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A new beginning? Obstacles and debates at the relaunch of the Argentine Nuclear Program (1999-2015)

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Abstract

In the 1990's, experts predicted that a 'Nuclear Renaissance' would take place in the 21st century, bringing nuclear energy back onto public agendas. This forecast was based on the increase in energy consumption in some Asian countries and the rise in oil prices. In this context, Argentine governments tried to relaunch the nuclear program, which had been paralyzed in 1994. After the recovery from the economic crisis of 2001 and the increase in electricity demand, the energy supply became a crucial aspect of public policies.

However, it soon became clear that it was not an easy task. Through the analysis of official legislation, institutional sources and interviews, this paper will explore the main milestones of the relaunch of the Argentine Nuclear Program, as well as the limitations of such planning. We propose that after 2003 the government redefined the role of the actors without questioning the institutional panorama inherited from 1994 and paying little attention to the structural transformations that the sector had undergone after the 1990s. Although a nuclear program for the medium and long term was outlined, said planning was based on immediate political considerations rather than a strategic perspective. That's why certain objectives, such as the installation of a fourth nuclear power plant or the promotion of the local industry, could not be sustained in the long term.

Keywords: Argentine Nuclear Program, State, Industry, Development, Energy

Un nou inici? Obstacles i debats en el rellançament del Programa Nuclear Argentí (1999-2015)

Resum

A la dècada dels 1990, els experts van predir que al segle XXI tindria lloc un "renaixement nuclear" que tornaria a portar l'energia nuclear a les agendes públiques. Aquesta previsió es basava en l'augment del consum energètic d'alguns països asiàtics i en la pujada del preu del petroli. En aquest context, els governs argentins van intentar rellançar el programa nuclear, aturat l'any 1994. Després de la recuperació de la crisi econòmica del 2001 i l'augment de la demanda elèctrica, l'oferta energètica es va convertir en un aspecte crucial de les polítiques públiques.

Tanmateix, aviat es va veure clar que no era una tasca fàcil. Mitjançant l'anàlisi de la legislació oficial, les fonts institucionals i les entrevistes, en aquest treball s'exploraran les principals fites del rellançament del Programa Nuclear Argentí, així com les limitacions d'aquesta planificació. Proposem que després del 2003 el govern redefinís el paper dels actors, sense qüestionar el panorama institucional heretat del 1994, i prestant poca atenció a les transformacions estructurals que havia experimentat el sector a partir dels anys noranta. Tot i que es va esbossar un programa nuclear a mitjà i llarg termini, aquesta planificació es basava en consideracions polítiques immediates més que en una perspectiva estratègica. És per això que determinats objectius, com ara la instal·lació d'una quarta central nuclear o el foment de la indústria local, no es podrien sostenir a llarg termini.

Paraules clau: Programa Nuclear Argentí, Estat, Indústria, Desenvolupament, Energia

¿Comenzar de nuevo? Obstáculos y debates en el relanzamiento del Programa Nuclear Argentino (1999-2015)

Resumen

En los años 1990, los expertos pronosticaron que en el siglo XXI se produciría un "renacimiento nuclear" que comportaría que la energía nuclear volviera a las agendas públicas. Esta previsión se basó en el aumento del consumo energético en algunos países asiáticos y en el alza de los precios del petróleo. En ese contexto, los gobiernos argentinos intentaron relanzar el programa nuclear, que se había paralizado en 1994. Tras la recuperación de la crisis económica de 2001 y el aumento de la demanda eléctrica, el abastecimiento energético se convirtió en un aspecto crucial de las políticas públicas.

Sin embargo, pronto quedó claro que no era una tarea fácil. A través del análisis de la legislación oficial, fuentes institucionales y entrevistas, este trabajo explorará los principales hitos del relanzamiento del Programa Nuclear Argentino, así como las limitaciones de dicha planificación. Proponemos que después de 2003 el gobierno redefinió el rol de los actores sin cuestionar el panorama institucional heredado de 1994 y prestando poca atención a las transformaciones estructurales que había experimentado el sector después de los años 90. Aunque se trazó un programa nuclear a medio y largo plazo, dicha planificación se basó en consideraciones políticas inmediatas más que en una perspectiva estratégica. Por eso, ciertos objetivos, como la instalación de una cuarta central nuclear o el fomento de la industria local, no pudieron sostenerse en el largo plazo.

Palabras clave: Programa Nuclear Argentino, Estado, Industria, Desarrollo, Energía

Introduction

In the 1990s, experts projected a 'Nuclear Renaissance' in the 21st century, envisioning a resurgence of nuclear energy on public agendas. These forecasts were based on the escalating energy consumption in some Asian countries and the upward trend in oil prices, leading to expectations of nuclear power generation undergoing a similar expansion as witnessed in the 1970s. However, a retrospective analysis suggests that there was a disconnect between these expectations and the reality in Western Europe and North America (Van de Graaf 2016). While the United States, France, England, and Russia maintained an active yet relatively stable nuclear share, certain countries, such as Spain, Belgium, and Italy, opted for a nuclear moratorium (IAEA 2010; Josephson, Meyer, and Kaijser 2021). Undoubtedly, accidents like Three Mile Island (1979) and Chernobyl (1986) continue to cast a shadow over the public perception of nuclear power. Furthermore, nuclear power costs were affected by multiple factors, including increasingly stringent safety measures, the inclusion of the costs of waste management, and more expensive financing. Additionally, after 1980s there was a slowdown in the growth of electricity demand, which influenced the overall costs of nuclear power projects (Rubio Varas and De la Torre 2017; Rubio Varas 2021).

