never advanced to hostilities that could lead to an arms race in the region (MALLEA 2012). Thus, throughout the 1980s, as the transition to democracy advanced in both countries, the feasibility of nuclear cooperation continued, culminating in the inclusion of the topic in the 1985 Iguaçu Declaration, which consolidated the neighbors' interest for a broad cooperation agenda in South America (WHEELERS, 2009, p. 437; BRASIL, 1985).

During the 1990s, as a result of the difficulties from the continuation of the Navy Nuclear Program and the end of the Cold War, there is a discontinuity in the pursuit of the consolidation of the general objectives of nuclear submarine construction. In this period occurs what Batista (2000) considers a dismantling of the national nuclear program, in the governments of Fernando Collor de Mello and, in particular, of Fernando Henrique Cardoso (CARPES, 2006).

At the regional level, however, there were advances in the nuclear area. In 1991, Brazil and Argentina signed the agreement that would allow the creation of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC – *Agência Brasileiro-Argentina de Controle e Contagem de Material Nuclear*) (BRAZIL, 1991a). In the same year, Brazil, Argentina, ABACC, and the International Atomic Energy Agency (IAEA)

signed a quadripartite treaty that would, in practice, place both Brazil and Argentina's nuclear programs under international safeguards (BRASIL, 1991b). Not only is ABACC the only agency of its kind in the world, as it has also become an international model for building bilateral trust in the nuclear field. Externally, the NPT was signed and ratified in 1998, which contributed to the reduction of public expenditure on the nuclear matters, which began to be more coerced at national and international levels, since Brazil entered the Treaty. (CORRÊA, 2008). Thus, these budget cuts made it impossible for the Navy to continue prioritizing the nuclear submarine project over the maintenance of existing human resources.

In the administration of Luis Inácio Lula da Silva (2003-2010), there is the resumption of the Brazilian Nuclear Program (PNB – *Programa Nuclear Brasileiro*), which begins with the revision of the existing program and the confirmation of its original objectives, namely: the construction of the nuclear submarine and the inauguration of the commercial uranium enrichment plant. In this context, the PNB was reinstated as a state policy precisely to ensure its continuity and budget. Still in the domestic context, this program was part of the arguments to resume the diversification of the national energy matrix from the use of an energy considered clean considering CO2 emissions. Regarding foreign policy, it is worth noting that the motivations for the resumption of the program revolved around the theme of autonomy in science, technology and innovation in strategic areas that could confer international prestige to the country and demonstrate its maturity in highly complex issues (CARPES, 2006).

Internationally, Brazil made use of its historical trajectory as the only country in the BRICS[10] that has never developed nuclear weaponry, despite having the core technology for it – as it is located in a region of low tension and conflicts – and therefore has no external motivation for the development of nuclear weapons – and as is it a signatory to virtually all regional and international agreements prohibiting the development, storage, or use of nuclear weapons – with the exception of the NPT Additional Protocol.[11] In this sense, Brazil has presented itself

[10] Group of countries formed by Brazil, Russia, India, China and South Africa (the latter joined the group in 2011 after its creation).

[11] Brazil is currently party to the following multilateral nuclear agreements: Partial Test Ban Treaty (PTBT) (1963), in force in Brazil since 1964; Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Tlatelolco) (1967), in force in Brazil since 1994; Treaty on the Non-Proliferation of Nuclear Weapons (NPT) (1968), in force in Brazil since 1998; Nuclear Suppliers Group (NSG) (1974), whose Brazilian entry occurred in 1996; Missile Technology Control Regime (MTCR) (1987), which the country joined in

as a responsible country, without geopolitical motivations to proliferate and committed to international efforts on both nonproliferation and disarmament (SPEKTOR 2013). At the same time, the country has advocated the legitimate right – guaranteed by the NPT – to develop nuclear technology for peaceful purposes.

Still on the international scene, Brazil has been undertaking nuclear cooperation efforts with India under the India-Brazil-South Africa Dialogue Forum (IBSA) Created in 2003, the Forum seeks to bring together three major multiethnic democracies in the developing world, working in political coordination, sectoral coordination and the IBSA Fund (BRAZIL, 2017). In 2007, during their second Summit, the three countries agreed to explore proposals for cooperation in the peaceful use of nuclear energy, under appropriate IAEA safeguards (AMERSUR, 2007).

The main objective of cooperation would be to ensure the supply of nuclear energy – safe, sustainable and from non-polluting sources. Moreover, the use of technology for nuclear medicine development and food preservation are also among the purposes of the trilateral project. However, cooperation may also address the issue of the fuel cycle, depending on the effectiveness of the safeguard agreements designed by the countries (CHADE, 2007). At the same meeting, the leaders of the three nations reinforced their commitment to the complete elimination of nuclear weapons and expressed concern about the lack of progress towards this goal. Thus, the cooperation agreement was a way of strengthening the commitment to disarmament and nonproliferation of nuclear weapons (AMERSUR, 2007).

