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PARALLEL POWER PLAY: NUCLEAR TECHNOLOGY AND DIPLOMACY IN ARGENTINA AND BRAZIL, 1945-1995

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Abstract

This dissertation examines the parallel historical development of nuclear technology and diplomacy in Argentina and Brazil between the end of World War II and 1995, when the neighbors accepted and adhered to bilateral and international weapons nonproliferation measures, then led broad economic integration efforts on the continent. Brazil's and Argentina's pursuit of autonomous nuclear energy capabilities has vexed political scientists, who have produced some excellent scholarship on a historical process of building and refining technology, diplomacy, and law; nonetheless, these developments defy most models to explain them. As a work of history, this dissertation recasts this process as the interplay of two mutually constitutive pairs. Nuclear technology and diplomacy, linked since before the bombing of Hiroshima and Nagasaki, played a fundamental role in shaping Argentina and Brazil, connected by geography and competition for nearly 500 years.

Both nations began this period by trading newly valuable nuclear minerals to the hemispheric superpower, the United States, but developmentalist governments in the South American neighbor countries invested quickly and heavily in beginning the human and physical infrastructures for nuclear energy. Only with a fearless and forceful early start, political leaders and scientists believed, could the gifts of the Atomic Age lead to economic and social benefits for the people of Argentina and Brazil, vault each country out of middle-power dependency and above the geopolitical vicissitudes of the Cold War. In this way, the two nations would complete the elusive process of technological autonomy from multinational corporations and North Atlantic technology transfer partners, a possibility that their diplomats defended vociferously in the drafting of the Treaty of Tlatelolco (1967) and outright rejection of the United Nations Non-Proliferation Treaty (1968).

Political leaders, military generals, and scientists in both nations continued to believe in this transformative power of nuclear energy, and made expensive bets on a future where it would be integral to continued industrial development. The goal to complete the nuclear fuel cycle in Brazil and Argentina exemplified and intensified a complex, competitive bilateral relationship for influence and power on the continent, particularly from the mid-1960s to the mid-1980s, when both nations were under military government. A serious and continuous effort to ensure cooperation on peaceful use of nuclear energy began in diplomatic and high political circles nearly a decade before the return of electoral democracy to either country, while efforts to master the sensitive processes of uranium enrichment, heavy water production, and spent fuel reprocessing continued unabated. But by 1995, both nations had ceased early-stage weapons development programs, accepted full safeguards and international verification of all nuclear activities, and transformed the "imported magic" of nuclear energy technology into their own. How this all happened, and why, is the story of the parallel power play at the heart of this dissertation.

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Quiero hacerla un cuadrado,

deformarla en un triángulo,

pero la vida siempre vuelve a su forma circular. -- Café Tacuba, "El Ciclón," 1994

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Preface: A Note on Sources

A few words of explanation about the body of sources upon which this dissertation is based are both necessary and appropriate here. While I have endeavored to provide a balanced treatment of nuclear technology and diplomacy between actors and sources in Brazil and Argentina, the source base for a comparative historical study like this one certainly challenges the historian in several ways.

First, there is the matter of secrecy. Many government sources on nuclear energy are less restricted in Brazil or Argentina than in the United States, particularly after a Brazilian declassification/freedom of information law was passed in 2012. Gradually, that law is expanding its reach to military archives. The absence of nuclear weapons or programs to develop such weapons in the South American countries certainly mitigates the problems of secrecy and classification in sources, as do the efforts of American organizations such as the National Security Archive (George Washington University, Washington, D.C.) or the Wilson Center and its Nuclear Proliferation International History Project to obtain recently declassified documents from D.C., Brasília, or Buenos Aires under freedom of information legislation.

Yet institutional walls still block researchers from information on sensitive technology development in the 1970s and 1980s, particularly at the foreign relations archive in Argentina (MRECIC), where a small handful of high-ranking diplomats and ambassadors control researchers' access to these restricted folders. In Brazil, this type of secrecy concerns most aspects and activities in the military's "parallel program" for autonomous development of uranium enrichment, submarine propulsion technology, or spent fuel reprocessing, as a few examples. Documentation pertaining to parts of both programs is still secret, and may remain so for some time. Fortunately, the openness of individuals (as opposed to institutions) to sharing information and documents about their own roles in nuclear energy history helped to counteract some of the official bureaucratic secrecy that I encountered at government archives.

Second, there is a fundamental discrepancy in the type, quality, and topical coverage of sources on nuclear energy in both countries. Despite an Argentine interviewee's humorous (if not entirely accurate) concession that "Brazilians are much better at documenting everything," I found that Argentine sources were stronger for certain chapters, topics, and time periods in this dissertation, while Brazilian sources proved more illuminating in other contexts. The reasons for this lack of comparability are both myriad and complex, ranging from the close involvement of the military in nuclear energy activities in Brazil vs. the officially civilian nature of the Argentine program, to differences between each nation's hierarchies and institutional divisions of labor that control, plan, and carry out the range of nuclear technology projects, to essential distinctions between the legislative practices of Argentina and Brazil (the latter legislature, for instance, has conducted four Parliamentary Inquiry Commissions on nuclear energy, roughly one per decade between 1956 and 1990, which offer scholars essential perspectives by participants and planners alike within the nuclear energy program; Argentina has no such practice).

Third, this research ultimately benefits from an exponential growth from decade to decade in the documentation and scholarship – again, uneven in both its kind and topical coverage – produced about nuclear energy and technological development in general. However, the signal-to-noise ratio, of course, decreases in strength from the 1950s to the 1990s. I am grateful to archivists, librarians, and fellow academics who have helped me separate the wheat from the chaff.

Introduction

This study traces the parallel evolution of advanced nuclear technology programs in Brazil and Argentina from 1945 to1995. Populist governments' backing for initial efforts in nuclear energy development after World War II transformed, by the 1970s, into durable state policy that rewarded breakthroughs leading to "technological autonomy." Technological autonomy, within the field of nuclear energy, meant national self-sufficiency in all stages of the nuclear fuel cycle from mining to uranium enrichment to spent fuel reprocessing. Argentina even began, in the late 1970s, to export research reactors to developing countries. Because neither government seriously pursued building a nuclear weapon, this is more a history focused on technology, development, energy policy, and the interplay of scientific and diplomatic communities in Argentina and Brazil, than on confronting the supposed specter of nuclear war menacing the world from South America.[1]

Nevertheless, the rest of the world's interest – particularly the United States – in the nuclear activities of the two nations that, between them, possess more than half of South America's land, population, and economic power,[2] *was* primarily motivated by minimizing the potential for nuclear weapons development by either country. In the extraordinarily tense

[1] How far Argentina and Brazil progressed toward developing weapons is a topic of vigorous debate to this day. I weigh the evidence in Chapters 4 and 5.

[2] GDP (Purchasing Power Parity) data taken from 2016 CIA World Factbook estimates, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2001rank.html. Using GDP per capita, Argentina and Brazil come in third and fourth, respectively, in South America behind neighbors Uruguay and Chile. http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=ZJ&year_high_desc=true. Brazilian population estimate from *Instituto Brasileiro de Geografia e Estatística* (IBGE) population clock, http://www.ibge.gov.br/apps/populacao/projecao/index.html. Argentine population estimate from *Instituto Nacional de Estadística y Censos* (INDEC). http://www.indec.gob.ar/nivel2_default.asp?id_tema=2&seccion=P. Land area given for Brazil, by IBGE, at http://ibge.gov.br/home/geociencias/cartografia/default_territ_area.shtm and for Argentina, by INDEC, at http://www.indec.gob.ar/nivel4_default.asp?id_tema_1=1&id_tema_2=15&id_tema_3=25. (Even without the disputed Malvinas Islands or Argentina's Antarctic claims being counted in the national land area, the statistic holds).

geopolitical environment of the Cold War, and after the first successful Soviet nuclear test in August 1949, nuclear nonproliferation dominated 1960s international diplomacy at the United Nations, resulting in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), signed July 1, 1968.[3] The NPT separated the world's nations into two groups: the five recognized nuclear weapon states, where weapons or nuclear explosive devices had been tested before 1967, and all others, collectively called non-nuclear-weapon states.[4] The triad of "pillars" that support the NPT – nonproliferation, disarmament, and peaceful use of nuclear energy[5] – were seen in Brazil and Argentina as insufficient to protect the rights of smaller and less powerful countries to develop a full range of peaceful nuclear technologies. The phrase "disarmament of the disarmed," evocatively used as a title of a 1987 book by Argentine Ambassador Julio Cesar Carasales, assailed the NPT regime as a discriminatory agreement that infringed on the inherent rights of sovereign nations to develop technology without interference. Carasales offered three speeches at the United Nations by Argentine officials over a sixteen-year period as

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[3] I accept Odd Arne Westad's definition (2007) of the "global Cold War" as the *time period* from 1945-1991 dominated by the conflict between the United States and the Soviet Union. Its flexibility helps to shift the focus away from the actions of those two nations per se, particularly in discussions of non-aligned countries still affected by the conflict, like Brazil and Argentina.

[4] Article IX, Treaty on the Non-Proliferation of Nuclear Weapons. https://www.un.org/disarmament/wmd/nuclear/npt/text Perhaps not coincidentally, the five recognized nuclear weapon states in the NPT are also the permanent members of the United Nations Security Council: the United States, United Kingdom, France, China, and the Soviet Union (now Russia).

[5] Ibid, Article I. The NPT is often discussed in terms of these three "pillars," including in official positions by Canada (http://international.gc.ca/world-monde/issues_development-enjeux_developpement/peace_security-paix_securite/nuclear-nucleaire.aspx?lang=eng), the United States Department of State (https://2009-2017.state.gov/t/isn/npt/statements/239606.htm), and an Indonesian ambassador at a speech in 2004 (https://web.archive.org/web/20051120114626/http://www.indonesiamission-ny.org/issuebaru/Events/opening_npt.htm). In brief, though the NPT will be discussed more in Chapters 2-5, its pillars are the following: "Nonproliferation" prohibits nuclear weapon states from transferring such weapons or nuclear explosive devices to any non-nuclear-weapon state, or from "assist[ing,] encouraging, or inducing any non-nuclear-weapon State to manufacture or otherwise acquire nuclear weapons." The disarmament pillar reads as one of the most quixotic clauses of the treaty's preamble, calling on parties to "achieve at the earliest possible date the cessation of the nuclear arms race and to undertake effective measures in the direction of nuclear disarmament." The last of the three pillars is outlined in Article IV as "the inalienable right of all the Parties to the Treaty to develop research, production, and use of nuclear energy with peaceful purposes" through "the fullest possible exchange of equipment, materials and scientific and technological information," with a new legal innovation called *safeguards* (Article III) to prevent the diversion of any material into unauthorized, covert weapons programs.

evidence of the country's long-standing and consistently reasoned opposition to that treaty. The reaction in Brazil to the terms of the Non-Proliferation Treaty mirrored Argentina's, reflecting frustration at being pushed to the margins of a major international negotiation process on uses and controls of nuclear energy.[6] In the past, when given the opportunity to act as representatives in these international fora, delegations from Brazil and Argentina had wielded considerable influence: Brazil was included in the United Nations Atomic Energy Commission (UNAEC) from 1946 forward, then alternated the Latin American seat on the International Atomic Energy Agency's (IAEA) Board of Governors with Argentina. But the South American neighbors featured even more prominently in the negotiations of the world's first regional nuclear nonproliferation treaty in Mexico City between 1964-1967.[7]

In Mexico, the extensive debates, working groups, and plenary sessions that would lead to the Treaty of Tlatelolco, signed on February 14, 1967, offered the delegations of Brazil's and Argentina's foreign ministries a peerless opportunity to shape the legal distinction between allowed (peaceful) nuclear activities and prohibited (military) uses of nuclear energy. The Tlatelolco negotiations are discussed extensively in Chapter 2, but Argentina's and Brazil's outsize role in them helps underscore the primary argument of this dissertation. Throughout the Atomic Age, the bilateral relationship between Brazil and Argentina shaped the path that each nation took in developing the technology and diplomacy that undergirded fiercely independent nuclear energy programs, pursuing aims of industrial development and national pride while motivated by a centuries-old competition for influence within South America.

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[6] It is true that Brazil was one of the delegations represented on the Eighteen-Nation Disarmament Committee that negotiated the NPT, as well as Mexico. Their inclusion among eight non-aligned nations on the UN committee did not ultimately prevent clauses in the final treaty that the South American neighbors would reject outright as discriminatory.

[7] The Latin American seat on the IAEA Board of Governors is discussed by Julio César Carasales in *De rivales a socios* as an arrangement made in 1962 that marks one of the earliest overt examples of cooperation between the two nations on nuclear energy policy.

Nuclear energy, in turn, as an exceptional form of technology with nearly unlimited potential either for catastrophic destruction or for cheap electricity and advances in medicine and agriculture, offered both countries a fresh start in the 1940s to climb to new heights on the geopolitical hierarchy of the postwar world. Argentina and Brazil both ran with this opportunity immediately after the end of World War II, "going their own way together," a phrase that I argue sums up each country's consistently independent orientation and action toward nuclear technology development. At the same time, each remained ever mindful of the presence and policies of the other. It would not be too much of a stretch to say that nuclear energy profoundly shaped modern Argentina and Brazil, both in their own pursuit of technological autonomy through nuclear energy independence, and in their relationship to one another.

By so characterizing the mutually constitutive nature of the two entities at the heart of this dissertation – nuclear energy technology and the complex special relationship between Brazil and Argentina – I do not assume that the countries shared a cooperative relationship. Such an assertion would be both simplistic and incorrect. Rather, I accentuate the idea that the actors responsible for technological and diplomatic developments within the nuclear energy field in Brazil or Argentina *always* took stock of what was happening – or what policymakers believed was happening – in the other country, whether in an adversarial, cooperative, or merely interested way. In blazing a "third way" in advanced and comprehensive peaceful nuclear energy programs for two countries not aligned with either Cold War superpower (though de facto in the Western camp), the South American neighbors were extremely successful. They gradually moved away from a dependent relationship with the United States in the 1950s toward their shared ambitious goal of autonomous control of the full nuclear fuel cycle in the 1980s. Scientists and technicians working to replace imported technology with domestically developed equivalents created an innovative substitute for the global nonproliferation regime that had been constructed largely without input from Argentina and Brazil, over the vociferous and repeated objections of officials from both countries. Tensions between the two nations reached their height in the 1970s as two military governments wound a conflict over Brazil's ambitious hydroelectric energy plans and advanced nuclear energy development outside international control ever more tightly. In the 1980s, however, military presidents Jorge Rafael Videla and João Figueiredo made nuclear energy cooperation a priority among many opportunities to improve the bilateral relationship between Argentina and Brazil. Scientific and technical communities played a key role in implementing the political project behind this rapprochement, as Brazilians explained intricate technical details of nuclear facilities to their counterparts in Argentina, and vice versa; an informal setup to exchange this type of information evolved in the mid-1980s. That informality actually helped build mutual confidence, which developed into law, treaty, and a mutual inspection regime. In Argentina and Brazil, nuclear energy paved a path to bilateral and regional peace instead of brinkmanship or war. In 1991, the neighbors crafted a most unusual resolution to the problem of weapons proliferation, creating a bilateral nuclear verification and control agency called ABACC that conducts over 100 inspections across vast swaths of Brazilian and Argentine territory per year. In no other part of the world has the successful pursuit of advanced nuclear technologies led to the practice and policy of nuclear nonproliferation in this way.

In analyzing the construction of nuclear energy technology and diplomacy in these two countries, I show how historical relational patterns shaped engagement with an unprecedented form of energy and its associated technologies to produce an unexpected outcome: a historical rivalry transformed into peaceful technological and economic cooperation. Two developing countries that began the Atomic Age by selling the United States their nuclear minerals ended it by exporting reactors and advanced technological knowhow to other nations in Africa, Asia, and Latin America, in some ways much like their own. Along the way, a series of irreversible decisions with enormous financial consequences by the state and nuclear energy authorities – Enriched or natural uranium fuel? Which bid to accept for imported technology? To budget for another surefire power plant or take a chance on an exciting but risky new type of reactor? - shaped the future of each nation's nuclear energy program and, in doing so, changed the delicate bilateral relationship of which energy policy was only a part. This is where historians can best contribute to a topic whose literature is dominated by political scientists and international relations experts. Irreversibility and contingency are at the heart of these parallel stories from Brazil and Argentina, where nuclear technology in many ways outpaced industrial development. But that is the end of a story that began billions of years ago, the denouement of a tale first built from elements in outer space and deep within the earth.

A Deep History of Uranium

The history of nuclear energy in Argentina and Brazil actually begins not in 1945, nor when uranium's radioactivity was discovered in 1896 by Henri Becquerel at his laboratory in France, but between six and seven billion years ago.[8] Atoms of uranium, thorium, and any other chemical element heavier than iron first formed in supernovae, or explosions of large stars with 20 or more times the mass of our Sun. Large stars are composed of onion-like layers of chemical elements, growing in atomic number and mass from the outside (hydrogen) to the core (iron).[9] But the iron core is a problem for the star. Unlike the fusion of lighter elements, which puts energy into the star and pushes against gravity, iron fusion requires a massive input

[8] Clifford A. Hampel, ed. *The Encyclopedia of the Chemical Elements.* New York: Reinhold Book Corp., 1968. Quoted in Iqra Zubair Awan and Abdul Qadeer Khan, "Uranium – The Element: Its Occurrence and Uses," *Journal of the Chemical Society of Pakistan* 37, no. 6 (2015): 1056.
[9] T.W. Hartquist and D. A. Williams. *The Chemically Controlled Cosmos.* Cambridge, UK: Cambridge University Press, 1995, 148.

of energy to hold its nuclei together. An iron-core star of sufficient age has no nuclear energy at the center and must cool unless a different energy source is available. The star succumbs to gravity, a collapse that creates heat, as the core itself disintegrates to form a neutron star.[10] The heat generated by the core's disintegration triggers a supernova, which releases an amount of energy whose magnitude humans can scarcely comprehend: the Sun radiates (in one year) a millionth of a millionth of the energy of a supernova in 1987 that was detected in the Large Magellanic Cloud.[11]

For the purposes of uranium and thorium formation, we are most concerned with two or three crucial, chaotic seconds of the supernova in which the rapid neutron capture process, or *r-process* for short, occurs.[12] A carbon or iron nucleus from the star's core or one of the 'onion layers' is bombarded with so many neutrons that it cannot decay by the more gradual *s-process* – slow capture of neutrons – that produces many lighter elements. In shocks like those of a supernova, a series of "neutron capture" reactions is unleashed to make elements heavier than iron, as an iron nucleus forms an extremely neutron-rich and unstable isotope; these isotopes then shed their excess neutrons, transforming some into protons through beta decay. Thus the iron nucleus becomes the (more stable) nucleus of an atom of a heavier element with a higher atomic number (number of protons) such as cobalt.[13]

The heaviest naturally occurring elements such as uranium and thorium are synthesized via the r-process almost instantaneously from lighter "seed nuclei" with masses between 50-100

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[10] Hartquist and Williams, *Cosmos*, 147.
[11] Hartquist and Williams, *Cosmos*, 144.
[12] Though much of the tremendous energy of a supernova is expelled as a huge number of neutrinos, these are electrically neutral subatomic particles so tiny that their mass was once believed to be zero, and S. A. Colgate and R. H. White's theory of supernova neutrino production was confirmed by this same 1987 supernova. Neutrinos interact very little with matter such as the nuclei surrounding the star's core, however, and are somewhat beyond the scope of the discussion here.
[13] Anna Frebel, *Searching for the Oldest Stars: Ancient Relics from the Early Universe* (Princeton, NJ: Princeton University Press, 2015).

atomic mass units, rather than by iterative addition of neutrons to heavier nuclei.[14] Formation of heavy nuclei such as the radioactive metals discussed here happens first in a state outside nuclear statistical equilibrium, as a high-temperature (post-supernova) stellar environment expands and cools to a point where quantities of various chemical elements shift to regain this equilibrium, the stage at which the entropy (or randomness) of the stellar system is at its maximum.[15] "The abundance of heavier nuclei," Meyer writes, "grows at the expense of free [protons or neutrons] and light nuclei." In purely numeric terms, the odds of the heaviest nuclei forming are infinitesimal. In a universe composed almost 98 percent of the lightest two elements, hydrogen and helium, an atom is nearly 300 million times more likely to be one of those gases (the input and product of solar fusion, respectively), than to be a heavy metal r-process product like uranium or thorium.[16] In Earth's crust, however, uranium is the 44th to 47th most abundant element, somewhat rarer than thorium, which is estimated to be around the 37th to 39th most common.[17]

The paradox of the formation of heavy elements, according to German astronomer Anna Frebel, is that nuclear fusion can only go so far in creating atoms no larger than iron. From that point, a complex series of radioactive decay processes takes over after that point of the periodic table to build heavier, unstable isotopes that decay into atoms of greater mass and numbers of protons.[18] "Like trying to walk up a downward-moving escalator," the *r-process*

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[14] Bradley S. Meyer, "The r-, s-, and p-processes in nucleosynthesis," *Annual Review of Astronomy and Astrophysics* 32 (1994): 164.
[15] Meyer, "Nucleosynthesis," 155; 161-163.
[16] Abundance of elements information taken from Margaret Burbidge, G.R. Burbidge, William A. Fowler, and F. Hoyle, "Synthesis of the Elements in Stars." *Reviews of Modern Physics* 29, no. 4 (1957): 553. This article was absolutely fundamental to the astronomical and astrophysical research of the later authors cited above. Calculations are my own.
[17] Averages of abundance taken from six data sets here: https://en.wikipedia.org/wiki/Abundances_of_the_elements_(data_page)#Earth_bulk_continental_crust_and_upper_continental_crust. Ranges given are for average abundance among all six data points and for average of four middle data points in each set, with highest and lowest values removed.
[18] Frebel, *Searching*,107.

builds a heavy nucleus as one might "run up the escalator pretty fast, faster than it is moving down, otherwise you would not get to the top."[19] These words, coincidentally, work as well to describe Brazilian and Argentine engagement with nuclear energy in a complex and unequal geopolitical context as they do to describe the statistically unlikely construction of heavy nuclei in space.

After this brief summary of the truly astronomical energy input required to create the heaviest naturally-occurring atomic nuclei, perhaps the immense quantity of energy locked inside atoms of thorium and uranium is slightly less surprising, but the number is still astonishing: One kilogram of completely fissioned uranium-235 has the same hypothetical fuel value as 1.6 million kilograms of coal.[20] Uranium was initially prized for its color; a glass or ceramic object found near Naples, Italy, and dated to around 79 AD/CE, had been dyed a yellowish color using uranium oxide.[21] German chemist Martin Heinrich Klaproth discovered elemental uranium in 1789 when analyzing pitchblende, an ore of the radioactive metal that is a blend of uranium dioxide (UO_2) and triuranium octoxide (U_3O_8), and French chemist Eugène-Melchior Péligot first isolated a sample of uranium metal in 1841. Another French scientist, physicist Henri Becquerel, discovered radioactivity in 1896 after leaving a sample of potassium uranyl sulfate on an unexposed photographic plate in a drawer; even in the absence of light, the plate became "fogged," which Becquerel inferred to be the effect of invisible light or rays emitted by the uranium in the salt.[22]

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[19] Frebel, *Searching*, 114-115.
[20] John Emsley, *Nature's Building Blocks: An A to Z Guide to the Elements* (Oxford, UK: Oxford University Press, 2001), 479.
[21] http://web.ead.anl.gov/uranium/guide/facts/ and Hammond, C. R., "The Elements," in annual editions of the *CRC Handbook of Chemistry and Physics*, p. 4-32.
[22] Emsley, *Building Blocks*, 478.

From the point of view of nuclear energy, the radioactivity discovered by Becquerel, also called spontaneous fission, is much less important than induced fission. In an induced nuclear fission chain reaction, one of two *fissile* isotopes of uranium (233 or 235, but not the "natural" 238 that makes up more than 99% of uranium deposits) or plutonium-239 are bombarded with free neutrons. The odd number of nucleons (protons + neutrons) in these fissile isotopes is key, as the "extra" neutron which triggers the fission reaction can be absorbed into the same nuclear orbital as the unpaired, odd neutron. Thus, any single neutron supplies the energy required to split the uranium or plutonium nucleus into two (or sometimes three) smaller nuclei and a few neutrons, which keep the chain reaction going by causing fission of more uranium or plutonium nuclei. Induced nuclear fission "works" to produce energy because of Einstein's famous $\mathbf{E = mc^2}$ mass-energy equivalence; the products of a fission reaction – for example, krypton-95 and barium-137[23] and a few neutrons – are lower in mass than the nucleus that was broken apart, and this difference in mass is released as a tremendous burst of heat and radioactive gamma rays.

Around 140 million years ago, the continent of South America began to separate from Africa, forming the South Atlantic Ocean as the supercontinent Pangea continued to break up in the Early Cretaceous period. The silver veins of Potosí, Zacatecas, and other famous sites scattered through the territory of modern Mexico and within roughly 1,000 km of the Pacific coast of South America poured forth the treasure that would enrich the Spanish Crown. The Portuguese colonists of Brazil waited and waited for their own precious metal rush, motivated by "the apparently undeniable logic that a continent that had rewarded the Spaniards with gold, emeralds, and silver must also possess precious metals in that part allocated to [them] by the

[23] http://www.nuclear-power.net/nuclear-power-plant/nuclear-fuel/uranium/uranium-235/uranium-235-fission/, sourced from JANIS (Java-based Nuclear Data Information Software); ENDF/B-VII.1.

Treaty of Tordesillas (1494)."[24] Eventually, their patience was rewarded in the early eighteenth century with the discovery of gold and precious gems that lay under the mountains of Minas Gerais, a fortune that would have "immediate and far-reaching repercussions not only on the society and economy of Brazil, but also on the mother country and her political and economic position within Europe."[25]

In the mid-twentieth century, the mineral resources of Brazil and Argentina were again highly desired by a global economic power, but this time it was the United States, enmeshed from 1942 through 1946 in the Manhattan Project, an ultra-secret quest to develop a nuclear weapon, eventually fueled by uranium ore purchased from around the world. Getúlio Vargas sold some of Brazil's monazite sands, containing thorium, to the United States one month before the Hiroshima bomb was detonated.[26] The ground had been laid for another extractive relationship between Latin American states and a faraway power based on important and valuable mineral resources, but scientific and political leaders in Brazil and Argentina were determined not to repeat the mistakes of the colonial past in the Atomic Age.

The government of Argentina's new National Atomic Energy Commission (CNEA) began uranium exploration in 1951, finding the Huemul sandstone-type deposits in Mendoza province in 1954 and treating its ores at the Malargüe plant built in the same year. By 1986, Argentine prospectors had found uranium deposits spanning roughly the western one-third of the country, scattered across eight major uranium districts spanning from Aguiliri in the north to Pichiñan and Sierra Cuadrada in the southern province of Chubut. 90% of Argentina's recoverable uranium – thirty thousand tons – lay in sandstone-type deposits formed in the

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[24] A. J. R. Russell-Wood, "Colonial Brazil: The Gold Cycle, *c.* 1690-1750," in *Cambridge History of Latin America*, vol. 2 (Cambridge, UK: Cambridge University Press, 1984), 547.
[25] Russell-Wood, "Colonial Brazil," 550.
[26] Carlo Patti, "The origins of the Brazilian nuclear programme, 1951-1955," *Cold War History* 15, no. 3 (2014): 2.

Upper Cretaceous period, 100 million to 66 million years ago. An IAEA panel in 1987 discussed metallogenesis[27] within the practice of uranium exploration, and argued that deposits should be no smaller than "8000 tons U_3O_8 with an average grade of 0.3%" to make their exploration economically viable.[28] While debates about geologic processes that occurred millions of years ago may seem tangential to current uranium exploration and mining, that panel warned that "much more emphasis" should be placed on "studying the mechanisms of the formation of higher grade uranium concentrations," while their colleagues in two other panels recommended "a classification scheme for minable uranium deposits" due to the near future expectation that uranium demand would exceed production capacity, and to mitigate the gradual reallocation of private and governmental funds away from uranium research.[29]

As if a mirror of its neighbor Argentina, Brazil's uranium deposits primarily cluster in the east, hugging the Atlantic littoral in states from Ceará in the northeast to Rio Grande do Sul in the south, with the notable exceptions of sandstone deposits at Amorinópolis and a polymetallic breccia complex at Carajás.[30] Systematic uranium exploration began in 1952, but was cut back in 1984 – ironically, the same year that Brazilian scientists noted the potential of uranium to alleviate the national energy deficit in an IAEA publication on South American geology and metallogenesis – and discontinued entirely in 1991 before resuming in the Lagoa Real (Bahia) region in 2000.[31] Unlike Argentina, Brazil's recoverable reserves of 278,400 tons

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[27] "Study of the origin of ore deposits and of the interdependence in time and space of this process with other geologic processes such as tectonics." *A Dictionary of Earth Sciences*, Oxford, UK, Oxford University Press, 1999.
[28] International Atomic Energy Agency, *Metallogenesis of Uranium Deposits: Proceedings of a Technical Committee Meeting, Vienna, 9-12 March 1987* (Vienna: IAEA, 1989), 475.
[29] IAEA, *Metallogenesis*, 473, 478, 480.
[30] Franz J. Dahlkamp, *Uranium Deposits of the World: USA and Latin America* (Berlin: Springer-Verlag, 2010), 451.
[31] Dahlkamp, *Uranium Deposits*, 451, and C.V. D'Elboux, "Principales modelos brasileños de mineralizaciones uraniferas," in International Atomic Energy Agency, *Geology and Metallogenesis of Uranium Deposits in South America: Proceedings of a Working Group Meeting, San Luís, Argentina, 21-23 September 1981*. Vienna: IAEA, 1984, 143-144. "Breccia" is a geological term derived from Italian that refers to rock consisting of clasts (broken

of uranium are sufficient to place it among the top ten nations in the world, but its historical production of uranium falls far below the other nine; the ninth producer among the top ten reserve nations is China, outproducing Brazil almost ten to one by 2014.[32] In light of what is now known about the comparative uranium reserves of Argentina and Brazil, the two countries might better have exchanged their eventual decisions on the most prudent technological path to nuclear power. Technicians and politicians in relatively uranium-poor Argentina opted for natural (unenriched) uranium fuel in their power reactors, with imported deuterium oxide, or heavy water, as a moderator, while those in uranium-rich Brazil chose enriched uranium fuel with regular (or light) water moderator, which had to be imported until the Navy mastered autonomous enrichment capabilities in the 1980s, a decision that will be discussed in Chapters 3-5.

Historiographical Debates and Background

This dissertation intervenes in several vigorous historiographical questions and debates about nuclear energy and its uses in the developing world and Global South; the formation and networking of scientific and technical communities; the nature of the relationship between the state and technology in post-World War II Latin America; the role of technological and scientific advancement in a nation's self-conception, and in how that nation is seen by others; the value of pharaonic projects in state-led industrial development; the power of "big science" and state-funded technology to shape and change complex bilateral and international relationships; and the role of the military in politics, technological development, and economic and industrial planning.

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fragments of rock) held together by a fine-grained matrix, which in turn is made of microscopic crystals, clay, or silt. www.meteorlab.com/METEORLAB2001dev/glossary.htm

[32] Dahlkamp, *Uranium Deposits*, 452, and OECD Nuclear Energy Agency (NEA) (2016), *Uranium 2016: Resources, Production and Demand*, OECD Publishing, Paris. http://dx.doi.org/10.1787/uranium-2016-en

Recent dissertations on nuclear energy in Argentina and Brazil, mostly from departments of political science or government, have helped me a great deal to set the disciplinary boundaries and scope of this project. Particularly useful dissertations from political science have collected historical data to make arguments about the theory or practice of governance. I proceed chronologically through a brief analysis of each dissertation, except when two authors are in direct conversation with one another in terms of topic or conclusion.

Though 1970 is hardly recent, John Redick's dissertation on the Treaty of Tlatelolco is a standard-bearing, comprehensive account of "the negotiating process and ultimate significance" of the world's first regional nuclear nonproliferation agreement.[33] (Thankfully, 45 years of scholarship since Redick's have given me some new arguments and cases to consider in Chapter 2). Walton Brown argues that between 1975 and 1980, Argentina and Brazil challenged US nonproliferation policy in three ways: Brazil's technology transfer deal with West Germany showed a decreasing US ability to have its European allies support it on the issue of nonproliferation; American policy makers were ignorant of potential economic and military motives for both the European countries and the South American countries involved in transfer agreements; and the US had no tactics ready to counter a nuclear market among developing countries, where Argentina and Brazil had been quite successful.[34] Michael Joe Siler takes up a similar topic to Walton Brown, focusing on the effectiveness of US policy in preventing nuclear weapons proliferation in four Global South countries, India, Brazil, South Korea, and Egypt, but comes to the opposite conclusion: that "US influence is instrumental in

[33] John Robert Redick, "The Politics of Denuclearization: A Study of the Treaty for the Prohibition of Nuclear Weapons in Latin America" (PhD dissertation, University of Virginia, 1970.)
[34] Brown, Walton L. "Assessing the Impact of American Nuclear Non-Proliferation Policy, 1970-1980: An Analysis of Six Cases" (PhD dissertation, University of Michigan, 1982.)

determining Southern states' compliance with the global nonproliferation and safeguard regime(s)."[35]

Regis Cabral wrote perhaps the first comparative dissertation on Brazil and Argentina that discussed the decade immediately following World War II, analyzing the heady starting days of both nuclear programs, and he used his work as a test case for improving scholarly treatment of the "cultural aspect of human relations" in both dependency theory and national security doctrine.[36] Jean Krasno goes very much in the direction later taken by Jacques Hymans (2006) to ask why Brazilian leaders let a weapons program go as far as they did. Her work, based upon detailed interviews, is a useful exploration in considering the chaotic 1980s in terms of nuclear Brazil and its rapidly changing relationship with Argentina.[37] James Doyle is also involved in a scholarly conversation about the psychology of nuclear proliferation, but examines the phenomenon of nuclear rollback, when a nation steps away from the brink of developing a nuclear weapon (or, in the case of South Africa, dismantles existing weapons and renounces their use going forward). His work explores the motivating factors for a "voluntary decision by either a potential proliferator or a state with nuclear weapons to give them up." Doyle's argument that "Argentina and Brazil derived political benefits from supporting one another's decisions to remain outside the global nonproliferation regime" has helped to shape my discussion of the bilateral relationship in this dissertation.[38]

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[35] Michael Joe Siler, "Explaining Variation in Nuclear Outcomes Among Southern States: Bargaining Analysis of U.S. Non-Proliferation Policies Towards Brazil, Egypt, India, and South Korea" (PhD dissertation, University of Southern California, 1992), 7.
[36] Regis Cabral, "The Interaction of Science and Diplomacy: Latin America, The United States and Nuclear Energy, 1945-1955" (PhD dissertation, University of Chicago, 1986.)
[37] Jean E.C. Krasno, "The role of belief systems in shaping nuclear weapons policy preference and thinking in Brazil" (PhD dissertation, City University of New York, 1994.)
[38] James Edward Doyle, "Nuclear Rollback: A New Direction for US Nonproliferation Policy?" (PhD dissertation, University of Virginia, 1997), 5, 123.