In Latin America, the unfolding circumstances took a different course. During the 1980s, both Argentina and Brazil experienced significant cutbacks in their nuclear programs but, unlike developed countries, these reductions were not the result of anti-nuclear movements. Instead, they were primarily driven by delays and financial difficulties following the onset of the debt crisis in 1982 (Bandarra 2016; Hurtado de Mendoza 2012; Patti 2023; Rodriguez 2015, 2020).[1] The third nuclear country in the region, México, could be seen as an intermediate case. After 1986, the plans for the expansion of nuclear power were reevaluated due to economic deterioration resulting from the crisis, the decline in international oil prices, and the emergence of anti-nuclear environmentalist movements (Lugones y Vera 2023; Sarquis 2013).[2]

If the 1990s can be considered 'the lost decade' for the Argentinian and Brazilian nuclear program, these projects experienced a revival after 2000 and can be considered part of the so called 'Nuclear Reinassence'. The aspirations of both countries find expression in Argentina's 'Plan Nuclear' of 2006 and Brazil's 'Plano Nacional de Energia 2030' announced in 2008. Furthermore, by 2010, ten non-nuclear countries in Latin America, including Bolivia, Chile, Dominican Republic, Ecuador, El Salvador, Haiti, Jamaica, Peru, Uruguay, and Venezuela, had approached the AIEA for guidance to better understand the requirements to embark on a nuclear power program. Mexico was the only nuclear country in the region that did not experience a resurgence of its nuclear activities after the turn of the century (Sarquis 2013).

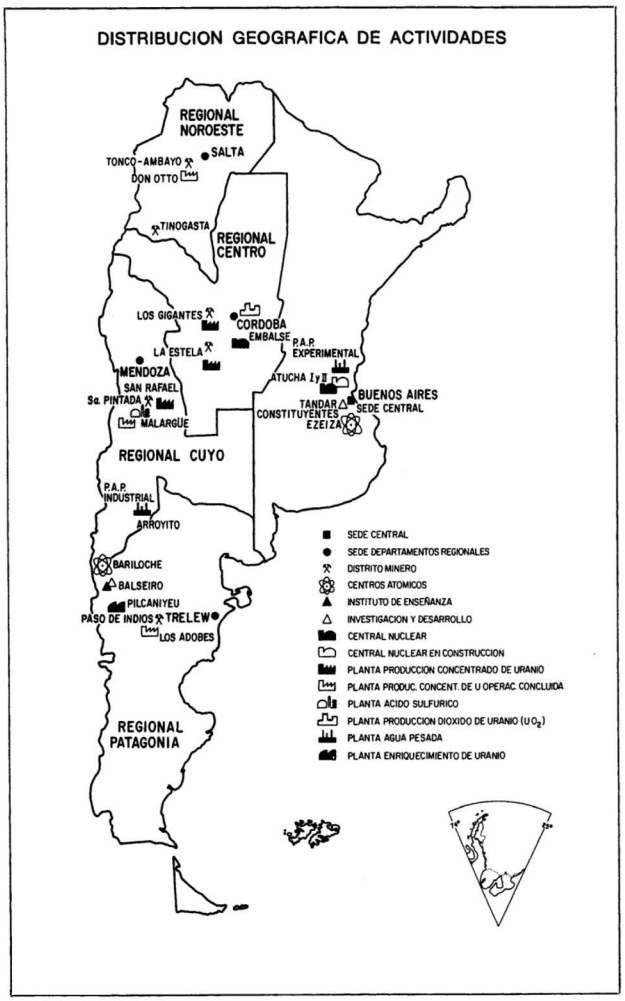
Twenty years later, it becomes pertinent to inquire about the 'Nuclear Renaissance' outcomes and the obstacles faced in Latin America. This study aims to identify the key aspects of the Argentine experience,

[1] In those years, several projects were suspended, such as the construction of the nuclear power plants Angra 2 and Angra 3 in Brasil and nuclear power plant Atucha II in Argentina (Patti 2023; Rodriguez 2020).

[2] In Mexico, the development of a local nuclear industry was hindered by the influence of the United States, fragmented decision-making, and an import-oriented equipment policy, resulting in less progress compared to Argentina and Brazil (Vera 2018; Azuela and Talancón 1999; Sarquis 2013).

considering financial, technical, and political perspectives. One distinctive aspect of the Argentine case is its early entry into nuclear era with the establishment of the National Atomic Energy Commission [Comisión Nacional de Energía Atómica, CNEA] in 1950. Subsequently, the Nuclear Program consolidated as a state monopoly based on public funding, and private companies did not play a significant role in its decision-making processes.[3]

FIGURE 1. GEOGRAPHICAL DISTRIBUTION OF CNEA'S NUCLEAR FACILITIES



Sources: CNEA (1992).

Unlike other scientific institutions, CNEA enjoyed full autonomy in setting its own objectives, focusing on technological autonomy and the development of know-how. This way, by 1994, Argentina had two operational nuclear power plants based on heavy water and natural uranium, Atucha I (1974) and Embalse de Río Tercero (1984), which accounted for 13% of the country's total electricity generation (CAMMESA 2009, 7). Construction was underway for Atucha II nuclear power plant, and numerous facilities associated with the nuclear fuel cycle were scattered throughout the nation (Fig. 1). These facilities included the manufacturing of fuel elements, production of radioisotopes, exploitation and purification of uranium minerals, production of heavy water, and small-scale uranium enrichment. Additionally, there were significant technological developments and studies related to the reprocessing of irradiated fuel elements and the disposal of high-activity radioactive waste.

However, 1994 were a turning point for the Argentine Nuclear Program. Following the 'British Model', Carlos Menem's administration (1989-1999) promoted the reform of the sector and the privatization of nuclear power plants.[4] Although the sale never materialized, the new legislation had far-reaching consequences. Notably, it brought an end to long-term planning and resulted in significant financial cuts for the main public institutions involved in the program. As a consequence of these changes, critical research and development (R&D) entities, along with the facilities responsible for the fuel cycle, became heavily

[3] It should be noted that, until the end of 1980s, 98% of the total energy generated in the country was managed by public companies (FIEL 1987).

[4] The 'British Model' emerged during the administrations of Margaret Thatcher (1979-1990) and John Major (1990-1997). It refers to the process of selling state-owned companies, which extended to sectors that had been considered strategic, such as energy and railroads (Thomas 2004).

reliant on the operation of just two plants: Atucha I and Embalse. Meanwhile, the construction of the third plant, Atucha II, was paralyzed in 1995 along with the project for the building of a small modular reactor (CAREM-25).[5]

The reforms of 1994 also reordered the institutional panorama. The CNEA, which had centralized the functions of coordination, research, development, energy production and management of the fuel cycle, was divided into three new entities: a Nuclear Regulatory Authority [*Autoridad Regulatoria Nuclear*, ARN], a nuclear power plant operator [*Nucleoeléctrica Argentina SA*, NASA], and an R&D public entity (a 'remaining' CNEA).[6]

After the Alianza party took office in 1999, the nuclear matter regained political attention, and talks of reviving the Nuclear Program emerged. Unfortunately, the severe economic crisis of 2001, which remains the deepest in Argentine history, thwarted any immediate possibilities of realizing those ambitions. Only after economic recovery and political stabilization took place post-2003, the prospect of relaunching the Nuclear Program became a viable option once again.