It is also noteworthy that the resumption of the nuclear program focused on four major technological initiatives in the 2008 National Defense Strategy (NDS): i) to complete, with regard to the nuclear-powered submarine program, the nationalization and industrial scale development of the fuel cycle and reactor construction technology; ii) to accelerate the mapping, prospecting and exploitation of uranium deposits; iii) to develop the potential to design and build nuclear thermoelectric plants, with technologies and capacities that end up under national domain, even if developed through partnerships with States and foreign

1995; Quadripartite Agreement Argentina-Brazil-ABACC-IAEA (1991), in force in Brazil since 1994; Comprehensive Nuclear Test Ban Treaty (CTBT) (1996), in force in Brazil since 1998; Treaty on the Prohibition of Nuclear Weapons (TPNW) (2017), to which Brazil is a signatory.

companies, in order to, above all, stabilize the national energy matrix and to supply the renewable energy demand; iv) to increase the capacity to use nuclear energy in a wide range of activities (BRASIL, 2008). In this sense, the current scenario of the PNB concisely presents a commercial dimension – for an eventual participation of Brazil in the international market for enriched uranium – and a strategic one – from the construction of the nuclear-powered submarine.[12] Currently in the world, few countries have technologies for the development of this class of submarines – China, United States, France, India and Russia (all being holders of nuclear weapons) (LEITE; ASSIS; CORRÊA, 2015). Again, on this matter, the Brazilian interest is related to the issue of prestige and the projection of international power – besides also serving as a political and strategic deterrent. The acquisition of this advanced capacity, at the end of the partnership with France, will represent a significant step towards the recognition of Brazil as an even more important actor in discussions and decisions regarding nuclear energy.

BRIEF CONTEXTUALIZATION OF NUCLEAR DEVELOPMENT IN INDIA UNTIL 2005

The Indian trajectory in the nuclear area will be presented here in two phases. The first, from independence in 1947 until 1974 – in which India, when testing its first nuclear explosive, gives the first demonstration of the war capability it would develop in the future. The second, post-1974, marks the Indian trajectory toward the development of a nuclear arsenal that would be demonstrated to the world with the 1998 nuclear tests (GANGULY; PARDESI, 2009, p. 04; PERKOVICH, 2001, p. 04). It is interesting to note in the Indian case that the colonial past marked the construction of independent India to morally shape both domestic and Indian foreign policy – on both fronts, India would advocate for pacifism even though in practice this was not sustained (GANGULY; PARDESI, 2009, p. 04).

[12] The commercial dimension of the Brazilian nuclear sector presents still small numbers when compared to other segments of the Defense Industrial Base. This is especially due to the low specialization of companies in this area and the fact that the new public policies for the sector are very recent (LEITE; ASSIS; CORRÊA, 2015). To deepen Brazil's investments in advancing its nuclear capabilities, therefore, also means to expand the opportunities of the country – and of national companies – in the international markets of this field, such as uranium.

In the nuclear field, this moral assumption has made India's decisions somewhat ambiguous. While the country advocated internationally for nuclear nonproliferation and especially nuclear disarmament, it also advocated the right to develop nuclear technology for civil use – as a way of boosting national economic development – and the right of countries to master nuclear technology in all its duality, an argument also verified in the Brazilian case (PERKOVICH, 2001, p. 06). This is especially justified by the fact that the technologies used in nuclear weapons also serve peaceful purposes.[13]

In India, as in Brazil, nuclear power was initially associated with national modernization and international prestige. In the Indian case, however, the deterioration of regional conditions has led the country to adopt a proliferation policy, as technology for peaceful uses of nuclear energy had already been acquired through international cooperation agreements (CARPES, 2015, p. 141).

FROM THE BEGINNING OF THE INTEREST ON NUCLEAR ENERGY TO THE FIRST ATOMIC TEST: FROM THE 1940S TO THE 1970S

India's nuclear history is born together with its new condition of independent State. As early as 1948, the Indian Prime Minister Jawaharlal Nehru launched an ambitious plan for the production of nuclear power considered cheap to finance the country's economic development (NTI, 2016). In this context, the 1948 Atomic Energy Act established the Atomic Energy Commission (AEC), which oversees the entire Indian nuclear area and is, among other things, responsible for promoting research in the sector, train scientists, and prospect and extract radioactive minerals (DAE, 2016). At that time, Indian interest also contemplated the development of nuclear technology, considered a source of international prestige.

Throughout the 1950s, Nehru continued plans to acquire nuclear technology for India and the national development of this energy. In 1954, the Atomic Energy Department (DAE) was created under the supervision of AEC and was directly linked to the Prime Minister's office. Like its highest body, this department had as its priorities the development of nuclear technology and the application of such technology in the fields

[13] As is the case, for example, in the development of explosives for use in large engineering works (referred to as "Peaceful Nuclear Explosions" – PNEs).

of agriculture, medicine, industry and scientific research (ÍNDIA, 2015a). The following year, India's first research reactor, Aspara Research, was built in India in partnership with the United Kingdom. Still in 1955, India bought from Canada the pressurized moderate-to-heavy-water research, the Canada-India Reactor (CIR). It is also worth mentioning that India, as well as Brazil benefited from the US Atoms for Peace program, which aimed at the diffusion of nuclear technology for peaceful purposes. One of the benefits came in the form of the agreement to supply heavy water to the CIR reactor (now CIRUS, incorporating the US to the acronym to mark its participation in the project), as well as training of Indian scientists in the US and the construction of Tarapur reactors (CHARNYSH, 2009).

In the 1960s, three events permanently changed the correlation of regional forces, initiating a process of change in Indian nuclear ambitions. The first event was the Indian defeat in the war against China in 1962. From that moment on, India, despite its pacifist political narrative, began to invest heavily in its conventional military force. The next event was the first Chinese nuclear test in 1964, which directly affected the understanding of the Indian intelligence sector on the regional balance of power. Finally, in 1965, India and Pakistan clashed in the second of four wars for territorial claims, consolidating the Indian perception of regional instability (KENNEDY, 2001, p. 213-215; GANGULY; PARDESI, 2009). It is important to note that at this time, despite the progressive deterioration of the regional balance of power, India's nuclear program would still not assume clear warlike contours and the country's official pacifist-moral narrative would continue to guide choices in this area.