Paulo de Mesquita Neto studies the transformation in the Brazilian military from 1974-1992, arguing that the process of shifting its behavior pattern from intervention to participation was ultimately more significant than its formal withdrawal from politics and played a preventative role, too, keeping a fragile elected democracy in power from 1985-1992.[39] Carina Miller uses Argentina's advanced nuclear energy program as a case to show how that nation, as a middle power, used international organizations to achieve its foreign policy goals. She argues that her work provides a needed corrective to studies on international organizations, focusing not on the organizations themselves, but how states have used them toward their own ends.[40]

Michael Barletta, while not explicitly in conversation with Regis Cabral, extends the temporal scope of his earlier analysis by conducting dozens of interviews of participants in the nuclear programs of both Argentina and Brazil. Barletta used framing analysis and a constructivist approach to more accurately analyze the historical events in a bilateral relationship where he argued that realist and neorealist theories had poor predictive power.[41] Andrea Oelsner undertakes an ambitious "comparison of comparisons," showing why a faster *rapprochement* between Argentina and Brazil took place compared to a slower improvement in Argentine-Chilean relations. Her overall argument explains that the Southern Cone countries moved at different paces toward "ceas[ing] to perceive one another as potential enemies," and instead began to look toward cooperation and integration as official foreign policy. [42]

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[39] Paulo de Mesquita Neto, "From Intervention to Participation: Transformation of Military Politics in Brazil, 1974-1992" (PhD dissertation, Columbia University, 1995.)
[40] Carina J. Miller, "Potential and Limits of Influence Without Power: Argentina's Pursuit of Foreign Policy Goals Through International Organizations" (PhD dissertation, Georgetown University, 1997.)
[41] Michael Anthony Barletta, "Ambiguity, Autonomy, and the Atom: Emergence of the Argentine-Brazilian Nuclear Regime" (PhD dissertation, University of Wisconsin-Madison, 2000.)
[42] Andrea Oelsner, "Security in Latin America: Development of a Zone of Peace in the Southern Cone" (PhD dissertation, London School of Economics and Political Science, 2003), 22. ("Comparison of comparison" is my characterization, not hers).

Isabella Alcañiz argued for the power of ideas in bringing together the two national epistemic communities to effect the agreement between civilian presidents Sarney and Alfonsín in 1985.[43] Sara Kutchesfahani's dissertation on epistemic communities in nonproliferation policy formation is both comparative and chronologically later in its focus, but speaks to Alcañiz's work on the interplay between policymakers and technical experts in comparing the ABACC (Brazil-Argentina) nuclear verification organization with the Cooperative Threat Reduction agreement to denuclearize Belarus, Kazakhstan, and Ukraine.[44]

Taking a broader view of the historiographies that inform this dissertation, one of the most evident scholarly conversations that this research contributes to and takes from is that around the development of science and technology in Latin America. Thomas Glick, in 1995, explained the region's scientific and technological development as having "rarely been smooth or lineal" in his introduction to twentieth-century science and society in Latin America. In a survey of the topic that mostly focuses on reception of (rather than engagement with) scientific ideas from the North Atlantic "core" countries, Glick's treatment of physics, particularly in Argentina and Brazil, stands out as surprisingly charitable.[45] At least two distinct and opposed schools of thought have emerged on developing world science. One follows George Basalla's fundamental 1967 essay, "The Spread of Western Science," which posited a three-step model for how "nonscientific societies or nations" first provided sources for Western European science, then proceeded through a period of "colonial science," followed by "completing the process of transplantation with a struggle to achieve an independent scientific tradition (or culture)."[46]

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[43] Isabella Alcañiz, "Ideas, Epistemic Communities and Regional Integration: Splitting the Atom in Argentina and Brazil" (PhD dissertation, Northwestern University, 2004.)
[44] Sara Z. Kutchesfahani, "Politics & The Bomb: Exploring the Role of Epistemic Communities in Nuclear Non-Proliferation Outcomes" (PhD dissertation, University College of London, 2010.)
[45] Thomas Glick, "Science and Society in Twentieth-Century Latin America." *Cambridge History of Latin America*, Vol. 6, 1995.
[46] George Basalla, "The Spread of Western Science." *Science*, 156 (May 5, 1967), 611.

Even as late as 1987, Argentine-Venezuelan anthropologist Hebe Vessuri wrote that "today attention is focused upon the cultural backwardness of particular countries, the cultural and technological heterogeneity of the region, the science and technology lag in Latin America *vis-à-vis* advanced countries…" as a deficiency model seemed to grip even researchers within the region trying to understand scientific practice in their own countries.[47] Vessuri's later work, however, moved toward understanding the linkages between the university system and scientific research and development activity, and opportunities that this linkage offered Latin American nations and institutions for international cooperation, and still later, toward synthesizing the history of science in Venezuela.[48] Marcos Cueto, historian of medicine at Fiocruz in Rio de Janeiro, has worked to illuminate local and indigenous medical practice throughout Latin America, whether in analyzing the treatment of yellow fever in Peru,[49] explaining laboratory styles in Argentine physiology,[50] or documenting efforts to eradicate malaria in Mexico.[51] Most importantly for this dissertation, Cueto's efforts to elucidate the transnational connections between the Rockefeller Foundation and Latin American governments and scientific institutions are an effective model of not only how to "follow the money" in historical research on science, but to integrate treatment of different national contexts and aims.[52]

Later Latin American historians of science, led by revisionists such as Mexican scholar

[47] Hebe Vessuri, "The Social Study of Science in Latin America," *Social Studies of Science* 17, no. 3 (1987): 520.
[48] Hebe Vessuri, "Higher Education, Science, and Engineering in Late 20th Century Latin America: Needs and Opportunities for Co-operation," *European Journal of Education* 28, no. 1 (1993): 49-59, and "Investigación y desarrollo en la universidad latinoamericana," *Revista Mexicana de Sociología* 59, no. 3 (1997): 131-160, for example.
[49] Marcos Cueto, "Sanitation from above: Yellow Fever and Foreign Intervention in Peru, 1919-1922," *Hispanic American Historical Review* 72, no. 1 (1992): 1-22.
[50] Marcos Cueto, "Laboratory Styles in Argentine Physiology," *Isis* 85, no. 2 (1994): 228-246.
[51] Marcos Cueto, *Cold War, Deadly Fevers: Malaria Eradication in Mexico, 1955-1975* (Baltimore: Johns Hopkins University Press, 2007).
[52] Marcos Cueto, "The Rockefeller Foundation's Medical Policy and Scientific Research in Latin America: The Case of Physiology," *Social Studies of Science* 20, no. 2 (1990): 229-254.

Juan José Saldaña, have offered a vigorous challenge to Basalla's "colonial science" model, going beyond even the pioneering work of Vessuri and Cueto, and disputed Glick's emphasis on passive reception versus active engagement with scientific ideas in the region. In the introduction to *Science in Latin America: A History*, Saldaña explains that history of science, as a subfield, has moved toward analyzing scientific ideas and the external conditions that facilitate science. Specifically in Latin America, historians of science have begun "thinking our science," a geographically situated alternative that Brazilian historian of science Shozo Motoyama called a "social process that could be understood even outside the European framework."[53] Eden Medina, Ivan da Costa Marques, and Christina Holmes edited a 2014 collection of papers on science, technology, and society in Latin America called *Beyond Imported Magic*. Their introduction identifies two key themes, one analytical and focused on the creation, movement, change, and adaptation of technologies and scientific ideas, and the other situational, portraying the realities of Latin American experience undergirding the history of science and technology in that region of the world.[54]

The key role of the military, particularly in Brazil, of advancing nuclear technology in line with its security goals, is but one example within a long history of the active involvement of the armed forces in technological development in Latin America; the brief mentions here are meant to focus on energy topics and are not at all inclusive of this body of literature. Michael Barzelay handled a related case to nuclear energy in his analysis of the military government's ambitious project for sugar alcohol to replace gasoline in Brazil's cars,[55] while Emanuel Adler

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[53] Motoyama is also the coordinator and editor of an excellent and detailed survey of Brazilian scientific history with chapters co-authored by leading historians of science, *Preludio para uma história* (São Paulo: EDUSP, 2004).
[54] Eden Medina, Ivan da Costa Marques, and Christina Holmes, eds, *Beyond Imported Magic: Essays on Science, Technology, and Society in Latin America* (Cambridge, MA: The MIT Press, 2014).
[55] Michael Barzelay, *The politicized market economy: Alcohol in Brazil's energy strategy*. Berkeley, CA: University of California Press, 1986.

took a comparative approach, explaining Brazil's success in developing a national microcomputer while Argentina enjoyed a considerable edge in nuclear energy technology over its northeastern neighbor.[56] Sociologist Peter Evans' study of the triad of transnational corporations, the Brazilian state, and private local capital as the engines of technological development during military rule, *Dependent Development: The Alliance of Multinational, State and Local Capital in Brazil*, has served as an excellent model for what questions to ask of the intricate linkage between technological development and the state in Latin America.[57] Yet his cases do not take into account the relative independence of the armed forces in pursuing autonomous or parallel nuclear technologies between 1979 and the late 1980s. Within nuclear energy activities, the Brazilian military played at least two roles, one in governing and managing the mechanism of the state, and another in advocating for and developing indigenous capabilities to execute the full nuclear fuel cycle. (Argentina's overt military involvement in nuclear energy development was limited to the appointment of high-ranking members of the armed forces to chair CNEA during periods of military rule in that country).

This dissertation also explores the connections between three related historical phenomena: the military in politics in Latin America, the transition from military to electoral governance and persistent influence of the armed forces in nominally democratic decision-making processes, and a *longue durée* view of the rapprochement between Argentina and Brazil centered at first on energy policy and then on plans for a more overarching and ambitious economic integration. The work of David Rock, such as *Authoritarian Argentina: The nationalist movement, its history, and its impact*, explains the prevailing intellectual culture among military

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[56] Emanuel Adler, *The power of ideology: The quest for technological autonomy in Argentina and Brazil*. Berkeley, CA: University of California Press, 1987. Adler convincingly shows the impact of ideology and institutionalization on a state technology project's failure or success.
[57] Peter Evans, *Dependent Development: The Alliance of Multinational, State and Local Capital in Brazil*. Princeton, NJ: Princeton University Press, 1979.

and civilian nationalists alike in that country, which fueled anti-Communism, anti-Americanism, and lay the groundwork for the authoritarian dictatorships that would take power between 1966-1973 and 1976-1983. Robert Potash's three-volume account of the Argentine military from 1928-1973 is lighter on its treatment of the military as policymakers, but maintains a focus on the army (and its repeated entrances into and exits from politics) that Rock's work does not take up as forcefully. The Argentine military journal *Estrategia*, published 1969-1983, offers a broad view of the constellation of issues and crises faced by the military in government and as guarantors of the nation's security, containing dozens of articles by generals (or prominent foreign authors) on Argentina's relationship with Brazil, nuclear energy development, or the simmering conflict with Chile that would eventually nudge military leaders toward a rapprochement with Brazil.

Scholarly analyses of the 21-year military regime in Brazil, at least in English, owe a great deal to the pioneering monograph of Alfred Stepan, *The Military in Politics: Changing Patterns in Brazil* (1971.) David Pion-Berlin pinpointed Stepan's book in a 1995 article as the source of heightened scholarly interest in the dictatorships, but until 1988, this wave of research focused more on the societal factors and structures that led to authoritarian regimes, at the expense of analyzing the regimes themselves.[58] Thomas Skidmore's comprehensive *The Politics of Military Rule in Brazil, 1964-85* was one of the first books to rectify this narrative gap; scholars of comparative politics such as Wendy Hunter then began to explore the persistence of military influence under civilian electoral government.[59] Hunter's work is particularly apt for helping to understand the military's continued leadership in determining the direction of

[58] David Pion-Berlin, "The Armed Forces and Politics: Gains and Snares in Recent Scholarship," *Latin American Research Review* 30, no. 1 (1995): 149.
[59] Wendy Hunter, *Eroding Military Influence in Brazil: Politicians Against Soldiers* (Chapel Hill, NC: University of North Carolina Press, 1997.)

nuclear energy development in Brazil after 1985 and civilian president José Sarney's acquiescence to this pattern.

As historians and political scientists have begun to make sense of the events leading to economic integration of South America between 1991-1994, many scholars have analyzed the fundamental role of the changes in the bilateral Argentine-Brazilian relationship in effecting those broader processes. Martin Mullins's *In the Shadow of the Generals* treats Argentine foreign policy in the Southern Cone as discontinuous and marked by an intense internal debate as to the ultimate goals of its architects; Brazilian foreign relations, in contrast, show a trademark desire to be a global actor on a stage bigger than the country's Latin American backyard.[60] Marcelo Gullo's *Argentina, Brasil: La gran oportunidad* (2005) posits that both countries' "historical survival" in a post-Cold War geopolitics dominated by the United States "depends on the urgent arrangement of a strategic alliance" between them.[61] Alessandro Candeas takes a longer chronological view of two centuries divided into periods of rivalry (1810-1851; 1870-1880), cooperation (1852-1870), short periods of rivalry and cooperation (1880-1915), and a general tendency toward cooperation with relapses into rivalry (1915-1961) before the rupture of the military regimes, then the eventual turning point in 1979 toward more stable and permanent cooperation and integration.[62]

Andrea Oelsner argues that Chile is a necessary actor to gain a full understanding of the relationships that define the modern Southern Cone, and analyzes the development of two "dyads," the relationship between Argentina and Brazil, and that between Argentina and Chile. These two dyads are key to understanding both the process of "desecuritization" and the

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[60] Martin Mullins, *In the Shadow of the Generals: Foreign Policy Making in Argentina, Brazil, and Chile* (Hampshire, England: Ashgate Publishing Limited, 2006.)
[61] Marcelo Gullo, *Argentina, Brasil: La gran oportunidad* (Buenos Aires, Biblos, 2006): 14-15.
[62] Alessandro Candeas, *A integração Brasil-Argentina: história de uma ideia na "visão do outro,"* (Brasília: Fundação Alexandre de Gusmão, 2010.)

dissipation of antagonistic Southern Cone geopolitics that defined the decades of foreign policy of those three countries until the 1980s.[63] Roberto Russell and Juan Gabriel Tokatlian offer an account – *El lugar de Brasil en la política exterior argentina* – to mirror Miriam Gomes Saraiva's *Encontros e desencontros: o lugar da Argentina na política externa brasileira.*[64] The work of these scholars, and many more, has been important in developing a fuller context for the intervention of this research into understanding a crucial bilateral relationship in South America.

Chapter Structure and Summary

In tracing the coevolution of nuclear energy technology in Brazil and Argentina and the complex bilateral relationship between the neighbors, some chapters of the dissertation are necessarily comparative – Chapter 4 covers the same period of time and area of nuclear activities in Argentina as Chapter 5 does in Brazil, for example. Other chapters are explicitly interactive, such as Chapter 3, which analyzes the problems that motivated the innovative technological and diplomatic resolution described in Chapter 6. Each chapter carries a one-word title that is also the name of a stage within the nuclear fuel cycle, except for Chapters 2 and 6, which are named "Swords" and "Plowshares". My point in naming these chapters in this way is not that history is cyclical or static. Rather, I aim to emphasize the deliberate budgetary, ideological, technological, and geopolitical decisions that shaped the consequences – intentional or unintended – of Brazil's and Argentina's herculean efforts to achieve a new type of political independence in the second half of the twentieth century.

Chapter 1, **Exploration**, "Atoms for Peace and the Nuclear 1950s in the Americas," begins with the promise and hope that peaceful nuclear technology offered for the developing

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[63] Andrea Oelsner, *International Relations in Latin America: Peace and Security in the Southern Cone* (New York: Routledge, 2005.)

[64] Roberto Russell and Juan Gabriel Tokatlian, *El lugar de Brasil en la política exterior argentina* (Buenos Aires: Fondo de Cultura Económica, 2003), and Miriam Gomes Saraiva, *Encontros e desencontros: o lugar da Argentina na política externa brasileira* (Belo Horizonte, Brazil: Fino Traço Editora, 2012.)

world, and the steady rise in national, regional, and global institutions to control and facilitate the utterly radical and new form of energy production. I introduce the community of notable physicists that had begun to form in Argentina and Brazil as part of an analysis of the creation of nuclear energy organizations and agencies in Brazil and Argentina. Argentine president Juan Domingo Perón and his Brazilian counterpart Getúlio Vargas both saw nuclear energy as a state project worthy of effort and enormous financial investment to create highly specialized technological capital quite literally from the ground up, and rushed to provide financial support for the immense startup costs of serious and substantive nuclear energy research programs. As outlined in Eisenhower's 1953 "Atoms for Peace" speech at the United Nations, overt United States rhetorical and financial encouragement of peaceful technology development shaped Latin America's early efforts in civilian nuclear energy.

But Brazilian and Argentine nuclear policymakers, most notably Álvaro Alberto (1889-1976), naval admiral, mad scientist specializing in explosive technology, and architect of Brazil's earliest nuclear energy ideas and efforts, knew that a close relationship with the United States might carry a heavy price of dependence. Alberto introduced the idea of "specific compensation," taken up by Juscelino Kubitschek in his ambitious program of Brazilian industrialization. Alberto fought to use the intrinsic value of nuclear minerals to the United States' nuclear weapons and peaceful energy programs to Brazil's advantage, enabling the South American nation to "purchase" nuclear know-how and infrastructure from the United States and Europe with payments of minerals. Alberto's idea of specific compensation echoed strongly in future ideas on technology transfer in both South American nations. The leaders and technical communities of Brazil and Argentina went all in on early nuclear energy development, and the vertiginous pace of institutionalization and budgetary spending marked the beginning of their "own way" through the Atomic Age.

Chapter 2, **Swords**, "Brazil and Argentina: From the Forefront of Non-Proliferation Toward an Uncertain Nuclear Future, 1963-1970," traces the effects of military rule on the negotiations of the world's first regional nuclear nonproliferation treaty, motivated by the terrifying Cuban Missile Crisis. Brazil's last democratically elected president before the military coup, João Goulart, had joined four other Latin American heads of government to call in 1963 for preliminary work on such a treaty, while Argentina was at least not opposed to this idea. Yet at Tlatelolco, in Mexico City, their delegations would work together to dilute or scuttle some of the treaty's most visionary, contentious, and far-reaching ideas, favored by a group of nations led by Mexico. The actions and positions taken by officials and diplomats from the South American neighbor countries clung tightly to the sovereign right of nations to pursue the full range of non-military nuclear technologies, including "peaceful nuclear explosions," a permission of the treaty that Mexico and the United States identified as a dangerously exploitable weakness. Chapter 2 analyzes *why* Brazil and Argentina held these positions so tenaciously, using formerly classified diplomatic communications, and examines the idea and practice of peaceful nuclear explosions through the proceedings of a 1970 IAEA conference on the topic. In the mid- and late 1960s, Brazil and Argentina placed more distance between their own trajectory in nuclear energy and that of their fellow Latin American nations, particularly Mexico, clearing the brush at Tlatelolco away from the broadest possible path for peaceful use.

Chapter 3: Partitioning, "Nuclear Power and the Divergence of Technological Paths, 1966-1974," is the third of the interactive chapters that compose the first half the dissertation. Argentina and Brazil both faced narrower and more irreversible tracks for the development of nuclear energy technologies, and made key decisions in an environment of hazy economic information, growing mutual distrust motivated by hard-line military leaders in power in both countries, and a paralyzing petroleum crisis. Energy policy and scarcity badly damaged the close relationship forged between Argentine and Brazilian delegates at Tlatelolco, as Brazil substituted the colossal potential for hydroelectric power from the Itaipu Dam, constructed during this period, for its stalled efforts to produce nuclear power plants from West Germany. Then, the administration of Ernesto Geisel turned to West Germany for help restarting Brazil's nuclear energy plans through a massive technology transfer deal in 1975. Meanwhile, Argentina's first nuclear power reactor went into operation, relatively smoothly and on schedule. Military rule did not change the high importance granted to the goal of technological autonomy through nuclear energy self-sufficiency, one fundamental continuity in a tense period that divided the neighbor countries along the crucially important fault lines of energy policy in times of extreme scarcity, and in Argentina's case, disruptive political instability. Especially in periods of bilateral conflict, like that analyzed in Chapter 3, Brazil and Argentina kept a watchful eye on each other, particularly on their responses to the global petroleum crisis; in Chapters 4 and 5, the paths of the two nations would draw nearer once again as both countries developed autonomous uranium enrichment capabilities.

Chapter 4: Enrichment, "Autonomous Nuclear Development in Argentina, 1975-1985," is one of two chapters constructed in parallel (with the same years in Brazil) to analyze the ideology and development of autonomous nuclear energy technologies under military rule. Wealthy industrial nations who had supplied nuclear technology and fuel to developing nations were spooked by successful Israeli (1966), Indian (1974), and South African (1979) nuclear weapons tests and the threats they posed to the fragile nonproliferation regime, toward which major nuclear energy players such as Argentina and Brazil maintained their defiance.[65]

[65] Israel is believed to have built its first operational nuclear weapon in December 1966, according to Ari Shavit, *My Promised Land* (2014). Avner Cohen gives an exhaustive account of Israel's nuclear program in *Israel and the Bomb* (New York, Columbia University Press, 1999). The official policy of Israel regarding its nuclear weapons

Argentina hit two major blockages as it planned its next steps for nuclear energy after the *Atucha* power reactor became operational in 1974, the first such achievement in Latin America or the Caribbean. The brutality of the *Proceso de Reorganización Nacional* military junta that had taken power in a March 1976 coup spared no suspected political leftists or communists. The country's universities – centers of the scientific and technical communities – were believed to harbor such purported enemies of the state, and when the military regime found them, they were persecuted to the point of torture, exile, or sometimes death. The United States Congress and President Jimmy Carter made Argentina into an international pariah in the late 1970s, both for its perceived proliferative actions in nuclear energy and widespread, appalling violations of human rights. Accordingly, the Nuclear Non-Proliferation Act of 1978 severely curtailed technology transfers from the United States to nations like Brazil and Argentina that were not party to the NPT. This did not deter the military regime or the national nuclear energy commission; Chapter 4 details how Argentina navigated an increasingly restricted market for nuclear technology as its technicians mastered gaseous diffusion enrichment and the production of heavy water neutron moderator in the chaotic early 1980s, while the military government undertook a disastrous war against the United Kingdom to reclaim the Malvinas Islands in the South Atlantic Ocean.

Chapter 5: Fabrication, "Parallel Nuclear Development in Brazil, 1975-1985," compares and contrasts Brazil's nuclear energy activities with those of Argentina in the decade where self-sufficiency as a replacement for international technology transfer relationships became most necessary and most feasible. Disappointment in the failure of the Brazil-West Germany nuclear technology transfer to deliver on its promises led the Brazilian armed forces

status is one of ambiguity, so it is very difficult to ensure the accuracy of dates of any landmark event in that nation's nuclear energy history.

to begin a “parallel program” in 1979, essentially a race between the Army, Navy, and Air Force to develop indigenous uranium enrichment technology. In six to eight years, technicians working in Brazil’s parallel program had successfully reworked Soviet-style centrifuges to enrich uranium and had put the South American nation on the path toward a nuclear submarine, all at a tiny fraction of the cost of the “official” program based on the technologies transferred from West Germany. The parallel program was not entirely peaceful in nature, however, as José Goldemberg, prominent physicist and Minister of Science and Technology under President Fernando Collor de Mello (in office March 1990-December 1992), exposed secret deep shafts dug in the Amazonian state of Pará, intended for underground nuclear explosives tests. The conclusion of Chapter 5 will discuss this controversy.

Chapter 6: Plowshares, “ABACC and the Evolution of Nuclear Verification between Argentina and Brazil, 1974-1992,” is the fourth interactive chapter of the dissertation, and concludes by tracing a parallel diplomatic history to the scientific and technical histories analyzed in Chapters 4 and 5. Chapter 6 explains how and why Brazil and Argentina created a bilateral regime responsible for accounting of nuclear materials and mutual inspection of all nuclear facilities in both countries, permanently placing Brazil’s and Argentina’s nuclear activities under the international safeguards regime There is no easily identifiable date when the bilateral relationship around nuclear energy took on a more cooperative character, but certainly began before the famous 1980 meetings between Jorge Rafael Videla, military president of Argentina, and João Figueiredo, military president of Brazil. Though much credit for the formalization and growth of nuclear cooperation between Brazil and Argentina is duly given to a warm relationship between elected presidents José Sarney and Raúl Alfonsín from the mid-1980s forward, restored democracy was certainly not a precondition of a nuclear energy *rapprochement*, as indicated by Videla’s and Figueiredo’s significant previous progress toward the same goal. Even in the late 1980s, key leaders – whether military, scientific, political, or diplomatic – in the nuclear energy programs of both countries preferred the language of "confidence" to that of "control," and opposed a rigorous verification scheme. The Quadripartite Agreement of 1991 thus marks an end to this story that was as unlikely as it was unprecedented. Never before, or since, have two regional powers promised each other to forego nuclear weapons after years of growing collaboration on peaceful energy use, then adhered to a regional nonproliferation measure (Tlatelolco), and lastly joined the NPT as non-nuclear-weapon states in 1995 (Argentina) and 1998 (Brazil). In the coda to Chapter 6, I highlight the role of the technical community in bringing about an agreement often seen as a "top-down" project from presidents and their foreign ministers.

Chapter 1: Exploration

Brazil and Argentina Enter the Atomic Age, 1945-1962

> "The special Brazilian problem is a sense of urgency, a feeling that, unless technical development goes quite rapidly, the free development of science and other human institutions may be replaced by a forced development in which men are far more contained and less free."
>
> --Robert Oppenheimer, in Rio de Janeiro, July 28, 1953

On August 6, 1945, at 8:15 AM, a uranium gun-type bomb, flown on a Boeing B-29 Superfortress from Tinian in the Northern Mariana Islands, obliterated the city of Hiroshima, Japan, changing the world forever. Three days later, US forces detonated a plutonium bomb over the civilian target of Nagasaki, a key industrial city in Japan's war machine. The United States Department of Energy estimates that 110,000 Japanese citizens died immediately, with 60,000 more dead by the end of the year from burns, radiation sickness, and other longer-term deleterious effects of the terrifying weapon, under development by the top-secret Manhattan Project for the first half of the 1940s.[1]

Just over six weeks later, *de facto* president of Argentina General Edelmiro Julián Farrell, along with his vice president Juan Domingo Perón and seven others, signed a "Decree Prohibiting the Exportation of Uranium Minerals," justified by the expectation that "these minerals will be used within a comparatively short time in the process of obtaining power applicable to industrial uses." Therefore, the ministers reasoned, it was "advisable to assure the preservation of minerals the mining development of which should be strictly regulated in accordance with their importance," so the decree forbade exportation of uranium minerals after

[1] United States Department of Energy, "The Manhattan Project: An Interactive History." https://www.osti.gov/opennet/manhattan-project-history/Events/1945/hiroshima.htm and https://www.osti.gov/opennet/manhattan-project-history/Events/1945/nagasaki.htm. The Manhattan Engineer District's estimate of immediate combined casualties from Nagasaki and Hiroshima, available at http://www.abomb1.org/hiroshim/hiro_med.html#CASUALTIES, and other sites such as Yale Law School, are slightly lower at 105,000.

Sept. 26, 1945.[2] Argentina's neighbor, Brazil, began its process of developing nuclear technology in part as a supplier of monazite sands to the scientists and engineers of the Manhattan Project under a secret agreement signed in Chapultepec, Mexico, exactly one month before the detonation of the Hiroshima bomb.[3] Monazite sands, found primarily along the Brazilian coast in northern Rio de Janeiro, Espirito Santo, and southern Bahia states, as well as in riverbeds of landlocked Minas Gerais, Goiás, and Mato Grosso states, contain thorium minerals.[4] These minerals were used in the production of mantles for gas lighting after their discovery in 1886. In the early years of nuclear energy research in the United States, thorium-232 became useful in a reaction that could produce fissile uranium-233.[5] Within a year of that secret agreement with the US, the chairman of the Brazilian Academy of Science (*Academia Brasileira de Ciências*), Álvaro Alberto da Mota e Silva (1889-1976), would begin agitating for strict controls on exports of Brazil's valuable atomic minerals as part of the creation of a National Atomic Energy Commission. Alberto's plans would not be realized in full for another decade, though, when Brazil's Atomic Energy Institute (IEA) and National Nuclear Energy Commission (CNEN) were created by presidential decree of Juscelino Kubitschek in January and October of 1956, respectively.

This introductory chapter argues that 1945-1962 was an intensive period of scientific and technical institutionalization spurred by the advent and promise of nuclear energy in Brazil and Argentina, a burst of technological and diplomatic activity and government

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[2] "Decree Prohibiting the Exportation of Uranium Minerals," National Archives and Records Administration, College Park, MD [NARA]; RG 59, Box 43, Folder: Argentina General, 1946-1952; September 26, 1945.
[3] Carlo Patti, "The origins of the Brazilian nuclear programme, 1951-1955," *Cold War History* 15, no. 3 (2014), 2.
[4] Paulo Lainetti, Antônio Freitas, and Ana Mindrisz. "IAEA Technical Meeting on World Thorium Resources: Review of the Brazilian Interest in the Thorium Fuel Cycle and the Experience in the Purification of Thorium Compounds Obtained from Monazite Sands." October 17-21, 2011. Slide presentation available at https://www.ipen.br/biblioteca/2011/eventos/17015.
[5] Ana Maria Ribeiro de Andrade and Tatiane Lopes dos Santos, "A dinâmica política da criação da Comissão Nacional de Energia Nuclear, 1956-1960," *Boletim do Museu Paraense Emílio Goeldi* 8, no. 1 (2013): 115.

expenditure unparalleled within Latin America.[6] In these first seventeen years of the Atomic Age, scientists, technicians, political leaders, and military personnel in the neighbor countries built legal, institutional, and physical structures to advance research in nuclear energy, a development so unprecedented that it gave rise to a new class of political institutions to facilitate and contain its potential. Internationally, institutions such as the United Nations Atomic Energy Commission and International Atomic Energy Agency represented the best efforts of political leaders and scientists around the world to grapple with the terrifying uncertainties of tectonic shifts in international relations in the first two decades of the new Atomic Age. As officials from Argentina and Brazil sought their own way forward in early nuclear energy research, facility construction, and institutionalization, they sought arrangements with technicians and organizations from the most technologically advanced member of the defeated Axis, Germany, and from that country's postwar occupiers and unquestioned leaders in nuclear energy for war and peace, the United States. As the Cold War froze around South America, Brazil and Argentina committed to a complicated dance not with the resurgent Soviet Union, but rather with the United States and Germany, bitter adversaries during both world wars. I am indebted to Argentine and Brazilian historians of postwar science, technology, and diplomacy for their contributions to understanding this narrative; while the two postwar decades are essential to the story I tell here, my own archival research essentially did not touch the period before 1963.

Though South America was the only inhabited continent untouched by direct combat in World War II,[7] it was certainly not insulated from the first tectonic shifts in science and

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[6] Javier R. Fernández, "El surgimiento de las comisiones de energía atómica en Argentina y Brasil (1945-1956)," *Eä Revista de Humanidades Médicas & Estudios Sociales de la Ciencia y la Tecnología*, 2, no. 3 (2011): 4.
[7] The naval Battle of the River Plate notwithstanding, between a German heavy cruiser, the *Admiral Graf Spee*, and three British cruisers, the *Achilles*, *Ajax*, and *Exeter*, which took place east of Montevideo on December 13, 1939, resulting in a decisive British victory.

technology, geopolitics, intra-hemispheric, and global relations unchained by the cataclysm. Brazil and Argentina, at the end of the war and during its immediate aftermath, primarily contributed nuclear minerals such as thorium and uranium to the United States, the world's only possessor of a nuclear weapon until 1949. But the potential of atomic energy, as it was then called, to aid the nations' economic outlook (through increased energy for industrial development) and their geopolitical prospects (by building international prestige through the possession and development of advanced technologies) quickly drew the support of postwar leaders in Brazil and Argentina. Scientific communities, political leaders, and diplomatic officials in those countries sought ever-greater regional and global influence in the legislation and international deal-making that shaped the first two decades of the Atomic Age. Argentine President Juan Perón spoke to Congress in September 1946 with stirring words that could just have easily been used across the border in Brazil. "The Argentine Republic must not remain behind in the study of fundamental issues in global technological progress; we must, then, handle this work without delay, and carry it out in one direction in order to not ruin efforts that, if made in an isolated way, could end up as ineffective."[8]

Brazil and Argentina began the postwar period as sellers of newly valuable nuclear minerals to the United States, in a quasi-colonial relationship where the gold and silver of the Atomic Age – uranium and thorium mineral deposits – fueled both the peaceful and military nuclear energy expansion of the postwar superpower to the north. The South American neighbors ended up in the early sixties, however, as the two undisputed leaders in nuclear energy technologies within Latin America. How each country's scientists and technicians interacted with political and military leaders to create domestic institutions and shape

[8] Juan Domingo Perón, "Buenos Aires, septiembre 1946, Al Honorable Congreso de la Nación," Congressional Record, Sept. 12, 1946, p. 1366. National Archives and Records Administration, College Park, MD: RG 59, Box 43, Folder Argentina General 1946-1952.

international consensus on nuclear energy and diplomacy is a story of fast starts, boundless optimism, and staunchly independent insistence on the rights to develop the new technologies of the atomic era, but still using the age-old language of national sovereignty. With so much to gain, and little time to lose, in the vast Wild West of the globe's first two decades of nuclear energy development and legislation, Argentina's early nuclear efforts unfolded when a con man was run out of town. Brazil's first years of nuclear energy, meanwhile, were shaped by a gunpowder expert and an adept thief.