Although in recent years the nuclear issue in Argentina has aroused academic interest, the period after the 1994 continues to be less studied. In recent years, a national history is beginning to be outlined from the point of view of the of Social Studies of Science and Technology, but economic history plays a limited role in it.[7] Through the analysis of official legislation, institutional sources and interviews, this paper will explore the main milestones of the relaunch of the Argentine Nuclear Program, as well as the limitations of such planning.

This study proposes that after 2003, the government redefined the roles of actors in the nuclear sector without critically examining the institutional landscape inherited from 1994. Moreover, it paid insufficient attention to the significant structural changes the sector had undergone since the 1990s, hindered its capabilities to develop a nuclear program suitable for the 21st century. While a nuclear program for the medium and long term was outlined, the planning was primarily driven by immediate political considerations rather than taking a strategic perspective. This approach may have limited the program's ability to address long-term challenges and fully capitalize on the industrial and scientific opportunities in the nuclear sector. Finally, the lack of policies to ensure sustained economic and financial support for the Nuclear Program over time exacerbated the challenges. As a result, certain objectives, such as the installation of a fourth nuclear power plant or the promotion of the local industry, could not be sustained in the long run. The conclusions drawn from this analysis will contribute essential elements to broaden the debate about the future of Argentina's nuclear sector.

[5] The CAREM-25 is the first nuclear power reactor fully designed in the country, with the aim of supplying electricity in remote regions. Its original conception dates to the 80's (CNEA 2004, 4).

[6] For an analysis of the privatization project and the reasons of its failure see Rodríguez (2015).

[7] An approach from the Social Studies of Science and Technology can be found Hurtado de Mendoza (2014). For an Economic History perspective, see Lugones (2015) and Rodríguez (2015, 2019, 2020).

The Nuclear Renaissance

In the late 1990s, experts predicted a 'Nuclear Renaissance,' foreseeing the return of nuclear power to public agendas after the accidents at Three Mile Island and Chernobyl (Nuttall 2005).[8] This resurgence was primarily driven the rising energy demands in Asian countries like China and India. In 2006, the North American agency US Energy Information Administration forecasts indicated a rise in energy consumption of 1% annually for OECD countries and 3% for non-OECD countries between 2003 and 2030 (Us Energy Information Administration 2006, 7). Secondly, the war in the Middle East, intensified after the terrorist attack on the United States in December 2001, led to a significant surge in oil prices. By 2006, the price of a barrel of oil had reached up to 80 dollars and was expected to keep increasing in the subsequent years. In this critical situation, nuclear energy once again emerged as a viable alternative capable of competing with conventional energy sources. The escalating oil prices further underscored the importance of exploring nuclear power as a potential solution to address the world's energy needs. Thirdly, the Kyoto Protocol (2005), which involved a commitment to reduce carbon dioxide emissions, enabled the inclusion of nuclear power plants within the category of 'clean' energy.

Yet, despite initial optimism, these conditions did not turn into a nuclear expansion that resembled the postwar era. As mentioned earlier, while countries like the US, France, England, and Russia maintained an active and relatively stable nuclear share, others, such as Spain, Belgium, and Italy, ratified a nuclear moratorium, suspending the development of new nuclear projects during that period. Additionally, the German government announced a program for a nuclear phase out that should have concluded in 2020 (IAEA 2010).

The limited 'Nuclear Renaissance' in the west was attributed to both the minimal growth in electricity demand and technical and industrial challenges. The years of withdrawal led to the disintegration of supply chains and a shortage of specialized personnel. The International Atomic Energy Agency (IAEA) highlighted a decline in new graduates in the nuclear field, primarily due to the industry's past stagnation and perceived poor career prospects (International Atomic Energy Agency 2001, 4). To overcome the difficulties, nuclear companies focused on developing modern designs, including 'simplified' reactors (Generation III and III+) that aimed to reduce costs and risks. Additionally, the European Union explored Small Modular Reactors for remote regions, offering non-electric applications like water desalination, hydrogen production, and oil extraction from tar sands and heavy fuels. (2002, 29).

This way, the most significant expansion of nuclear power took place in the Asian scenario: through five-year planning, the government of China managed to quintuple its nuclear share between 2001 and 2022 (Power Reactor Information System 2023).[9] However, while there had not been a period of decline in nuclear energy during the 1980s and 1990s, the idea of a nuclear revival did not appear relevant within the region's context.

[8] The term became known in 1990 through a brief publication by Charles Venyvesi in *US News and World Report* but was spread in 1999 by Mark Yost of the *Wall Street Journal* (Nuttall 2005, 2).

[9] Nuclear power share in China went from 1.14% of electricity production in 2001 to 5% in 2022.

Fukushima's accident in Japan in 2011 reignited the global debate on nuclear power, leading to different responses in various countries. Germany, Italy, Switzerland, and Belgium reinforced decommissioning initiatives due to strong anti-nuclear movements, permanently shutting down older power plants. Spain and Japan, on the other hand, canceled new projects but continued operating existing ones due to the scarcity of alternative fuels.

While Fukushima's accident did not completely dismiss nuclear power, it did challenge one of the main arguments of the 'Nuclear Renaissance': the economic competitiveness of nuclear power plants against natural gas and oil. The implementation of new safety requirements increased costs, with Generation III+ reactors proving more expensive than initially estimated (Thomas 2012). As a result, nuclear expansion appeared more feasible in regions with high growth rates and electricity demand (Rubio Varas 2021).