At the same time, Pakistan was also advancing its nuclear program, largely driven by rivalry with India. However, until 1974, nuclear activities in that country were also developed from a peaceful narrative and benefited from international partnerships, including with the US, under the Atoms for Peace program. China, in turn, began developing nuclear technology in 1955 for military employment. Unlike the other two states, the Chinese received Soviet rather than US support.

Throughout the 1960s and 1970s, India invested in research for the development of nuclear technology that would lead the country, from 1974 on, to the possession of a latent warfare capability and the adoption of a strategy of "options" in the nuclear area (PAUL, 2000, p. 128; PERKOVICH, 2001, p. 3; KAMPANI, 2014; p. 88). The death of Prime Minister Nehru and Chinese tests led his successor, Prime Minister Lal Bahadur Shastri, to

deal with internal pressure from politicians and the scientific community to develop nuclear weapons. Despite refusing nuclear weapons, Shastri approved studies on the so-called Peaceful Nuclear Explosions (PNEs) in 1965 through the Underground Nuclear Explosions Program (WEISS, 2010, p. 259). It is noteworthy that India had signed in 1963 the Partial Test Ban Treaty (PTBT), but it only vetoed atmospheric nuclear tests in space and underwater, not offering restrictions on underground tests (PTBT, 1963).

Despite Shastri's approved program on PNEs, the issue only gained relevance after the Indo-Pakistani War of 1971, which resulted in Bangladesh's independence. Despite the Indian victory, the post-conflict accentuated in the Indian government the understanding that there was an asymmetry of regional power unfavorable to India, as Pakistan had received military support from both the US and China and, in the postwar context, had launched its nuclear program (SZALONTAI 2011).

In subsequent years, India would prepare for its first nuclear test. In January 1972, the State Department's Bureau of Intelligence and Research brought to the then Prime Minister Indira Gandhi's office a report assessing the conditions of the Indian nuclear program, signaling the country's ability to perform atomic tests. In September of the same year, Gandhi authorized preparations for a nuclear test (THE NATIONAL SECURITY ARCHIVE, 2011).

INDIAN DEVELOPMENT OF NUCLEAR TECHNOLOGY BETWEEN 1974-2005: RIVALRIES AND PARTNERSHIPS

In 1974, the director of the Bhabba Atomic Research Center, Raja Ramanna, informed the prime minister that India was ready for its first nuclear test, receiving the green light for the test in May of the same year. The answers to the Indian test came immediately. Despite being presented to the world as peaceful, the 1974 test had an intense and negative international repercussion. The US, in particular, reacted with numerous sanctions on India, which would not be suspended until 34 years later. The test impacted India's relationship with the world and also indirectly affected other countries with nuclear pretensions at the time – such as Brazil negotiating its nuclear agreement with West Germany (SZALONTAI 2011, KENNEDY, 2011, p. 126).

The Indian test was made possible by reprocessing the CIRUS reactor fuel to obtain plutonium. The Indian achievement showed, on the

one hand, the fact that it was possible for a developing country with a limited budget to develop nuclear explosives and, on the other, that international cooperation in the nuclear field for peaceful purposes could be diverted to warlike purposes if the recipient country's political will were enough. Thus, the Indian test also slipped into peaceful international nuclear cooperation projects. In this context, the Nuclear Suppliers Group (NSG) was created to precisely control the proliferation of nuclear technologies and materials for peaceful purposes, thereby preventing their diversion to war purposes. Even today, despite claiming entry to the NSG, India is not part of the 48-nation group, – which includes Brazil. Contrary to the entry of non-NPT countries, such as India, Brazil opposed the acceptance of the Asian country into the NSG – as well as Austria, New Zealand, Ireland and Turkey. In late 2016, however, following bilateral defense cooperation negotiations, the Brazilian government waved its support to India's aspiration to become part of the group (HINDUSTAN TIMES, 2016; CHAUDHURY, 2016).

It is noteworthy that, although successful, the 1974 test was not followed by new tests, nor was there at the time in India an effort to develop vectors and launchers that would have given the country the capability of nuclear weapons. Kennedy (2011, p. 126) notes that the economic costs for developing a nuclear arsenal, on the one hand, and international pressures, on the other, would explain the slowness with which India dealt with its nuclear program in the years following the 1974 test.

It is in the 1980s that Indian actions would advance in technological terms. There has been a gradual shift in Indian decision makers' perception of whether or not the peaceful nature of the Indian nuclear program should be maintained, driven by the continuing deterioration of the regional balance of power in South Asia (Kampani, 2014). The US, Soviet Union (USSR) and China were interested in the region; and India and Pakistan could not end their historic rivalries. The inconsistency of the games of the great Cold War actors in the region generated, in both India and Pakistan, the perception that their safety depended exclusively on internal efforts. Thus, after her reelection in 1980, Indira Gandhi revived the Indian nuclear program, launching in 1983 a program for the development of ballistic missiles (Kampani, 2014). Gradually, India's strategy of maintaining nuclear "options" gave way to the clear interest of developing a warlike nuclear arsenal.

From the second half of the 1980s onwards, India adopted what Perkovitch (2001, p. 3) considered as nuclear deterrence without the use of nuclear weapons, and Kennedy (2011, p. 141) defined as a "covert weaponization". The aim was to increase national security without triggering an arms race in the region – hence investments in developing vector technology without further nuclear testing. Over the next decade, India's strategy hitherto would show signs of exhaustion, raising a growing number of opponents to the "covert weaponization" policy at the domestic level.