The institutions and structures that make up the bulk of this chapter include those responsible for coordinating national policy on science, technology, and nuclear energy: Argentina's National Nuclear Energy Agency (CNEA), Brazil's National Council for Research (CNPq), a central agency for nuclear energy research activities that preceded its own counterpart to Argentina's agency, founded in 1956 (CNEN). Internationally, the United Nations Atomic Energy Commission (UNAEC), active from 1946-1949, and the International Atomic Energy Agency (IAEA) were two of the most important organizations created to navigate the problems in international relations that arose from peaceful uses of nuclear energy as well as the proliferation of weapons. Brazil's leadership in the UNAEC is particularly illustrative in this context and offers an opportunity to discuss the career of Álvaro Alberto, the founding father of that nation's nuclear energy program.

The first five years after World War II, in terms of nuclear energy, proceeded quite differently in Brazil and Argentina. In Brazil, institutions to foster scientific activity and atomic energy grew near major population centers in the southeast of the country, often developing from (or alongside) existing universities that provided advanced training in physics and engineering. In Argentina, however, the remote town of Bariloche – some 250 miles closer by road to Santiago, Chile, than to Buenos Aires, grew from a sleepy hamlet in 1945 to a legitimate scientific and technological center for the nation in 1962, in large part thanks to an ambitious gamble on a nuclear energy program based on fusion of small atoms, called the Huemul Project. A brief account of the unusual project and its cast of characters follows. Other authors have discussed the Huemul Project, named for the lake island near Bariloche, Rio Negro province, in great detail. Mario Mariscotti's 1985 monograph *El Secreto Atómico de Huemul* stands out as the definitive historical account of the project from its origins through its exposure by Argentina's leading physicists as an elaborate fraud, a sequence of events that I briefly recount here. Regis Cabral also discussed the episode at length in his 1986 doctoral dissertation, while later works, such as Diego Hurtado's *El sueño de la Argentina atómica*, sought to put the bizarre scientific and political episode into the longer trajectory of Argentina's history of nuclear energy development.

Bariloche was chosen in part by Colonel Enrique P. González as the site for secret nuclear fusion research that would take place in the late 1940s and early 1950s under a German physicist born in the Austrian empire, Ronald Richter. González, along with Juan Domingo Perón, led the GOU military officers' coup in 1943 that eventually brought the latter to power in the election of February 1946. In the immediate aftermath of World War II, it was difficult for Argentina to gain the favor of the United States in matters of nuclear energy aid or international diplomacy; the South American country was almost left out of the United Nations at its creation.[9] Argentina's official neutrality during the war, seen by the United States as a pro-Axis stance, complicated Perón's efforts to improve relations with the US in the 1950s, and his administration, to Washington, had the indelible stain of fascism.[10]

[9] Fernández, "El surgimiento," 4.
[10] Fernández, "El surgimiento," 4.

Ronald Richter, "a relatively unknown German scientist of Austrian descent" who had been part of the Nazi atomic bomb project, met Juan Perón in late 1948, and convinced the Argentine leader of the viability of his plans to "create a tiny Sun…[by] thermonuclear reactions that use hydrogen, the most abundant element in nature, as fuel."[11] Jonathan Hagood's revisionist article in *Beyond Imported Magic* departs from more traditional scholarship on the Huemul Project to ask what conditions in Argentina and historical contingencies of Juan Perón's presidency shaped the country's ambitious plans for nuclear energy and built the Argentine leader's nearly unshakeable confidence in Richter and certainty of the eventual success of his nuclear fusion research project. Understanding the developments in Argentina's nuclear energy program during the 1950s is impossible without some discussion of Richter and his close collaboration with Perón, and the coordinated backlash from a quite advanced, if small, scientific community, close to the prominence of that of neighboring Brazil.

How Richter got to Buenos Aires, then Córdoba, then even further into Argentina's remote mountainous west, was a story that at first had more to do with a German aeronautical team building a fighter jet for the South American nation, and the GOU military officers' often overt sympathies for the defeated Axis, than it had to do with the ambitious goal of beginning a nuclear energy program per se.[12] Richter had met a fellow German citizen, aeronautical engineer Kurt Tank, in London in 1945 and explained his ideas on how the energy from nuclear fusion might be used to power airplanes. Tank and a group of colleagues -- with microfilm of the design plans for the most recent Messerschmidt airplane -- had gotten word to the Spanish embassy in Buenos Aires that they wished to escape occupied Germany to "some

[11] Richter, quoted in Mario Mariscotti, *El secreto atómico de Huemul* (Buenos Aires: Sudamericana/Planeta, 1985), 96. Richter was born in Sokolov in what is now the Czech Republic, when that territory was part of the Austrian empire.
[12] Mariscotti, *El secreto atómico*, 24.

South American country." They then accepted an offer from Perón to work at Argentina's Aerotechnical Institute of Córdoba and develop a fighter jet, the *Pulqui II*.[13] Tank "warmly recommended" Richter to Perón as a visionary in the emerging field of nuclear energy. Mariscotti reasoned that this recommendation must have been both genuine and quite positive, since Perón arranged a meeting with Richter within a week of the scientist's arrival, despite the fact that Richter had come to Argentina without a contract.

Perón recalled one of his preliminary conversations with Richter to a group of journalists three years later. The scientist gave Perón a stark choice between following the American path to unleashing the tremendous energy trapped inside the atom for six billion dollars – based on the fission of heavy radioactive elements like uranium or thorium – or pursuing research on the fusion of light gaseous elements for "pennies" relative to the cost of a fission-based program.[14] Richter apparently brought up the risks of pursuing the nuclear road not yet taken, warning that "by this path we may arrive, or not," but said that only "two or three discoveries" stood between them in 1948 and knowing whether the fusion path would be viable for nuclear energy on an industrial and commercial scale in Argentina in the 1950s, setting that nation apart as a world leader in technology not mastered by the United States or Soviet Union.

After his first meeting with Perón in August 1948, Richter moved to Córdoba to work with Tank. In November, a contract for his work finally arrived, obligating the German scientist to "lend his professional services at the Aeronautical Institute in the city of Córdoba in the capacity of scientific advisor on atomic energy, in any of its establishments, factories, or

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[13] Mariscotti, *El secreto atómico*, 92, 95-96; Jonathan Hagood, "Bottling Atomic Energy: Technology, Politics, and the State in Peronist Argentina," in *Beyond Imported Magic: Essays on Science, Technology, and Society in Latin America*, ed. Eden Medina, Ivan da Costa Marques, and Christina Holmes (Cambridge, MA: The MIT Press, 2014,) 267.
[14] Mariscotti, *El secreto atómico*, 96-97.

other dependencies of the Argentine Republic."[15] In exchange, Richter was promised by the government of Argentina "a laboratory set up according to his instructions with all components of [scientific] work, including workshops, machinery, tools, measuring devices…in sufficient quantity and promptness to not impede the good progress of research."[16] For this work, he was paid the princely sum of US $1,250 *per month* in late 1949, or nearly $13,000 in 2017 dollars.[17]

Richter continued working for Perón in Córdoba after a fire in early 1949 that was caused by a short circuit, and not, as the scientist believed, an intentional act of sabotage.[18] Increasingly paranoid and obsessive about the secrecy of his work, Richter labored on to achieve his "tiny suns" of nuclear fusion energy.[19] One of Perón's most trusted advisers and military colleagues, Col. Enrique González, played a leading role in carefully crafted plans to move Richter's laboratory facilities after the fire.[20] González sought to fulfill Perón's "interest in assisting the colonization of Patagonia" and the president's desire for Richter to work in "the most absolute independence," possibly in an isolated desert setting like Los Alamos, New Mexico, the cradle of the American atomic bomb. The colonel eventually settled on Huemul Island in the middle of Bariloche's mountain lake, Nahuel Huapi, as the new location for Richter's laboratory.[21] The political ideal of a remote desert did not quite match the scientific realities of Richter's demands for his work, which the scientist articulated after a flyover of potential sites in Patagonia: he would need abundant fresh water for refrigeration, available

[15] Mariscotti, *El secreto atómico*, 98.
[16] Mariscotti, *El secreto atómico*, 98.
[17] Mariscotti, *El secreto atómico*, 98. Inflation calculations from Nov. 1949-June 2017 given by US Department of Labor CPI Inflation Calculator, https://www.bls.gov/data/inflation_calculator.htm.
[18] Mariscotti, 99.
[19] Cabral, 147-148.
[20] Mariscotti, *El secreto atómico*, 24, 100.
[21] Mariscotti, *El secreto atómico*, 101-102.

from the lake, and the altitude would provide a relative absence of dust and particles in the air that the scientist claimed could harm sensitive scientific machinery.[22]

Richter moved his operations to Bariloche in March 1950 when the construction on his new facility was complete. Two months after Richter's move to the southwest, Perón's Decree no. 10936/50 created Argentina's *Comisión Nacional de Energía Atómica* (CNEA). The new agency would have four specific functions – to "coordinate and stimulate atomic research carried out within the country, to control official and private atomic research in all territory of the Nation, recommend to the Executive Power the adoption of necessary steps toward the ends of defense of the country and persons against the effects of atomic radioactivity, and recommend measures designed to ensure the good use of atomic energy in economic activity of the country: medicine, industry, transportation, etc."[23] The justification for the new national commission, found in the first six paragraphs, included applying atomic energy to public life, mitigating the threat that atomic radiation posed to human health, and realizing the "enormous" promise that radioisotopes and other nuclear technologies carried for medicine. Outside of the biomedical sciences or threats that radiation posed to human life, the decree recognized the potential economic and industrial benefits of atomic energy for electrical power. The decree expressly denied any interest in developing nuclear weapons and instead sought "peace in benefit of humanity," and sought a role for the government in "preventing the dispersion or overlap of efforts" in public and private "research of this character."[24]

Almost one year after the creation of CNEA, in March 1951, Perón declared Richter's research a success in an elaborately choreographed declaration at the *Casa Rosada* presidential

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[22] Mariscotti, *El secreto atómico,* 102.
[23] Decreto N° 10936/1950, May 31, 1950, 3. Downloaded from http://www.cnea.gov.ar/sites/default/files/DECRETO-10936-50.pdf.
[24] Decreto N° 10936, 2.

palace in Buenos Aires. Though the Argentine president excluded foreign journalists from the ceremony as he was "not interested in what the United States or any other country in the world thinks," the fact that there was an official translation into English of the statement that he read, and a few of his carefully-targeted comments in that ceremony, seemed to indicate Perón's need for Argentina's news to have international ramifications.[25] Cabral notes the worldwide skepticism among scientists that followed Perón's improbable claims in the United States (Enrico Fermi believed the claim to be "rather strange," and other leading nuclear experts in the United States noted that without uranium to provide fission energy, Richter's claims had, at best, a tiny chance of being legitimate), Australia (Mark Oliphant conceded only a very small chance that Richter's experiments were not fraudulent), Italy (Eduardo Amaldi called Perón's announcement a 'colossal bluff'), Richter's native Germany (Werner Heisenberg and Otto Hahn, two Nobel laureates, labeled the supposed fusion success 'fantastic'), the Soviet Union, and Sweden. The delegation from Nationalist China (Taiwan) at the United Nations pointedly asked that "any nation, but particularly Argentina, with new atomic methods should report its findings" to the intergovernmental organization.[26] Perón sought to insulate Richter's activities from criticism by Argentina's scientific community in part by issuing Executive Decree 9697, which placed Richter's program under his direct control and Argentina's physicists under the umbrella of a new nuclear energy institution, the National Directorate of Atomic Energy (DNEA), to be overseen by the Ministry of Technical Affairs.[27]

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[25] Jonathan Hagood, "Bottling Atomic Energy: Technology, Politics, and the State in Peronist Argentina," in *Beyond Imported Magic: Essays on Science, Technology, and Society in Latin America*, ed. Eden Medina, Ivan da Costa Marques, and Christina Holmes (Cambridge, MA: The MIT Press, 2014), 271.

[26] All national scientific community reactions to Perón's announcement as described here are sourced in Cabral, 168-181.

[27] Zulema Marzorati, "Plantear utopias. La formación de la comunidad científica: CNEA (1950-1955)." *Cuadernos de Antropología Social* 18 (2003): 126-127.

In a somewhat ironic twist, González, Perón's trusted colonel who had helped move Richter's facilities from Córdoba after the fire to the new Bariloche site, rose in prominence within Argentina's nuclear energy program as a result of this measure intended to marginalize him. González was the first *de facto* manager of the new CNEA, and until 1952, one of its only four members, along with Perón, Raúl Mendé, the Minister of Technical Affairs, and Richter.[28] He astutely realized that Richter's research left no resources for CNEA's other planned nuclear energy projects, and created a National Directorate of Technical Research (DNIT), which sponsored efforts both outside and inside the nuclear energy field. Nuclear energy efforts were to be directed toward searching for "atomic materials," heavy water, and strategic minerals.[29] González's skillful management of these two scientific research agencies helped in "setting the tone for CNEA's future after the collapse of Richter's dreams," and one anecdote in particular shows his significant role in exposing the German scientist's dreams as a chimera.[30] In May 1950, Richter's team worked to carry out his orders to construct a large reactor, twelve meters high by twelve meters in diameter, made entirely of concrete, with a hollow center four meters high and four meters across. The construction crew had apparently violated Richter's orders to build the reactor chamber without iron. The German scientist used a small crack in the concrete shell as a pretext to destroy the large cylinder, a conclusion with which engineers strongly disagreed. González, conflicted after gathering all the evidence from Richter and the engineers, did not know what to do. Richter then bypassed the judgment of CNEA's leader by asking for support from his former boss on the fighter jet project, Kurt Tank. Tank's defense of Richter's work convinced Perón to support the decision to destroy the cylinder.[31]

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[28] Mariscotti, *El secreto atómico*, 117.
[29] Mariscotti, *El secreto atómico*, 118.
[30] Regis Cabral, "The Interaction of Science and Diplomacy: Latin America, the United States and Nuclear Energy, 1945-1955" (PhD diss., University of Chicago, 1986), 151-153.
[31] Cabral, "Interaction," 153-154.

Apparently, Richter had gained the upper hand in Perón's confidence, even over González, such that anytime Richter was asked by political figures to demonstrate his research to scientists or the public, the German scientist was able to scale down or delay the demonstration in order to avoid exposure of his fraudulent research. This change in loyalties was confirmed in February 1952, when a commission convened by González to investigate Richter's ongoing and increasingly suspect research in Bariloche was suddenly called off by Perón after the president had met Richter.[32] Within Argentina, criticism of the secrecy of Richter's work, and Perón's dubious claims of its successful outcome, came from scientists as well as from opposition politicians seeking to block Perón's party and policies.[33] Physicist José Antonio Balseiro, after whom Argentina's premier center for physics higher education would be named a few years later, used concealed gamma ray detectors to investigate Richter's laboratory. When the detectors did not indicate the presence of radiation, scientific evidence had finally confirmed the growing fears among Perón's opponents and the Argentine physics community that Richter's activities were as fraudulent as they were expensive. Argentina's good fortune of a decade-long trade surplus and a booming economy thanks to strong wartime exports of food and raw materials enabled them to pay the astounding costs of the infrastructure and human resources built and gathered at Huemul Island: – 62.5 million Argentine pesos, or $15 million US dollars in 1950.[34] In September 1952, Richter could no longer postpone or cancel the arrival of a new investigative commission at Huemul Island, this time headed by CNEA President Pedro E. Iralagoitía and leading physicist José Antonio

[32] Cabral, "Interaction," 198-199.
[33] Hagood, "Bottling Atomic Energy," 268.
[34] Hagood, "Bottling Atomic Energy," 268. Cabral (p. 152) also notes that Richter seemed to have Perón's associates at his beck and call, working with "about 400 men" on the island with special flights that brought materials and equipment. Richter's research "received top priority for any request." Immediate response to the many demands of the mercurial German scientist cannot have been cheap.

Balseiro. Each commissioner wrote an individual report after days of intensive grilling and inspection by politicians, military leaders, and scientists. Only one, a Jesuit priest, Juan Bussolini, wrote that he had found any evidence to support Richter's claims of success in controlled nuclear fusion.[35]

Two last straws finally led the Argentine leader to abandon support for Richter's fraudulent research project. First, an internationally known German-born physicist who had founded the Physics Institute at Universidad Nacional de La Plata, Richard Gans, joined the commission and was ultimately unpersuaded by Richter's evidence. Second, Peronist agents disclosed a secret conversation between Richter and a friend in a hotel room in Buenos Aires where the German physicist bragged about swindling Perón. Only then did the Argentine leader finally (and officially) abandon any support for Richter and his work. Iralagoitía, also a naval captain, led a military operation in cooperation with the DNEA to dismantle the Huemul Island operation on Nov. 22, 1952. Argentina's international disgrace ended so quietly that it took the *New York Times* two weeks to pick up the story, but the cloud of fraudulent fusion experiments still had its silver lining.[36]

Perón had spent such lavish sums on Richter's research that he had given Argentina's scientific community quite a bit of physical capital to work with. Juan G. Roederer, born in 1929 and recipient of a Ph.D. in physical-mathematical sciences from the Universidad de Buenos Aires in 1952, wrote in 2002 that "the development of our cosmic radiation [research] program was interwoven, in a subtle way, with the Ronald Richter affair. In effect, and in spite of the high price and international disgrace that this case brought about for Argentina, it is fair to say that without him, during the 1950s, no physics would have developed, nuclear or

[35] Cabral, "Interaction," 207.
[36] Cabral, "Interaction," 210.

otherwise, with such an unusual speed."[37] Roederer's point can be taken further: without Richter's activities and Perón's largess, Argentina's first nuclear energy efforts would probably not have been institutionalized or centralized under the CNEA and DNEA (National Atomic Energy Directorate) as early as 1950, and the resources used to build the physical infrastructure that would support a legitimate and sophisticated nuclear energy program after Richter's departure might well have been put to other uses.

Why did Juan Perón alienate the strong community of physicists and engineers that could have been his natural allies, then make a huge losing bet on a German charlatan promising cheap, mass-produced energy via an unproven nuclear fusion technology? Perón's motivations for supporting the Huemul Project are indeed less well-understood than the scientific details of the now-infamous fraud and deception that accompanied Richter's research efforts, part of why historian Jonathan Hagood wished to focus on the political factors behind what seemed with hindsight to be an utterly foolish decision. Three primary political motivations undergirded the risky decision to throw state support behind what was believed to be nuclear fusion research.[38] First, Perón wanted to make public and visible efforts to support the expansion of Argentine industry, growing the nation's energy infrastructure even beyond the 37 hydroelectric plants and oil pipeline that the administration funded over its nine years in office. Second, he sought to create a "third way" for Argentine foreign policy, aligned neither with the United States nor with the Soviet Union, and correctly envisioning nuclear energy as a new field in which to seek this alternative path.[39] (This orientation sought by Perón would become much more salient a quarter-century later, under the Jorge Rafael Videla military

[37] Juan G. Roederer, "Las primeras investigaciones de radiación cósmica en la Argentina 1949-1959: Un relato personal." *Ciencia Hoy* 12, no. 71 (2002), 38-48.
[38] Hagood, "Bottling Atomic Energy," 271.
[39] Hagood, "Bottling Atomic Energy," 272.

regime and Carlos Castro Madero's deft leadership of CNEA, than during the Argentine nuclear program's infancy in the early 1950s).

Lastly, according to Hagood, Perón needed to provide a complex distraction from his administration's growing authoritarian, repressive, and illiberal measures; the particularly egregious example of Perón shutting down a popular opposition newspaper, *La Prensa*, then timing the Richter announcement to direct public and media attention away from his assault on journalistic freedom, was highly illustrative of the president's diversionary tactics. The Argentine media was completely taken in by the feint; even the *New York Times* placed the nuclear fusion announcement on page 8 and buried the *La Prensa* story on page 122.[40] Javier Fernández raises another factor that Hagood did not discuss: Perón, even by 1950, had exiled or alienated much of the scientific community in Argentina's universities that might otherwise have built the beginnings of a nuclear energy program for him. Four months after the 1943 GOU officers' coup, a group of intellectuals and university faculty signed a petition to reestablish constitutional rule in Argentina; between 1943 and 1946, more than a thousand university professors were fired or resigned their positions in solidarity with the original authors of the petition.[41] In short, the Huemul Project was "an understandable attempt at technological development within Argentina, which suffered from a profound divorce between the academy and government and where, moreover, the production of energy was a strategic concern."[42]

There were many potential directions in which the physics and nuclear energy communities might launch from the failed Huemul Project, but the path forward from Richter's fraudulent research was risky. Physicist Enrique Gaviola believed that "a School of Physics on

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[40] Hagood, "Bottling Atomic Energy," 273-274.
[41] Fernández, "El surgimiento," 4.
[42] Fernández, "El surgimiento," 16.

the international level" should be created from the ashes of Huemul, and conveyed this idea in May 1953 at a meeting of the Argentine Physics Association. Iralagoitía was sufficiently interested to bring Gaviola's plans to Perón, but they ran aground when Iralagoitía was told of Gaviola's citation for contempt of court, in the words of the physicist, for refusing to accept used calculation machines in place of the new ones for which he had bid as director of the Observatory.[43] José Antonio Balseiro and Richard Gans would, however, take Gaviola's idea forward after Gaviola left academic physics to work as a consultant to General Electric Argentina in 1952. Balseiro and Gans took positions at the Department of Exact and Natural Sciences at the Universidad de Buenos Aires, then suffering from a wave of politically-motivated faculty departures, and began a summer school course on reactors in Bariloche, expanding their offerings in a second summer to include nuclear physics, solid-state physics, and training courses for teachers of physics.[44] As closely identified as Argentina's beginnings in nuclear energy might be with the name of Ronald Richter, enough other scientists and technicians – José Antonio Balseiro, Jorge Sábato, Enrique Gaviola, for example – were a crucial part of CNEA's earliest years that Richter was less a towering figure than a source of national embarrassment.

In Brazil, the beginnings of atomic energy research and infrastructure took a decidedly different shape from those in Argentina, formed by an ingenious, ambitious explosives expert navigating the dynamics of occupied postwar Germany in search of a head start on autonomous possibilities for nuclear energy technologies. For Brazilian politicians and planners, nuclear energy was much more the personal quest of one man, polymath Admiral Álvaro Alberto da Mota e Silva (1889-1976). During the war, Alberto had risen to become the

[43] Diego Hurtado, *El sueño de la energía atómica: Política, tecnología nuclear y desarrollo nacional, 1945-2006*. Buenos Aires: Edhasa, 2014, 65.
[44] Hurtado, *El sueño*, 67.

head of the Physical Sciences department at the Escola Naval, a position he retained from 1942-1946.[45] In 1945, he organized a large conference on nuclear energy and invited Brazilian academic experts on the topic, primarily from Rio de Janeiro and São Paulo. Alberto certainly had characteristics of the mad scientist as an expert in explosives. In 1917, he developed a chemical, called *rupturita* in Portuguese, at his home, using raw materials purchased in town. He founded a small firm, F. Venâncio & Cia., located in Rio de Janeiro's Baixada Fluminense suburbs and employing "no more than a dozen workers," which supplied *rupturita* to small quarries and coal mines.[46] (A more powerful version of the explosive, developed by the Navy, was added to the aerial bombs dropped on the rebels of the *Revolução Paulista* in July 1924).[47]

Unlike Richter, Alberto was no scientific charlatan. After his admission to the Brazilian Academy of Sciences in 1921, he published 32 articles in the organization's journal over the next twenty-five years. At the dawn of the Atomic Age, a term that he used repeatedly in speeches and other communications, Alberto worked tirelessly on two fronts: within Brazil, toward an ambitious nuclear energy plan for the nation, and also internationally, as Brazil's representative to the United Nations Atomic Energy Commission (UNAEC) during 1946 and 1947.[48] Perhaps unsurprisingly, given his scientific interests and impressive work ethic, after the atomic bomb detonations over Hiroshima and Nagasaki, he wrote four articles on atomic explosives and transuranic elements within the next nine months before departing for the New York to serve on the UNAEC. There, he met Bernard Baruch, Truman's representative on the commission, and proposed collaboration between Brazilian and American scientists. The Americans would provide nuclear technology to Brazil in exchange for the South American

[45] João Carlos Vitor Garcia, *Álvaro Alberto: A ciência do Brasil*. Rio de Janeiro: Contraponto, 2000, 9.
[46] Garcia, *Álvaro Alberto*, 10.
[47] Garcia, *Álvaro Alberto*, 11.
[48] Garcia, *Álvaro Alberto*, 16.

country's continued supply of uranium and thorium ores.[49] Baruch was perhaps best known for a plan bearing his name, introduced during the summer of 1946 at the UNAEC. An International Atomic Development Authority would be entrusted with "all phases of the development and use of atomic energy, starting with the raw material," responsibility for supervising and controlling all military and peaceful nuclear activities, and "fostering the beneficial uses of atomic energy."[50]

Alberto came out solidly in favor of the Baruch Plan in a speech to the UNAEC on December 20, 1946, praising it as the "generous American plan to control this new and tremendous source of power" while moving away from unequal postwar geopolitics toward "juridical equality of the Nations."[51] Brazil's National Security Council, however, did not agree, believing the Baruch Plan to be dangerous to Brazilian sovereignty by placing the country's biggest bargaining chip for nuclear energy, its national mineral reserves, under international control. From this point forward, Alberto advocated for the rights of nuclear mineral exporting countries, like Brazil, to use those natural resources to develop indigenous nuclear energy programs if they so chose, abandoning his support for the Baruch Plan.[52] India and South Africa, two other vital sources of Manhattan Project-era minerals, had taken similarly independent positions soon after the war's conclusion.[53] Alberto wrote to the head of Brazil's UN delegation, João Carlos Muniz, on July 19, 1947, to complain that the UNAEC was overreaching its mandate, thus infringing on the sovereignty of these mineral-exporting

[49] Garcia, *Álvaro Alberto*, 18.
[50] "Address by Captain Álvaro Alberto, Brazilian Representative on the Atomic Energy Commission, at a Luncheon Given by General A. G. L. McNaughton…," September 4, 1946. CPDOC/FGV digital archive [ACPDOC], folder CMa pi Alberto, A. 1947.01.06, page 34 of 69.
[51] "Atomic Energy Commission: Lake Success, December 20, 1946." ACPDOC, folder CMa pi Alberto, A. 1947.01.06, page 63 of 69.
[52] Garcia, *Álvaro Alberto*, 19.
[53] Patti, "Brazilian nuclear programme," 1.

nations. The commission "was not convened to effect an economic restructuring of the world," and its control should be limited to "general security and not the internal economy of [its component] nations."[54]

Baruch, apparently, did not take Alberto's retraction of his initially favorable position to his plan personally, since he would later play a significant role in connecting the Brazilian scientist to James Conant in 1954 in order to attempt to facilitate the transfer of West German ultracentrifuges to Brazil. (Conant would have the final say on whether technicians in occupied West Germany would be allowed to send "pilot training laboratory equipment" to Brazil for non-military nuclear purposes.[55]) But long before that interaction, Alberto threw himself into a new plan for the nation's nuclear energy future at the end of 1947, advocating that all thorium and uranium mines be nationalized, that all mining concessions be revised, that primary treatment of these nuclear minerals be carried out in Brazilian territory, that a training infrastructure for technicians be instituted, that specialized research centers be inaugurated to accompany an increase in scientific and technical activity, and that two institutions be created to deal with the challenges and opportunities that Brazil faced in nuclear energy, a National Research Council (CNPq) and National Atomic Energy Commission (later CNEN).[56] The National Security Council had already established the Commission for the Study and Control of Strategic Minerals in January 1947, and in 1948 and 1949, the Brazilian Society for Progress in Science (SBPC) and Brazilian Center of Physics Research (CBPF) were founded, respectively.[57] Scientists, ministers, and military personnel seemed to agree that rapid and specific institutionalization was an effective way to deal with the headwinds of the Atomic Age.

[54] Alberto, quoted in Garcia, *Álvaro Alberto*, 20.
[55] Patti, "Brazilian nuclear programme," 12.
[56] Garcia, *Álvaro Alberto*, 20-21.
[57] CNEN timeline, 1947-48, http://memoria.cnen.gov.br/memoria/Cronologia.asp?Unidade=Brasil.

President Eurico Dutra brought Alberto's cherished CNPq into existence on January 15, 1951, signing into law a bill that was introduced to the National Congress in April 1949 by a commission of 22 prominent scientists, named by Dutra but chaired by the admiral-scientist.[58]

The CNPq would operate directly under the President and "enjoy technical-scientific, administrative, and financial autonomy," promoting scientific and technical research by coordinating and funding the efforts of universities, institutes, and connecting Brazilian scholars to their foreign counterparts. Only in the third section of the law's third article does its original motivation become clear: to provide incentives toward the research and exploration of national reserves "appropriate for use in atomic energy," and to prohibit the exportation of uranium and thorium minerals or composites except between governments.[59] The CNPq was also to serve as the institutional intermediary for "control by the State…of all activities related to the use of atomic energy, without endangering the freedom of scientific and technological research," with the military's Estado Maior (responsible for coordinating the activities of the Army, Air Force, and Navy) or other designated entity stepping in when necessary. The new scientific research organization took on crucial importance after Getúlio Vargas's second term as president of Brazil had begun at the end of January 1951. Vargas ardently promoted a large role for the state in economic development and saw nuclear energy as a key component of his plans to develop this role, and already enjoyed a close relationship with Alberto.[60] In turn, Vargas could count on the expertise of a worldwide scientific network of Alberto's colleagues and friends from his tenure on the UNAEC, connections that the chemist brought into play in a

[58] Patti, "Brazilian nuclear programme," 3; Garcia, *Álvaro Alberto*, 21.
[59] Congresso Nacional do Brasil, Câmara dos Deputados. Lei nº 1.310 de 15 de janeiro de 1951. http://www2.camara.leg.br/legin/fed/lei/1950-1959/lei-1310-15-janeiro-1951-361842-publicacaooriginal-1-pl.html
[60] Patti, "Brazilian nuclear programme," 4.

tour of nuclear energy research centers of North America and western Europe to develop his own vision of what Brazil needed to do.[61]

It is not clear when Alberto first met Robert Oppenheimer, American physicist and architect of the Manhattan Project, but it was certainly in (or before) July 1953, when the Brazilian scientific research organization hosted the world-famous scientist. During his visit to Rio de Janeiro, São Paulo, and Belo Horizonte to survey scientific research in Brazil, Oppenheimer spoke to CNPq members on July 28, 1953, in words that were full of both praise and caution for the young institution. "You may have many different duties, but you clearly have two: one is to support research and the training of scientists, and the other is to develop atomic energy," Oppenheimer said to the members of the CNPq in the summer of 1953. Conceding that the Brazilians had to improvise to create an organization that would support scientific and technological research as citizens of any other nation would need to do, Oppenheimer saluted the "skillful, precise, and constructive intervention" by the two-year-old body – perceptible in newly obtained equipment, in the accounts of scientists returning from abroad, and "proper facilities, and libraries for contemporary periodicals, and all these budget-breaking requirements."[62]

But the American physicist cautioned that atomic energy might not always be so closely related to scientific research as it was in 1953. As the inevitable specialization of Brazil's nuclear program proceeded from its more general early phases, perhaps another form of institution, such as a state enterprise for mining and purification of nuclear mineral ores, or for

[61] Patti, "Brazilian nuclear programme," 4.
[62] "Palestra do Professor Robert Oppenheimer realizada na 162ª sessão do Conselho Deliberativo do Conselho Nacional de Pesquisas," July 28, 1953. ACPDOC, folder JT dt Energia Nuclear, pp. 14-15 of 412. Oppenheimer's American security clearance had not yet been suspended on grounds of the physicist's alleged prior Communist associations, so his acceptance of the CNPq invitation carried much more prestige than when he visited Latin America again in 1962.

providing nuclear power, might be a better use of scarce financial resources than an institution bifurcated between promoting research and controlling atomic energy activities.[63] Oppenheimer – of course, speaking before Eisenhower's "Atoms for Peace" speech, in December 1953 – was also less than sanguine about Brazil's outlook for developing a nuclear power program in a short time span. Secrecy was still the order of the day, and moreover, the most advanced nation in nuclear energy, the United States, did not yet have a power reactor to offer, or even a "sensible prototype," that would be appropriate for use in Brazil. Reactors, he noted, were still very close to atomic explosives, and either made bomb material or used bomb material; a well-run nuclear power program would be a judicious combination of buying, building, and studying these reactors.[64]

Alberto and Vargas did not seem inclined to heed Oppenheimer's public warnings, though, and on November 25, 1953, the president, supported by political officials, scientific and economic experts, and influential military personnel, approved plans that would yield "all phases of nuclear energy production, including the construction of power plants."[65] Alberto had also been secretly meeting with German scientists at the Physical-Chemical Institute in Bonn during that year, from whom he had arranged to purchase three ultracentrifuges for uranium enrichment.[66] When Bernard Baruch used his good offices in 1954 to set up a conversation between Alberto and James Conant, US High Commissioner in West Germany, the Brazilian sought the Allies' authorization for the West Germans to export these centrifuges to South America. Alberto's craftiness, however, could not overcome the US Atomic Energy Commission's suspicions or power to regulate transfers of technology from occupied Germany

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[63] "Palestra do Professor Robert Oppenheimer," 18.
[64] "Palestra do Professor Robert Oppenheimer," 24-25.
[65] Patti, "Brazilian nuclear programme," 9.
[66] Garcia, *Álvaro Alberto*, 29.

that their officials considered sensitive, and the German export of the centrifuges was denied without right of appeal.[67] In June 1954, the US Embassy in Rio learned from a CNPq member that Alberto had asked four German chemists to research centrifuge separation of uranium-235, a task that the Brazilian knew would violate the laws of the occupying military forces.[68] Alberto's number was up. The United States had relaxed restrictions on sharing nuclear energy technology for *peaceful* use as outlined in "Atoms for Peace," but its Atomic Energy Commission began to severely curtail exports of sensitive ("dual-use") technologies to prevent possible proliferation of nuclear weapons. The centrifuge technology from West Germany, which American scientists had not even mastered themselves,[69] certainly fell into this latter category.[70] Somehow, Alberto's predicament got even worse, as his chief patron, President Getúlio Vargas, shot himself in the chest at Catete presidential palace in Rio de Janeiro on August 24, 1954. When Vargas's vice president João Fernandes Campos Café Filho took over the presidency, he placed General Juárez Távora in charge of his military cabinet and also of Brazil's nuclear activities. Távora moved quickly to discredit his predecessor Alberto, and conducted a "re-evaluation" of the country's nuclear energy policy on the basis of four secret documents, later attributed to the United States Embassy in Rio de Janeiro and dated to the beginning of 1954.[71] Távora willingly did the bidding of the American Department of State and

[67] Patti, "Brazilian nuclear programme," 12.
[68] Patti, "Brazilian nuclear programme," 13.
[69] Patti, "Brazilian nuclear programme,"12.
[70] Carlo Patti's article outlines on pages 10-11 a long-standing interest in the details of, if not an active desire to build, atomic weapons by key officials within the Brazilian military and National Security Council. Alberto had reportedly met in secret with Robert Oppenheimer in the United States in August 1953, one month after the American physicist had addressed CNPq in Rio, but Oppenheimer had steadfastly refused to give Alberto any detail on weapons construction when asked. The "Christmas report," delivered to Alberto on that holiday in 1953, outlined the possibility of creating thermonuclear reactions in Brazil after local officials had tested an implosion bomb called the *Bomba Marambaia*. Importantly, Patti is the only author I have encountered that mentions this explosion test, perhaps because it is mentioned in a secret CNPq internal document, *Sobre as reações termo-nucleares na bomba de implosão*, December 25, 1953, now in the Álvaro Alberto archive at USP. If this document went beyond mere speculation, US authorities were right to be concerned with the odds of weapons proliferation in Brazil.
[71] Garcia, *Álvaro Alberto*, 30. The four documents, all from the beginning of 1954, were the following: an agreement on mineral research between Brazil and the US, a draft of another agreement for nuclear cooperation, a

Atomic Energy Commission, moving away from Alberto's cooperative line with West Germany and toward arrangements friendlier to the United States. Itamaraty, Brazil's ministry of foreign relations, took control from CNPq on diplomatic matters concerning nuclear energy.[72] This change in responsibility for nuclear diplomacy was one more attempt to lessen Alberto's influence after his resignation on March 2, 1955. Later that year, Brazil would sign a nuclear cooperation agreement with the United States, but Alberto's downfall and the scuttling of the idea of "specific compensations" were not the only events that made that accord possible. The change in international nuclear energy sharing policy that followed an address to the United Nations by US President Dwight Eisenhower in December 1953, later known as the "Atoms for Peace" speech, also played a huge role.