The relaunch of Nuclear Program in Argentina

During Fernando de la Rúa's government (1999-2001), the plan to privatize the nuclear power plant was officially canceled, but the economic crisis hindered any potential relaunch. The administration's economic policies prioritized tackling state inefficiency and reducing public spending, especially in the context of high external debt interest payments. As a result, the focus was on fiscal cuts, leading to a decrease in the budget and human resources of CNEA. By 2001, research funds had fallen by 30%, and the organization had implemented three voluntary retirement plans, with no job vacancies available for new applicants (La Nación 2001).

By that time, Aldo Ferrer was appointed as director of CNEA, and the central objective of his administration was to promote the reactivation of the Atucha II project, a nuclear power plant paralyzed in 1994 and based on heavy water and natural uranium.[10] According to Ferrer, the plant would not only increase energy generation but would also foster the reactivation of activities linked to nuclear power: the production of radioisotopes and heavy water, the radiological protection system, the training of highly specialized human resources and the development of basic science and the manufacture and export of research reactors, among others (Rougier 2014, 207). As stated in the CNEA's Annual Report:

> It is necessary to remember that countries like Germany or Italy, with strong national science and technology systems, can afford to suspend nuclear power without critically compromising the development of the many applications of nuclear energy. This possibility does not exist in a country like Argentina […], the development of the sector in the country was carried out, to a great extent, in the context of investments in the nuclear power plant" (CNEA 2001, 6)[11]

A few months later, CNEA published a report highlighting the uncertain situation of the sector and emphasizing the urgent need to relaunch Atucha II. At that point, around 2,730 million dollars had already been invested in the plant, and the physical progress stood at approximately 81%. To complete the project, an estimated amount of 686 million dollars was required, without taking into account taxes (which added 109 million dollars) or the cost of the first load of fuel. Additionally, it was

[10] Aldo Ferrer was an economist graduated from the University of Buenos Aires and played a major role in politics since the 1950s. Ferrer's ideology was aligned with developmentalism.

[11] Author´s translate.

projected to take four and a half years to start the plant's operation.

The focus on Atucha II was also a response to certain government members who were pushing for the cancellation of the project. In this regard, the report argued that finishing Atucha II would make it possible to increase the energy supply, maintain the scientific and technological capabilities, promote the nuclear technology export, and activate the rest of the industries in the sector. In addition, a third reactor connected to the grid would lower the costs of life extension tasks and eventual decommissioning of the Atucha I and Embalse power plants.

Despite the initiative of Ferrer's administration, the criticism against De la Rúa's policies caused his removal from the CNEA in August 2001 (Hurtado de Mendoza 2014, 288; Rougier 2014, 206). From then on, the intensification of the economic and institutional crisis gave little opportunity to continue the debate, while the sector kept on operating by inertia, with scarce budgets and without a defined nuclear policy (Hurtado de Mendoza 2014).

After the worst phase of the crisis had passed, an alternative economic model began to be laid during the Eduardo Duhalde (2002) and Nestor Kirchner's administrations (2003-2007). Although the devaluation of the Argentine currency implied, in the short term, a deep recession, after 2002 it became the basis of a new stage of prosperity. The high exchange rates led to an increase in the prices of foreign goods and services, which in turn promoted import substitution. The reduction of financial costs and low wages further incentivized this process of replacing imported goods with domestically produced alternatives (Azpiazu and Schorr 2010, 229; Gaggero, Schorr and Wainer 2014, 44; Piva 2015, 41).

This transition was accompanied by a stroke of luck in the external sector: the increase of raw materials prices and the improvement of terms of trade allowed Latin America to experience a boom that resembled the 1960s (Bértola and Ocampo 2013). In this context, China began to replace the United States as the main supplier of manufactures and capital and those investments achieve a significant role in tertiary sector and extractive activities. Argentina benefited from these changes because the sale of soybeans resulted in an extremely rare commercial and fiscal surplus (the 'twin surpluses') between 2002 and 2007. Consequently, the country was able to reestablish its connections with foreign creditors following the debt swap in 2005 and the debt cancellation with the IMF.[12]

After 2003 a slow but sustained recovery of the consumption and the domestic market began to take place. The state played a leading role in those years as the main promoter of public works and social development plans. This trend was crystallized with the establishment of the Ministry of Federal Planning, Public Investment and Services created in 2003. Under Julio De Vido's leadership, energy and housing infrastructure programs received significant funding, reaching 3.8% of GDP in 2003 and 18.7% in 2007 (Castellani 2009, 228).

While it marked the first economic recovery in many years, the increase in global and manufacturing GDP concealed certain productive limitations. Certain studies suggest that the growth model lacked structural foundations and argue that the expansion did not lead to new patterns of industrial specialization. In fact, there is a consensus that the absence of long-term strategic planning hindered the resolution of difficulties inherited

[12] The external debt went from 102,566 million dollars to 35,261 million (Kulfas 2016, 116).

by the industrial sector from the 1990s (Damill and Frenkel 2013; Gaggero, Schorr, and Wainer 2014; Kulfas 2016; Porta, Santarcangelo, Schteingart 2017).

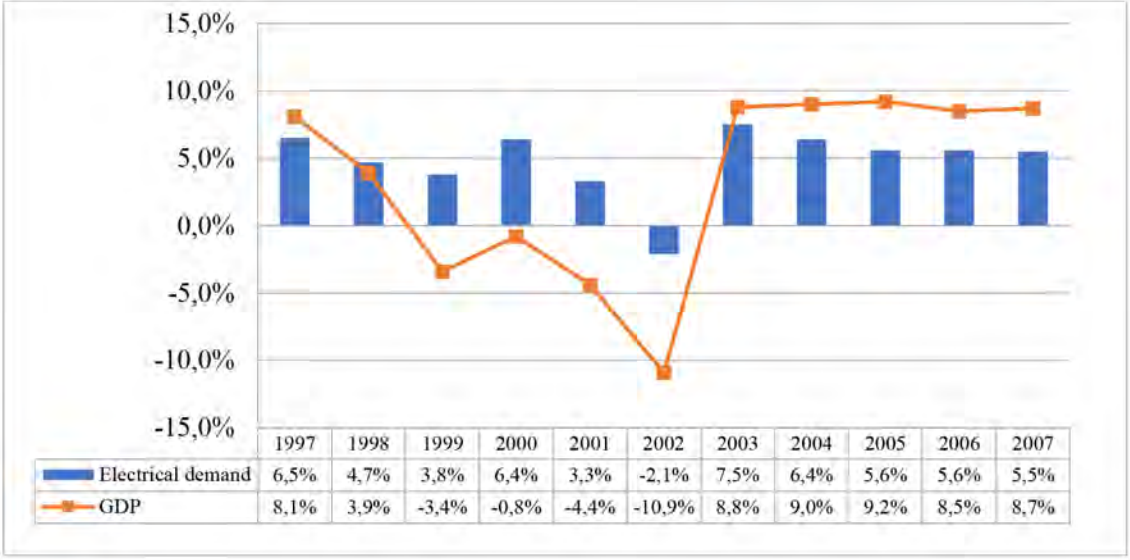
In the energy sector, one of the primary challenges was the decrease in generation capacity. During Menem's administration, the privatized electricity companies did not make substantial investments to diversify and expand the energy matrix. While there were no supply problems during the crisis, the subsequent economic growth from 2002 onwards necessitated the construction of new plants to meet the increasing energy consumption demands (Figure 2).