In 1995, the NPT was revised and extended indefinitely, consolidating in the world two distinct classes of countries: the possessors and the non-possessors of the most advanced nuclear technology – the one of armaments. Such a situation had been precisely the basis of India's international criticism toward the NPT since the treaty had been opened for signatures in 1970. Given this international picture and the being clear the impossibility of the regional instability cooling off despite the end of the Cold War, it was only a matter of opportunity until India made public its advanced nuclear capability. This opportunity was created in 1998 when the Bharatiya Janata (BJP) party – which had always advocated for the development of an Indian atomic arsenal – assumed the government (GANGULY; PARDESI, 2009, p. 15; PAUL, 2000, p. 130). In May of 1998 India conducted new nuclear tests, which were similarly answered by Pakistan.

In nuclear terms, India's entry into the 21st century was marked by the intensified debate on nuclear military doctrine that began in 1999. In 2003, after discussion in the Cabinet Committee on Security, the State issued a statement to operationalize its nuclear deterrence (KANWAL, 2014). Another interesting point was the Russian participation in the leasing and construction of India's nuclear-powered submarines. Since the 1980s, Indians and Russians had been entering into military technology cooperation agreements – as in 1988, in 1997, and, in particular, in the 2000 Strategic Partnership Statement, which emphasized the "consolidation of defense and technical-military cooperation in a long-term perspective and the deepening of service-to-service cooperation" (INDIA and RUSSIA, 2000).

COMPARISON BETWEEN OFFICIAL BRAZILIAN AND INDIAN PROGRAMS

This analysis shows that the nuclear programs of both states have advanced in the last twelve years.[14] As already mentioned, in the 1990s, Brazil had a period with low investment in the nuclear sector, changes in human resources, and a change in the understanding of what was strategic for the country. In addition, the country had adhered to virtually all regional and international treaties and regimes regarding its commitment to the peaceful uses of nuclear technology. From 2005, there was a crucial change for Brazil in the nuclear area, with the revision of PNB and its resumption as State policy. In India, in turn, the deepening of relations with Russian favored advances in military terms, as well as with the US regarding the civil uses of nuclear energy. In addition, this period brought an international change for Indians with NSG's dismissal of India in 2008, which allowed it to participate in the international market of nuclear materials and technologies market (HIBBS, 2016).

The next section is an overview of the nuclear programs of Brazil and India in recent years, portraying their main advances, difficulties and perspectives. Then, the main aspects of each program will be pointed out comparatively, highlighting the main similarities and differences in approaching the theme and the development of technologies in this area. Thus, this article intends to give greater density to its comparative character, as well as contribute to the public policies of the sector from the systematic analysis of the Brazilian and Indian experiences.

THE BRAZILIAN PERFORMANCE IN RECENT YEARS (2005-2017)

In Brazil, the beginning of the new century brought advances in the nuclear area, such as the Angra II thermonuclear plant in 2001. Angra II was the first and only thermonuclear built as a result of the Teuto-Brazilian agreement from 1975 to the present day. Its construction began in 1981, but its completion came only in 2000. The second Thermonuclear plant resulting from the agreement with Germany, Angra III. Its construction began in

[14] A period of twelve years was selected for analysis so that the research, in this stage, comprised from the year of the resumption of the Brazilian Nuclear Program to the present day.

1984 but was halted two years later, being resumed only when PNB was revised, but its commissioning remains without a definite date. Currently, electricity generation from uranium fission occupies approximately 3% of Brazil's electricity generating capacity. In the reference scenario indicated by the National Energy Plan (PNE – *Plano Nacional de Energia*) 2030, the nuclear share in the Brazilian energy matrix would need to increase by 4000 MW after the implementation of Angra III, meaning the construction of two more plants in the Southeast and two plants in the Northeast of Brazil (BRAZIL, 2007).

Besides electricity generation, the nuclear issue was also linked to the National Defense Strategy, the White Book of Defense (*Livro Branco da Defesa*), and different documents from the Ministry of Defense, then Ministry of Science, Technology and Innovation[15], and the Ministry of Mines and Energies, in order to link the nuclear agenda simultaneously to the strategic agendas of national innovation and economic development agendas.

In financial terms, although the resumption of PNB was a great contribution to the sector, it remains below the feasibility needs of the main proposed projects: Angra III, the nuclear submarine and the multipurpose reactor. The latter had its construction postponed to 2019 due to resource contingency. At the same time, some achievements could be celebrated in the sector such as the creation of the Nuclear Power Generation Laboratory (Labgene) – completion scheduled for 2017 –, and the inauguration of the Uranium Hexafluoride Production Unit (Usexa) at the Centro Experimental Aramar facilities in February 2012. According to Leite, Assis and Corrêa (2015), the Brazilian State, having the Labgene and Usexa together, will obtain control of all phases of the uranium fuel cycle.