"Atoms for Peace" and the American Nuclear Hegemon

On December 8, 1953, United States President Dwight D. Eisenhower stood in front of the United Nations General Assembly in New York City and laid out an expansive vision for collaboration between the United States and countries seeking to develop civilian nuclear energy programs. While the foreign policy and defense motivations undergirding Eisenhower's speech have been the topic of intense debate among scholars, it seems unambiguous that what is now known as the "Atoms for Peace" speech marked a shift toward overt nuclear cooperation with a broader circle of countries than the European powers of Great Britain and France, and argued for global control of nuclear fuel stockpiles.[73] Eisenhower spoke gravely in the "new language…of atomic warfare," and noted that the United States had conducted 44 atomic test

criticism of Alberto's actions as head of CNPq, and a denunciation of Brazil's negotiations with Germany to purchase the ultracentrifuges.

[72] Garcia, *Álvaro Alberto*, 30.

[73] Britain is named six times in the speech, while France is mentioned five times, always in conjunction with Britain. Canada is named alongside Britain once as an ally "whose scientific genius made a tremendous contribution to our original discoveries and the designs of atomic bombs." The Soviet Union/Russia is mentioned ten times by name, and once more by implication as the other "atomic colossus."

explosions in the prior eight and a half years. By the end of 1953, Eisenhower said, atomic bombs had become "more than 25 times as powerful as the weapons with which the atomic age dawned, while hydrogen weapons are in the ranges of millions of tons of TNT equivalent."[74] Reminding the ambassadors and delegates assembled in front of him that the Soviet Union had tested a series of atomic devices, "including at least one involving thermo-nuclear reactions," he stated that two facts were of even greater significance than the US's loss of its atomic power monopoly. "First, the knowledge now possessed by four nations will eventually be shared by others. Second, even a vast superiority in numbers of weapons, and a consequent capability of devastating retaliation, is no preventive, of itself, against the fearful material damage and toll of human lives that would be inflicted by surprise aggression." [75]

Only relatively late in the speech – at the bottom of page six of a little more than eight pages of text – did Eisenhower pivot toward the specifics of his proposals for a global collaboration toward peaceful ends for atomic energy. In order to realize the vision of a worldwide community of scientists and engineers devoted to advancing technologies for peaceful atomic energy use, the US president proposed that "the Governments principally involved, to the extent permitted by elementary prudence, begin now and continue to make joint contributions from their stockpiles of normal uranium and fissionable materials to an International Atomic Energy Agency" with an eye toward a global repository of nuclear fuel "made essentially immune to surprise seizure" by the resourcefulness of scientists involved with atomic energy.[76] These same experts would carry out an even "more important

[74] Dwight Eisenhower, "Atoms for Peace" Speech Press Release, Dec. 8, 1953, online as scanned PDF at https://eisenhower.archives.gov/research/online_documents/atoms_for_peace.html. In a somewhat chilling change from the Nov. 28 draft, available at the same site, the number of US atomic explosion tests has increased by one in the final speech.

[75] In the final draft from the Eisenhower Presidential Library, the word "four" is circled in pen or pencil and the word "several" written in cursive above it.

[76] Eisenhower, "Atoms for Peace," 7-8.

responsibility" for the proposed international agency under United Nations auspices, "mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities…[a] special purpose would be to provide abundant electrical energy in the power-starved areas of the world."[77]

Eisenhower outlined a four-part plan to submit to the United States Congress "not…merely to present strength, but also the desire and hope for peace." In encouraging global research into "the most effective peacetime uses of fissionable material," the president urged a concurrent process to "begin to diminish the potential destructive power of the world's atomic stockpiles." The last two parts of his plan were more philosophical or ideological. The third was no less lofty than an aim for the human race itself, to "allow all peoples of all nations to see that, in this enlightened age, the great powers of the earth, both of the East and West, are interested in human aspirations first and foremost rather than building up the armaments of war," and the last shrank back somewhat to a diplomatic goal, to "open up a new channel for peaceful discussion and initiate at least a new approach to the many difficult problems that must be solved in both private and public conferences if the world is to shake off the inertia imposed by fear and make positive progress toward peace."[78] The most important sentences, though, to developing nations and nascent industrial economies like those of Brazil and Argentina, were those that pledged the United States "to undertake these explorations in good faith" as "a not unreasonable or ungenerous associate," and that the country would be "more than willing – it would be proud to take up with others 'principally involved' the development of plans whereby such peaceful use of atomic energy would be expedited."[79] The Soviet Union's "principal

[77] Eisenhower, "Atoms for Peace," 8.
[78] Eisenhower, "Atoms for Peace," 8.
[79] Eisenhower, "Atoms for Peace," 7-8.

involvement" in Eisenhower's plan was of paramount importance, a point that he made in one simple declarative sentence before laying out the four points of Atoms for Peace.

It is difficult to discern any kind of direct trajectory toward concrete aid for peaceful nuclear energy in developing nations from Eisenhower's undoubtedly lofty, arguably quixotic, but frustratingly vague goals to take this "weapon out of the hands of the soldiers…[and] put [it] into the hands of those who will know how to strip its military casing and adapt it to the arts of peace."[80] Eisenhower likely intended Atoms for Peace to be something between the two extremes of positions taken by those who have interpreted it either as a literal and legitimate arms control and disarmament plan, or as mere propaganda. Instead, it sought to accomplish objectives across three broad groups of "nuclear, economic, and foreign policy," by outlining actions that would "blunt nuclear fears in order to quiet criticisms of the American nuclear project, support postwar development projects while encouraging American businesses, and cement old alliances while creating new ones."[81] Viewed this way, Atoms for Peace was the product of a president as committed in favor of nuclear weapons as he was against global disarmament negotiations, intended to be "the source of a new atomic diplomacy, a foreign policy, and set of practices that centered on reactors instead of weapons…[that] remade the global technological and political map through the export of knowledge, fissionable material, and equipment."[82]

Fortunately, the texts of and amendments to mid-1950s agreements on peaceful nuclear energy sharing between the United States and Brazil, and a separate but similar agreement between Argentina and the US, illuminate the details of Atoms for Peace aid in a region and

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[80] Eisenhower, "Atoms for Peace," 7.
[81] Mara Drogan, "Atoms for Peace, US Foreign Policy, and the Globalization of Nuclear Technology, 1953-1960" (PhD diss., State University of New York at Albany, 2011), iii.
[82] Drogan, "Atoms for Peace," 1, 8.

continent that eluded even one mention in the December 1953 speech. Both South American nations made initial agreements with the United States in the summer of 1955 – Argentina on July 29, and Brazil on August 3. [83] At the twilight of the Atoms for Peace era, the United States renegotiated some of the terms of these agreements on civil uses of atomic energy with each of the countries of interest in this dissertation.[84] Article I of the Argentina agreement defines nine terms in a legalistic fashion; the analogous article IX of the accord with Brazil defers to the Atomic Energy Act of 1954 for definitions of "restricted data," "atomic weapons," and "special nuclear material." Of course, these terms are quite interdependent, as "special nuclear material," defined as plutonium, uranium enriched in the 233 or 235 isotopes, or "any other material which the [US Atomic Energy] Commission determines to be" in that category, is tightly guarded in these agreements because of its potential use in creating "atomic weapons," for which all data "concerning…design, manufacture, or utilization" was considered restricted until declassified.[85] (These definitions are in fact identical to those found in the 1954 Atomic Energy Act).[86]

The following table shows which articles of the Argentine-US agreement of 1962 correspond to various portions of the Brazil-US agreement three years later. The two texts are

[83] United States Department of State, Treaties and Other International Acts Series 5125, "Atomic Energy Cooperation for Civil Uses: Agreement between the United States of America and Argentina, Signed at Washington June 22, 1962," 1, and United States Department of State, Treaties and Other International Acts Series 5676, "Atomic Energy Cooperation for Civil Uses: Agreement between the United States of America and Brazil, Amending the Agreement of August 3, 1955, as Amended," 1.
[84] Full texts of the agreements with Argentina (1962) and Brazil (1965) are available at the United States Library of Congress, Manuscripts Division, hereafter referred to as LOCM. The LOC also holds several amendments to similar earlier agreements. The 1962 agreement with Argentina is both longer and more detailed, containing eleven articles to Brazil's nine.
[85] United States Department of State, Treaties and Other International Acts Series 5125, "Atomic Energy Cooperation for Civil Uses: Agreement between the United States of America and Argentina, Signed at Washington June 22, 1962," 2, and United States Department of State, Treaties and Other International Acts Series 5676, "Atomic Energy Cooperation for Civil Uses: Agreement between the United States of America and Brazil, Amending the Agreement of August 3, 1955, as Amended," 9. LOCM.
[86] United States Nuclear Regulatory Commission, Nuclear Regulatory Legislation, 112th Congress, 2nd Session. Republished September 2013 at http://pbadupws.nrc.gov/docs/ML1327/ML13274A489.pdf#page=23, accessed March 8, 2017.

actually quite similar; several articles match almost word for word except for the name of the country receiving the technology, a surprising balance given that the Cuban Missile Crisis had occurred between the two renegotiations.

Table 1

Comparison of Argentina-US Agreement on Cooperation for Civil Uses of Atomic Energy (1962) and Brazil-US Agreement (1965)

Argentina Article #	*Brazil Article #*	*Topic*
I	IX	Definitions of terms used in the agreement
II	V	Prohibition of communication of Restricted Data; mutual pledge to assist in peaceful atomic energy use
III-IV	I	Scope of unclassified information to be shared; application or use of any information, material, equipment and/or devices is responsibility of the country receiving same
V part A	III part A	Materials of interest connected to research projects may be transferred in transaction that might be otherwise prohibited
VI	IV	Private individuals or organizations may deal directly with their counterparts in the other country regarding nuclear technologies
VII	II	Particulars of uranium enrichment and "special nuclear material" maxima that can be transferred from US to each South American country
VIII	III	In absence of commercial availability of any non-special nuclear material, arrangements can be made to purchase in amounts greater than what would be needed for research purposes
IX	VI	US retains rights to review design of reactors, other equipment, and devices to ensure effective application of safeguards; requires maintenance and production of operating records; US has right to purchase or require storage of special nuclear material produced from agreement.
X	VII	Guarantees maintenance of safeguards from article IX (Arg) / VI (Br), and guarantees peaceful use.[87]
XII	VIII	Details on when agreement enters into force and its duration

[87] "No material, including equipment and devices, transferred to the Government of [the Argentine Republic/Brazil] or authorized persons shall be used for atomic weapons or for research on or development of atomic weapons or for any other military purposes."

Article XI in the Argentina agreement is parallel to Article VII (A) in the Brazilian one, but with one important difference. The 1962 agreement with Argentina discusses the process by which the document would be modified by either party and how the degree of involvement or enforcement by the IAEA might be determined. The IAEA could administer safeguards on material transferred from the US to Argentina, *assuming representatives of those nations agreed to transfer that responsibility* "without modifying the terms of this Agreement," indicating both a growing role for the IAEA in administering nuclear safeguards and developing trust by nations in its ability to carry out that role. In the 1965 agreement between the US and Brazil, there is no flexibility on the role of the IAEA; the parties would "agree that the Agency *will be* requested to assume responsibility for applying safeguards to materials and facilities subject to safeguards under this Agreement for Cooperation…through an agreement to be concluded between the Parties and the Agency by August 2, 1965…"[88]

The other major difference in the US peaceful nuclear cooperation agreements with Argentina and Brazil, besides the much smaller amount of special nuclear material allowed to the latter for transfer and the optional vs. mandated role of the IAEA in enforcing safeguards, respectively, was the duration of the agreement. Argentina's accord was to "remain in force for a period of two years," and made no explicit mention of renewability, while Brazil's would be effective "until August 2, 1975, and shall be subject to renewal as may be mutually agreed." Mere weeks before that projected expiration date, on June 27, 1975, representatives from Brazil and West Germany would sign what was then the largest transfer of nuclear energy technology in history, a transaction discussed at length in Chapter 5.

[88] "Atomic Energy Cooperation for Civil Uses: Agreement between the United States of America and Brazil, Amending the Agreement of August 3, 1955, as Amended," 7.

Numerous revisions and clarifications would shape this cooperation over the following decade as United States policymakers became increasingly worried about nuclear weapons proliferation while the two South American nuclear programs sought greater independence from outside inputs and control. Article II of a 1962 amendment of the Argentina-US agreement stipulated the scope of American nuclear energy aid: "the development, design, construction, operation, and use of research, materials testing, experimental power, demonstration power, and power reactors, and reactor experiments," research on health and safety problems related to the above, and information on the role of radioactive isotopes and radiation in "physical and biological research, medical therapy, agriculture, and industry."[89]

Brazil's nuclear sharing agreement with the United States, amended biennially in July 1958, June 1960, and May 1962, limited the transfer of fissile uranium and plutonium to no more than "100 grams of contained U-235, 10 grams of U-233, 250 grams of plutonium in the form of fabricated foils and sources, and 10 grams of plutonium in other forms." By 1965, these limits had been relaxed somewhat; enriched uranium-235 content within US shipments to Brazil could be up to 15 kg, or 150 times the 1962 maximum. (Brazil's first research reactor, IEA-R1, began operation in 1957, so the reason for the precipitous increase in the American allotment of enriched uranium is unknown, or at least unexplained in the amended agreement). A side-by-side comparison of the Argentina-US and Brazil-US agreements from 1962 and 1965, respectively, yields many more similarities than differences.[90] However, in terms of the maximum allotment of enriched uranium that the United States would provide to each nation in the 1962 agreements – 65 kilograms for Argentina, but a mere 100 grams for Brazil, or 1/650th the maximum allowed to its neighbor – we see that the United States did not treat all

[89] United States Department of State, "Atomic Energy Cooperation: Argentina," 1962, 3.
[90] These are the agreements with the earliest dates for which I have full texts for each country, rather than merely the parts amended from the 1955 accords.

of its technology transfer partners and recipients of Atoms for Peace aid equally. The comparison and contrast of how the United States conducted its separate nuclear energy relationships with Argentina and Brazil is an instructive thread woven throughout this dissertation. Accordingly, at the end of this chapter, I briefly analyze and compare these two agreements before discussing the Treaty of Tlatelolco prohibiting the manufacture and storage of nuclear weapons in Latin America and the Caribbean in Chapter 2.

Reorganization of National Nuclear Energy Authorities

After Alberto's resignation as head of CNPq in March 1955 and the negotiation of Brazil's first nuclear cooperation agreement with the United States in August, the tensions that Oppenheimer had identified in his speech to the organization's members in Rio two years earlier had become quite acute. Furthermore, the unequal division of financing for nuclear energy activities and promotion of scientific research had aggravated the problem.[91] Juscelino Kubitschek, who took office on January 31, 1956, sought a nuclear policy much more along the lines of Getúlio Vargas and Álvaro Alberto than of Café Filho and Juarez Távora, and gave it a place of prominence in his *Plano das Metas* to industrialize Brazil in a short period of time.[92] Quite a lot had changed since 1946, when Alberto first had proposed establishing a national commission on nuclear energy: information about peaceful uses of nuclear energy circulated widely in the world's capitals and major cities, much was still unknown about the potential risks of nuclear accidents, and opposition to nuclear weapons had not crystallized in any significant way.[93] Alberto's tireless work at the UNAEC and among his colleagues across the globe to bring physical and human resources to Brazil's nascent nuclear energy program had also significantly changed the picture since the end of World War II. He ended up on the

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[91] Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 114.
[92] Patti, "Brazilian nuclear programme," 18.
[93] Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 117.

wrong end of a power struggle as Café Filho's chief of staff, Juarez Távora, had entered direct negotiations with the United States in order to take advantage of the terms of "Atoms for Peace" aid.[94] One condition that the US imposed for this aid was an exclusive relationship with Brazil; CNPq could not take that offer, as its representatives had already entered into agreements with Italy, France, and West Germany.[95] Alberto did not like to be overly dependent on one country, and consistently hedged his bets in this way.

The issue of exports of Brazil's nuclear minerals took center stage among the public in November 1955, when the *Diário Oficial* published the exchange of notes that confirmed the trade of American wheat for Brazilian thorium minerals.[96] 5,000 tons of monazite and the same quantity of cerium salts and rare earth metals were traded to the United States for 100,000 tons of wheat in 1954, and a "4th Atomic Agreement" arranged a similar trade in November of the following year.[97] The Commission on Exportation of Strategic Materials within the Ministry of Foreign Relations (Itamaraty) had undermined Alberto's specific compensations idea, where Brazil's mineral wealth was to be traded in exchange for nuclear technology or know-how. More seriously, Juarez Távora, in the capacity of Café Filho's chief of staff, had illegally traded the minerals to the United States by acting without CNPq's express consent.

As Távora's deception came to light through a Parliamentary Inquiry Commission (CPI) in 1956, a circle of powerful generals surrounding Kubitschek[98] sought to regain control over exports of strategic nuclear minerals. Work on the CPI proceeded for over two years, and

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[94] Patti, "Brazilian nuclear programme," 16.
[95] Patti, "Brazilian nuclear programme," 17.
[96] Garcia, *Álvaro Alberto*, 31.
[97] CNEN timeline, 1954 and 1955.
[98] Ribeiro de Andrade and Lopes dos Santos' article calls this wing of the military "developmentalist nationalists," and their opponents, such as Távora, "developmentalist non-nationalists." Stated more clearly along the argumentative lines of this chapter, the latter were a pro-American faction seeking looser controls on exports of strategic minerals, while Kubitschek and his allies sought closer state control over nuclear activities.

Dagoberto Salles of Kubitschek's Social Democratic Party (PSD)'s final report mostly echoed changes in Brazil's nuclear energy and mineral export policies that had already been made: exploration and protection of fissile and fertile mineral reserves, creation of a national atomic energy agency with broad political and financial autonomy, measures to stimulate the training of technicians, dissemination of results from mineral and mining research, and perhaps most pointedly, the suspension of Itamaraty's Commission on Exportation of Strategic Minerals.[99]

Where Salles' recommendations focused on remedies for past actions, Kubitschek's *Plano de Metas* outlined an ambitious future for nuclear policy in Brazil, including domestic manufacturing of fuel elements and a program to install nuclear power reactors.[100] Almost exactly concurrently with the CPI, a Special Commission for the Study of Atomic Energy in Brazil began its work, composed of foreign ministry officials, military personnel from each of the three branches, the presidents of the Council on Economic Development and the CNPq, the head of the Estado Maior das Forças Armadas, and secretary-general of the National Security Council; 60% of its participants were affiliated with the military.[101] Bilac Pinto, an opposition UDN party member from Kubitschek's home state of Minas Gerais, assailed the military predominance on the commission as a sign that the president knew nothing of "the most important problem of our time in the energy sector," was ignorant of the repercussions of peaceful nuclear energy use on society, politics, and the economy, and put Brazil's best interests in industrial and agricultural development at the mercy of the military, who presumably might wish to develop a nuclear weapon.[102]

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[99] Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 120-121. Dagoberto Salles himself published an account of the CPI in *Energia atômica: Um inquérito que abalou o Brasil* (São Paulo: Editora Fulgor Ltda., 1958), whose preface title, "Brasileiros contra o Brasil," leaves little doubt as to the position of Salles and his PSD allies on the illegal trade of nuclear minerals to the United States.
[100] Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 121.
[101] Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 122.
[102] Quoted in Ribeiro de Andrade and Lopes dos Santos, "A dinâmica política," 122.

Kubitschek carried out the recommendations of the Special Commission, undaunted by criticism such as Pinto's, creating two important new nuclear energy institutions: the Atomic Energy Institute, a collaboration between the CNPq and Universidade de São Paulo, and the National Nuclear Energy Commission, or CNEN. The Institute, to be inaugurated on the USP campus,[103] was charged, by Decree no. 39872, with facilitating research on peaceful use of nuclear energy, producing radioisotopes for studies and experiments across Brazil, contributing to training in nuclear science and technology, and establishing "bases, constructive information, and prototypes for reactors destined for the use of atomic energy for industrial ends, according to the country's needs."[104] The true purpose of the IEA was to serve as the home of the research reactor that US officials had agreed on August 3, 1955 to build and ship to Brazil, as the first major "Atoms for Peace" transaction with the South American country. Awkwardly, Kubitschek had to champion the IEA in order to receive the reactor that Távora, his opponent in the 1955 election, had negotiated as part of US nuclear energy aid. As described above, Távora and Itamaraty had parted ways with Alberto's CNPq in order to sidestep its insistence on specific compensations and multiple nuclear transfer partners.[105]

Back in Buenos Aires, the Argentine military was in open rebellion against Perón. Naval jets bombarded the Plaza de Mayo and Casa de Gobierno on June 16, 1955, as part of a failed coup attempt, but such turmoil did not delay the last stages of planning for the Bariloche physics institute.[106] Within fewer than three years of the denouement of the Huemul scandal,

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[103] The IEA is still located at USP's *Cidade Universitaria*, but has been renamed IPEN (*Instituto de Pesquisas Energéticas e Nucleares*) or the Nuclear and Energy Research Institute.
[104] Decreto nº 39.872, Senate of the Federative Republic of Brazil. August 31, 1956. http://legis.senado.leg.br/legislacao/ListaTextoSigen.action?norma=462455&id=14289556&idBinario=15660442
[105] Patti, "Brazilian nuclear programme," 16-17.
[106] Arturo López Dávalos and Norma Badino, *J.A. Balseiro: Crónica de una ilusión, una historia de la física en la Argentina* (Mendoza, Argentina: EDUINC, 2015), 142.

CNEA and the Argentine academy had combined to create the first institution of its kind in Latin America for specialized physics training for advanced undergraduates.

In the mid-1950s, too, one of Argentina's leading figures in nuclear energy rose to prominence as CNEA's new metallurgical expert. Jorge Alberto Sábato had been trained as a teacher of secondary school physics in the immediate postwar period, but made his living as a freelance journalist since 1947. He directed a small research laboratory for the Guillermo Decker metallurgy firm beginning in 1952, leaving in 1954 to serve as a "personal advisor and representative" to CNEA of a metallurgy research organization that he and Luis Boschi founded.[107] CNEA contracted with this company to obtain Sábato's advice on metallurgy and fuel elements for research reactors at the end of 1954, then placed the scientist at the head of a Metallurgy Service in early 1955, then a Division within CNEA in 1957, and finally a full-fledged Department in 1960.[108] Around this time, Pedro Iralagoitía issued a full-throated defense of CNEA's activities since the collapse of the Huemul Project, printed in full in *Mundo Atómico*. He recounted the inauguration of "over 100 laboratories [that deal with] physics, chemistry, radiochemistry, reactors, detectors, electronics, cosmic radiation, and biology," as well as "precision workshops where specialized Argentinian workers are building devices and mechanical objects to liberate us from foreign industry."[109]

The CNEA president mentioned three facilities for the processing and purification of uranium ores, in Córdoba, Villa Malargüe, and Buenos Aires province, and thirty geologists working in "the most remote regions of the country" to find uranium deposits and develop Argentina's capacity to produce heavy water, nuclear pure graphite, and beryllium. The geologists were part of "170 scientists and 230 technicians" working for CNEA at the time that

[107] http://www.houssay.org.ar/hh/bio/sabato.htm; Hurtado, *El sueño*, 67.
[108] Hurtado, *El sueño*, 67.
[109] Quoted in Hurtado, *El sueño*, 70.

Argentina inaugurated the first synchrocyclotron in the Southern Hemisphere in December 1954, the occasion for Iralagoitía's speech.[110] But the CNEA president saved his most shocking statistic for last: From its founding on the last day of May 1950 through the end of October 1954 – that is, including most of the expenses for the Huemul Project and the exorbitant start-up costs for nuclear energy infrastructure, laboratories, and facilities, Argentina's nuclear activities had cost roughly what the US Atomic Energy Commission had spent in the previous year alone.[111]

Iralagoitía had, in fact, aggregated several achievements in his defense of CNEA's spending over its first four years, which serve as evidence of the effectiveness of measures taken to rapidly institutionalize nuclear energy in Argentina. In 1950, the Nuclear Research Laboratory at the National University of Tucumán was created. Argentina's first known uranium deposit, called "Papagayo," was discovered in Mendoza province on Oct. 9, 1951 as well as its second, "Huemul," in May 1952. In February 1952, CNEA authorities finalized a contract with the Dutch firm Philips to purchase two particle accelerators, a synchrocyclotron and a simpler, older Cockroft-Walton model, to be installed at the agency's headquarters, and in that same year, uranium extraction from the "Agua Botada" deposit begain in Malargüe, Mendoza.[112] In 1953, as Iralagoitía briefly mentioned, a pilot plant began operation at Ezeiza, a short distance from the Argentine capital, for producing uranium metal by calciothermic reduction. The educational infrastructure for training in advanced physics and nuclear energy science sought by Gaviola and Balseiro began to take shape in 1953 as well with the first university course on nuclear reactors and creation of a professorship in nuclear chemistry. In 1954, construction began on a network of observatories to measure cosmic radiation that

[110] Hurtado, *El sueño*, 70.
[111] Hurtado quoting *Mundo Atómico* in *El Sueño*, 70.
[112] Hurtado, *El sueño*, 68, and CNEA timeline, http://www.cnea.gov.ar/historia.

would span from the far north of Argentina (Jujuy province) to Antarctica, at the Ellsworth base.[113] In terms of institutionalization and education, CNEA moved under the direct control of the President in 1954, by Executive Decree number 12205/54, and representatives of the Universidad de Cuyo and CNEA signed the agreement that created the Institute of Physics in Bariloche (soon renamed *Instituto Balseiro*) in 1955, the same year that CNEA headquarters offered its metallurgy course for the first time. That year, too, scientists and technicians had the opportunity to show the astonishing progress of nuclear energy research in Argentina so passionately defended by Iralagoitía to the world at the First International Conference on Peaceful Uses of Nuclear Energy in Geneva. Argentines presented 37 scientific papers on topics ranging from uranium deposits to medical use of radioisotopes, and reactor engineering calculations to chemical analysis techniques.[114] This burst of scientific research activity at Geneva would parallel the participation of Brazilian and Argentine scientists and engineers in another international academic forum, the Inter-American Nuclear Energy Commission's Symposia on Peaceful Uses in 1960 and 1962, discussed later in this chapter. After the false start at Huemul Island, Argentina's physics community had, it seemed, turned the nascent nuclear energy program onto a productive course by the middle of the decade.

Criticism from the United States

In the summer of 1956, United States Atomic Energy Commission (USAEC) chairman Lewis Strauss wrote his ninth report to Eisenhower on the status of the international peaceful atomic energy cooperation agreement. Eleven new agreements and six amendments to previously existing ones had been concluded during the recent congressional session, and this diplomatic activity "[brought] to 39 the number of agreements completed to date." Much of

[113] CNEA timeline.
[114] CNEA timeline.

these endeavors had focused on Latin American countries, as Costa Rica, Cuba, and the Dominican Republic had joined Austria, Ireland, New Zealand, and West Germany as countries with new general research (as distinct from nuclear power) agreements with the United States.[115] Australia, the Netherlands, and Switzerland had each concluded agreements that would facilitate nuclear power construction, including "the transfer of 500 kilograms of special nuclear material during the life of the agreement."[116]

Beginning with Strauss's memorandum, a hierarchy of needs – or at least of the AEC's technical ability and diplomatic willingness to meet those needs as the world's leading provider of nuclear technology and fuel – begins to emerge among the countries, spread across five of six inhabited continents, mentioned in this document. Amendments to agreements with Canada and the United Kingdom allowed for the exchange of information on military nuclear reactors, certainly the most secretive and restricted kind of nuclear energy cooperation agreement.[117] France, only four years from its successful bomb test in 1960, would receive "unclassified information and the transfer of 40 kilograms of special nuclear material," without any specification of the time span over which this material would be distributed. Denmark, Sweden, and West Germany's allotments of special nuclear material were doubled, via amendments, from six to twelve kilograms. Brazil, Cuba, Italy, and Norway appeared in a list of countries where negotiations for nuclear power agreements were underway, while Ecuador, Haiti, and Nicaragua were among the developing nations that had begun preliminary discussions of research reactor agreements.[118] (Notably, Brazil and Cuba were the only "third

[115] Lewis Strauss, United States Atomic Energy Commission Memorandum from Chairman to President Dwight Eisenhower, Aug. 30, 1956. Digital National Security Archive (hereafter DNSA), http://nsarchive.gwu.edu/publications/dnsa.html, downloaded March 2011.
[116] Strauss, "Peaceful Uses of Atomic Energy," 1.
[117] Strauss, "Peaceful Uses of Atomic Energy," 2.
[118] Strauss, "Peaceful Uses of Atomic Energy," 2.

world"/developing nations to be negotiating a power reactor cooperation agreement with the United States, and were two of the four nations that were pursuing, or had already secured, agreements for cooperation on both research and power reactors).

The report contained a paragraph specifically on "South American Interest in Atoms-For-Peace Program," praising the successful mission sent to the continent having returned "after holding successful discussions in Argentina, Brazil, Uruguay, and Venezuela." Rather generically, it continued by stating that both political officials and scientists "indicated a high degree of interest in moving forward in the atomic energy field" in these four nations, and hoped for US guidance in beginning and developing the technological and human infrastructure required to run nuclear energy programs. Argentina and Uruguay were invited to send delegations to "visit Washington and [US Atomic Energy] Commission installations for discussion on the peaceful uses of atomic energy." Lastly, Strauss mentioned that American industry would lend its hand to the cooperation plans with Latin American countries, specifically in building "research facilities…incorporated in three nuclear power plants projected by the American and Foreign Power Company Incorporated for construction in Latin America…available on a non-profit basis to local scientists for experimentation in nuclear projects."[119] In a Summary section on the following page, thirty-two countries with existing agreements for cooperation on research reactors are listed, as well as eight countries with such agreements pending.[120] A much smaller set of seven countries – all wealthy, industrial nations of Western Europe, as well as Canada and Australia – had existing cooperation agreements for power reactors in Strauss's list.

[119] Strauss, "Peaceful Uses of Atomic Energy," 3.

[120] Of the thirty-two countries with extant research reactor agreements in August 1956, eleven are in Latin America or the Caribbean; of the eight nations then in negotiation for this type of nuclear energy aid with the United States, two – Ecuador and Nicaragua – were from the broader region.

A secret policy planning memo from the Joint Chiefs of Staff meeting on February 23, 1960, painted a bleak picture of US-Latin American relations, the widespread presence of military governments in the region, and the combined dampening effects of these historical developments on an effective (Western) hemispheric defense policy. The anonymous author of this report painted Latin America as a region where "the inability of the indigenous forces to maintain even such relatively uncomplicated equipment as bulldozers" negated the effectiveness of employing military forces in civil construction projects.[121] Even if these efforts were moderately successful, economic instability in Latin America meant that "the number of troops available for these projects is not constant." His account was both paternalistic and condescending, in stark contrast to the rapid developments in science and technology, particularly around nuclear energy, that had taken place over the last decade in Brazil, Argentina, and other countries in the region.[122] (The issues of Latin American peaceful use of nuclear energy and guarantees of hemispheric defense would become inextricably linked in the discussions and debates that led to the Treaty of Tlatelolco over the course of the 1960s).

Despite the prevalence of military governments in Latin America, the Joint Staff concluded that any cooperation toward hemispheric defense from south of the Rio Grande would be unlikely. "Anti-submarine warfare is the only contribution expected from Latin America toward hemispheric defense during a global conflict." The author (perhaps one of the three listed representatives from the State Department or six from the Department of Defense) conceded that, for the preceding three decades, the US had "treated Latin American citizens as 'poor relations'," a period during which "the military elements in Latin America [had] been responsible for maintaining stability and the only element capable of maintaining internal

[121] Declassified Policy Planning Staff-JCS Joint Staff Meeting Report, February 23, 1960, NND 959001 [reproduced at the National Archives], DNSA.
[122] "Policy Planning," 1-3.

security."[123] The efforts of the United States military to minimize the role of Latin American forces had been unsuccessful "because of the Latin American temperament and attitude that they want what the US has." The author offers the example of the sale of a $10 million cruiser from the United Kingdom to Brazil as evidence of the Department of State's failure to check Latin American governments' "international pride and jealousies" as manifested by "desires and requirements" for military aid. The overall message of this report was even more damning than the paternalism and condescension toward Latin America. The idea of unified Western hemispheric defense, at the beginning of Eisenhower's last year in office, was no more than a "political…myth" that was the only "unifying factor" tying the United States to its southern neighbors, yet one that the United States would be unwise to shatter "for political reasons." In the next and final section of this chapter, I discuss the formation of the Inter-American Nuclear Energy Commission as well as papers given at its Symposium by Argentine and Brazilian scientists in the early 1960s. Their scientific work shows how far their nuclear energy research, institutions, and human resources had come after building them from scratch after World War II, and how transnational nuclear energy endeavors had become under Atoms for Peace.