For this reason, the government announced the National Energy Plan 2004-2009 that would be overseen by the Ministry of Planning through the creation of a public company, Energía Argentina (ENARSA SA). The works included the expansion of gas pipelines and compression plants, the completion of the Yaciretá dam and Atucha II and the installation of new thermoelectric and hydroelectric plants. To alleviate the deficit in the short term, a plan of rational use of energy was implemented, which would eventually be reinforced by the importation of Venezuelan fuel oil, Bolivian gas, and Brazilian electricity (Cameron 2003; CAMMESA 2009). It was estimated that the plan would require a total investment of 4,000 million dollars and would be completed between 2008 and 2009.

Argentine Nuclear Program at the crossroads

Between 2003 and 2005 the first stage of nuclear reactivation began. However, it's important to note that the government did not modify the institutional scheme inherited from 1994: the only exception was the creation of a Nuclear Energy Unit within CNEA aimed at advising Presidency, but this entity did not seem to have a significant role in planning, and it is poorly mentioned in official sources (CNEA's Resolution, 195/05). During those years, CNEA, NASA, and ARN continued to fulfill their assigned functions from the 1990s as public entities: CNEA focused on research and development, NASA handled nuclear

Figure 2. Evolution of GDP and Electricity Demand between 1997 and 2007



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Electrical demand	6,5%	4,7%	3,8%	6,4%	3,3%	-2,1%	7,5%	6,4%	5,6%	5,6%	5,5%
GDP	8,1%	3,9%	-3,4%	-0,8%	-4,4%	-10,9%	8,8%	9,0%	9,2%	8,5%	8,7%

Source: own elaboration from CAMMESA (2009).

operations, and ARN was responsible for nuclear regulation.

In the context of economic expansion, the relaunch of Atucha II became a central issue. However, it soon became apparent that this would not be an easy task. The project was over 23 years old and, being a prototype with no other reference in the world, presented unique challenges and complexities.[13] Furthermore, the original designer of Atucha II, the nuclear division of Siemens-KWU, was retiring from the atomic market. These circumstances encouraged a fierce debate regarding the organizational structure responsible for completing the project (Clarín 2004). An 'easy' solution would be to negotiate a turnkey contract and external financing with a nuclear company. However, this alternative became increasingly unlikely. During the first stage of negotiations, Siemens-KWU offered to rescind the current contracts in favor of Areva T&D, but the latter had no experience in heavy water and natural uranium technology.[14] Additionally, due the devaluation of Argentine peso, the cost of foreign engineering would be nearly a 600% more expensive than local (AATN 2004, 13).[15] Anyway, in 2005, the Areva consortium announced that they would not finish Atucha II due to technical problems. Besides, it was clear that the project was not financially attractive; 'the big deal' was already made in the 80's by Siemens with the sale of large components and engineering.[16]

This situation left the Atucha II Power Plant at a difficult crossroads, given that it could only be completed with local engineering. Yet, it was not clear which institution could carry out the task. Apart from technical concerns, the critical question was how the project would be financed. With Areva formally out of the picture, the National Treasury emerged as the sole alternative for funding the completion of the project.

The issue was finally settled in mid-2005 with the official designation of NASA to complete and start-up not only Atucha II but also future nuclear plants (Executive Power Decree 981/05). To carry out the project management, NASA created the Atucha II Central Management Unit (UGCNAII) headed by Engineer José Luis Antúnez, an electromechanical engineering graduate from the University of Buenos Aires who had several experiences in the public and private electricity sector.

Once the institutional scheme was established, the government officially announced the reactivation of Nuclear Program on August 23, 2006. From then on, it would be articulated as a specific program within the Energy Plan with the aim of increasing the generation of nuclear power, promoting the medical and industrial applications of the activity, and encouraging the training of highly specialized human resources. Planning included the commissioning of Atucha II, a fourth nuclear power plant to be located in Buenos Aires, the Life Extension Project of the Central Embalse [*Proyecto de Extensión de Vida,*

[13] In 2012, there were nine cases of nuclear power plants around the world that were stopped for more than 20 years. While the American project Watts Bar-2, that started in 1972, was at the top of the ranking, Atucha II was in second place (Schneider and Froggatt 2012).

[14] By then, KWU and the French company Areva T&D, formerly Framatome ANP, had merged in 2003, forming the world's main provider of nuclear energy solutions and services.

[15] While the French engineering hour was $180, the local cost was only $30 (Clarín 2004).

[16] Interview to Oscar Mazzantini, NASA's Licensing Manager, conducted by the author on August 25, 2014.

[17] The Embalse Nuclear Power Plant Life Extension was a reconditioning process that extends operational life in 30-year cycle and increases its power by 6%.

PEV],[17] the reactivation of the fuel cycle, the promotion of radioisotopes and the development of the CAREM reactor (De Vido 2006). Along with project Atucha II, the CAREM reactor prototype was also declared of national interest.