Besides the commercial-scale fuel cycle domain, the other highlight of PNB after its resumption is the nuclear submarine construction project. Despite the retrenchment throughout the 1990s, the nuclear submarine program was kept in operation. As already mentioned, from Lula's administration, with the resumption of PNB, the nuclear submarine project received a new breath. Already in 2005, the Navy completed the construction of the pressurized reactor of the prototype of the nuclear submarine, which is located at the Aramar Experimental Center. From 2007, when President Lula visited the Center, an annual investment of US$ 63 million was announced for the project. In the following year, the General Coordination

[15] Currently the Ministry of Science, Technology, Innovations and Communications (MCTIC – Ministério da Ciência, Tecnologia, Inovações e Comunicações).

of the Development Program of the Submarine Powered by a Nuclear Reactor (COGESN – *Coordenadoria-Geral do Programa de Desenvolvimento de Submarino com Propulsão Nuclear*) was created with a budget expectation of US$ 250 million annually (KASSANOVA, 2014, p. 28).

In December of the same year, Brazil signed a cooperation agreement with France, resulting in the Submarine Development Program (Prosub), which foresees the construction of four conventional (diesel-electric) submarines and a nuclear submarine. Regarding the agreement, two aspects should be highlighted: (1) the agreement involves transfer of technology and training of Brazilian professionals for the future building of new conventional and nuclear submarines, and (2) France will work with Brazil only on the construction of the non-nuclear part of the submarine, with the nuclear part – uranium enrichment, construction and adaptation of the reactor – being the sole and exclusive responsibility of Brazil.

In 2012, given the need for human resources composition to take on actions related to the construction and absorption of submarine technology, the *Amazônia Azul Tecnologia de Defesa* (Amazul) was created through the split with another state company that is part of the Navy, the *Empresa Gerencial de Projetos Navais* (Emgepron). This meant the transfer of the workforce present in this company to the new firm and the creation of new positions by hiring staff through competitive civil-service examination (LEITE; ASSIS; CÔRREA, 2015).

Finally, in 2014, the shipyard where four new conventional submarines will be built was inaugurated in Itaguaí, Rio de Janeiro; there, the sections and the reactor of the nuclear submarine will be assembled. At the site, the Metallic Structures Manufacturing Unit (UFEM – *Unidade de Fabricação de Estruturas Metálicas*) also began operating, which will receive the hulls of submarines built by Nuclebrás. After submarines and technology transfer have been completed, products made in Brazil should have up to 95% national content.

The Brazilian achievement of nuclear submarines could put the country at the forefront in international nuclear safeguards. This is because, to date, only nuclear-armed countries have nuclear-powered submarines. In the current context there is little need to reflect on a safeguard system for nuclear reactors in strategic condition and use but still operating for peaceful purposes. Moreover, there is no precedent within the IAEA for constantly moving nuclear reactors whose location cannot be revealed, otherwise it will undermine their strategic and deterrent component (KASSENOVA,

2014, p. 38). Thus, when Brazil concludes the construction of its nuclear submarine, it will have been the first non-nuclear weapon country to own nuclear submarines in the world, which should force the international nuclear non-proliferation regime to adapt to the new conditions that the spread of nuclear technology for peaceful purposes can promote.

THE INDIAN PERFORMANCE IN RECENT YEARS (2005-2017)

On the Indian context, two related events in the last decade deserve emphasis because they have altered the country's international status regarding nuclear matters. The first happened in 2005 when the then-U.S. President George W. Bush made a commitment to the then-Indian Prime Minister Manmohan Singh for cooperation in the peaceful uses of nuclear energy. The second was India's insertion in the international trade in nuclear materials and technologies. On September 6, 2008, the NSG granted India a special waiver allowing the country to trade nuclear products even though it is not a member of the NPT and has not signed the CTBT. The waiver was granted after three years of meetings between the NSG and India and was conditional on maintaining India's commitment to nuclear nonproliferation, including periodic checking mechanisms on these commitments, the ban on new nuclear testing, and the restriction on transfer of technologies for enrichment and reprocessing of nuclear material for India (MISTRY, 2014, p. 213). According to the Nuclear Threat Initiative (NTI, 2015), for granting the waiver to India, an IAEA safeguard system has also been agreed so that IAEA technicians can visit Indian civil nuclear program facilities.[16]

It should be emphasized that the NSG waiver granted to India was closely linked to the agreement between India and the U.S. in 2005. Since then, a series of procedures has been adopted in the U.S. and India to enable the country to enjoy the rights previously held by NSG members: ratification of the Indo-U.S. Civil Nuclear Agreement by the United States Congress; the Hyde Amendment to exempt nuclear cooperation

[16] As pointed out in the previous section, India has been seeking entry to the NSG, but is opposed by several countries – notably China. Brazil, a member who was opposed to India's entry into the group, has been presenting a more moderate discourse, indicating that any new membership should be assessed on the basis of previously defined criteria and allowing for acceptance of the Indian aspiration. In this sense, there was also a signal that Brazil would effectively support the Asian country's entry into the body and would work with other countries to do so (BRAZIL, 2016; CHAUDHURY, 2016; ABBASI, 2017).

with Indians in 2006; and the training of Indian conditions to the U.S. standard from the provisions of the U.S. Atomic Energy Act of 2007, and the separation of India's civil and military nuclear programs.

As noted by Ramana (2013), the waiver received by India served the economic interests above all of France and Russia – which aimed to resurrect their nuclear reactor export markets – and the United States which has broader economic interests in India as well as geopolitical motivations for this approach. Not for free, it was these three countries that put the most pressure on granting the NSG waiver and are currently among India's main partners in the civil nuclear sector.