…And an answer: The Inter-American Nuclear Energy Commission

The Council of the Organization of American States (OAS), acting on the recommendation of the Inter-American Committee of Presidential Representatives, created the Inter-American Nuclear Energy Commission by approving its statutes on April 22, 1959. Alwyn V. Freeman placed this new organization, IANEC, alongside other manifestations of "collective effort of the Western Hemisphere" such as the Inter-American conferences, the

[123] "Policy Planning," 1.

Council of the OAS, the Inter-American Economic and Social Council, and even the Inter-American Council of Jurists. In the field of nuclear energy, its most obvious parallel was Euratom, the European Atomic Energy Community, founded two years prior in 1957.[124] The new commission sought to achieve four primary goals: to act as a center for consultation on technical, economic, and administrative challenges related to peaceful appropriation of nuclear energy; to assist national-level planning for nuclear research and training; to help solve the specific problems of member states' nuclear energy programs, when requested; and to "provide a channel for scientific communication" via a bulletin and "conferences…to exchange knowledge."[125] One representative from each of the OAS' 21 member countries, "familiar with the nuclear energy programs of his country," would serve on the IANEC under the direction of a chair and vice-chair, each elected to one-year terms.

In October 1959 the new IANEC met for the first time in Washington, with representatives of fifteen countries – including Argentina and Brazil, and Mexico and the United States – seeking to develop "cooperative programs for training, education, and research in the nuclear sciences and for dissemination of information on nuclear energy in Latin America…[and] a survey of radioisotopes in research in the Americas, symposia on the peaceful applications of nuclear energy, and the elimination of tariff barriers on materials used in scientific training and research."[126] Eisenhower had suggested at a meeting of presidents from the Americas in July 1956 that nuclear energy represented a promising path toward closer hemispheric cooperation "among the American republics."[127] The nascent organization had

[124] Alwyn V. Freeman, "The Development of International Cooperation in the Peaceful Use of Atomic Energy." *The American Journal of International Law* 54, no. 2 (1960), 384.
[125] "Inter-American Nuclear Energy Commission to Hold First Meeting." *Science* 129, no. 3362 (Jun. 5, 1959): 1539.
[126] "Conference Spurs Nuclear Energy and Basic Sciences in Pan American Union," *Science* 130, no. 3383 (Oct 30, 1959): 1176.
[127] "Conference Spurs Nuclear Energy," 1176.

rejected the idea of a "single, large center" for cooperation on nuclear training, research, and education, opting instead for "increased utilization of existing national facilities and encouragement of worthwhile new endeavors in the various fields of nuclear specialization on a regional, rather than purely national, basis."[128]

The IANEC member nations would focus primarily on mathematics, basic and nuclear physics, and nuclear engineering and technology. These items' position atop an ordered list of priorities reflected "the general view among the delegates that nuclear studies cannot be pursued *in vacuo*, and that a general advancement in all the sciences underlies progress in the nuclear sciences."[129] J.D. Perkinson, executive secretary of IANEC and a former member of the US Atomic Energy Commission's training and education division, noted that the reverse effect often was observed as well: instituting a national nuclear energy program led to improvements in basic science and research infrastructure. Member delegations also sought to develop radioactive isotope use in agriculture, industry, and medicine, increase understanding of health and safety in nuclear materials research, and expand the geology and mining of nuclear materials.

The office files of US Atomic Energy Commissioner John F. Floberg, who held his post from 1957-1961, offer some insight into the direction and aims of the new IANEC, as well as the considerable efforts of its leaders and members to shape a hemispheric network of expertise and cooperation in peaceful use of nuclear energy. In a letter from Floberg to Sen. Clinton Anderson of New Mexico, chairman of the Joint Congressional Committee on Atomic Energy, the atomic energy commissioner highlighted "the most significant accomplishment of the IANEC" at its Oct. 20-24, 1959, meeting in Washington as "the establishment of an ad-hoc

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[128] "Conference Spurs Nuclear Energy," 1176.
[129] Ibid.

committee to formulate a coordinated and complete plan for the development of training, education, and research in the nuclear sciences, including mathematics, biology, chemistry, and physics."[130] Representatives of the US, along with Argentina, Brazil, Colombia, El Salvador, and Mexico, composed the ad-hoc committee. In Floberg's capacity as delegate, he reaffirmed that the US would increase financial and technical support to national centers and specialized research and training facilities across the Americas, and present an "Atoms for Peace Library" to the IANEC.

More concretely, Floberg also pledged up to US $50,000 (approximately $413,000 in 2017 dollars) toward the Third Inter-American Symposium on Peaceful Applications of Nuclear Energy to be held in Brazil in 1960. Six other recommendations followed from the first meeting, described by Floberg as "successful in that it established a definitive program for the coming year and brought about close ties between various key atomic energy officials from Latin America and the United States," and "free from political issues and marked by an air of cordiality."[131] Delegates had urged member states to study how nuclear energy information could be disseminated most efficiently, and suggested a "workshop of librarians and information specialists" to handle that task. They recommended an ongoing study and review of health and safety regulations in member nations, opportunities for training, and the creation of national or regional centers that would calibrate sensitive instruments and sources of radiation. In terms of the economic and legal infrastructure for emergent nuclear energy programs in the Americas, delegates recommended that member countries "give proper consideration to two draft conventions on tariff barriers and other import restrictions, prepared by the Pan-American Union," and that the same Pan-American Union continue its

[130] Letter from Atomic Energy Commissioner John F. Floberg to Sen. Clinton F. Anderson, Nov. 13, 1959. NARA. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission," 1.
[131] Letter from Floberg to Anderson, 3.

studies of cooperative nuclear energy legislation that would supplement, not supplant, national legislation in member states. To this end, the last recommendation was that the "Executive Secretary consult with other inter-governmental organizations concerned with the peaceful uses of atomic energy, and in particular with the International Atomic Energy Agency, on the possibility of cooperation between them and the [IANEC.]"[132]

Four days later, on Nov. 17, 1959, Floberg received a letter from Jesse Perkinson, Chief of the OAS's Division of Science Development, summarizing the informal IANEC meeting on training and education initiatives that had taken place on Oct. 24.[133] Two Argentine representatives, Rear Admiral Helio López and Dr. Eduardo Pardo, joined two Brazilians, Admiral Otacílio Cunha and Dr. Luiz Cintra Prado; Mexico also had two representatives present, and four Americans joined the single representatives of Colombia and El Salvador as well. An undated report on "Implementation of the Inter-American Nuclear Energy Commission Resolution on Training, Education, and Research in the Nuclear Sciences" prioritized the fields mentioned in the *Science* article – nuclear science mathematics, basic physics, nuclear engineering, and so on – and requested very specific information from member states in order to best implement the resolution.

The Executive Secretary would be responsible for detailed studies to determine the exact number of students (in a given country) that could be trained, qualifications required of those students, detailed subject matter to be taught in training, the facilities presently available and a budgeted request for increased space and equipment, the number of visiting faculty positions required, "housing availability for students, subsistence and other factors," and

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[132] Letter from Floberg to Anderson, 2.

[133] Jesse D. Perkinson, Jr., to John A. Floberg, Nov. 17, 1959. NARA. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission," 1.

administrative details such as institutional or governmental contributions to effect the plans.[134] In the countries with smaller research infrastructures, delegates recognized, financial and logistical assistance might be needed to collect this information; the OAS Direct Technical Assistance program "would be utilized whenever possible," and the Executive Secretary of IANEC offered to earmark $10,000 within the 1960 budget for the Division of Science Development. Delegates also suggested international pools of money; Eduardo Pardo, the Argentine permanent representative to the IAEA in Vienna mentioned a US $200,000 direct technical assistance fund held by that agency, as well as the United Nations' "very extensive fund for expanded technical assistance in excess of US $20 million."[135]

Once funding had been secured for this collection of detailed information and it was underway, the ad hoc advisory committee would be regularly updated on the progress of the ambitious project. The Executive Secretary would submit a report to the committee when all information had been gathered, two to four weeks before the committee's scheduled meeting. Ideally, that meeting would take place with sufficient time before the second general meeting of the IANEC to prepare and revise a final report of the ad hoc committee's work.[136] In late 1959 or early 1960, a suggestion that this second IANEC meeting be combined with the Third Inter-American Symposium on the Peaceful Application of Nuclear Energy had been all but accepted by Perkinson, the IANEC's Executive Secretary. In uniting the two hemispheric nuclear energy cooperation events in Brazil, at the invitation of its president Juscelino Kubitschek, Perkinson argued that "savings can be realized in technical and administrative secretariat services…[and]

[134] "Implementation of the Inter-American Nuclear Energy Commission Resolution on Training, Education, and Research in the Nuclear Sciences." Undated; attached to a memorandum dated Nov. 16, 1959. NARA. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission," 4.
[135] "Memorandum: Informal Meeting of ad-hoc Advisory Committee on Training and Education." Nov. 16, 1959. NARA. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission," 2.
[136] "Implementation of the IANEC…," 2.

travel expenses…by member governments."[137] In addition to conferring a significant financial advantage, Perkinson believed that combining the two events would lead to a more fruitful collaboration, and "considerably strengthen [the IANEC meeting] by the presence of scientific and technical experts who will be present for the Symposium."

Days later, Perkinson formally requested the transfer of the $50,000 to support the Symposium that the United States had promised at the October 1959 meeting.[138] Kubitschek would get a chance to show off his glistening capital city of Brasília when the symposium opened there on July 18, 1960, then technical sessions lasting four days would begin in Petropolis, approximately 42 miles northeast of Rio de Janeiro city. In those five days, Brazil's CNEN, the United States Atomic Energy Commission, and the IANEC secretariat planned to achieve five objectives, perhaps seen most clearly as five separate but related discussions. An overall aim of a "thorough appraisal of the technological and industrial benefits that can be achieved through the application of nuclear energy" was buttressed by three more focused goals – to present "specific nuclear power projects under consideration," to discuss research on the application of radiation and radioisotopes to industry, and to analyze "progress in reactor physics, chemical engineering, health and safety, and training and education." The fifth goal was explicitly aimed at deepening connections "among the scientific and administrative leaders in nuclear energy throughout the Americas" through exchanging technical information and developing personal contacts.[139] Participants would be chosen by the Symposium Planning Committee; those 32 individuals invited to make oral presentations would receive international

[137] Letter from Jesse D. Perkinson, Jr., to John A. Floberg, February 17, 1960. National Archives and Records Administration, College Park, MD. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission," 1.
[138] Letter from Perkinson to Floberg, 1.
[139] Letter from Perkinson to Floberg, 2.

air travel to Brazil, while Kubitschek's government picked up the check for local expenses and travel once its guests had arrived.[140]

Before serious plans for nuclear power plants became a national priority in both Brazil and Argentina, scientists and technicians in CNEN and CNEA as well as those in major universities in both nations contributed to IANEC's international Symposia on the Peaceful Application of Nuclear Energy. Without going into excessive detail, a discussion of the papers presented at the third and fourth Symposia by Brazilian and Argentine scientists and nuclear energy technicians will both illuminate the most important problems facing the countries' leading researchers in physical science and nuclear engineering as they began to interact with a wider community of experts provided by IANEC's ambitious goal of hemispheric cooperation on expanding and developing peaceful uses of nuclear energy.

At the Third International Symposium at Petrópolis, in July 1960, Argentine and Brazilian technicians presented thirteen papers on various advanced nuclear energy research projects. The most ambitious papers that contemplated a future national nuclear power program and the combinations of fuel and extant technology that were most practical in local conditions both came from Brazilians. Sergio de Salvo Brito, a technical advisor to Brazil's CNEN, analyzed how long fuel supplies would take to double in a hypothetical uranium-233/thorium cycle "as the basis of a national program of electric power from nuclear sources." Salvo Brito's ideas drew on the relative abundance of thorium under Brazilian soil in contrast

[140] Of the $50,000 budget for the United States funds for the symposium, $21,000 was allocated for air travel by the 32 participants; $10,500 for simultaneous interpretation in English, Spanish, and Portuguese, and the transportation and per diem expenses of those working as translators, and $9,000 to transport, lodge, and feed the Secretariat of the IANEC. The $9,000 remaining was to be used on equipment rental, conference materials, communications, and contingencies. From "Proposed Budget, Third Inter-American Symposium on the Peaceful Application of Nuclear Energy." Attached to February 24, 1960 letter from Jesse D. Perkinson, Jr., to John A. Floberg, National Archives and Records Administration, College Park, MD. RG 326, Box 3, folder "Inter-American Nuclear Energy Commission."

to uranium's "insufficiency and generally difficult and expensive extraction."[141] Hypothesizing an annual growth in energy demand of 10%, Salvo Brito argued for a national nuclear power program based on fuel-regenerating power reactors that turned plentiful thorium into fissile uranium-233 by capturing one neutron from thorium-232. Salvo Brito calculated the minimum neutron flux measurements to allow for fuel regeneration given various levels of initial enrichment of the fuel rods, to be made "of thorium that had previously been irradiated to an optimum U_{233} concentration," but warned that high fluxes would produce too much protactinium-233, an element with a "long half-life…that could poison the reactor and diminish the generation of uranium-233 by the unproductive absorption of neutrons."[142] The ideal thorium-fueled reactor would have a "high power output, high flux, and large dimensions," but the engineer did not sugarcoat his conclusion that "too short a useful life can be expected" because of the lingering problem of the poisonous protactinium.

Octavio Augusto Dias Carneiro devoted his paper not to an innovative idea for nuclear fuel, but rather to a broader consideration of the Brazilian demand for electricity and local conditions that both made nuclear power a desirable national asset and complicated the initial efforts to plan the massive capital investment that it would require. Dias Carneiro adopted three predictive hypotheses in his account of how CNEN came to issue its Decree 47.574 to begin technical and economic feasibility studies on a specific potential power reactor site on the Mambucaba River. One hypothesis was of scarcity - Brazil's international finance situation would still be precarious and the country's "administrative, managerial, technical and professional capacity would all remain lacking" for the next ten or twenty years. The second was that energy sector planners in Brazil would opt for short-term expediency at the cost of

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141 Sergio Salvo Brito, "Ciclo U_{233}-Torio em Reatores Térmicos de uma Região: Discussão Paramétrica." Third IAS Symposium Program, 91.
142 Salvo Brito, "O Ciclo U-233," 89, 92.

long-term efficiency, relying on traditional and quickly constructed thermoelectric power plants to meet energy demand in areas that were approaching the limits of their hydroelectric resources – like the densely populated center-south – instead of contemplating the possibilities of nuclear power. The third was that Brazil's nuclear planners would willingly assume a degree of risk and uncertainty in any planning, given that "even in 1965 [five years after the symposium], it is improbable that we would have complete knowledge about all the types of reactors that would allow for a proper evaluation of the economic and engineering aspects of nuclear power."[143] Brazil's burgeoning center-south, with the megacities of Rio de Janeiro and São Paulo providing both the population and industrial might that were fundamental to the nation's economic development, was for Dias Carneiro the ideal region to serve as a test case for nuclear power. Contending with economies of scale – nuclear power plants with larger capacities, while more expensive initially, produced cheaper power per kilowatt installed[144] - would prove another challenge for CNEN, which had begun exploratory studies on nuclear power immediately after its founding in 1956, and sent observers to Italy to witness that country's first nuclear power decision process in 1958. In conclusion, Dias Carneiro wrote that it would be "foolish" for Brazil not to be prepared to confront, "if not resolve," the social and technical problems around the inevitable necessity for nuclear power as an invaluable "investment in the future of the country."[145]

Other scientists and engineers took the research reactors of Brazil and Argentina themselves as their objects of study. Francisco de Assis Magalhães Gomes, director of Brazil's Institute of Radioactive Research at the School of Engineering, Universidade de Minas Gerais,

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[143] Octavio Augusto Dias Carneiro, "O projeto da Central Nuclear de Mambucaba," Third IAS Symposium Program, 398.
[144] Dias Carneiro, "O projeto da Central Nuclear," 362.
[145] Dias Carneiro, "O projeto da Central Nuclear," 365.

sought to apply the experimental TRIGA reactor, inaugurated there in 1960, to industry in Brazil.[146] The reactor, which had arrived in Brazil from the United States, but was not installed at the time the paper was written, would occupy an area of around 40,000 square meters along with related laboratories.[147] CNEN had obtained a concession of 3 kilograms of uranium-235 from the US Atomic Energy Commission to fuel the reactor, which was "particularly suited to the fabrication of radioisotopes," and capable of making "close to 80% of the isotopes employed in nuclear research."[148] These isotopes, far from being a matter of mere academic curiosity among physicists or nuclear engineers, could be used in at least six functions that would benefit industry. As an analytical tool for detecting chemical impurities, radioisotopes rivaled spectrographic analysis for accuracy and precision, and could be introduced in concentrations as low as one part per million.

In solids, like steel, isotopes could serve as a measure of purity as well, useful in detecting "non-metallic inclusions" in ingots of industrial metal alloys. The author used another steelmaking example to illustrate how isotopes could be used for "study and control of industrial processes," to trace the loss of metal during the melting process in blast furnaces, or leaks of petroleum products in pipelines. As a means of conducting quality control for the products of large industrial processes, Magalhães Gomes noted, cobalt-60 and cesium-137 had been used successfully to measure the thickness of paper and plastics; other isotopes might measure different qualities of materials, such as pressure, density, or concentration of solutions.[149] Lastly, isotopes were of great value to some processes of industrial production

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146 CNEN timeline, 1960.

147 Francisco de Assis Magalhães Gomes, "Serviços que o reator Triga, do Instituto de Pesquisas Radioativas da Escola de Engenharia da Universidade de Minas Gerais pode prestar à indústria." Third IAS Symposium Program, 228.

148 Magalhães Gomes, "Serviços," 229.

149 Magalhães Gomes, "Serviços," 230.

themselves – polymers and plastics – and as preservatives for food and pharmaceutical products. The Institute of Radioactive Research stood ready to help Brazilian industry with its technicians specialized in nuclear energy generation, with its isotopes that would be produced by the new reactor, and with its offers of technical assistance in applying radiation and radioisotopes to a broad variety of industrial processes and controls.

In a paper of much narrower focus than that of Magalhães Gomes – but one that nonetheless helps to elucidate the value of nuclear energy to industry, particularly the use of radioisotopes as tracers – a research team of five from the Division of Radiochemistry in the Department of Chemistry at Argentina's CNEA described how they had used a radioactive tracer, bromine-82, to determine the path of gases in a pipeline distribution system running along Belgrano Avenue in Buenos Aires.[150] The tracer needed to be gaseous in the range of temperatures in the pipeline, chemically similar to the components of the gas in which it was dissolved, not reactive with the materials of the pipeline itself, have low solubility in water, a short half-life, and be easily detected by a Geiger-Müller counter.[151] The 200-300 millicuries of radioactivity in the methyl bromide distributed through the gas pipeline, the authors wrote, were more than sufficient; the method of detection was sensitive enough that one-tenth of that amount would have led them to declare the experiment successful "to resolve problems of this type."

Another Argentine team from CNEA presented a short paper on equipment built in Argentina for industrial gamma radiography, noting the advancement of non-destructive testing techniques and their application to "various problems in manufacturing, especially

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[150] J. Pahissa-Campá, E. Alvarez, C. A. Henkel, L. J. Anghileri, and O. O. Gatti, "Detección de intercomunicaciones en cañerias de gas con el empleo de radioisotopos." Third IAS Symposium Program, 233.
[151] Pahissa-Campá, Alvarez, Henkel, et al, "Detección," 231.

smelting and soldering of metal pieces."[152] In an intriguing partnership between CNEA's Department of Radioisotopes and small private firms, technicians and industrial employees constructed seven large instruments, charged with cobalt-60 or iridium-192, to be used in quality control for concrete production, inspection of industrial tubing, and other tasks, where the short wavelength of emitted gamma rays permits them to enter and exit hard materials such as metals and manifest defects not otherwise visible to the human eye. Not only did the industrial radiography devices find a displaced lead cap on a fuel element intended for use in Argentina's newest research reactor, RA-3,[153] but their design and construction proved the country's "relative industrial capacity" and led to industry's acceptance of the new nuclear technology's superiority over X-rays and older radiography methods.

Coda: Cuba and Nuclear Missiles in Latin America, 1962

The Atomic Age exploded into existence with the unprecedented devastation of Hiroshima, Japan, on August 6, 1945. Seventeen years later, the United States found itself under a grave threat from Soviet nuclear ballistic missiles that had been covertly placed over the late summer and early fall near Havana, Cuba, and at other sites on the Caribbean island. It is not the place of this dissertation or chapter to discuss that crisis in detail, but the effects of the late October 1962 standoff put Latin American nations at the heart of the Cold War. Before the October Crisis, an entire continent and geopolitical region of the world had been relatively free of both the superpower conflict between the United States and Soviet Union and the threat of nuclear war.

Almost six months to the day after the peaceful resolution of the October Crisis, on April 29, 1963, five Latin American heads of state, including João Goulart of Brazil, signed a

[152] A. Capo, N. Mundiroff, and C. Papadópulos, "Los equipos de gammagrafia industrial construidos en la Argentina." Third IAS Symposium Program, 235.
[153] Capo, Mundiroff, and Papadópulos, "Los equipos," 238.

declaration on the denuclearization of Latin America. A country's leaders could forever renounce the path to developing a weapon, but how could they prevent nuclear-armed states from unleashing another similar crisis in the region? And if the military forcibly took the reins of government from elected leaders, how might the nascent and fragile ideas of nuclear nonproliferation be changed? I turn to Chapter 2, Swords: "Brazil and Argentina: From the Forefront of Non-Proliferation Toward an Uncertain Nuclear Future, 1963-1970," to answer.

Chapter 2: Swords

From the Forefront of Non-Proliferation Toward an Uncertain Nuclear Future, 1963-1970

Less than five years after the peaceful conclusion of the two-week Cuban Missile Crisis of October 1962, delegates from Latin American and Caribbean nations celebrated the first treaty creating a nuclear weapon free zone in a populated area of the world.[1] On February 14, 1967, representatives of 14 nations signed the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean, which forbade signatories from "the testing, use, manufacture, production, or acquisition…of any nuclear weapon… and the receipt, storage, installation, emplacement, or any form of possession of a nuclear weapon, directly or indirectly, of their own volition, that of a third party, or in any other form."[2] The strangely specific language about receipt and emplacement evoked the tension of the Cuban Missile Crisis, but Cuba would not sign or ratify the treaty for almost three decades. Brazil and Argentina, however, signed the treaty in fairly short order, on May 9, 1967, and September 27, 1967, respectively. If the Treaty of Tlatelolco had been a more traditional international agreement, this story would be quite uneventful, indeed.

During the negotiations in Mexico City toward what was erroneously called a "denuclearization" agreement from its beginnings in November 1964 through its final draft in February 1967, delegations from Brazil and Argentina steadily moved to a common position nearly opposite that of their hosts on many of the treaty's most contentious issues.[3] This

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[1] The first nuclear-weapon-free zone treaty in the world in fact banned such arms from Antarctica (1961); later in 1967, after the Tlatelolco agreement was signed but before it went into force, the Outer Space Treaty banned nations from placing weapons of mass destruction in orbit around the Earth, on the Moon, or elsewhere in outer space.

[2] Article 1, Treaty of Tlatelolco. http://www.opanal.org/texto-del-tratado-de-tlatelolco/. Number of nations signing on first day taken from http://www.opanal.org/status-del-tratado-de-tlatelolco/, and also given in Appendix B.

[3] REUPRAL was the official acronym in Spanish for the Preliminary Meeting on the Denuclearization of Latin America, a one-week gathering from Nov. 23-27, 1964 that established a majority of countries in favor of a

chapter argues that Brazil and Argentina handled the challenges of Tlatelolco both adroitly and defiantly, as the energy which both nations had poured into massive investments in physical infrastructure and human capital to begin the region's leading nuclear programs shifted toward a new form as diplomacy and negotiation. In doing so, representatives and officials from the two nations pushed the South American neighbors toward a "third way" in nuclear energy and continued to chart parallel paths through the Atomic Age. The Spanish American colonial maxim "*Obedezco pero no cumplo*" (I obey, but I do not comply) seems especially apt to describe the neighbors' relationship to the treaty: they both signed within the year it was finished, but had no indication of bringing it into force for a very long time. A brief history of the weighty issues confronted by the Tlatelolco negotiators, their responses, and resolutions of the conflicts that arose in the process, follows here. Brazil and Argentina initially ceded much of the early work to other delegations, gradually taking on more significant roles, until the finished treaty bore their indelible imprint.

Rather than view the agreement in the context of global security and the creation of other nuclear weapon free zones, I analyze the Treaty of Tlatelolco primarily as a key event in the nuclear energy histories of Argentina and Brazil, and as a chance for their delegations to both understand and articulate the role of nuclear energy technology within their own political and technological environments.[4] In this larger global context better explored in the historiography and scholarship, much attention has been focused upon both the virtues and

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resolution to proceed toward a regional agreement. COPREDAL, where the treaty itself was negotiated, stood for the Preparatory Commission for the Denuclearization of Latin America. Strictly speaking, since the Soviet missiles had been removed from Cuba, Latin America – with the possible exception of Puerto Rico, if any US nuclear weapons were stored there – did not need to be "denuclearized." The term was ambiguous in addition to being historically inaccurate, since only nuclear weapons were at issue, and not all forms of nuclear technology.

[4] Ian Bellamy, *Curbing the Spread of Nuclear Weapons* (2006), Leonard Spector, *The Undeclared Bomb* (1988), Gasparini Alves and Cipollone, *Nuclear-Weapon-Free Zones in the 21st Century* (1997) and Ramesh Thakur, *Nuclear Weapons-Free Zones* (1998) are a few of the works that analyze nuclear weapon free zones in a global security context.

flaws of Tlatelolco as the world's first regional nuclear nonproliferation agreement, with only brief asides explaining that complicating language and provisions were added to mollify the concerns of the two neighboring powers about the agreement restricting their sovereign freedom to develop autonomous nuclear technologies. Accordingly, this chapter will move between a wider perspective, focused on the negotiations as a whole, and one centered upon the newly available evidence showcasing Brazilian and Argentine delegations' roles and positions taken within those negotiations.

After more than a decade of disappointing and ultimately frustrated attempts to limit or ban the production of nuclear weapons, both in Latin America and across the globe, it is in many ways surprising that such an unprecedented and far-reaching attempt at nuclear arms control as the Treaty of Tlatelolco gained enough support to become a legal reality. Nuclear disarmament had been both a complex and contentious topic for international diplomats at the relatively new forum that was the United Nations (UN), even before serious discussions on the topic began in Latin American countries. The leadership of Latin American diplomats in these early global talks, chief among them Alfonso García Robles of Mexico, would link a long historical trajectory of relative peace between nations in the region[5] with the new, immense challenges posed by the atomic bomb to world peace and order. García Robles' account situates the beginning of official global disarmament discussions within the UN in 1952 with Resolution 502(VI), which created the United Nations Disarmament Committee under the

[5] This phenomenon is well historicized and analyzed in a monograph with a somewhat misleading title, *Blood and Debt* (Miguel Ángel Centeno, 2003). Centeno argued that political violence on the continent occurred largely *within* nation-states (civil conflicts) and not *between* them, and posited that weak, constrained governments exhausted themselves fighting internal enemies and had little energy or impetus to pursue military conflicts beyond their borders. His monograph derived its conclusions from roughly the first century of Latin American independence, but that trend – international peace marred by internal discord and violence – held steady through the end of the Cold War.

auspices of the Security Council.[6] This resolution dissolved the UN Atomic Energy Commission, of which Álvaro Alberto had been both member and chair, and recommended to dissolve the Commission for Conventional Armaments, essentially placing nuclear and conventional arms control under one UN umbrella. Two years later, in 1954, diplomats would build upon the preliminary effort of Resolution 502(VI) with some "primordial objectives" in the text of Resolution 808(IX). This early (and perhaps hopelessly idealistic) "one size fits all" approach to disarmament sought "the total prohibition of the usage and fabrication of nuclear weapons and all types of weapons of mass destruction, as well as the transformation of existing reserves of nuclear weapons to peaceful ends."[7] Britain, which had conducted its first successful nuclear weapons test in 1952, had recently joined the United States and Soviet Union in the "nuclear club" of nations possessing atomic weapons. The Cold War rivals joined Britain in categorically rejecting this first UN disarmament plan. To this day, only one nation that has developed nuclear weapons, South Africa, has since "denuclearized," renouncing and disabling those arms;[8] less than a decade into the nuclear age, complete atomic disarmament was absolutely out of the question for the nations that would need to give up weapons already orders of magnitude more powerful than those detonated in Japan.

A concerted set of efforts designed to slow the proliferation of both nuclear and conventional weapons specific to the Latin American region began later in the 1950s. Ambassadors and diplomats devised these attempts partially in response to deadlocks at the global level of the United Nations, and often used the language of "hemispheric security" in

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[6] http://www.un.org/documents/ga/res/6/ares6.htm. This is *not* the same body as the Eighteen-Nation Committee on Disarmament (1962-1969), or ENCD, that would draw up the preliminary Non-Proliferation Treaty (1968).

[7] Alfonso García Robles, *México en las Naciones Unidas*, vol. 1. (Mexico City: UNAM, 1970): 135.

[8] Anna-Mart Van Wyk, "South Africa's Nuclear Programme and the Cold War," *History Compass* 8, no. 7 (2010): 562.

doing so. In January 1958, almost five years before the Cuban Missile Crisis, Costa Rica's ambassador proposed a hemispheric disarmament statute at the Organization of American States (OAS), prohibiting Latin American nations from either developing nuclear weapons or purchasing these arms from the United States. The US would be able to deploy its nuclear weapons in situations where they were deemed essential to "hemispheric security." The plan's prospects for success suffered, though, as these early Latin American advocates of nuclear disarmament grew suspect of the degree of American support and enthusiasm for the initiative.[9] After all, Costa Rica's plan was "fully consistent with [the United States'] foreign policy toward the region…to prevent and exclude any external power from establishing a military presence in the hemisphere."[10] That language was almost certainly intended to call to mind the Monroe Doctrine; Costa Rica's plan seemed to undermine what one scholar called "the multilateralization of the Monroe Doctrine" that had been in place since the 1947 Treaty of Reciprocal Assistance, or Rio Treaty.[11] "It now appeared that the unilateral Monroe Doctrine, the idea that the United States *alone* would decide when to fight to defend its neighbors, had ceased to exist…something they had wanted almost without hope for so long."[12] Not only did the critics of the Costa Rican plan argue that the scheme had the potential to play into the Americans' hands all too neatly, but several Latin American leaders also felt that the regional level was inappropriate to address what was fundamentally a global issue. Mexico's ambassador to the OAS attempted to discredit the Costa Rican plan using the above logic, protesting that

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[9] The Tlatelolco agreement would eventually ban *any* nuclear-armed nation from deploying such weapons in the zone covered by the treaty. As I see it, this is the most important distinction between Costa Rica's early plan and the agreement that would define the Latin American nuclear weapon free zone a decade later. Otherwise, the two proposals actually appear quite similar in both their aims and the means planned for achieving them.

[10] Mónica Serrano, *Common Security in Latin America: The 1967 Treaty of Tlatelolco* (London: Institute of Latin American Studies, 1992), 11-12.

[11] Gene A. Sessions, "The Multilateralization of the Monroe Doctrine: The Rio Treaty, 1947." *World Affairs* 136, no. 3 (1973-1974): 259.

[12] Sessions, "Multilateralization," 260.

nuclear disarmament plans should be hashed out in the United Nations, and not an inter-American hemispheric cooperation forum.[13]

A more promising attempt for regional weapons limitation by Chile's President Jorge Alessandri in 1959 was derailed by US hypocrisy, according to Mónica Serrano. Alessandri had called for an inter-American conference to limit all armaments "beyond the reasonable limits for defense against aggression." United States diplomats had indicated their support for the proposal, hoping that funds that might be used for weapons in Latin American nations could instead be re-appropriated toward economic development. However, arms manufacturers and dealers in the United States were alarmed by recent increases in Latin American purchases from competing European makers of weapons. Manufacturers of weapons and warships in the United States opposed Alessandri's partial disarmament plan for the region, instead urging efforts to make their destroyers and submarines available to "friendly nations." This idea seemed both to undermine Latin American disarmament efforts under Alessandri's plan and to cast doubt on the sincerity of United States diplomats' words of support for the Chilean president's arms limitation plans.[14] The prospects for disarmament or arms limitation at the global level seemed no more hopeful than those in Latin America. Brazil and Mexico, representing the region at the Eighteen-Nation Disarmament Committee of the United Nations after December 1961, had found themselves playing a "mediating role between the nuclear powers"[15] within a body where, paradoxically, the goals of general and complete arms reduction

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[13] Again, it is difficult, and indeed counterproductive, to ignore the similarities between plans rejected out of hand in the late 1950s and those accepted as the best response to what many political and diplomatic leaders saw as a global crisis of nuclear proliferation in the mid- and late 1960s. Mexico and Brazil would play leading roles on the UN Eighteen Nation Disarmament Committee (ENDC) over its existence from 1962-1969, and the writings of Brazil's representative there, Antônio Azeredo da Silveira, are illuminating on the role of nuclear energy in global security and economic development.

[14] Serrano, *Common Security*, 15. The analysis of the reaction to Alessandri's proposal in her work implies that Latin American leaders rejected nuclear weaponry as a category of arms well outside those "reasonable limits" to which the Chilean president had alluded.