Regarding financing, the government announced that Atucha II would be finished in 2009 with a total amount of 490 million dollars. The works would be founded by national budget through an escrow account. However, it is important to note that first estimations were clearly underrated regarding previous reports, and even then, some specialists began to question the viability of these projections.[18] The available sources do not provide enough information to determine whether the underestimation of costs was a result of the preliminary study carried out by NASA or if it was part of a political strategy. However, what is clear is that after this point, the deadlines and costs were continuously extended due to unforeseen circumstances that emerged during the project. Over the following years, the significant discrepancy between estimated and actual costs became a subject of criticism and intense debate.

According to the macroeconomic model, the government aimed to prioritize national suppliers and contractors while also intending to create 4,000 jobs during the completion of Atucha II. To achieve this, the promotion regime that was implemented since the 1980s was reinstated, although without significant modifications. The regime involved tax exemptions, customs relief, and the 'Buy National' policy to encourage the development of local suppliers (Executive Power Decree 1085/06). However, the disintegration of the industrial value chains that had occurred since the 1990s posed new challenges, and finding a solution went beyond relying solely on the National Buy policy or the tax mechanisms reintroduced by the government. Indeed, the absence of specific promotion regimes aimed at addressing industrial problems is noteworthy and can be understood within the broader context of avoiding long-term strategic planning.

A second stage began during 2006 and 2007, aimed to settle basic infrastructure. Regarding human resources, the main strategy was to offer higher salaries to attract the 'surviving' staff that had participated in the project before 1995. By then, most of the scientists and technicians migrated, were working in other sectors, or were already retired (Campos 2014, 6). According to the director of one of the main technical training centers in Atucha II, "We had to go out looking for retirees to help us recover that knowledge" (Vales 2006).[19] However, it is estimated that only 10% agreed to return (Arias 2020).

Furthermore, the shortage of young professionals in critical fields such as nuclear, electrical, mechanical, and chemical engineering, among others, had hindered the natural transfer of knowledge and experience to a new generation. This trend in Argentina mirrored what was happening in developed countries in the Western world. As a consequence, the average age of professionals in the sector was estimated to be between 50 and 55 years old, with a noticeable deficiency in the 20 to 30-year-old age group. (CNEA 2001, 73). To adress this problem, young graduates with 5 or 10 years of practice in the specialty were incorporated to the project. Additionally, in 2007 the welding school was reopened and a year later it would become the Atucha II Project

[18] Current dollars amounts were calculated on the exchange rate extracted from Officer (2023).

[19] Author´s translate.

Welding School (Suárez 2020). This initiative was crucial as the nuclear plant required approximately 610 skilled welders. Finally, specialists linked to the CNEA and the Balseiro Foundation were hired through technical assistance services (Informe Industrial 2006, 9).

Regarding construction site, the UGCNAII conducted a survey of the stored components and the already assembled infrastructure, revealing the meticulous work undertaken by the maintenance personnel during the previous stage. According to Antúnez, it involved 40,000 tons of materials that were in 85 deposits distributed throughout the property and 126,000 engineering documents (Krakoviak 2013). However, a large part of the equipment was in a state of obsolescence and had to be replaced by modern systems. This was particularly true for the area of instrumentation, control, and information, which heavily relied on analog technology. Additionally, it is important to note that, given the disappearance of Siemens and the destruction of local industrial framework, the production of many supplies had been discontinued (Bertoni et al. 2004).

To address this issue, the UGCNAII conducted a comprehensive analysis to identify the elements that needed replacement. Additionally, they converted the information stored on paper to CAD format for easier management and compatibility with modern systems. A critical aspect of the solution was updating warranties and negotiating with Siemens to acquire the design modifications without infringing on their property rights. The negotiation process concluded successfully in July 2006, allowing for the necessary updates and replacements to be carried out in a legally compliant manner (Echeverría 2015).

From the point of view of construction, the major tasks that remained were the completion of the hydraulic works, electromechanical assembly, and start-up, in which national industry participation should be maximized (Informe Industrial 2006, 9). However, it soon became clear that the industrial outlook was bleak. Neoliberal policies had destroyed small and medium-sized establishments, while large firms had reconverted to other economic activities. To tackle this issue, a specific department called 'Recovery of Contractors and Suppliers' was created within the UGCNAII to recompose links with local industry.

Finally, regarding the fuel cycle, the government of Néstor Kirchner initiated the reactivation process of the Heavy Water Plant and the Uranium Enrichment Plant in Pilcaniyeu (CNEA 2006, 12). These initiatives would be complemented with the reopening of the San Rafael Manufacturing Mining Complex. Uranium mining had been suspended since 1997 due to the increase in local production costs and from then on, the raw materials had been imported from Canada, Kazakhstan, and the Czech Republic. This was an important detail, given that Atucha I, Embalse and Atucha II would consume a total of 210 tons of uranium per year, and it represented between 5% and 7% of the total cost of kilowatt. Despite efforts to reactivate mining in San Rafael, progress was impeded by environmental objections raised by the provincial government of Mendoza. This obstacle led to the exploration of alternative deposits that could be exploited. However, to date, no other mining ventures have been successful in the region (Gallegos 2014).

The last year of Nestor Kirchner's administration ended with the promise of continuity for the Nuclear Program. In August 2007, together with his wife and presidential candidate, Cristina Fernández de Kirchner, the president visited the site of Atucha II. On that

occasion, Nestor announced that the project would be inaugurated in 2010 by Cristina (Página12 2007; La Nación 2007). He also remarked the political significance of the relaunch, lauding national work, production, and industry (Casa Rosada 2007). However, it became evident that the original estimates were far from accurate, and both the schedule and budget were insufficient to complete Atucha II. In response, a new deadline of 2010 was set, and an additional investment of 740 million dollars was announced by Nestor to finish the plant.

The years of stabilization

The government of Cristina Fernández de Kirchner (2007-2010 and 2011-2015) was signed by the end of the 'twin surpluses' phenomenon (Kulfas 2016, 127). After a brief recession caused by the international crisis of 2008, the economy returned to growth between 2010 and 2011 and wages, consumption and public employment raised again. However, unlike what happened during Nestor's administration, the creation of jobs in the private sector was lagging behind production. Furthermore, there was a growing trend towards consumption of imported goods over locally produced ones. Indeed, after 2011, the period was characterized by the resurgence of external restrictions and a fiscal deficit, leading to inflation (Kulfas 2016; Porta, Santarcángelo, and Schteingart 2017).