In this sector, one of India's main demands is for uranium. Thus, in recent years, in addition to the partnership with the U.S., India has established partnerships with Canada and Kazakhstan among other countries (CANADÁ, 2015). It is worth pointing out that given the separation between India's civil and military programs, all uranium received by India from international partnerships can only be used for the civil program under international safeguards. In 2015, after two years of deep debate and negotiations between the governments of India and Canada, a five-year contract was signed for the supply of 3,000 metric tons of uranium for US$254 million. Another country posed as a partner and provider of India's nuclear and economic needs is Kazakhstan. Since 2009, these two states have been approaching each other and the cooperation agreement for peaceful uses of nuclear energy has consolidated this approach. In 2015, after four years of negotiations, a contract was signed for the supply of 5,000 metric tons of uranium between the KazAtomProm President, Askar Zhumagaliyev, and DAE Chief, Anil Shrivastava, valid until 2019, with the value of each sale being set from the variation in the international market (WNN, 2015).

Still in the civil field, the Indo-Russian partnership also deserves attention. We highlight the strengthening of relations between DAE and the Rosatom Group, in order to build five thermonuclear plants. The name of the plant is Kudankulam Nuclear Power Plant (KKNPP) and currently unit 1 is operational (started in July 2013 and reached its maximum potential in July 2014). Unit 2 is also active, and contracts are expected to be signed for units 3 and 4 (SASI, 2015; INDIA, 2015b).

It should be noted that despite India's number of nuclear plants and its interest in expanding this number in the coming years, nuclear energy currently accounts for just over 2.5% of the electricity produced

in India, which is a country largely dependent on thermoelectric power plants on coal and oil.

In the military field, the specific advance in the construction of nuclear-powered submarines must be considered, thanks to the partnership with the Russians. Therefore, members of India's state-owned companies were present at the premises of Russian firms such as the Central Design Bureau for Marine Engineering (or Rubin). As a result of this relationship, the following stand out: i) the lease of a submarine powered by nuclear reactor class Akula I, transformed into INS Chakra for a period of ten years; and ii) the contribution to the design of the first submarine powered by nuclear reactor made in Indian soil, the INS Arihant, at the Indian Navy Shipyard in Visakhapatnam, in India's Eastern Naval Command Headquarters (GADY, 2015).

COMPARED ANALYSIS: NUCLEAR PROGRAMS OF BRAZIL AND INDIA

From the historical summaries performed and presented earlier, this study found two comparative patterns between the Brazilian and Indian nuclear experiments. From the first half of the 20th century until the mid-1970s, the research of both countries in the nuclear area was based on the idea of achieving modernity and acquiring international prestige. Since 1970s, especially after the Indian nuclear test carried out in 1974, the trajectories of Brazil and India at the nuclear level have been drifting apart. While Brazilians pursued autonomy for the development of their civilian program, actively participating in international mechanisms (especially from the 1990s onwards), Indians advanced their program to the point of becoming one of the nations which are holders of nuclear weapons, currently not being part of the multilateral groups and instruments who deliberate on the subject – even if they present the official discourse on nonproliferation and peaceful use of nuclear energy.

From the observation of the first moments of the Brazilian and Indian nuclear programs, it is possible to notice a greater prominence of India on the theme – almost 10 years of difference, between the two countries, in the formalization of nuclear policies and the creation of official bodies devoted to the issue (the first nuclear plan was launched in 1948 in India and in 1956 in Brazil); the construction of an Indian nuclear reactor in 1955, while the first developed in Brazil was the Argonaut, ten

years later; the establishment of agreements between India and other countries for the progress of its nuclear programs, such as the United Kingdom, Canada and the USA, while Brazil began to deal only with the US on the nuclear issue, creating some dependence and distancing from autonomy in the sector. Still, like many other countries, Brazil and India participated in the USA's Atoms for Peace program and received benefits for the first steps of their respective nuclear programs.[17]

Contrary to the environment in Latin America, far from any kind of nuclear arms race (as the signature of the Tlatelolco Treaty in 1967 demonstrates, creating the first populated zone free of nuclear weapons), the regions near South Asia, where India is located experienced troubled episodes throughout the 1960s. In 1962, there was the defeat of India to China in the Sino-Indian War, causing the expansion of Indian investments in the military sector. The first Chinese nuclear test in 1964 made the regional power imbalance even clearer, resulting in internal pressures in India on the development of nuclear weapons.

Therefore, India's "policy of options" seemed to take on different shapes from its 1974 nuclear test – which was followed by strong negative international repercussions and sanctions. From this episode, the international community began to disregard the Indian narrative of pacifism and to perceive the country as a warlike nuclear power. In accordance with the divergences in regional contexts, this episode represented the point of divergence between the nuclear programs of Brazil and India, whose contrast was deepening in the following years.

From the 1970s, Brazil, until then dependent on the supply of enriched uranium from the US, began to seek autonomy after the US failed to comply with its supply agreement. In 1975, the Brazilian government signed an agreement with West Germany to ensure the construction of new nuclear plants (until then it had built only Angra I, with US support) and to achieve the technology needed for uranium enrichment. Also seeking to achieve these objectives independently, Brazil launched in 1979 the Parallel Nuclear Program, which resulted in important advances in nuclear research. Although it had studies on nuclear explosions (within the scope of the PNEs), the Program was based on the principles of nonproliferation and nuclear disarmament, advocating for the civil use of developed technologies.

[17] In Brazil, however, US participation was more decisive for the acquisition and assembly of the first reactor in the country. As for India, its first reactor happened through a partnership with the United Kingdom.

The following decades accentuated the differences between the positions and nuclear purposes of Brazil and India. In the 1980s, Brazil proceeded with the Parallel Nuclear Program and entered into agreements with different countries[18] for the peaceful use of nuclear energy, thereby reducing its dependence on the US. India, in turn, continued its progress in nuclear research over the decade by adopting the policy of "covert weaponization". In 1983, for example, the country began its ballistic missile program, reinforcing evidence of India's tendency to follow the arms path.