[15] Serrano, *Common Security*, 18.

would become, except between 1962-1964, "merely an academic matter."[16] Brazil's own representative to COPREDAL, the body that would negotiate and draft the Treaty of Tlatelolco, would later refer somewhat poetically to this frustrating history of international forums on disarmament as "a cemetery of lost hopes."[17]

It was not in any hemispheric or continental forum particular to Latin America, but rather at the 17th session of the United Nations General Assembly, in 1962, that the idea of a Latin American "denuclearization" agreement was first advanced with Brazil in a leadership role. President João Goulart, in the aftermath of the Cuban crisis of October 1962, sought to be a mediator with the Caribbean nation, and thus capitalize on a relationship where "within the American community, Brazil was the country that inspired Fidel Castro's trust the most."[18] Goulart, too, had unknowingly been the key figure of an elaborate scheme by President Kennedy and the Executive Committee during the crisis itself, to use Brazil's ambassador in Havana, Luis Batian Pinto, to convince Castro that Goulart himself wanted the Cuban leader to stand down.[19] (Brazil's primary representative at Tlatelolco, José Sette Camara, the author of the characterization of Goulart's political sympathies above, had a rather acerbic, at times unsubtle, wit and sarcasm in discussing people with whom he disagreed and ideas that he did

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[16] Alfonso García Robles, *México en las Naciones Unidas*, 136. (The Mexican diplomat argues that US and Soviet proposals were given serious and honest consideration on the Eighteen-Nation Disarmament Committee from 1962-64). For a more complete analysis of the ENDC from García Robles's perspective, see *El Comité de Desarme: Antecedentes, constitución, y funcionamento* (Mexico City: Editorial de El Colegio Nacional, 1980).
[17] COPREDAL/AR/10, 95. From a nine-volume compendium of documents concerning Tlatelolco and OPANAL released by the Mexican Secretariat of Foreign Relations, these documents are referenced by widely accepted codes – "AR" for *Actas resumidas*, 10 for the tenth plenary session of negotiations – because they are found in many different groupings and formats. (Secretaría de Relaciones Exteriores de México. *Colección de documentos de la Reunión Preliminar sobre la Desnuclearización de la América Latina, 1964-1967*. Mexico City: Secretaría de Relaciones Exteriores, 1968). This preparatory commission, in which this representative, José Sette Camara, and his counterparts debated topics that would shape nuclear diplomacy for decades to come, took the name of COPREDAL (*Comisión Preparatoria para la Desnuclearización de América Latina*).
[18] José Sette Camara, memorandum from 3/30/1965, folder 953.0(20), Anexo II, Archivo de Itamaraty, Brasília, Brazil, hereafter AMREB.
[19] Dean Rusk, US Secretary of State to US Ambassador to Brazil, diplomatic cable. October 26, 1962. National Security Archive, George Washington University, hereafter DNSA.
http://nsarchive.gwu.edu/NSAEBB/NSAEBB395/

not support.[20] The leftist president whom the military government had ousted from power in 1964 was certainly not exempt from this treatment). Preliminary contacts with the United States in 1962 by then-head of the Brazilian UN delegation, Afonso Arinos, indicated that the US was open to the South American country acting as mediator. But the United States government had not yet processed the full weight and effects of the missile crisis, and as 1962 drew to a close, began to "consider the Brazilian suggestion from other angles and draw up serious reservations to it." The delegation from Brazil, thwarted by the indecision and unease of the regional hegemon that would need to be a key ally, or, at the very least, a tacit supporter of the project, then withdrew the denuclearization proposal until the next General Assembly.

Latin American leaders supporting disarmament in regional and global forums indeed seemed to articulate the wishes of publics back home, who tenaciously supported regional arms reduction agreements. The effects of the Cuban Missile Crisis of October 1962 played a central role both in heightening fears of nuclear cataclysm and increasing public hopes for a global and durable diplomatic solution. A 1963 poll, after all, showed Latin American public opinion to be ardently in favor of "abolishing nuclear weapons worldwide." In Caracas, 90 percent of those polled supported this idea; in Mexico City, 87 percent; in Buenos Aires, 84 percent; and in Rio de Janeiro, 65 percent did so.[21] A prominent scholar of global disarmament interprets these

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[20] It might be reasonable to assume that Brazil's ruling generals would send lower-level diplomats to Mexico City to occupy their time on a matter that was of little concern in the highest political circles, but Rogério de Souza Farias, Brazilian diplomat and scholar of Itamaraty, explained to me via email (July 23, 2017) that Sette Camara and Sergio Corrêa da Costa, Brazil's chief negotiators at Tlatelolco, both reached the level of first-class minister (*ministro de primeira classe*) with unusual speed – 15 years and 23 years, respectively, compared to an average tenure of 27 years in a sample size of 447 diplomats before attaining that rank. Sette Camara was part of the last group to pass through the *Departamento Administrativo do Serviço Público* (DASP) founded at the beginning of Getúlio Vargas's *Estado Novo* government in 1938. Even before entering Brazil's foreign service, Sette Camara had strong contacts with the elite of Minas Gerais, according to Farias; his close friendship with Kubitschek was rewarded with a prestigious spot in the president's Casa Civil. At the time that Tlatelolco negotiations were underway in the mid-1960s, Sette Camara headed the Brazilian diplomatic delegation in New York, which Farias called"one of the most prestigious posts in the diplomatic network."

[21] Lawrence Wittner, *Resisting the Bomb* (Stanford, CA: Stanford University Press, 1997), 278.

numbers as showing high support for a complete prohibition on nuclear weapons. I see an additional meaning in these numbers, however: a type of geographical distribution of concern, with percentages roughly correlated inversely with each capital's distance from Havana. In the year before formal negotiations on a Latin American nuclear weapon free zone began, Wittner's data show broad public support for complete global nuclear disarmament within the capitals of the three most technologically advanced countries in the region, Mexico, Brazil, and Argentina. These two South American neighbors, however, would unite on the opposite side of the debates from Mexico on many questions of nuclear energy and weaponry during the negotiations at Tlatelolco. Each of these three nations carried sufficient diplomatic and political weight within the region that none could be ignored; the final treaty, therefore, reads as a sometimes awkward amalgamation of overlapping, often conflicting, sets of anxieties about global politics and nuclear weapons. Argentina's and Brazil's roles in regional and global nuclear diplomacy from the mid-1960s through 1970 are the subject of the rest of this chapter.

"An Unchanging Peace-Loving Tradition"

A push from Latin American heads of state, rather than one from the concerned publics discussed above, began an organized and concerted discourse around nuclear weapons and the threats they posed to the region and Western Hemispheric security after the Cuban Missile Crisis. Brazilian diplomat José Sette Camara succinctly lays out this prehistory to the negotiations in Mexico City in a memorandum to his country's Adjunct General Secretary of International Organizations from March 30, 1965.

Mexican President Adolfo López Mateos, in early 1963, stepped into the void left by Goulart's failed mediation attempt with Cuba to ask the presidents of the four countries who had sponsored that UN resolution - Brazil, Bolivia, Chile and Ecuador - to join him in making a joint declaration supporting a region free of nuclear weapons and proliferators of these arms, and urge the rest of the Latin American republics[22] to help create the legal framework that would specify the conditions, processes, and organizations essential to creating and maintaining this zon. On April 29, 1963, López Mateos and his four counterparts and heads of state published this declaration; Sette Camara, the Brazilian diplomat, sardonically noted that none of those five were still in power in early 1965 when he wrote the memorandum. In the preamble to this Joint Declaration, the presidents refer to the "unchanging peace-loving tradition [in] the Latin American States" motivating them to transform the region into a denuclearized zone, "thus helping to reduce the dangers that threaten world peace."[23] This statement is important for at least two reasons: leaders framed the rationale for their call for disarmament in regional and transnational terms, and posited a common, if somewhat vague, continuity between a peaceful past and a nuclear weapon-free future.

The eventual UN resolution 1911(XVIII) of 1963 was a much diluted version of the original Brazilian proposal, "express[ing] the hope that the States of Latin America initiate studies on the measures to carry out the proposals in the referenced Declaration [by the five presidents] as they judge appropriate, in light of the principles of the Charter of the United Nations and regional agreements…"[24] (The contrast between the vagueness of this resolution text and Goulart's straightforward, declarative language, both written in 1963, could hardly be starker. The president of Brazil announced that he was "prepared to sign a multilateral Latin American agreement, by which countries would promise not to fabricate, receive, store or test

[22] Throughout these treaty negotiations, the nations of South and Central America and the Caribbean are referred to in this somewhat quaint way, even after military rule had begun in Brazil and Argentina, with Cuba under Communist rule by Fidel Castro.
[23] Alfonso García Robles, *The Denuclearization of Latin America* (trans. Marjorie Urquidi). Washington, DC: Carnegie Endowment for International Peace, 1967, 69. The word "denuclearized" was used in the original declaration, as discussed above with REUPRAL and COPREDAL.
[24] United Nations General Assembly, "Resolutions Adopted by the General Assembly during its Eighteenth Session," 1911 (XVIII), Nov. 27, 1963. https://daccess-ods.un.org/TMP/5410693.88389587.html.

nuclear weapons or missiles."[25]) Mexican President López Mateos, in Sette Camara's interpretation, saw an opportunity to distinguish his country in a new, uncharted type of diplomatic challenge, and enthusiastically threw his weight behind the nascent regional nonproliferation agreement. The proposed arms control project in Latin America and the Caribbean became a diplomatic reality in November 1964 when representatives from seventeen Latin American nations – those that had voted for Resolution 1911 in the United Nations General Assembly – agreed to create a Preparatory Commission and place this group in charge of a preliminary draft of a regional nuclear-weapon-free zone (hereafter NWFZ) agreement.

Sette Camara attended this initial meeting as Brazil's official diplomatic representative with "express instructions to frame the problem [of nuclear nonproliferation] in practical, realistic terms, and attempt to secure a delay of the debates, which would permit the new Brazilian government its detailed study and taking of a knowledgeable position at the problem's foundations."[26] Any delay would obviously also allow Brazil to keep its full range of nuclear energy options open. In what would be a recurring theme in the Brazilian delegate's writings, he points out that Mexico's "capable and astute" ambassador Alfonso García Robles sought, in part, to "assure President Lopez Mateos, then in the waning days of his power, a glorious crowning achievement for his term." Sette Camara consistently portrays himself in his memoranda and other writings as the agent of cautious, prudent, and incremental diplomacy at the bidding of Itamaraty, and an important check to the excessive ambitions of García Robles. The Brazilian diplomat would often caricature his Mexican colleague as rushing a collective

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[25] Alfonso García Robles, *La desnuclearización de la América Latina* (Mexico City: El Colegio de México, 1966), 89-90. Goulart would be deposed by military coup less than one year after the five-nation declaration on non-proliferation. Brazil's ambassador José Sette Camara, representing that country's military regime, somewhat surprisingly remarked pointedly on the watering down of Goulart's plan in Res. 1911 in his memorandum for the Adjunct Secretary General for International Organizations of March 30, 1965.
[26] José Sette Camara, "Memorandum para o Senhor Secretário Geral Adjunto para Organismos Internacionais, em 30 de março de 1965." Folder 953.0(20), *Desnuclearização…*, AMREB.

effort toward an agreement that would put unacceptable limits on peaceful uses of nuclear energy for Brazil, all the while supported by a majority of like-minded, but deluded, Latin American delegates.

The Brazilian delegation, for all of Sette Camara's posturing as an outlier and underdog in the negotiations that were to take place, played a fundamental role in slowing what Brasília believed to be a breakneck pace of the conversations in Mexico City, detrimental to its interests in developing nuclear technologies. Instead of a full draft of a regional nonproliferation treaty, as the Mexican delegation wanted from the preliminary meetings, Sette Camara made certain that five points of potential contention would be resolved before any drafting took place. First, the geographic limits of the nuclear weapon free zone would need to be clearly defined. Second, delegates would need to agree on methods of verification, inspection and control to ensure that no nuclear weapons were being developed within (or moved into) the region. Lastly, three groups of countries would need to be included in the discussions and eventual treaty: Latin American and Caribbean nations not represented at the preliminary meetings; nations outside the geographical bounds of the zone, but with "international responsibility" for territories inside of it (for example, the Netherlands, with territorial possessions in the Caribbean); and nations that possessed nuclear weapons and had declared such capabilities. Cuba flatly refused to take part in negotiations of the agreement, a factor which made Soviet adherence to the treaty complicated.[27] Though Soviet officials favored the creation of a nuclear weapon free zone in Latin America as a nonproliferation measure, the recent history of the Cuban Missile Crisis made their adherence to an additional protocol, binding nuclear weapon states to respect the

[27] John Redick, "The Politics of Denuclearization: A Study of the Treaty for the Prohibition of Nuclear Weapons in Latin America," 27.

Latin American and Caribbean zone's prohibition on stationing or deployment of weapons, at least somewhat problematic.

As the negotiations proceeded, though, Sette Camara saw his position, and that of Brazil, as an "intermediate, constructive, and even conciliatory" one between Mexico and Argentina, a position best outlined in a telegram from Brasília to the country's mission to the UN in New York. An upcoming meeting in Toronto would offer the perfect opportunity to use "frequent and informal contact with Ambassador Garcia Robles [to] convince him that Brazil's position on COPREDAL, far from being intransigent, opposed to Mexico's, or adverse to projects of denuclearization, it is, much to the contrary" that middle ground, the voice of moderation, and the reasonable compromise between two extremes.[28]

The Mexican Secretariat for Foreign Relations published nine volumes of documents on the negotiations of the Treaty of Tlatelolco by this body. Within this large body of evidence, the detailed summary minutes (*Actas resumidas*) of the 50 meetings are not only the closest of what we have available to verbatim transcripts of the negotiations, but also they provide the most complete means of tracing how new ideas, disagreements, and compromises formed and changed within those rooms. In other words, what diplomats said and debated there quite literally shaped the world's first nuclear-weapon-free zone governing a populated region. Without taking everything that diplomats said at the Tlatelolco conference at face value, I am convinced that the *Actas* yield a solid basis for understanding the overarching conflicts and compromises that drove the proceedings in Mexico City, and particularly, the roles of the South American neighbors in creating a treaty that reflected both their priorities and acceptable compromises.

[28] "Secreto-Urgentíssimo: Para a missão do Brasil junto às Nações Unidas, Nova York", June 22, 1966, from Itamaraty to unnamed recipient. Folder 953.0(20), *Desnuclearização*…, Anexo II, AMREB.

Scholars in the social sciences often correctly mention that Tlatelolco was the first nuclear agreement of its kind. Its finished text, however, masks the challenges, newness, and gravity of the issues and questions awaiting the diplomats as they debated and shaped the final text over four sets of meetings spanning a year and a half, from August 1965 to February 1967. Everything from the geographical limits of the zone to a precise definition of a nuclear weapon would need to be worked out in legalistic and precise detail. At the close of the first meeting of the drafting Commission, Alfonso García Robles, its president, made a first attempt to define the limits of the proposed nuclear-free zone in political and historical terms. The non-proliferation agreement he had in mind would be an accord among "the representatives of the twenty republics that have traditionally constituted this region."[29] Venezuela's Rolando Salcedo Delima would later try to bring some geographic precision to the zone that García Robles had proposed. Delegates should strive for the "unanimous ratification or adhesion" of all Western Hemisphere nations south of the 30th parallel (running through Texas and the panhandle of Florida) as well as all nuclear-weapon states *and* countries on the cusp of joining the five such recognized nations.[30] Uruguay's María Rocha de Barthaburu sought help instead from outside, demurring her own opinion in favor of a definition of the zone "from experts in the subject."[31]

In fact, five points that Rocha de Barthaburu of Uruguay made in the twenty-third session of negotiation neatly laid out the crucial tasks before the committee. As I retrace the questions and compromises that dominated the negotiations, her points serve as conceptual anchors within the complex chronology of the treaty's negotiation. She argued that countries holding colonies or dependent territories in the Latin American and Caribbean zone be

[29] COPREDAL/AR/8, 81.
[30] COPREDAL/AR/13; original is "las potencias nucleares y…las que pudieran llegar a serlo." Salcedo would eventually lose out on this point; only the five nuclear-weapon states named in the NPT are party to Additional Protocol II.
[31] COPREDAL/AR/23, 211-12.

included in some way in the treaty zone; these nations would later comprise the countries required to sign and ratify Additional Protocol I. In her view, too, the question of the zone's borders needed to be resolved conclusively, and she sought the "perfect geographic delimitation" of the zone. Third, Rocha urged the adoption of methods to verify adherence to the treaty and control the extent of nuclear sharing. Fourth, as divisions had begun to form between groups of nations at the negotiations, she sought to exhaust all possible means to urge every Latin American republic to join the zone so that a solid group of contiguous nations would benefit from its protection. Lastly, touching on perhaps the most important and vexing issue to the delegates present, Rocha stated her unwavering opposition to "measures that…would constitute impediments for the development of nuclear energy with peaceful ends."[32] Additionally, a decade and a half of very liberal global transfer of nuclear technology and matériel under US President Eisenhower's "Atoms for Peace" plan had further complicated the delegates' task of creating a document of international law to draw the line between peaceful and bellicose uses of nuclear energy.

Eisenhower's "Atoms for Peace" program, launched at the end of 1953 and already briefly discussed in Chapter 1, illuminates one of the most spectacular and complex displays of unintended consequences of nuclear-age policymaking. Without this program, David Fischer argued counterfactually, the International Atomic Energy Agency (IAEA) would not exist, nor the international safeguards system to which the Latin American diplomats (and all future negotiators of NWFZs) would commit their signatories to joining.[33] In his speech to the UN outlining the program, Eisenhower signaled that officials from his nation were "prepared to

[32] COPREDAL/AR/23, "Propender a la eliminación de medidas o disposiciones […] que constituyeran trabas para el desarrollo de la energía nuclear con fines pacíficos." Castañeda's list appears five pages later in the detailed minutes of the same session.
[33] David Fischer, *The International Non-Proliferation Regime* (New York: United Nations, 1987), 70.

meet privately with such other countries…to seek 'an acceptable solution' to the atomic armaments race which overshadows not only the peace, but the very life, of the world."[34] His proposed IAEA would have been a sort of international bank of nuclear fuel ("normal uranium and fissionable materials") set up under UN control, and not the "nuclear police" under that same acronym that maintains safeguards and conducts inspections today. More importantly for nations of the developing world, the new organization's primary task would be to marshal the help of "experts" to explore peaceful uses of nuclear energy in improving agriculture, medicine, and electrical power production.

Eisenhower's IAEA remained a mere idea until 1958, however, by which time Fischer writes that the United States had arranged "a score of agreements for nuclear cooperation with 'friendly governments'," derisively noting that this label essentially represented "any government outside the Soviet bloc and China." A letter from Admiral Lewis Strauss, chairman of the Atomic Energy Commission, reveals Fischer's casual estimate to be too small by half. Dated August 30, 1956, the letter identifies 39 agreements by the US completed on or before that date, including those with 11 Latin American nations (plus the Iberian countries of Spain and Portugal) to which the Atoms for Peace benefactor would provide research reactors, far smaller and less powerful than those needed for nuclear power or weapons development.[35] The United States provided these countries with technical training in addition to the necessary tools for nuclear power generation. In early 1965, the highest echelons of US policymakers debated among four options for the globe's nuclear future, along a continuum from "permissive or selective proliferation" to "all-out efforts to stop proliferation." A background paper framing

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[34] Quoted in Ian Bellamy, *Curbing the Spread of Nuclear Weapons* (2006), 185.
[35] Letter from Lewis Strauss to Dwight D. Eisenhower, August 30, 1956, "Peaceful Uses of Atomic Energy." Digital National Security Archive, http://nsarchive.chadwyck.com/marketing/index.jsp. Hereafter "DNSA."

the debate concluded, quite ominously: "A great deal of hope is being pinned on IAEA, which is currently little more than a token operation."[36]

There is absolutely no way of knowing how much nuclear fuel and technology countries "shared" during the early and lax years of the IAEA, yet the sale by Argentina in 1964 of 80-100 *tons* of natural uranium to Israel "without safeguards of any kind," only an Israeli guarantee that it would be put to peaceful uses, begins to give us an idea of how uncontrolled and massive the global nuclear fuel and technology exchanges under Atoms for Peace might have been.[37] Israeli authorities had decided in the 1950s that extracting uranium from phosphate deposits in the Negev Desert would be too expensive. The CIA learned in 1960 that the French were helping Israel to construct a major nuclear facility in that same desert, but limited their provision of uranium to the Israelis in 1963.[38] This spurred the United States and United Kingdom's concerns that Israel might seek a large quantity of uranium from another source, a possibility confirmed by a Canadian intelligence report from March 1964.[39] The US's role as an architect of the Atoms for Peace framework, moreover, placed it at an awkward policy juncture in the years surrounding the Tlatelolco meetings. American diplomats and government personnel did not take long to realize that the lax controls of nuclear sharing under Atoms for Peace played a fundamental role both in creating worrisome situations around the globe for developing nations with nuclear energy capabilities and in decreasing the enticement to

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[36] "Four Courses on Nuclear Nonproliferation: Course III Checklist of Possible Recommendations – With Staff Notes," December 1965 [exact date unclear], page 11. Box 7, Nuclear Nonproliferation Data Set, National Security Archive, Washington, DC.

[37] "Nuclear Export Controls of Other Countries," p. 8, folder 1306. Box 7, Nuclear Nonproliferation Data Set, National Security Archive, Washington, DC. In the summer of 2013, the National Security Archive discussed the Argentine-Israeli uranium connection at length and Canadian intelligence's role in uncovering it. *Foreign Policy*'s article from July 2, 2013 neatly sums up the findings: http://foreignpolicy.com/2013/07/02/israels-secret-uranium-buy/

[38] William Burr and Avner Cohen, "Israel's Quest for Yellowcake: The Secret Argentine-Israeli Connection, 1963-1966." http://nsarchive.gwu.edu/nukevault/ebb432/

[39] Ibid.

countries considering membership in nuclear weapon free zones. Precisely which countries these would be, though, was not yet settled back in Tlatelolco.

Brazil's multifaceted demands steered the proceedings away from a large plenary group and toward a divide-and-conquer approach, as the eighteen nations present at the preliminary meetings were split into three groups of six delegations each. Argentina, Mexico, and Brazil each went with a different working group, and tasked with either devising the borders of the zone, reaching agreement on methods of verification, inspection, and control, or obtaining the participation of nuclear-weapon states. When the negotiating parties separated into working groups in the first Commission sessions of March 1965, Group C, of which these two nations were part, had been assigned the task of "obtaining from the nuclear powers the commitment that they will respect strictly, in all its aspects and consequences, the juridical statute of Latin American denuclearization."[40] Sette Camara sought a place on this working group, essentially the group most directly responsible for preventing another Cuban Missile Crisis. The location of this working group's activities in New York, he argued, would help delegates to "escape the pressure of the Mexican government and [allow me] to exercise a certain direct influence, and take a decisive step to control progress on the matter from this point forward." In his later account of the two sessions that had already taken place, he wrote that "…the minutes of the meetings will show that Brazil was the most active country in the debates. So in no way will we turn over the initiative to Mexico."[41]

Sette Camara then outlined the nuclear weapon states' likely views on the prospects for such a treaty, noting that the Soviet Union would "have an obvious interest in a program that would create difficulties for the United States in the areas under consideration, but its final

[40] COPREDAL/9, p. 25.
[41] José Sette Camara, memorandum from 3/30/1965, folder 953.0(20), Anexo II, Archivo de Itamaraty, Brasília, Brazil, page 7.

position will depend on the attitude of Cuba, who has so far refused to attend any meetings on the topic and abstained from the voting on Resolution 1911." France, the United Kingdom, and the United States would likely find a treaty constraining their range of military response in the region at least distasteful, and probably unacceptable, yet the prospects for Chinese cooperation were even worse: "there are no plans, nor paths, nor means of obtaining any commitment by Communist China." As the treaty became more developed and debated, and particularly as Mexico's terms aimed at creating a nuclear weapon free zone as quickly and efficiently as possible began to gain adherents among other Latin American and Caribbean representatives, the Brazilian delegation would come to depend on this very refusal from Cuba and China to consider the terms of the agreement as a stalling tactic.

Two factions quickly formed on the linked questions of the geographical extent of the treaty zone and the complexity of the process to bring the treaty into force. Brazil and Argentina favored a high number of member nations and fairly strict barriers to entry as the most likely path to a zone free of geographical and legal holes. Mexico sought a more accommodating position, wishing to begin the zone with a smaller number of nations and have it grow over time. Sette Camara of Brazil used the sheer geographical size of the proposed treaty zone – all of Mexico, Central and South America, and the Caribbean islands – to mock an early Mexican plan of having only five nations ratify before the treaty entered into force. In doing so, he began to build consensus for a more rigid and complex set of requirements for the nascent agreement's entry into force, hoping to ensure that Latin American nations, particularly the more technologically advanced ones, were not giving up too much in exchange for too little. Mexico's scheme, Sette Camara argued, might create a nuclear-weapon-free zone full of holes; the plan could mean that "Mexico, in the extreme north, the Dominican Republic, on an island, Uruguay, on the east side of La Plata River, Chile, in the extreme south of the

Pacific region, and Ecuador, in the center of the same [Pacific] coast" could be the only ones bound to its terms, leaving the rest defenseless.[42]

Luís Santiago Sanz of Argentina echoed his Brazilian neighbors' concerns regarding geographical and legal holes in the zone later in the session, and joined with Sette Camara to take a hard line in favor of the proposed involvement of the US in the zone. He assailed the United States' flat refusal to include their dependent territories in the Caribbean, the Virgin Islands and Puerto Rico, as an outcome that "apparently the delegate from Mexico had accepted."[43] (Jorge Castañeda represented the particular interests of Mexico in a capacity that his countryman, García Robles, as president of the commission, could not. Castañeda would later clarify that the "five nations" ratification plan was the absolute minimum number of countries necessary in the Mexican view, and that they would indeed continue to seek and advocate for the largest zone possible). Further attempts to shift the US's inflexible position on the Virgin Islands' exclusion from the zone, Castañeda continued in response to the South American delegates, would be to enter into matters of sovereign nations' "integral territory," a potentially counterproductive usage of the proposed Treaty that its negotiators had explicitly prohibited in early drafts.[44]

Early in the proceedings, Panama's José Cárdenas had urged the commission to grapple with some of his concerns surrounding the rights of nuclear-weapon states within the zone. He especially opposed nuclear-weapon states' presumption of their ability to transport these arms through any part of the proposed nuclear weapon free zone – the Panama Canal obviously his greatest concern – and lamented the reluctance of these armed powers to allow inspections or

[42] COPREDAL/AR/24, 237.
[43] COPREDAL/AR/24, 242-43.
[44] COPREDAL/AR/24, 22. The pagination of the digitized *Actas resumidas* differs from that in the nine-volume set from Mexico's foreign relations ministry, however, Castañeda's statement about the Virgin Islands appears on the 22nd page out of 24 in either version.

make concrete guarantees not to station nuclear weapons in the zone.[45] His counterpart from Colombia would, in the eighteenth meeting on September 2, 1965, reiterate the importance of buy-in from nuclear-weapon states and argue unambiguously that the Caribbean nations and colonies be included in the treaty zone. Brazil and Colombia were jointly responsible for drafting the Additional Protocols I and II the following year, and Colombia appears as a key Brazilian ally several times in later memoranda. The Additional Protocols appear in draft form for the first time in COPREDAL/DT/1, the "working draft" of April 1966.[46]

Early in the negotiations, Argentina objected vehemently to the presence of Great Britain in any eventual agreement that might result. The root of this objection lay in the ongoing territorial dispute between the two countries over the Malvinas (or Falkland) Islands. Frank de Mendonça Moscoso, one of Sette Camara's countrymen and colleagues at the Tlatelolco negotiations, recounted a conversation in February 1966 with the head of the Argentine delegation, who strenuously opposed the "current text of article 20, as it would imply admitting the simultaneous presence of Argentina and Great Britain in one Organism, in which both would be representing the Malvinas Islands."[47] One year later, Argentina had taken an even more rigid position, opposing any British participation whatsoever in the treaty organization, though as both a nuclear weapon state and a nation with *de facto* control over both the Malvinas, Guyana, and parts of the Caribbean, Britain's adherence was deemed necessary by many Latin American delegations. "The Argentines are indefinitely opposed to

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[45] COPREDAL/AR/14, 138. Also, Cárdenas explicitly mentions the Panama Canal as a sovereign possession of his country; understandably, he was more concerned about transport rights of the nuclear weapon states than were most other delegates at the Commission.

[46] Sometime between the first draft of the Additional Protocols and opening of the Treaty to signature, though I am certain it was relatively late in the process, the Protocols to which Roman numerals I and II were appended switched. "Protocol I" had referred to the attempt to extract "negative guarantees" from the nuclear-weapon states, and "Protocol II" ensured that countries with "international responsibility" for territories in the proposed treaty zone would not allow nuclear weapons to be introduced there. In the final treaty, as it exists today, the protocols are vice versa.

[47] Frank de Mendonça Moscoso, Memorandum 2/2/66. Itamaraty, Anexo II, Brasília, Brazil, page 1.

[Britain's] signature of the treaty, with the goal of impeding their participation in any organization created by the treaty, even in the informal meeting of signatories that we have proposed." The delegation from Argentina wanted to restore the second additional protocol, binding nuclear weapon states to the terms of the nuclear weapon free zone, but with added text that stipulated that representation of territories under dispute would be exercised only by Latin American countries exercising those claims.[48] Mexico sought a compromise solution to Argentina's use of the nuclear nonproliferation talks to exercise its territorial claims, suggesting that "occupying powers" of territories in the proposed nuclear weapon free zone make unilateral declarations "as Nasser had regarding transit in the Suez Canal." Brazil opposed this Argentine-Mexican plan on the grounds that unilateral declarations by nations outside the geographical treaty zone would create two different juridical areas of the treaty, one comprising the Latin American nations, subjected to inspections by the new regional treaty organization and bound to IAEA safeguards, and one of non-autonomous territories, free of any kind of inspection. In this way, longstanding international territorial disputes entered into the profound questions surrounding verification and control at the heart of some of the most contentious Tlatelolco negotiations.

The relative agreement on "negative guarantees" and the responsibilities of nations outside the zone masked deep divisions over how nations inside the zone would bring the treaty into force for themselves, and possible mechanisms of delay, should they have chosen to wait for any number of reasons. In the 23rd meeting of COPREDAL – roughly halfway, in terms of full meetings – on May 5, 1966, Jorge Castañeda of Mexico returned to the matter of gaining Latin American and Caribbean adherence to the treaty, momentarily turning away from the

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[48] Moscoso, memorandum reporting on Political Working Group, 2/9/67.

questions surrounding outside powers' involvement in the NWFZ. He admonished delegates who did not want to commit to a prohibition on nuclear weapons unless Cuba followed suit. Cuban non-participation was, in the Mexican delegate's view, a red herring distracting some of the most influential nations at the Commission, like Argentina and Brazil. The South American delegations' argument based on grounds of regional security was shaky, he said, since that security was threatened to a much greater extent by "the [established] nuclear powers not reducing their arsenals by one single bomb"[49] than by Cuba's refusal to consider signing the treaty.

Castañeda continued to critique unrealistic desires by unyielding delegations. In his view, Brazil's unequivocal requirement for negative guarantees from the nuclear powers meant that "the Latin American nations could not agree among themselves to renounce atomic weapons unless the People's Republic of China were to give its consent." (Functionally, Castañeda is exactly right on this point, and his worries, in hindsight, were quite prescient). Ignoring the Mexican delegate's pleas for compromise, Venezuela's Salcedo would come back the following day to make similar demands that Cuba participate in the treaty zone.[50] Further debates on the treaty's entry into force would wait until the 33rd session. Mexico's more lenient proposal, where five countries would need to sign and ratify before the treaty entered into force, could hardly have presented a larger contrast with Brazil's strict one, requiring all sovereign nations in the treaty zone to have signed and ratified the agreement, all nuclear-weapon states to have signed and ratified Protocol I, all extra-regional nations with "international responsibility" for territories in the treaty zone to have done the same with

[49] COPREDAL/AR/23, 217.
[50] COPREDAL/AR/24, 234.

Protocol II, and bilateral IAEA safeguards to have been implemented by all signatory nations.[51] Mario Rodríguez Altamirano, of Chile, sought a compromise between the two, expanding the number of countries required in Mexico's text to a "majority of nations participating in the Conference."[52] Delegates accepted this amendment to the Mexican text, but only after the majority had been redefined as eleven of twenty-one nations in the proposed zone, and *not* merely a majority of the number of countries who had sent delegations to COPREDAL.