As promised, the new government ratified the commitment to deepen the National Energy Plan. While energy demand was growing steadily, the international price of oil rose again between 2011 and 2014. This trend quickly translated into public spending on energy, which represented 27.1% of the total spending between 2003-2014 and 60% between 2012-2014 (Comisión Nacional de Valores 2010). As result, nuclear policies were reaffirmed, and the general guidelines proposed in 2006 become settled.

In 2009, the construction of a fourth nuclear power plant with one or two energy modules was declared of national interest, as well as the Project for Life Extension of the Embalse Nuclear Power Plant (PEV). While a special tax and direct purchase regime was established for the sector, the document formalized NASA's role as the project manager of future nuclear power plants (Law 25566, Law 26546). This way, the legislation ratified the roles of each of the institutions involved in the Nuclear Program: while NASA would continue to act as a company for the operation and construction of Nuclear Power Plants, the CNEA would be limited to carrying out the CAREM Project and to providing scientific and technical support to achieve the stated objectives, reinforcing the organization's R&D profile.

Along with the enactment of the law, Cristina Fernández announced the start of feasibility studies for the location of a fourth Power Plant and the CAREM. A few months later, Julio De Vido announced that a 100 or 150 MW prototype would be installed in the province of Formosa, based on the design that CNEA was developing (Ámbito Financiero 2009; Página12 2009). Additionally, the government aimed at installing a plant of between 1,000 and 1,600 MW of capacity in the same property of Atucha I and II, called 'Central IV'.

The Central IV awakened an old technological debate. On one hand, Argentina could choose CANDU line through a CANDU-6 reactor provided by AECL. Since much of the CANDU know how had been acquired through the purchase of Embalse in 1969, CNEA and NASA could carry out the design, construction, and commissioning. Although it was still necessary to have the assistance and certain supplies from

AECL, this possibility revived the aspirations of a *Made in Argentina* reactor without the aid of a foreign company. Even so, this initiative would cut the cost by 50% and allowed local industry to have a significant participation (CNEA 2009, 2). However, some experts argued that CANDU technology, based on heavy water and natural uranium (PHWR), could be considered an 'old-fashioned' design, given the prevalence of enriched uranium (PWR) in the rest of the world.

On the other hand, an enriched uranium plant through the purchase of a Generation III or III+ reactor was being considered, allowing Argentina to gradually acquire the *know-how* of PWR-type plants (Moledo 2010). For the first time in the history of the Argentine Nuclear Program, that had always chosen PHWR reactors, this last alternative had considerable support by the government and within the nuclear sector. This path not only would justify the reactivation of the Uranium Enrichment Plant in Pilcaniyeu but also it would make it possible to produce enriched uranium on a larger scale to supply research reactors and the CAREM project (CNEA 2009, 3). Moreover, the purchase of technology abroad could ensure stable financing from contractor.

This way, 2010 was a year of great activity in the sector. Once the evaluation and analysis phase were completed, the PEV received a 240 million loan from the Andean Development Corporation to extend Embalse's life by another 25 to 30 years. This amount meant 23% of the total cost, valued at 1,027 million dollars (Página12 2010). Also, that year, the reactivation of two emblematic facilities of the Argentine Nuclear Program were concluded: the Heavy Water Plant, which would produce the moderator for Atucha I, Embalse and Atucha II and the Pilcaniyeu uranium enrichment plant.

Regarding the installation of future nuclear power plants, negotiations were held during the NPT Review Conference (January) and the Nuclear Security Summit (April). By then, while Argentina publicly ratified its peaceful vocation, De Vido declared its intentions to buy an enriched uranium reactor from France, Russia or South Korea. The announcement coincided with the bankruptcy of AECL in early 2011, the main supplier of natural uranium technology (CNEA 2012, 3). This decision aroused criticism from the CNEA's internal union (ATE-CNEA) as they argued that a PWR design would strengthen technological dependency and undermine the capacity for self-design.

The accident in Fukushima that took place a few months later delayed any initiative regarding a new nuclear power plant. Nevertheless, in the absence of strong anti-nuclear movements and limited public opposition, the Fukushima accident did not have a widespread impact in Argentina. The only noticeable effects were a temporary slowdown in decision-making regarding the 'V Central' and a delay delay, along with cost overruns, in the Atucha II Project, resulting from the necessary updating of safety regulations.

While the economic growth brought Argentina's energy problem back into the public arena and a new electoral cycle was approaching, the government of Cristina Fernández formally ratified the continuity of the Nuclear Program in the following year. In 2012 and the government announced that two nuclear power plants would be installed. First, a natural uranium CANDU plant based on the design purchased from AECL in 1973 which would include all the latest updates. Although this choice would allow a 70% of national industry participation and would justify the reactivation of the Heavy Water Plant, the

strategy was presented as a disclosure stage to 'buy time' and acquire the know -how of enriched uranium. Indeed, in a second stage, a 'V Central' based on the PWR model was planned for installation, with the involvement of a foreign company to provide the design. (Krakoviak 2012). Clearly, the strategy concealed an economic objective since the future supplier of enriched uranium was expected to provide the financing for both projects (Barbarán 2015).

By 2014, both Russia (Rosatom Company) and China (China National Nuclear Corporation) were the main competitors to sell the technology for 'Central V'. The dispute was settled in favor of China after the signing of the Strategic Agreement of Integral Association, which solidified cooperation in strategic sectors such as transport and energy.[20] The formal announcement took place in July 2014 during the visit of the delegation led by President Xi Jinping and was reinforced in February 2015 with a Memorandum of Mutual Understanding and a Cooperation Agreement. Regarding this matter, Antúnez commented: "The advantage does not belong to the China National Nuclear Corporation over the other technology providers. It is from China compared to other countries" (Krakoviak 2015).[21]

The Agreement included an 800 Mw CANDU power plant and another central based on enriched uranium. In the first case, NASA would act as owner, designer and Industrial Architect and the Republic of China —which had acquired CANDU technology in 1993— would provide technical support, services, equipment, and the financial resources. The construction would take eight years and the total cost would be of 2,000 million dollars, plus 4,000 million dollars that would be spent in local industry.[22] This way, the local industry participation would be by 50% higher than imports. Additionally, China would provide 85% of the credit for all supplies and services through financial institutions, such as the Industrial and Commercial Bank of China (ICBC). Regarding the 'Central V', the project was presented as a long-term aspiration, based on a third-generation reactor type developed by China, known as ACP1000 or 'Hualong-1' (CNEA 2014, 55).