The events of the 1990s confirmed the changes in attitude between Brazil and India. Although the Brazilian government reduced investments and incentives for the country's nuclear development in the years after the end of the military regime, the decade also symbolized Brazil's entry into several multilateral instruments concerning nuclear energy. Thus, Brazil began to receive greater recognition of its commitment to nuclear issues, making it currently part of the main mechanisms that deliberate on the topic on the international scenario. India, on the other hand, continued nuclear warfare research and conducted new nuclear tests in 1998, reinforcing international disapproval about the country and increasing suspicion about its interests and intentions.

Based on the definitions of power by Joseph Nye (2002), and from the Brazilian and Indian nuclear experiences of the last decades, one can consider that Brazil makes use of its nuclear program as a means of soft power, while India treats the country's nuclear development to exercise hard power.[19] This understanding is corroborated by the intense Brazilian participation in the multilateral mechanisms dealing with nuclear energy from the 1990s onwards, and in the national commitment to nonproliferation and disarmament. India, in turn, still draws a negative view of its nuclear program, which has a warlike component – an option adopted before regional instability and rivalry with Pakistan, which also has nuclear warfare capabilities. Although both countries recognize nuclear development as a way of gaining international prestige, achieving

[18] Argentina (1980), Iraq (1980), Colombia (1981), Peru (1981), Venezuela (1983), Spain (1983), China (1984).

[19] Hard power consists of forms of exercise of power based on the military capabilities and strength of a country – including the use of elements such as coercion, deterrence, persuasion and feelings such as fear. Soft power, in turn, involves ideological, social and cultural aspects in the exercise of the power of influence on the international scene – encompassing principles related to democracy, freedom, pluralism, sustainability and development, being favored by the country's integration into international institutions and regimes (NYE, 2002, 2004; MARTINELLI, 2016).

modernity and projecting power, the way they deal with the issue presents significant conceptual differences.

Looking at the latest moves by the Indian government on the nuclear issue – the broad cooperation agreement with the US, the request for and obtaining the NSG special waiver, and the establishment of partnerships with Russia, France, Canada, and Kazakhstan – it follows that change of posture about the matter. By joining the MTCR in 2016 and applying to join the NSG, India expresses its intention to participate in international nuclear regimes, both for commercial and political and scientific reasons. Thus, it is clear that the country is moving towards a less militarized view of nuclear energy, approaching the theme more closely to the exercise of soft power, such as Brazil. However, insecurity arising from regional instability, in which China and Pakistan possess nuclear weapons, keeps India away from the NPT – thus undermining the international view of the country.

After presenting a historical comparative analysis of the Brazilian and Indian positions regarding their respective nuclear programs, as well as understanding how the foreign policy of each country deals with the issue, this section of the study intends to promote an objective and quantitative comparison of their nuclear resources. Therefore, this part will explore the aspects of power generation, nuclear reactors and uranium reserves available to each nation.

In Latin America, nuclear power production is practically restricted to Brazilians and Argentines. Brazil currently has the capacity to generate about 1.9 GW of power in its two reactors – Angra-1 (609 MW) and Angra-2 (1275 MW). Data from 2016 indicate that nuclear energy corresponded to 2.9% of the national energy matrix, producing a total of 14.97 TW-h of this type of energy. By comparison, India has a much larger number of nuclear reactors – 22, which add up to 6.2 GW generation capacity. The correspondence of this energy in the Indian energy matrix is similar to that of Brazil, reaching 3.4% in 2016[20] – the production, however, reached 35.01 TW-h, more than double the Brazilian production (AIEA, 2017).

Analyzing the historical series related to the nuclear energy production of both countries, the Indian evolution was more pronounced than the Brazilian one. From 1985 to 2016, India went from six reactors (1.1 GW) to the 22 (6.2 GW) it currently operates, while Brazil in the same period

[20] This is explained by the large difference in the number of inhabitants and, consequently, in the amount of energy produced annually by the countries.

went from one (626 MW) to two (1.9 GW) reactors. Considering energy production, nuclear participation in India's energy matrix increased from 2.2% (3.87 TW-h) in 1985 to 3.4% in 2016, while in Brazil, the share of nuclear energy increased from 1.7% (3.17 TW-h) in 1985 to the aforementioned 2.9% (IAEA, 2017). These data show that, in 1985, Indian nuclear production was higher than the current Brazilian nuclear production.

Finally, regarding the prospects for advancement in the respective nuclear programs, India is currently building five new nuclear reactors – one of them being a prototype –, while Brazil is continuing to build a new reactor – Angra-3. Furthermore, the Asian country plans to start the construction of four new plants over the next years. Brazil, in turn, also identified the need to build four more of these reactors, but has not yet begun the official planning for this construction (IAEA, 2017).