Argentina's representative soon returned to the larger question of limits of the entire NWFZ, rather than the details of bringing the agreement into force, indicating his delegation's strong desire to link the treaty with the hemispheric security system of the OAS. He suggested using the 1947 Rio de Janeiro Treaty's delimitation of "parallels and meridians" and "articles 1 through 5 of the Antarctic Treaty" to define the zone of application for the treaty, for which Great Britain had asked to aid its own debates on its protocols.[53] But no more discussion of the zone of application would take place until Sette Camara again raised the matter in the 38th session. "All Latin American republics,"[54] the Brazilian delegate said, should be included in the area of application, as well as "sovereign States of the western hemisphere completely situated to the south of the 30th parallel, north, and territories [situated in the same zone] for which

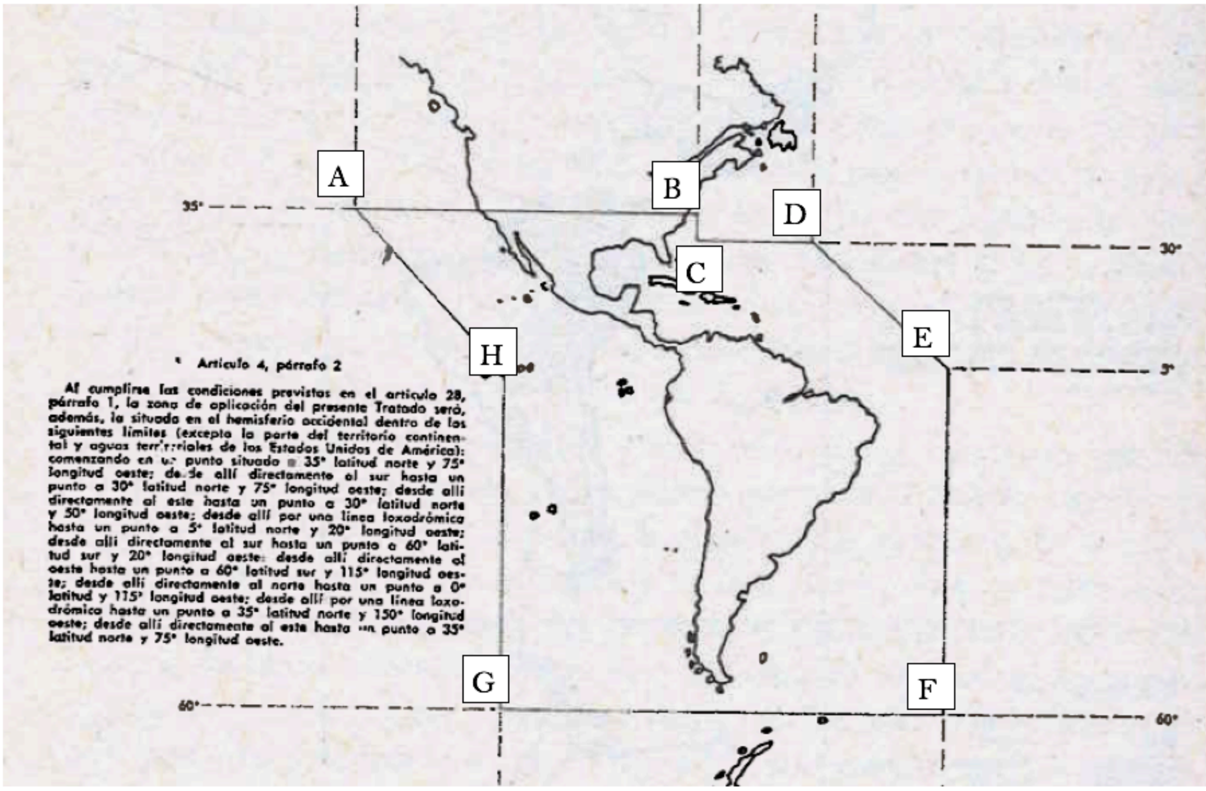
[51] Leopoldo Benites Vinueza, first Secretary General of OPANAL, called Brazil's conditions for entry into force "almost insurmountable," and argued that they were the impetus for "a most original" innovation in the history of treaties, the waiver required in addition to ratification. In the treaty's Article 29, the four terms for the treaty's entry into force are given: All parties in the Latin American and Caribbean zone have signed and ratified the treaty; all extra-continental or continental nations with "de jure or de facto international responsibility" for territories inside the treaty zone have signed and ratified Additional Protocol I; all nuclear-armed countries have signed and ratified Additional Protocol II, and all parties to the treaty having concluded bilateral or multilateral safeguards agreements concluded with the IAEA. If a nation wished to bring the treaty into force *in its territory only* before these four conditions were satisfied, its delegation had the option to sign a waiver of Article 29's requirements, in which case "this Treaty shall enter into force upon deposit of the declaration." (In this way, Brazil and Argentina could, and did, sign and ratify the treaty without bringing it into force).
[52] COPREDAL/AR/33, 358.
[53] COPREDAL/AR/27, 294. Sette Camara likely had in mind the highly specific definition of the Western Hemisphere in Article 4, which includes the Malvinas or Falkland Islands. (Any geographic definition of the treaty zone that did not include the islands would almost certainly have lost Argentine support).
[54] Among the delegates, this was a much more common way to refer to the countries than more generic nouns, perhaps indicating diplomats' desire to draw together Latin American and Caribbean nations in regional solidarity.

States within or outside the continent have *de jure* or *de facto* responsibility."[55] The map of the zone of application, seen in Figure 1 on the following page with its explanatory geographical text from the final treaty, would essentially follow Sette Camara's much more abbreviated definition.

In the documentation from Itamaraty, almost one year passes between the March 1965 memorandum and the next flurry of communication between Sette Camara and his bosses at Itamaraty. From New York on February 5, 1966, the Brazilian diplomat recounted the proceedings of the fifth session of the COPREDAL coordinating committee. "During the session, I opposed the other members of the Coordinating Committee at times for tactical effect, and countered all the suggestions of the president [García Robles] but was not supported in any of this by any other member of the committee…"[56] Sette Camara argued to García Robles that the Coordinating Committee was not prepared to consider the biggest matters in front of it, as only two governments (those of Mexico, the conference host, and Chile) had sent their comments on a draft treaty along the stricter lines that the Mexican delegation and its allies at the negotiations wanted. Furthermore, his own government had not had any time to review the working draft of the treaty, and he had no instructions on how to respond.

[55] COPREDAL/AR/38, 399.
[56] Sette Camara, memorandum from 2/5/1966, folder 953.0(20), 3. AMREB.

Figure 1. Map of Zone of Application, Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean



Text translated: To fulfill the conditions envisioned in Article 28, Paragraph 1, the zone of application of the Treaty shall be that situated in the Western Hemisphere within the following limits, excepting the portion of continental territory and waters of the United States of America: Beginning at a point situated at 35° latitude north and 75° longitude west (**B**); from there directly to the south until 30° latitude north (**C**) and 75° longitude west; from there directly east to a point at 30° latitude north and 50° longitude west (**D**); from there, by a loxodrome[57] to a point at 5° latitude north and 20° longitude west (**E**), then directly to the south until 60° latitude south and 20° longitude west (**F**), then directly to the west until 60° latitude south and 115° longitude west (**G**) then directly to the north until 0° latitude and 115° longitude west, then finishing at the end of a loxodrome at 35° latitude north and 150° longitude west (**A**).

[57] A loxodrome, also known as a rhumb line, is one that crosses all longitudinal meridians at the same angle from some initial bearing. They appear as straight diagonal lines on Mercator projection maps, as in this case here. Text from Treaty of Tlatelolco, Article 4. http://www.opanal.org/texto-del-tratado-de-tlatelolco/.

Argentina's support of an OAS-centered solution for an accord on nuclear weapons and Brazil's delay tactics would combine to place them in an odd and quite complex partnership. On June 6, 1966, Sette Camara confronted the problem of "American interference" in the proceedings on behalf of Mexico, to which US President Johnson had recently traveled and effected a "very close drawing together" between the Rio Grande neighbors.[58] "I fear that the efforts of the type that were made [by Mexico] toward [Brazilian] Ambassador Leitão da Cunha might be made to the other Latin American embassies, which could assure a majority favorable to the Mexicans at the heart of COPREDAL through the solid support of the Central Americans." Three courses of action were available to Brazil in order to "avoid showing up at the fourth session of COPREDAL under the threat of terms that we face a decision by vote in a condition of inferiority with relation to Mexico." First, Brazil could negotiate directly with Mexico to ensure that their positions, with which fellow South American delegations from Argentina, Colombia, and Venezuela were largely in agreement, were represented in the final text, noting that a treaty without those four populous and geopolitically important countries would be "a hollow victory for the Mexican government." Second, Brazil could opt for agreements with Argentina, Colombia, Guatemala, and possibly Venezuela "to take the problem of adjustment of viewpoints on the denuclearization program with existing commitments to the inter-American system" to the OAS, a solution particularly favored by Argentina, as noted above. Sette Camara noted that this option would "probably unleash a complicated debate, able to serve as a pretext for the delay of the fourth period of COPREDAL sessions, giving us time for better articulations [of our position.]" The third option was the most serious in its implications: to look at the option of "formal reservations to Article 23 of the future treaty,

[58] Original is "uma aproximação muito grande." Memorandum from 6/6/1966, "Secreto: Da missão do Brasil junto ás Nações Unidas, Nova York: Desnuclearização da América Latina." Folder 953.0(20), 1. AMREB.

which would have the advantage of assuring us the freedom of action until the conditions we consider essential are fulfilled…"[59] He closed by underscoring the extreme nature of such a move, as it would show an "evident erosion in our global position on disarmament."[60]

Yet the Brazilian delegation did *not* want the denuclearization project to fail as a whole. Sette Camara's forceful arguments sometimes gave way to a more moderate voice, such as on June 3, 1966, when he indicated Brazil's concerns about "the possibility that some countries might eventually take advantage of the Brazilian-Colombian demand for meeting some basic requirements, using it as a pretext to delay the celebration of the treaty, or simply to not commit to any denuclearization plan."[61] Still, Brasília was in no mood to negotiate many of its demands, replying three days after Sette Camara expressed his concerns at the effects of these "requirements." "The prerequisites established [in a preliminary working draft in collaboration with Colombia] for the conclusion of a treaty on denuclearization are fundamentally indispensable, as they guarantee national security while avoiding the outcome that we compromise our future in the field of peaceful [nuclear] research in exchange for an apparent but illusory denuclearization."[62] These lines brilliantly express the two guiding principles of Brazilian nuclear diplomacy, before, during, and following the negotiation of the Treaty of Tlatelolco: absolute freedom to pursue a vast range of nuclear technologies, and a fear that holes in the Tlatelolco zone – much more acceptable to Mexico and its supporters than Brazil,

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[59] A reservation allows a state to be party to a treaty, except for a specific provision in the document to which it objects. The draft of the agreement then under debate did not yet have a clause banning reservations, though the final text does contain this prohibition. According to the 1969 Vienna Convention on the Law of Treaties, a reservation is "a unilateral statement, however phrased or named, made by a State, when signing, ratifying, accepting, approving or acceding to a treaty, whereby it purports to exclude or to modify the legal effect of certain provisions of the treaty in their application to that State."

[60] Memorandum from 6/6/1966, "Secreto: Da missão do Brasil junto ás Nações Unidas, Nova York: Desnuclearização da América Latina." Folder 953.0(20), Anexo II, AMREB.

[61] Sette Camara, memorandum from 6/3/1966, folder 953.0(20), 3. AMREB.

[62] Memorandum, "Reunião da COPREDAL. Desnuclearização. Provável modificação da posição do Brasil." Folder 953.0(20), AMREB.

Argentina, Colombia, and Venezuela – would lead to regional safety in name only from the dangers of nuclear weapons.

Two documents had recently been distributed among the delegations from the International Atomic Energy Agency, one a position statement on how the IAEA could work within a Latin American nuclear weapon free zone, and the other a template for a possible agreement on the application of safeguards in the member countries of the zone. Sette Camara proposed closing the fifth session, distributing the Mexican and Chilean positions as well as the IAEA documents, without further comment, to all nations involved in the negotiations at COPREDAL, and reopening for a sixth series of meetings when all countries had responded to the call for comments. To his surprise, García Robles agreed to this plan, only slightly modifying the proposed dates for comments and reopening the next session. The rest of the Coordinating Committee approved this plan before adjourning until March 1966. But Sette Camara's most illuminating observations come after this point in the memorandum, when he laid out six conclusions based on what he had seen and heard already in Mexico. They bear quoting in full for their sheer explanatory power, casting light on Brazil's fundamental role in advancing or halting progress on the treaty in accordance with how the proceedings matched Itamaraty's desired outcomes.

> 1) The Mexican government, deeply engaged in capitalizing on the political effects of signature of the treaty of denuclearization under its leadership, is obviously maneuvering to force Brazil to accept the Treaty on the basis suggested by Mexico or take up the burden of failure of the statute for the continent. 2) To undo the Mexican machinations, we should from this point forward move onto the offensive, attempting to draft a Treaty that preserves Brazil's interests. To that end, we should propose at the March 7 meeting the changes that we believe to be indispensable to encompass fully the position on the matter established by the President of the Republic… 3) If Mexico does not accept the Brazilian plans, it will have, in the eyes of continental and world opinion, the shame of failure for the Treaty and the denuclearization initiative; 4) I wish to believe that, between the choices of a Treaty edited for Brazil's demands and non-signature of the Treaty, Mexico would prefer the former, since at least in public and internal opinion, it will try to make it into, and present it as, a Mexican victory; 5) the Treaty modified in this way

> would certainly be drafted, signed and ratified by all the Latin American republics, but would enter into force only with great effort, as Cuba and consequently the Soviet Union would find it difficult to sign it and Communist China surely would not sign the "First Additional Protocol and Guarantee," to be suggested by Brazil and outlined below; 6) consequently, *the onus of political damage that will occur from the failure of the Treaty to enter into force will fall onto Cuba, the Soviet Union, and Communist China.*

Essentially, what Sette Camara proposed here was a course of action that might well have derailed the proposed treaty or any nuclear nonproliferation effort in the region indefinitely.[63] Whether nuclear weapons would be banned from Latin America and the Caribbean appears to be secondary among his concerns; more important seemed to be the question of upon whom the blame would fall, which at all costs, could not be Brazil. For diplomatic reasons, and to preserve good relations in the region, it would be best if it did not fall on Mexico, either, though Sette Camara did not go into detail about why the Brazilian changes would certainly be made and approved by the other delegations, perhaps to minimize Itamaraty's concerns on this point. However, if the treaty must fail, a scapegoat outside the region – Russia or China – or regional pariah, Cuba, largely the reason that nuclear weapons came to occupy the attention of delegates in the first place – could certainly take on that role unproblematically within the group of US-aligned Latin American delegates.

Among the Treaty of Tlatelolco's notable "firsts" is a deceptively simple one: it was the first international treaty to provide a legal definition of a nuclear weapon. The characteristics of the nuclear weapons to be banned would prove more divisive even than the question of the borders of Latin America and the Caribbean. Though it may seem strange that delegates took as many meetings as they did before they squarely confronted the question of what exactly a nuclear weapon was, the underlying issue of which peaceful uses of nuclear technology should

[63] José Sette Camara, "V Sessão do Comitê Coordenador da COPREDAL. Regresso do Ministro Geraldo de Carvalho Silos a Nova York." Folder 953.0(20), Anexo II, AMREB. Emphasis is mine.

be allowed prevented any easy, early, or unanimous answer. The delegates at REUPRAL, the one-week conference that preceded COPREDAL, had defined "denuclearization" as "the absence of nuclear weapons and launching mechanisms,"[64] and these same representatives made tentative early attempts to prohibit nuclear weapons while encouraging development of peaceful atomic technologies. Paraguay's representative intervened in the fourth meeting to propose "a group that would structure a part of the treaty that referred to the peaceful use of the atom in Latin America." Delegates left aside the second part of his proposal, however, which hypothesized a sort of regional nuclear-sharing scheme analogous to the global one Eisenhower had laid out years before in the "Atoms for Peace" speech.

Representatives would emphasize the importance of maintaining access to peaceful uses of nuclear technology again and again during the proceedings. Some of the most intense debates of the Commission occurred as the diplomats considered the question of which nuclear test explosions, if any, should be allowed as "peaceful" or prohibited as "bellicose." Yet the most focused discussions on what defined a nuclear weapon would wait until approximately the last ten COPREDAL sessions (of 50 total). García Robles had, early in the proceedings, divided representatives into several working groups to hammer out more technical and contentious parts of the treaty. In their working document formally adopted by the larger conference on Sept. 2, 1965 – only the second month of meetings – Group B openly acknowledged its debt to the Protocol on Western European Union for the Control of Armaments for its proposed definition. "Whatever weapon containing…nuclear fuel or radioactive isotopes, using…explosion or any other form of uncontrolled transformation of nuclear fuel, radioactivity of same, or radioactive isotopes, may cause massive destruction, widespread

[64] COPREDAL/AR/1, 3.

injury, or poisoning…" was a nuclear weapon.[65] This eleven-year-old definition seemed sufficient for the diplomats of COPREDAL to put aside and return to when other, more straightforward issues facing the draft treaty had been resolved.

The working definition of Group B, based upon physical characteristics and potential effects of a possible weapon, ended up being more influential than a mere placeholder. More factions had formed in the negotiations, and a seven-nation group supported a formal definition of a nuclear weapon in the treaty very similar to that of Group B. Argentina and Venezuela, instead, sought to define a nuclear weapon by its *intended use*.[66] A corollary issue to that of the nuclear weapon definition was which, if any, nuclear explosions should be allowed by parties to the treaty in the name of developing peaceful technologies. Debate on articles 3 and 13, regarding the definition of nuclear weapons, and whether to allow peaceful nuclear explosions, respectively, most often overlapped for this reason. In the 41st meeting of the commission, diplomats finally tackled the semantics around nuclear weapons and began the debates that would lead to the version that appeared later in the Treaty.

William Epstein, a Canadian civil servant at the UN and disarmament expert present at Tlatelolco, explained that the question of these "peaceful nuclear explosions," or PNEs, was a delicate and complicated one, primarily because the technology for producing PNEs was identical to that used to test nuclear weapons.[67] Two or three of the most advanced industrial

[65] COPREDAL/19, 58.
[66] COPREDAL/AR/28, 301: "…se entiende por arma nuclear todo artefacto que contenga material fisionable o fusionable, destinado a emplearse con fines bélicos y a liberar energía nuclear en forma no controlada." John Redick discusses Soviet desires, dating to 1963, to check US nuclear submarine deployment through other nuclear-weapon-free zone proposals, namely in the Mediterranean, in "The Politics of Denuclearization: A Study of the Treaty for the Prohibition of Nuclear Weapons in Latin America," Ph.D. dissertation, 1970, 20, but there is little indication that Latin American delegations were concerned about nuclear submarines.
[67] COPREDAL/AR/41, 457. Redick (1970) discusses Panamanian objections to an overly strict definition of nuclear weapons that would not allow for peaceful nuclear explosions in constructing a new interocean canal (COPREDAL/AR/42), and Guatemala's counterargument that small countries needed the security guarantees that a specific and strict legal definition of such weapons might provide.

nations, he warned, could "easily, with certain adjustments, make nuclear weapons" having acquired the capability to produce a nominally peaceful nuclear explosion. In Toronto, Epstein said, nuclear weapons experts had discussed three plans for PNEs and their role in global peaceful use of nuclear technologies. The first option, a categorical ban, was rejected as short-sighted, closing off any potential benefit to science; the second, "the most economic and safest," would mandate that PNEs be carried out by nuclear-weapon states on behalf of those nations that did not possess them; the third would have created an additional regulatory agency to supervise and monitor non-nuclear weapon states carrying out these types of explosions.

The Argentinian representative, Luís Santiago Sanz, then made a somewhat paradoxical assertion that a scientific definition of a nuclear weapon created more ambiguity than one based on its potential use. In arguing to keep *intent* as the primary definition of a weapon, he reiterated his position from the twenty-eighth meeting. Defining a weapon scientifically by its capability to release nuclear energy in an uncontrolled fashion, as the opposing faction sought to do, "created greater uncertainty in the drafting of the treaty article."[68] Chile's diplomat intervened to say that any Latin American nation stockpiling peaceful nuclear devices, with even the potential to be turned into weapons, could have a detrimental effect on international relations and stability within the region. Countries with such capabilities, he continued, could "potentially be stronger in the military arena" if they could produce weapons with as little effort as in Epstein's example. Leopoldo Benites Vinueza of Ecuador pointed out that an "uncontrolled release of energy" would be exactly synonymous with an "explosion," and the definitional debate surrounding a nuclear weapon required first handling the issue of explosions.[69] Brazil's Corrêa da Costa, Sette Camara's replacement on the committee, took

[68] COPREDAL/AR/41, 461.
[69] COPREDAL/AR/41, 464-465.

Ecuador's argument to its logical extreme. One of the two competing texts under consideration would make *any* explosive illegal within the nuclear-weapon-free zone, even dynamite, which could be used for peaceful purposes, "in mining or to build highways." Bolivia's representative proposed a way out of the ambiguities in both texts, adding one clause to the definition of a nuclear weapon as releasing uncontrolled energy "for specifically warlike uses."[70]

Another session passed with delegates still deadlocked on the questions of PNEs and the linked definition of nuclear arms. García Robles took control as President to ask Working Group 1, responsible for revising the portion of the treaty containing both articles, to "take into account the opinions and suggestions expressed during the session," both texts for article 3 and the only one for article 13, then return the following day with texts that would "earn the unanimous approval of the members."[71] A proposal from Paraguay's Duarte Prado, linking the two articles explicitly, fell flat, but a compromise idea from García Robles would finally lead article 3 to its approval. Finally, the text read "For the effects of this Treaty, a nuclear weapon is understood to be any device capable of releasing energy in an uncontrolled form and one that has *a group of characteristics* appropriate for warlike uses."[72] Tellingly, this is a compromise between the phrasing that Brazil would have preferred, "destined to military use," and the language least acceptable to its delegation, "able to be used for military ends."[73]After ironing out the details of how peaceful nuclear explosions would be verified and controlled, García

[70] COPREDAL/AR/41, 469.
[71] COPREDAL/AR/42, 483-484.
[72] COPREDAL/AR/44, 490; this definition remains in the Treaty to this day.
[73] Memorandum, "Conferência do Desarmamento. Desnuclearização da América Latina. Definição de arma nuclear." March 10, 1967. AMREB. Though this document was addressed to the Brazilian delegation in Geneva, and thus intended for negotiations on the NPT, its position there was wholly consistent with that expressed at Tlatelolco.

Robles was able to declare article 13 approved as well. It exists in the present Treaty in much the same language.[74]

Another of the most contentious and complex issues at the drafting was the question of whether, and how strictly, nations armed with nuclear weapons would be bound to respect the nuclear-free status of the zone. The Additional Protocols came out of this discussion, and were, once again, a concession primarily made to gain the support of the Brazilian delegation. José Sette Camara again took the floor in the twentieth meeting of COPREDAL in May 1966 to make a radical proposal. The question of international security was inseparable, to him, from the obligations of Latin American nations once the treaty entered into force and carried the weight of international law. Non-nuclear weapon nations – a status that would soon, theoretically, be codified for all signatories of the treaty – had an obligation to future generations not to "assume gratuitous risk, nor transfer to other States the essential work of defending the prestige and security of their respective countries."[75]

His statement marked a bold rejection of a fundamental idea undergirding the inter-American alliance and the logic behind the 1947 Rio Treaty, and a rebuke to the delegation of his neighbor Argentina. This assumption held that the United States would guarantee security in Latin America through military deterrence, supported in large part by the northern nation's large stash of nuclear and conventional weapons. In Sette Camara's view, however, nuclear-weapon states had as great a share of responsibility in the denuclearization project as those nations that lacked such arms. He had accordingly introduced a modification to the working draft, one that was not unexpected given his earlier positions and speeches on the issue. The

[74] Treaty of Tlatelolco. "'[N]uclear weapon' is understood as any device that may be capable of releasing energy in an uncontrolled form and have a set [*conjunto*] of characteristics suitable for use with bellicose ends." http://www.opanal.org/texto-del-tratado-de-tlatelolco/
[75] COPREDAL/AR/20, 180.

treaty would not enter into force in *any* country until *every* nation in the proposed nuclear-free zone had signed and ratified, and *each* nuclear-weapon state and country with territorial possessions in that zone had signed additional protocols pledging to uphold its nuclear-free status by their own actions. Sette Camara's proposal proved controversial, as the treaty's entry into force seemed more distant with every complicating modification of its provisions, potentially dooming the agreement to the same history of "lost hopes" to which the Brazilian diplomat had alluded earlier. Yet Latin American representatives were almost unanimous in agreeing with him that "negative guarantees" by the nuclear powers such as the United States were fundamental to the spirit and letter of the treaty.

The key compromise on the issue of the treaty's entry into force among nations in the zone came about almost silently, as far as the detailed summaries of the *Actas resumidas* are concerned. In the forty-sixth meeting, the waiver idea that was at the heart of the resolution of the dispute suddenly appears in the text of a draft close to the final one: "After the entry into force of the treaty for all countries in the area, the emergence of a new nuclear weapon state will suspend the treaty for countries that ratified without waiving Article 23…until the new power, on its own or by petition from the General Conference, ratifies the Additional Protocol."[76] This text, though cryptic, is fundamental in concluding several lengthy discussions during the proceedings. Recall that the Venezuelan delegation, early in the negotiations, wanted new nuclear-weapon states bound to the terms of Protocol I, so this text represents a victory for Salcedo's position concerning the very likely emergence of new nuclear weapon states after 1967 and their potential impact on the Latin American NWFZ.

[76] COPREDAL/AR/46, 502-503.

Table 2

Latin American and Caribbean Dates of Signature, Ratification, and Waiver (Entry into Force) for Treaty of Tlatelolco of 1967, and Ratification or Accession to Non-Proliferation Treaty of 1968, Sorted by Date of Waiver (Column 4)

Country	Signed Tlatelolco	Ratified Tlatelolco	Waived Article 28/29	Ratification or Accession to NPT
Mexico	Feb 14, 1967	Sep 20, 1967	Sep 20, 1967	Jan 21, 1969
El Salvador	Feb 14, 1967	Apr 22, 1968	Apr 22, 1968	Jul 11, 1972
Dominican Republic	Jul 28, 1967	Jun 14, 1968	Jun 14, 1968	Jul 24, 1971
Uruguay	Feb 14, 1967	Aug 20, 1968	Aug 20, 1968	Aug 31, 1970
Honduras	Feb 14, 1967	Sep 23, 1968	Sep 23, 1968	May 16, 1973
Nicaragua	Feb 15, 1967	Oct 24, 1968	Oct 24, 1968	Mar 6, 1973
Ecuador	Feb 14, 1967	Feb 11, 1969	Feb 11, 1969	Mar 7, 1969
Bolivia	Feb 14, 1967	Feb 18, 1969	Feb 18, 1969	May 26, 1970
Peru	Feb 14, 1967	Mar 4, 1969	Mar 4, 1969	Mar 3, 1970
Paraguay	Apr 26, 1967	Mar 19, 1969	Mar 19, 1969	Feb 4, 1970
Barbados	Oct 18, 1968	Apr 25, 1969	Apr 25, 1969	Feb 21, 1980
Haiti	Feb 14, 1967	May 23, 1969	May 23, 1969	Jun 2, 1970
Jamaica	Oct 26, 1967	Jun 26, 1969	Jun 26, 1969	Mar 5, 1970
Costa Rica	Feb 14, 1967	Aug 25, 1969	Aug 25, 1969	Mar 3, 1970
Guatemala	Feb 14, 1967	Feb 6, 1970	Feb 6, 1970	Sep 22, 1970
Venezuela	Feb 14, 1967	Mar 23, 1970	Mar 23, 1970	Sep 25, 1975
Panama	Feb 14, 1967	Jun 11, 1971	Jun 11, 1971	Jan 13, 1977
Colombia	Feb 14, 1967	Aug 4, 1972	Sep 6, 1972	Apr 8, 1986
Grenada	Apr 29, 1975	Jun 20, 1975	Jun 20, 1975	Sep 2, 1975
Trinidad and Tobago	Jun 27, 1967	Dec 3, 1970	Jun 27, 1975	Oct 30, 1986
Bahamas	Nov 29, 1976	Apr 26, 1977	Apr 26, 1977	Aug 11, 1976
Suriname	Feb 13, 1976	Jun 10, 1997	Jun 10, 1977	Jun 30, 1976
Antigua and Barbuda	Oct 11, 1983	Oct 11, 1983	Oct 11, 1983	Jun 17, 1985
St. Vincent and Grenadines	Feb 14, 1992	Feb 14, 1992	May 11, 1992	Nov 6, 1984
Dominica	May 2, 1989	Jun 4, 1993	Aug 25, 1993	Aug 10, 1984
Argentina	Sep 27, 1967	Jan 18, 1994	Jan 18, 1994	Feb 10, 1995
Chile	Feb 14, 1967	Oct 9, 1974	May 30, 1994	May 25, 1995
Brazil	May 9, 1967	Jan 29, 1968	May 30, 1994	Sep 18, 1998
Belize	Feb 14, 1992	Nov 9, 1994	Nov 9, 1994	Aug 9, 1985
Saint Lucia	Aug 25, 1992	Jun 2, 1995	Jun 2, 1995	Dec 28, 1979
Saint Kitts and Nevis	Feb 18, 1994	Apr 18, 1995	Feb 14, 1997	Nov 6, 1984
Guyana	Jan 16, 1995	Jan 16, 1995	May 14, 1997	Oct 19, 1993
Cuba	Mar 25, 1995	Oct 23, 2002	Oct 23, 2002	Nov 4, 2002

Sources: Tlatelolco signature, ratification, and waiver dates: http://www.opanal.org/status-del-tratado-de-tlatelolco/. On NPT ratification or accession: http://disarmament.un.org/treaties/t/npt.

Article 23 functionally embedded Brazil's proposed four-part requirement, discussed above, into the text of the treaty regarding its entry into force. Three nations – Argentina, Brazil, and Chile – took decades to bring the Tlatelolco Treaty into force in their territories by exploiting that article's waiver clause.[77] (See Table 2 for the dates of signature, ratification, Article 23/28/29 waiver deposit, and accession to the Non-Proliferation Treaty of 1968). The three South American neighboring countries were, in fact, exempt from the terms of the treaty until their waivers were received, opening a gaping hole in the Tlatelolco zone – essentially, everything south of a narrow band of Andean countries running from Peru to Venezuela – that would become a near obsession of US advocates of nuclear nonproliferation, especially under the Carter administration, as discussed in Chapters 4-6.

Representatives of fourteen countries signed the Treaty of Tlatelolco on February 14 and 15, 1967; within one year, all twenty-one nations then eligible to sign the treaty had done so. Fourteen had waived Article 28 by the end of the decade, bringing the treaty into force in two-thirds of the twenty-one nations delegates had identified as belonging to the zone at the time of negotiations. The negotiation of the world's first regional nuclear non-proliferation pact at Tlatelolco was a landmark diplomatic achievement; the diversity of nations supporting the treaty with their assent, and the speed with which they navigated such a complex process to bring the treaty into force, are astounding. Of the three most technologically advanced countries in the region, however, only Mexico had definitively renounced nuclear weapons on the new treaty's terms. Brazil and Argentina would remain on the sidelines of the Tlatelolco zone until the 1990s, and the United States had not yet fully flexed its muscle on the matter of punitive measures toward potential proliferators in the region. The parallel power play of

[77] Article 23 during the time of drafting appears as Article 28 in the final treaty of February 1967, and as Article 29 in the modern, amended treaty. Cuba is not mentioned as one of these "delay" countries since its representatives did not sign the Treaty of Tlatelolco until 1995.

Brazil's and Argentina's technological quest had profound diplomatic effects on the agreement reached at Tlatelolco.

The actions of military governments in Brazil and Argentina toward developing nuclear power and fuel cycle technologies, essentially unconstrained by the terms of a nonproliferation treaty that they had largely bent in order to realize their desires for a minimalist agreement and maximal liberty to develop nuclear energy projects, form the subject of the next three chapters.

Chapter 3: Partitioning

Nuclear Power and the Divergence of Technological Paths: 1966-1974

By the time that the ink had dried on the first signatures and ratifications of the Treaty of Tlatelolco in February 1967, Argentina had been under military rule for seven months, and Brazil had been ruled by a junta with Gen. Humberto Alencar Castelo Branco as head of state for almost three years after the *Golpe de 64*. This chapter analyzes the military governments' responses to global challenges – nuclear nonproliferation, the petroleum crisis of 1973, the intensification of the Cold War – from the angles of nuclear energy policy and bilateral diplomacy. In the immediate aftermath of Tlatelolco up to the negotiation of the West Germany nuclear transfer deal with Brazil (1975) and the *Proceso de Reorganización Nacional* military coup in Argentina (1976), the push to develop nuclear energy technology and craft its attendant, complex diplomacy in Brazil and Argentina was sometimes disjointed, but often defiant toward industrial, nuclear-armed nations like the United States, increasingly viewed as policemen of a fundamentally discriminatory global nonproliferation regime.

Chapter 3 has three primary arguments. The first argument is that both nations faced paths that were both narrower and more irreversible for the development of nuclear energy technologies than they had been even a decade before. Political and technological leaders faced fundamental decisions on future technical and diplomatic means to attain ambitious energy and economic goals, but made those choices in an environment of imperfect economic information, growing mutual distrust, the fragile global context of Cold War tension, and a paralyzing spike in petroleum prices. As both nuclear energy commissions in Brazil and Argentina began concrete plans in this period to purchase and install nuclear power plants, Brazil diversified their energy profile in an additional major and confrontational way. In 1971, construction on the colossal Itaipu hydroelectric dam began according to a 1966 agreement between Brazil and

Paraguay, as Argentina's nuclear power plant at Atucha entered its third year of construction. The substitution of hydroelectric for nuclear power in Brazil stalled the conversations and plans leading to that country's first nuclear power reactor until 1974-1975. In those years, too, the economic impact of a close relationship with West Germany on nuclear cooperation became apparent in the largest nuclear technology transfer in the brief history of the Atomic Age. Documents from the Argentine Ministry of Foreign Relations show the effects of the Itaipu dam both on Brazil's long-term economic planning – as ambitious plans for nuclear power were overshadowed by the colossal potential of hydroelectric dams along the Paraná River – and on the worsening bilateral relationship between Argentina and Brazil as a consequence of foreign policy conflict centered on energy.

The second argument of the chapter thus deals with the complex bilateral relationship between the South American neighbors. Especially in the period after the final drafting of Tlatelolco, Brazil sought a basic memorandum of understanding as the basis of a sort of separate peace in nuclear energy diplomacy with Argentina. The two nations had stood together during the negotiations of that continental treaty, vociferously defending the right to conduct peaceful nuclear explosions as a path to economic development. Toward the end of the 1960s, however, Argentina's foreign ministry distanced itself from Brazil's idea of a joint statement between the neighbors on peaceful use of nuclear energy, and the post-Tlatelolco comity began to sour. Over a decade would pass before political leaders and diplomats from the two nations would seriously contemplate another such attempt.

Lastly, I argue here that military rule did not fundamentally change the policy of both nations in seeking nuclear self-sufficiency as a form of technological autonomy, which I view as a specific type of import-substitution industrialization policy for human capital and specialized scientific knowledge. Establishing this autonomy was a national priority in both Brazil and Argentina, predating both the 1964 and 1966 military coups, respectively.

Argentine Ambassador Julio César Carasales cites the 1967-1976 period in the nuclear energy history of Argentina as one of "establishing the first centers of electric energy production [via nuclear technologies] in Latin America," and supports his characterization by noting that construction began on the Atucha I power plant in 1968, and on Embalse, Argentina's second nuclear power reactor, in 1974. Diego Hurtado, a historian of twentieth-century science and specialist in nuclear energy does not challenge this above periodization by Carasales, either; one chapter's title, "On electricity and peripheral bombs," places the same emphasis on Argentina's decisive move toward nuclear power, and introduces the complication of India's bomb test to nuclear programs in other developing nations.[1] Political scientist Togzhan Kassenova does not lay out a distinct periodization for Brazil's nuclear energy history as the Argentine scholars did, but she notes that 1967 was a significant year in that country as well, as Artur da Costa e Silva, Brazil's military president that succeeded Castelo Branco, decided to pursue a full nuclear fuel cycle, expanding the sector "for a multitude of energy, industrial, and scientific purposes."[2]

Only a handful of scholars have taken the entire second half of the twentieth century as the focus for their analyses of the two South American nuclear energy programs; however, those that have researched the topic seem to agree on the key dates that bookend this chapter. The beginning of my chronological focus in this chapter is framed by the Onganía coup in Argentina in 1966 and the final drafting of the Treaty of Tlatelolco in 1967, while two pronounced pivots in nuclear energy policy and diplomacy frame the end of the period. Brazil

[1] Diego Hurtado, *El sueño de la Argentina atómica*. Buenos Aires: Edhasa, 2014, 135.
[2] Togzhan Kassenova, *Brazil's Nuclear Kaleidoscope: An Evolving Identity*. Washington, DC: Carnegie Endowment for International Peace, 2014, 18.

completed its outward turn toward Germany in 1975, taking advantage of a close scientific and technical relationship with West German firms and institutions to close a massive nuclear technology transfer deal. Argentina turned inward, however, toward developing its own autonomous nuclear capabilities in 1976 as a result of the authoritarian, isolationist *Proceso de la Reorganización Nacional* military government.