While this negotiation took place, the Atucha II project was finally inaugurated. The event was attended by Cristina Fernández and by Julio De Vido, who did not miss the opportunity to point out the future expansion of the nuclear power. However, far from the original estimations, the power plant took eight years and a total amount of 4,000 million dollars to get finished. This issue aroused criticism from political opposition and environmental organizations (Rodriguez 2020).

After 2014 and 2015, the government rushed to formalize the agreements before the presidential elections. By then, a new political coalition began to dispute the electoral arena, headed by Mauricio Macri. Effectively, the party 'Cambiemos' won the 2015 elections and though Macri did not declare himself against the Nuclear Program, a brief look at his administration points at the opposite direction. The only project of the original Nuclear Plan that had continuity was the Life Extension Project of the Central Embalse, which was reconnected again in May 2019. The rest of the nuclear activities did not share the same fate. In

[20] China would provide 4,714 million dollars to finance the "Kirchner" and " Cepernic " dams in Santa Cruz and the renovation of the Belgrano Cargas Railroad tracks. Additionally, trade agreements were signed with Russia that included the possibility of installing a Russian-designed plant after the V Central (Casa Rosada 2014).

[21] Author's translate.

[22] Current dollars amounts were calculated on the exchange rate extracted from Officer (2023).

a context of deep economic recession, which consolidated the dominance of capital over labor, public works programs were cut (Manzanelli, González and Basualdo 2017). Thus, the installation of the Central IV, that would begin during the first months of 2015, was progressively delayed until it disappeared from the official planning in mid-2018. Symptomatically, the abandonment of the CANDU-type power plant project coincided with the agreement signed with the IMF, through which Argentina went back into debt on the condition of reducing the fiscal deficit and inflation (CEPA 2019). In this way, only the installation of a Chinese enriched uranium Hualong-1 type plant remained, although the government did not materialize that initiative either.

Conclusions

The nuclear boom predicted for the new century would soon reveal its limitations, while the problem of profitability continued to be one of the central aspects of the discussion. In this context, the viability of the nuclear power option depended directly on the increase in the price of oil and consumption. Additionally, the restructuring of the sector was conditioned by the difficulties inherited from the decades of decline, such as the dispersion of specialized human resources and the disintegration of industrial value chains. As a result, the growth of the nuclear power was verified only in Asian countries that had maintained a constant level of expansion between 1980 and 2000.

Despite the limitations, Argentina re-launched the Nuclear Program after 2003 in the context of economic growth driven by the return of the state and the prosperity resulting from the 'twin surpluses.' However, certain obstacles to development persisted due to the failure to question some of the foundations inherited from neoliberalism. Consequently, the economic growth observed during the period did not lead to substantial structural changes, and the return of the centrality of the state did not materialize into comprehensive long-term strategic planning. The lack of strategic planning and the persistence of certain neoliberal policies hindered the country's ability to achieve significant transformation despite the period of economic growth.

Indeed, between 2003 and 2015, the nuclear sector regained prominence on the political agenda. It was seen as a crucial component to meet the growing electricity demand and was strategically aligned with the economic model formulated after the 2001 crisis. Furthermore, relaunching the Nuclear Program would encourage the development of local scientific and technical capacities, generate employment and provide a business opportunity for national industry. That's why the discussions about the contractual scheme to undertake the completion of Atucha II were a turning point. The final decision would not only be crucial to define the possibilities of participation of the local industry, but would also establish, in the future, the institutional roles in the eventual expansion of the nuclear power. In this context, Siemens' withdrawal and Areva's refusal to complete the project hindered the alternative of completing the works through a turnkey contract with external financing. From then on, the continuity of Atucha II would only be possible with local management and resources. The official support given to NASA to set up an Industrial Architect gave the institution greater relevance to the detriment of others such as CNEA or INVAP. It is also evident that, in the absence of a strong lobby of private companies, the Argentine state continued to play a guiding role in the Nuclear Program.

After those crucial decisions were made, the government of Cristina Fernández not only ratified the continuity of Nuclear Program but

also began to formalize the construction of new nuclear power plants. At this point, it is important to note that the technological crossroad became a key aspect of the debate and settled the basis for the current nuclear power plant project. Clearly, the financial problem played a central role and could explain why, for the first time, the facilities based on enriched uranium plants had official support, to the detriment of the development of the national industry or technological autonomy.

Finally, those negotiations were suddenly interrupted by the Macri's administration, and in a few years the whole program was progressively dismantled. By then, the technicians and scientists interpreted the period as a revival of the 90's. Antúnez himself argued: "What we should try to do is conserve capacities. We know something about this thanks to the experience of Atucha II [...] It is preferable to invest in preserving skills than to pay subsidies to the unemployed" (Agendarweb 2019).[23] This way, it's clear that the cut of the nuclear program highlights, once again, the fragility of long-term official planning in developing countries such as Argentina, as well as the absence of internal financing for large technological ventures.

The government's failure to critically examine the institutional landscape inherited from 1994 hindered the development of a nuclear program suitable for the 21st century. The absence of a strategic perspective in planning, primarily driven by immediate political considerations, limited the program's ability to address long-term challenges and fully capitalize on the industrial and scientific opportunities in the nuclear sector.

Furthermore, the lack of policies to ensure sustained economic and financial support for the Nuclear Program over time exacerbated the challenges. The financing payback periods for new-build nuclear projects are typically relatively long, which creates a need for an equally long-term financing (Rubio Varas 2021). The absence of a stable and consistent funding mechanism undermined the program's continuity and impeded its potential for growth and advancement. These limitations collectively impeded the establishment of a robust and forward-looking nuclear program that could have better addressed the country's energy needs and harnessed the full potential of the nuclear sector.

[23] Author's translate.

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