One of Brazil's main advantages, especially in relation to India, for the development of nuclear energy is the availability of uranium for exploration. Even without having carried out a search for the mineral throughout the country, approximately 277 thousand tons of the extractable element in the national territory have already been identified (about 5% of the identified reserves in the globe). The total production of this resource in Brazil reached 55 tons in 2014 – after reaching 326 and 192 tons in 2012 and 2013, respectively (ORGANIZAÇÃO PARA A COOPERAÇÃO E DESENVOLVIMENTO ECONÔMICO, 2016).[21]

India, on the other hand, has 138.7 thousand tons of uranium that can be extracted, and in 2014 the production was estimated at 385 tons.[22] Approximately US$ 38.5 million was invested in the country in 2013 in the exploration of the mineral and in the construction of new mines. In contrast, Brazil has invested about US$1.6 million for this purpose (ORGANIZAÇÃO PARA A COOPERAÇÃO E DESENVOLVIMENTO ECONÔMICO, 2016). These data, as well as those related to Brazilian nuclear energy production, demonstrate that, despite the abundant availability of the main element for this type of energy, its use and nuclear development has not been a high priority of recent governments – even though advances have been observed, they are still shy, especially in comparative spectrum with India.

[21] The reduction is in particular due to the depletion of part of the storage of Waterfall, one of the main in the country.

[22] Data on uranium production are not officially disclosed by the Indian government, so the numbers presented in this paper are estimates from international agencies and bodies.

CONCLUSION

From a historical analysis of the nuclear programs of Brazil and India, this article considered whether the Indian case could be taken as a parameter for the Brazilian nuclear development. Despite some similarities existing in the historical trajectories of these two countries in the nuclear area and the contemporary similarities of these two emerging powers, it is not possible to draw a parallel between the two countries in the nuclear area today. The main the argument found in this article to support this thesis rests on the political choices and motivations of these countries for the nuclear sector. As stated, the Brazilian expectation for the energy sector is to promote a modest expansion of this source in the country's generation of electricity, which will be achieved if the PNE 2050 confirms the reference scenario proposed in the PNE 2030, and if this scenario is effectively put into practice. Otherwise, a realistic scenario for Brazil would be the maintenance of the current 3% of nuclear power in electricity production, with the conclusion of Angra III in the coming years. On the contrary, the Indian perspective is to considerably increase the participation of uranium in the country's energy matrix, taking advantage of the good momentum since the civil nuclear agreement was signed with the US in 2005 and since the NSG waiver in 2008.

Indian intentions make this country a new and attractive market, drawing the attention of countries participating in international agreements to build nuclear power plants, such as France, the US, and Russia, for example. In contrast, the Brazilian market does not seem to arouse the same interest. To a large extent, this is due to Brazil's choice to maintain, but not to expand its capacity in this sector, and to the national legislation itself, which establishes some bottlenecks to private participation in the nuclear sector in the country. According to article 177, item V of the 1988 Constitution, "the research, mining, enrichment, reprocessing, industrialization and trade of nuclear ores and minerals and their derivatives with the exception of radioisotopes (…)" is a monopoly of the Union (BRASIL, 1988).

It is also worth noting that, despite the slowness that delayed India's decision to develop a nuclear arsenal, the nuclear program of this country remained constant thanks to continued state investment in DAE. In turn, as shown, the Brazilian program suffered oscillations and went through phases of: i) interest (1950-1970); ii) deep development (1971-1988); iii) cooling (1989-2003); and iv) restart (2004-present). This last and

current step puts Brazil in the process of trying to aim for both a higher rate of electricity supply from its thermonuclear plants and a center for the development of military nuclear technology, since it intends to build a submarine powered by nuclear reactor by 2025.

Still in the Brazilian case, in terms of public policies, some important points for the national nuclear development can be emphasized such as the need for the project to continue and acquire the response the Brazilian State. The Indian program has only reached its current level of development due to the steady use of the public machine for solid nuclear development. Although it is known that the Brazilian budget earmarked for the Ministry of Defense is not included among the largest ministerial figures, it also implies a greater financial importance, in this case, for the country to obtain better results and be a bastion in the region for future business with its neighbors taking advantage of the fact that Brazil is a major exporter of technology to South America.

In short, the main element that separates the Brazilian case from the Indian one is precisely the relevance that this theme occupies, in practical terms, in the agenda of the State. Therefore, the lesson that Brazil could learn from the Indian case would be to make the country more attractive in the nuclear area by valuing the sector. In this sense, for example, there would be a need to revise the Brazilian legislation so that public-private partnerships in the nuclear area of uranium extraction were possible, reducing the cost of exploration of this ore, and that the management of thermonuclear plants could also rely on such partnerships. Finally, it is noteworthy that the lack of relevance of the nuclear theme in the Brazilian public policy agenda generates, on the one hand, a progressive deficit of human capital, since, in the absence of expansion of this area, the labor market becomes small, and, on the other hand, the risk of loss of financial investments already made and technological advances achieved to date.

O DESENVOLVIMENTO NUCLEAR NO BRASIL E NA ÍNDIA: UMA COMPARAÇÃO DOS PROGRAMAS NACIONAIS DESSES PAÍSES

RESUMO

Frente às informações destacadas na análise da trajetória de cada um, o estudo investiga, então, se o Brasil poderia aprender com a experiência indiana e, se sim, quais lições seriam essas. Após a análise dos casos, a conclusão a que se chega é a de que, dadas as enormes diferenças entre os atuais programas nucleares do Brasil e da Índia, a adequação brasileira a um possível "modelo indiano" nãopareceexequível. Dasdiferençasidentificadas, destaca-se a divergência referente ao interesse político em priorizar a energia nuclear, algo que a Índia faz. Sem o devido destaque de um tópico na agenda política de um país, não é possível conceber políticas públicas para o setor. No caso da agenda nuclear, a falta de tratamento do tema como uma política de Estado tem implicações profundas, já que, em última análise, compromete a formação de capital humano e o avanço tecnológico.

Palavras-chave: Brasil. India. Programa Nuclear .

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