It is impossible to separate military rule in Brazil and Argentina during the second half of the 1960s from the omnipresent global conflict of the Cold War; the specter of Communist Cuba after that nation's 1959 revolution haunted Latin America, where military forces were on the front lines of a process by which "national security replaced national defense...The alarmist vigilance of the military, encouraged by Washington, resulted in their seeing communism everywhere…So it was that, between 1962 and 1966, the new Cold War 'crusaders' unleashed a series of nine coups d'état in the region."[3] As these military regimes institutionalized their rule in Brazil and Argentina, generals as heads of state and policymakers traced parallel paths of "virtually permanent, if not stable, military tutelage, in which the exception in constitutional terms has in fact become the rule," creating "Praetorian republics" like those of El Salvador and Guatemala in the two decades following 1965.[4] This chapter traces the management of energy policy, fundamental to industrializing economies in Argentina and Brazil, and bilateral diplomacy by the generals, ministers, and diplomats that constituted these twentieth-century Praetorian republics of the Southern Cone.

Though the Brazilian and Argentine military interventions into politics shared a more or less common typology, Brazil's military intended to "reinforce and protect the state by

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[3] Alain Rouquié, "The Military in Latin American Politics since 1930," *The Cambridge History of Latin America*, vol. 6. Cambridge, UK: Cambridge University Press, 1994, 245. Argentina's coups of March 1962 and June 1966 are, in fact, the first and last of the list that follows.
[4] Rouquié, "Military," 248.

purifying, not by abolishing, the existing democratic system" under General Humberto Castelo Branco's "revolutionary" leadership, an ideal that could not be attained after the "authoritarian liberal" generals had perceived the strength of Brazil's customary political parties and unwavering pressure from the far right elements of the military.[5] The lurch toward long-term authoritarian and anti-democratic rule under Gen. Emílio Garrastazu Médici in 1968 installed an 'invisible government' in the form of the National Intelligence Service and National Security Council; this intensive involvement of the military in an extensive authoritarian state mechanism had no parallel in Gen. Juan Carlos Onganía's Argentina, where the president "took all power into his own hands…but the armed forces were not themselves in power, and officers exercised a relatively limited share of executive functions."[6]

Two egregious instances of repression illustrate the deleterious impact of the military regimes in Argentina and Brazil on the scientific and intellectual activity of the late 1960s. The Onganía regime brutally ended, on July 29, 1966, what had been called the nine-year "golden age" of the Department of Exact Sciences at the Universidad de Buenos Aires, as well as over a half-century of legal autonomy of the universities in Argentina. In his first month as president, Onganía placed university control under deans and rectors, who were responsible to the Ministry of Education.[7] These rules, contained in Law 16.912, replaced a tripartite control system where faculty, students, and alumni shared administrative responsibilities.[8] UBA's rector was publicly opposed to the military dictatorship as unconstitutional, and he and the deans were given 48 hours to follow the new rules of the Onganía regime. Dean Rolando

[5] Rouquié, "Military," 252.
[6] Rouquié, "Military," 252-253.
[7] Wolfgang Bietenholz and Lilian Prado, "Revolutionary physics in reactionary Argentina."*Physics Today* 67, no. 2 (2014): 39.
[8] Felipe Pigna and María Seoane. *La noche de los bastones largos: 40 años del saqueo de la ciencia en la Argentina.*

García and a council of faculty in the exact and natural sciences (biology, geology, chemistry, mathematics, and physics) agreed to reject the rules, spending the night in the building.

Before the 48 hours had elapsed, the federal police invaded the building around 11 PM; their chief reportedly yelled an order to "Shoot them if necessary. We must clean this cave of Marxists!"[9] The police then arrested approximately four hundred faculty and students, took them outside and lined them up double-file, and began to indiscriminately beat them with the batons that gave the intervention its unofficial name. The federal police destroyed classrooms and laboratories next. In the aftermath of the "Night of the Long Batons," 1,378 faculty members at UBA would resign; 301 left the country, of whom 215 were scientists. Onganía's police forces had, in a matter of hours, destroyed the physical infrastructure and human spirit that powered one of Argentina's leading centers of science, leading 192 physicists across the globe – 14 future and present Nobel laureates among them – to sign a public letter of protest to the military president.[10]

The Brazilian military made no such dramatic interventions against purported communist infiltration of academic institutions, but especially in the *anos de chumbo* under Médici, torture and detention – or the "softer" punishment carried out through 10-year suppression of political rights or exile – of those believed a threat to the regime became increasingly common as repressive measures. A memorandum from Argentina's Ministry of Foreign Affairs described the revocation of political rights of eight scientists at Brazil's *Instituto Oswaldo Cruz* under the fourth article of AI-5. The information given by Medici's press secretary "gave no information on those punished" beyond their full names, nor the reasons for

[9] Pigna and Seoane; also Sergio Morero, Ariel Eidelman, and Guido Lichtman, *La noche de los bastones largos.* Buenos Aires: Nuevohacer Grupo Editor Latinoamericano, 2002.
[10] Bietenholz and Prado, "Revolutionary physics," 39.

which they were sanctioned.[11] Like those rounded up on the Night of the Long Batons in Buenos Aires, the scientists targeted in 1970 at Rio de Janeiro's premier institution for advanced study in biological sciences had an excellent reputation among colleagues in their fields; many seemed to be late-career scientists "in positions of great responsibility, who directed important programs of research, for which they enjoyed international renown."[12]

The dismissal of eight scientists had a catastrophic effect on research in a country with a small and fragile scientific community; the Institute's departments of physiology and entomology "practically disappeared." Journalists criticized the purge by marshaling "evidence of the losses that will come from the isolation [exile] of the sanctioned scientists." Médici's decision had a scientific and a political meaning, the author of the memorandum argued. For years, Brazilian scientists had left the country to pursue greater riches and fame in wealthier countries; Médici's invocation of AI-5 against eight prominent scientists would exacerbate a "brain drain" that the government had been trying to plug for years. Politically, the message could hardly be clearer: the hard-line president could, and would, use the revocation of political rights in AI-5 in any situation, regardless of its effects on valuable and fragile intellectual communities within a developing economy. Argentina's embassy in Brazil, the memo concluded, remained "interested in learning the reasons why such prominent scientists were 'sacked,' and would pursue measures to clarify the situation." No mention was made of the Night of the Long Batons and any parallels to Médici's repression of scientists on dubious political grounds.

On June 12, 1970, a brief one-page memorandum from the Argentine Embassy in Brazil mentioned that CNEN President Hervásio de Carvalho had received a letter from three

[11] Osiris Guillermo Villegas, Ministerio de Relaciones Exteriores y Culto, "Sanciones políticas a ocho científicos del Instituto Oswaldo Cruz." Archivo MRECIC, Caja AH/0043, Departamento América del Sur, Serie 47, 1.
[12] Guillermo Villegas, "Sanciones políticas," 1.

German scientists interceding on behalf of their eight Brazilian colleagues who had been dismissed and had their political rights revoked under AI-5. Carvalho defended Médici's action, saying that the scientists had used their professorships to spread "leftist propaganda." One of the "German" scientists was actually Guido Beck, born in Liberec in what is now the Czech Republic, who had moved between Argentina and Brazil since 1943 and played a fundamental role in training physicists in both countries. When Beck signed the letter opposing the regime's treatment of the eight scientists, he was living in Argentina, a fact that the Argentine military attaché made sure to convey because of the "friendly relations" that the attaché had with Carvalho, and Carvalho's desire to collaborate with Argentina.[13]

Forking Paths and the Beginning of Nuclear Power Planning

Brazil's advancement in nuclear energy continued to be marked, especially to those outside the country, by the formation of state enterprises, subsidiaries of its national nuclear energy agency, and special working groups to tackle the nuclear technology problems most pressing to the state. Two weeks prior to the Brazilian coup of March 31, 1964, the Nuclear Materials Company of Brazil (COMANBRA) was created by Goulart's government as a subsidiary of CNEN in order to cultivate, improve, refine, chemically treat, and market nuclear minerals, as well as to produce and commercialize "materials related to the use of nuclear energy."[14] Engineer Guilherme Camargo called the nuclear policy of the Castelo Branco government a "regression" because it limited the nation's goals for nuclear power to a pilot-size plant, reflecting a decision that atomic energy was not yet advanced to the point in Brazil to be

[13] Guillermo Villegas, Osiris. Ministerio de Relaciones Exteriores y Culto, "Gestión de científicos alemanes en favor de colegas brasileños recientemente sancionados." Caja AH/0043, Departamento América del Sur, Serie 47. AMRECIC.

[14] Decreto nº 53.735, Senado da República Federativa do Brasil. http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=88936&norma=114774, accessed March 27, 2017.

considered for providing electrical power on a large scale as many had hoped.[15] Foreign experts in engineering or physics working to help Brazil develop nuclear energy plans were dismissed, as they apparently cost the country too much money to employ toward the newly reduced goals of CNEN, a move that "paralyzed the entire Brazilian nuclear effort."[16]

Nevertheless, Brazilian technicians continued to work on scaled-down versions of their current projects. A Power Reactor Working Group concluded its two years of work, proposing in 1964 to construct a test-scale nuclear power plant based on natural uranium, with a subsidiary of Eletrobrás to be created to administer it.[17] Note that originally, *both* Brazil and Argentina sought to develop commercial nuclear power based on *natural* uranium as fuel, both to take advantage of their own considerable mineral resources as well as to avoid the de-facto monopoly that the United States controlled on sales of enriched uranium to other nations. A collaboration in 1964 between the *Instituto de Pesquisas Radioativas* (IPR) and France on general reactor technology and the nuclear fuel cycle accompanied a more specific agreement between the IPR and French *Commissariat a l'Energie Atomique* (CEA) to launch a subcritical assembly (or teaching reactor) called "Capitu," to be built in Minas Gerais. Capitu was the outcome of a Brazil-France partnership that had developed in part thanks to the role of Pierre Balligand, of Grenoble's Center for Nuclear Studies, within the IAEA.[18] At the end of 1966, Brazil signed an agreement on basic technical assistance in nuclear energy and other fields with the UN and

[15] Guilherme Camargo, *O fogo dos deuses: Uma história da energia nuclear*. Rio de Janeiro: Contraponto, 2006, 266.
[16] Marcello Damy, quoted in Camargo, *O fogo dos deuses*, 266.
[17] CNEN timeline, 1962-1964. http://memoria.cnen.gov.br/memoria/Cronologia.asp?Unidade=Brasil
[18] José Israel Vargas, "Desenvolvimento da Energia Nuclear: Minas e o Brasil." *Economia & Energia*, XVII (90), July/September 2013. Accessed April 25, 2017.
http://ecen.com/eee90/eee90p/desnvolvimento%20energia%20nuclear.htm

various international scientific associations such as the International Civil Aviation Organization and the World Health Organization.[19]

In 1965, CNEN President Luiz Cintra do Prado, in conjunction with the Federal University of Minas Gerais (UFMG), integrated the activities of the Institute for Radioactive Research into the National Plan for Nuclear Energy. He placed a five-member directorate in charge, with two persons to be chosen by UFMG's school of engineering, two by CNEN, and one representing the IPR's Technical-Scientific Body.[20] This new partnership between IPR and the UFMG paid almost immediate dividends as those two institutions hosted the Thorium Group, intended to develop human resources in the field of nuclear reactors, and its three serial projects Instinto (1966-67, to discuss options including enriched uranium and thorium), Toruna (1968-71 for natural uranium and heavy water), and Pluto (plutonium and thorium, 1971-73).

In terms of diplomacy, Brazil concluded three bilateral agreements on peaceful nuclear energy – with Portugal, the United States, and Switzerland – in a three-month span in the middle of 1965. In 1966 and 1967, Brazilian officials concluded agreements on nuclear cooperation with Peru and Bolivia. A Special Working Group, formed in "with an eye toward planning the use of nuclear plants for the ends of electrical energy production" between the Ministry of Mines and Energy and CNEN. The participation of the Secretary-General of the Council on National Security (CSN) in these developments signified the tighter linkages between peaceful nuclear energy and national security in the minds of Brazil's military heads of

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[19] Decreto nº 59.308, Senado da República Federativa do Brasil. http://legis.senado.gov.br/legislacao/ListaTextoIntegral.action?id=91330

[20] Convênio no. 11/65, "Integração – Instituto de Pesquisas Radioativas – Plano Nacional de Energia Nuclear." July 8, 1965. Accessed at http://memoria.cnen.gov.br/Doc/pdf/Tratados/CONV1165.PDF, March 27, 2017. Somewhat oddly, though the Belo Horizonte university was federalized in 1949, the 1965 agreement uses the old "UMG" acronym sixteen years later.

state. As Brazil increased its aid to developing nations' aspirations for peaceful nuclear energy, its leaders also took steps toward harnessing human and physical resources to provide electrical power from nuclear energy. However, Castelo Branco seemed to set the Brazilian nuclear program back again near the end of his administration, moving CNEN to an agency subordinate to the Ministry of Mines and Energy as part of an "Administrative Reform" measure, a move that represented a diametrically opposite policy from "practically all previous governments."[21] In Argentina, where experts on nuclear technology development estimated its progress to be about five years ahead of that of Brazil, the military takeover seemed to affect CNEA's operations very little.

On July 19, 1966, less than one month after Onganía's coup, the RA-2 research reactor at Centro Atómico Constituyentes reached criticality, and the following day, CNEA and its counterpart in Spain, the Junta de Energía Nuclear, signed a cooperation agreement pledging to increase reciprocal technical assistance. The beginning of 1967 was, for Argentina, an auspicious and audacious time of expectations for nuclear energy. CNEA and Argentine government personnel began to negotiate with foreign firms and governments on construction of the nation's first nuclear power plant. Because the United States held a *de facto* monopoly on enriched uranium to be sold to other nations, Argentine nuclear policymakers vastly preferred a natural uranium option – heavy water, required as a neutron moderator in reactors fueled by natural uranium, was available from several other countries and represented only a "short-term commitment [to purchase from outside Argentina], given that heavy water production would become one of CNEA's priorities."[22] By July 31, CNEA had received seventeen bids from ten firms in France, Canada, the United States, and Germany to construct this proposed power

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[21] Camargo, *O fogo dos deuses*, 267.
[22] Hurtado, *El sueño de la Argentina atómica*, 135. Chapter 4 provides a more detailed account of the drive in the late 1970s to produce heavy water within Argentina's borders.

plant; bids needed to include detailed information on financing, given CNEA's refusal to borrow from international agencies such as the World Bank, and were required to include "intensive participation" by Argentine industry.[23]

Important developments in nuclear energy technology were taking place in 1967 outside of Argentina's industrial-scale nuclear power plant negotiations as well. Another research reactor, RA-3, reached criticality in May at Ezeiza, just outside the city of Buenos Aires. This particular 0.5 MW reactor, while designed to run on imported 90% enriched uranium, represented a particular point of Argentine pride in its quest for nuclear self-sufficiency: 90% of its electronics and control panel were manufactured in Argentina.[24] In July and September, Argentina signed peaceful use nuclear energy agreements with Paraguay and Colombia, respectively. On October 3, Rear Admiral Oscar A. Quihillalt, president of CNEA, was unanimously elected Chair of the Board of Governors of the IAEA for the following two-year period, the first time an Argentine official had been elected to a high leadership post in the history of the decade-old agency.[25] And in December, the Centro Atómico Ezeiza was officially inaugurated, housing the RA-3 reactor which manufactured medical radioisotopes both for domestic use and export, and served as a center for research on uses of ionizing radiation as well as the storage of radioactive wastes.[26]

Argentina's eyes remained on their technologically advanced neighbor's nuclear energy program and intentions as well. A revealing document from the Argentine *Servicio de*

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[23] Hurtado, *El sueño de la Argentina atómica*, 136, 138.
[24] Hurtado, *El sueño de la Argentina atómica*, 127. On nuclear self-sufficiency, see Emanuel Adler, "Institutions, Ideology, and Autonomous Technical Development," *Latin American Research Review* 23, no. 2 (1988), or Adler, *The power of ideology: The quest for technological autonomy in Argentina and Brazil* (Berkeley: University of California Press, 1987).
[25] Currently, the IAEA Board of Governors meets five times per year to "examine and make recommendations to the General Conference on the IAEA's financial statements, program, and budget," also considering applications for membership, approving safeguards agreements, and publishing the agency's safety standards. Board members come from every region of the world; there are 35 Governors representing national delegations in 2017.
[26] http://www.cnea.gov.ar/cnea-pais-ba, accessed March 23, 2017.

Inteligencia Naval (Naval Intelligence Service) Subsection 1, Department "B," offers a detailed look at what the Argentine navy saw across the border in terms of Brazil's progress in nuclear energy technology. The innocuously titled "Perspectives in the Nuclear Energy Sector" was a twenty-page report dated July 6, 1967, not even six months after the first signatories accepted the Treaty of Tlatelolco. It briefly summarized the preceding decade (1957-1967) in terms of Brazil's developing physical and human capital in nuclear energy, focusing on installations in Minas Gerais, particularly mining and refinement of nuclear minerals at Poços de Caldas, a 1962 plan to construct three nuclear power centers,[27] the inauguration of the "Argonaut" research reactor at Isla do Fundão in Rio de Janeiro city, and the concentration of installations in São Paulo – the Van de Graaff linear particle accelerator and the "pool" research reactor IEA-R1.

The lofty plans for four Brazilian nuclear power plants – one in Mombucaba, Rio de Janeiro state, another near São Paulo city, one in the southernmost state Rio Grande do Sul, and the fourth in the Northeast to "meet the demand of the states of Maranhão, Piauí and Ceará" – seemed far beyond the human resources of the "approximately 300 technicians in nuclear energy" that Argentina's navy estimated to be working in the entire country – of which 50 were believed to be working outside Brazil.[28] Minister of Foreign Relations Juracy Magalhães had begun a course in nuclear energy for his diplomatic employees in 1966, and said that it "represented the first step for Itamaraty in the project of forming a team of personnel

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[27] Two pages later, the authors of the report write that CNEN had planned *four* nuclear power plants in 1962, not three; the naming of four distinct sites along with cost and capacity estimates seems to render the first figure an error.

[28] Servicio de Inteligencia Naval (Argentina), "Brasil: Perspectivas en el sector de la energía nuclear." Wilson Center/NPIHP Digital Archive. Documents on Argentine and Brazilian nuclear energy history and diplomacy are presented in collaboration with Fundação Getúlio Vargas, or FGV. Of particular interest to this research are the "Nuclear energy—Brazil," "Nuclear energy—Argentina," and "Argentina—Foreign Relations--Brazil" collections of documents collected primarily from the two countries' foreign ministry archives digitized here: http://digitalarchive.wilsoncenter.org/browse. Hereafter "WCDA." July 6, 1967, 4-5.

trained in dealing with matters connected to nuclear energy, and to negotiate technical cooperation agreements designed to direct the maximum amount of scientific material and nuclear technology to Brazil…"[29] Magalhães' endgame was commercial nuclear power, but the Angra I reactor became operational almost twenty years later.

Without any attribution to a source – and with clever use of the passive voice – the author of the report dates a project to study the possibility of Brazil constructing 'its own atomic bomb' back to 1961, implicating Presidents Quadros (January-August 1961) and Goulart (August 1961-March 1964) in a plan that apparently also involved naval admiral Otacílio Cunha and leading physicist Marcelo Damy.[30] Luiz Cintra do Prado, the fourth president of CNEN, and first one appointed by the military government, on May 26, 1964, may well have held sentiments in favor of building an atomic bomb that the Argentine naval report drew from statements that he had purportedly made to the press. Certainly, his 1966 remark that Brazil "was ready to produce the atomic bomb, but there is no order to do so; if there were, it would be made without difficulty" indicated that, in the view of the CNEN president, only a lack of political will from the head of state prevented a Brazilian bomb from becoming reality. Brazil's nominal adherence to the Treaty of Tlatelolco proscription on nuclear weapons was no deterrent to a faction of military personnel who wished that Brazil "rapidly possess the atomic bomb" and urged President Artur Costa e Silva to begin a military nuclear program "immediately."[31]

[29] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 5.
[30] Small factions of Brazilian nuclear authorities and military personnel debated nuclear weapons construction during at least three distinct periods of time: the *Bomba Marambaia* of 1953, the early 1960s discussion, and the *Programa Paralelo* or PATN beginning in 1979. The existence of these three periods of debate should *not* be taken to imply a continuous effort or desire by nuclear planners to construct a nuclear weapon or explosive device.
[31] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 8.

Cintra do Prado's successor as the head of CNEN, Uriel da Costa Ribeiro, purportedly reframed the question of the atomic bomb in Brazil as a merely defensive one: "Brazil will need to build an atomic bomb if the country is threatened with nuclear war, regardless of our decision to remain on the margins of any arms race and its elevated cost; no nation will be able to trust that its allies will provide it an atomic bomb in case of such an eventuality."[32] Eventually, the Argentine naval report moderated its stance on Brazil's potential to build an atomic weapon, citing its lack of sufficient uranium and plutonium and relying on the assessment of Brazilian nuclear engineer Hélcio Costa that "Brazil today is as far from [conducting] nuclear explosions as the Brazil of 20 years ago was from an automobile industry."[33] Costa's statement about military or peaceful test explosions notwithstanding, the authors of the Argentine report take Brazil's ambitious plans for peaceful nuclear explosions – the sticking point in the later phases of the Tlatelolco negotiations in Chapter 2 – at face value. "It is not unrealistic to think that Brazil would attempt to use atomic energy to connect the Amazon and [Rio de la] Plata basins by way of canals and tunnels, to open mines, to effect movements of earth for the construction of electric power stations and dams…"[34]

Much of this Argentine naval report on Brazil's nuclear capabilities and plans must be taken at least somewhat skeptically; the authors of the report were hardly insiders to the most closely guarded plans for nuclear energy of their chief regional rival. However, that is not to say that the rest of the report is not without value, particularly the Argentines' concern at the identities of Brazil's international technology transfer partners – France ("characterized by its international independence in this aspect [of nuclear energy and weapons]"), the United States ("the premier country in the field"), and Israel ("probably possessing a powerful reactor") – and

[32] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 9.
[33] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 9.
[34] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 10.

a prescient concluding comment on Brazil's sheer force of will as exemplified by the recent move of its capital to the arid center of the country.[35] "Brasília is an obvious demonstration of the above. In the middle of a full-blown economic crisis and a constant rise in inflation, [the city] grew in the middle of the jungle from the imperative of a personalist policy of the ex-president Kubitschek…It was a work of direct impact on the domestic and international order and a clear demonstration of what Brazil was able to do, even in moments of acute economic instability."[36] Meanwhile, in Argentina, plans for commercial-scale nuclear power proceeded relatively smoothly.

Arrangements for Argentina's first two nuclear power plants – Atucha I in 1968, and Embalse in 1972 – under the military leadership of the *Revolución Argentina* are certainly the most significant achievements in nuclear energy and industry under that government, and serve to mark the consolidation and fracturing of that seven-year period of military rule as well. In 1968, Argentina became the first country in Latin America to contract and plan a major nuclear power plant, which would be constructed in Lima, roughly 100 km northwest of the capital in the province of Buenos Aires. Onganía's Decree 749 authorized CNEA to accept the offer by the German firm Siemens to design, construct, and begin operation of a natural uranium/heavy water reactor with a planned capacity of 319 MW, based on an American design by Westinghouse.[37] An amendment to the contract with Siemens announced provisions destined to ensure "supply and services of Argentine origin" set aside 100 million German

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[35] The authors of the report make no comment on Argentina's sale of 80-100 tons of uranium oxide or "yellowcake" to Israel in 1963-1964; whether they knew of their country's complicity in advancing Israel's nuclear capabilities or not is unknown, but it is clear that they regarded Brazil's nuclear relationship with the Middle Eastern nation as suspect.
[36] Servicio de Inteligencia Naval, "Brasil: Perspectivas…", 21.
[37] Hurtado, *El sueño de la Argentina atómica*, 139.

marks, or roughly $175 million in 2017 US dollars,[38] for this purpose. Argentina's *Servicio de Asistencia Técnica a la Industria* (SATI, or Technical Assistance Service to Industry) compiled, over two and a half years, a list of 112 electro-mechanical parts, comprising (only) 12% of total purchase orders for the power plant project, the total cost of which would reach approximately 105 million USD in 1968, or $735 million in 2017 dollars.

In 1968, the Argentine government also signed peaceful nuclear cooperation agreements with Peru (May) and Uruguay (July), and inaugurated a linear electron accelerator at the Centro Atómico Bariloche. Argentina and the United States signed what was presumably an update of their civilian nuclear energy use agreement in 1969. Technicians also achieved successful chemical separation of plutonium from spent fuel elements – a crucial step in achieving the full nuclear fuel cycle capabilities that motivated Brazilian and Argentine policymakers and scientists. In what might be seen as a small sign of recovery from the Night of the Long Batons university intervention by the military in July 1966, the Faculty of Exact Sciences at UBA formed a partnership with CNEA and Conicet (the National Council on Scientific and Technical Research) in 1969 to create the Institute of Geochronology and Isotopic Geology.

1968 was a watershed year for nuclear energy in Brazil, as notable for what leaders did not do as what they did. Like that of its neighbor Argentina, the delegation from Brazil refused to sign the United Nations' Non-Proliferation Treaty for reasons analyzed in Chapter 2. Non-nuclear-weapon states like Brazil and Argentina were prohibited from receiving transfers of equipment or material that were necessary, but not sufficient, in constructing such weapons.[39]

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[38] Historical conversion rate between USD and German mark found by conversion calculator at https://goo.gl/Jr5AZN. Conversion of 1968 US dollars to 2017 USD found at the US Bureau of Labor Statistics inflation calculator, https://www.bls.gov/data/inflation_calculator.htm, accessed March 20, 2017.

[39] Article III of the Non-Proliferation Treaty states that "Each State Party to the Treaty undertakes not to provide: a) source or special fissionable material, *or b) equipment or material especially designed or prepared for the*

The South American neighbors' refusal to sign the NPT would restrict the potential for future transfers of nuclear technology from the industrialized North Atlantic to a rapidly dwindling number of willing partners. Between April and June, the Lane Group studied possible reactors and analyzed the economic feasibility of building commercial nuclear power plants, paying close attention to the potential role for national industry in this process. The Special Working Group convened the previous year did not answer which type of reactor technology best suited Brazil's needs and resources, but did indicate a minimum recommended capacity for the nation's first nuclear power plant of 500 MWe, stated in the CNEN/Eletrobrás agreement of April 26, 1968. Brazil negotiated another cooperation agreement with the United States, this time with an aim to build research and power reactors and exchange information to realize these more ambitious and concrete ends for peaceful applications of nuclear technology.

In Argentina, two more research reactors reached criticality at major national universities, RA-0 in Córdoba and RA-4 in Rosario (at the Universidad Nacional del Litoral), in 1970 and 1971. These years were part of CNEA's effort to expand the nation's physical infrastructure devoted to nuclear energy, as the Centro Atómico Ezeiza also opened its radioisotope production plant and a liquid radioactive waste management system. Internationally, the Argentine nuclear energy agency continued to branch out, signing a peaceful nuclear energy usage agreement with Bolivia as well as initiating a cooperation agreement with German firm Gesellschaft für Kernforschung. This is the same firm that would offer Brazil the "jet nozzle" uranium enrichment technology component as part of the 1975 nuclear transfer agreement between the South American nation and West Germany, discussed in Chapter 5. Two new domestic institutions – the Argentine Society of Radioprotection (SAR)

processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this Article." From https://www.un.org/disarmament/wmd/nuclear/npt/text.

and the Argentine Association of Nuclear Technology (AATN) – were created in 1970 and 1972, and the SAR would join the International Association of Radioprotection in 1972 as well. In 1973 and 1974, Argentina continued to expand its nuclear power program, contracting with Atomic Energy of Canada Limited (AECL) for its second power reactor, 600 MWe capacity, to be installed at Embalse, Córdoba province. The law authorizing Argentina's second power reactor was signed mere weeks before its first, Atucha I, reached criticality and was connected to the national electrical grid, beginning commercial operation in June 1974.

The last five years of the period discussed in this chapter, 1969-1974, preceded Brazil's negotiation of the massive nuclear technology transfer agreement with West Germany. As Brazil's relationship with West German nuclear suppliers grew in economic importance, in 1969, the Mineral Resources Research Company (CPRM) opened under the auspices of the Ministry of Mines and Energy with a "special credit of NCr$3 million for the ends specified."[40] More importantly, in that same year, Brazil took more definite steps toward a nuclear collaboration with West Germany that went far in scope beyond the proposed memorandum of understanding with Argentina, which is discussed in the next section. Naturally, Germany and Argentina had different things to offer Brazil in terms of nuclear energy at the end of the 1960s. Germany could transfer advanced nuclear technology to the Brazilians, which could bring them closer to Argentina's degree of progress in nuclear energy development; Argentina could offer Brazil and its neighbors peace of mind as to its renunciation of nuclear weapons. A joint communiqué, presumably from the governments or foreign ministries of Brazil and West Germany, provided some details on the March 25-29, 1969 visit by the German Minister of Scientific Research, Dr. Gerhard Stoltenberg.

[40] Decreto nº 813, Senado da República Federativa do Brasil, Sep. 4, 1969. http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=94394&norma=119228 accessed March 27, 2017.

Accompanied by his head of the sub-department for international cooperation, scientific director of the Jülich Nuclear Research Center, and press advisor, Stoltenberg visited the Instituto de Energia Atômica in the city of São Paulo, the Technical Aeronautics Center at São José dos Campos in São Paulo state, the capital in Brasília, and the hydroelectric dam at Três Marias, Minas Gerais, which had begun operation in 1962.[41] The West German minister conversed at length with Brazilian ministers of Foreign Relations and of Mines and Energy, who had consulted with high-ranking personnel in the Brazilian nuclear energy program such as CNEN President Uriel da Costa Ribeiro, Assistant Secretary General for Planning within Itamaraty, Paulo Nogueira Batista, a naval admiral, and an Air Force colonel in preparation for the European minister's visit.[42]

These conversations had led to a "basic understanding regarding the General Agreement on Scientific and Technological Cooperation" soon to be formalized between the two countries. It would be implemented across several agencies and fields of scientific and technological research and activity "by specific contracts covering programs and projects

[41] "Comunicado conjunto," West German Minister Gerhard Stoltenberg's Visit to Brazil, March 28, 1969, 1. WCDA.

[42] Nogueira Batista is important enough to the rest of this dissertation to merit a brief biography here. Born in Recife on Oct. 4, 1929, he completed his diplomatic training at the Instituto Rio Branco in 1952, graduating as a third-class consul, and began his career at Itamaraty in Rio de Janeiro as assistant to the secretary-general of the Foreign Ministry, before moving to the Ministry of Education and Culture in 1954, where he earned a merit-based promotion to second secretary. He returned to Itamaraty in June 1956 as assistant to the head of the Economic and Consular Department, and participated in various Organization of American States meetings as part of his post at Brazil's embassy in Buenos Aires until 1960. His first experiences in nuclear energy matters, from 1967-1969, took place as part of Foreign Minister Magalhães Pinto's cabinet, before he was promoted to be counselor-minister to Bonn, West Germany, from 1969-1971. Recalled to Brasília in 1973 to serve as Subsecretary on Economic Affairs, Nogueira Batista traveled to the Middle East to negotiate petroleum supplies in 1974 in order to help alleviate the oil crisis's disastrous effects on the Brazilian economy. But in 1975, Nogueira Batista took his most famous – and long-standing – position in the Brazilian government as president of Nuclebrás, the new state enterprise to coordinate the implementation of the technology transfer from West Germany. He traveled with Ernesto Geisel as part of the Brazilian delegation to Bonn in 1977, led the negotiations for nuclear cooperation with Iraq in 1979, and accompanied João Figueiredo on official visits to Caracas (1979) and Paris and Buenos Aires (1980). His career of nuclear diplomacy and state enterprise leadership came to a sudden end in 1983, when Figueiredo froze the plans to finish construction of eight power reactors by 1990, and finished his diplomatic career as Brazil's representative in the GATT trade talks (1983-1986) and Ambassador to the United Nations, where he was President of the Security Council in 1988-1989. Nogueira Batista died in São Paulo in 1994. Source: http://www.fgv.br/cpdoc/acervo/dicionarios/verbete-biografico/batista-paulo-nogueira.

primarily in the following areas: nuclear energy, space and aeronautical research, oceanography, scientific documentation, and electronic data processing." A prior German mission to Brazil of scientists in nuclear energy would serve as the model for similar travels by space and aeronautics experts and oceanographers.[43] In terms of nuclear energy, concrete and specific plans for areas of collaboration would include "computational methods for the optimization of nuclear energy production within the general context of the Brazilian energy program; prospecting of uranium; fuel cycles; development of advanced reactors."

Brazil's Minister of Foreign Relations, José de Magalhães Pinto, added some details to the joint communiqué of one week before through a telegram to President (Marshal) Artur Costa e Silva sent on April 2, 1969. The telegram outlined the proposed agreement with West Germany and the fact that an inter-ministerial working group, with representatives from Brazil's Navy, Air Force, Ministry of Mines and Energy, and Ministry of Foreign Relations, or Itamaraty, had made some changes to the proposal. The scientific and technical cooperation now had a more definite shape, involving "exchange of scientific and technical personnel as well as information, and simultaneous, joint, or collaborative research programs or projects."[44] In early May, "Brief Study no. 39/SG 1/69" from Brasília evaluated the proposal for a wide-ranging trans-Atlantic scientific and technological cooperation agreement. In section 3.2.3, part of a summary of pre-existing legislation, the relevant guidelines for national policy on nuclear energy appear as "immediate" – "stimulate the use of nuclear energy for peaceful ends, in the various sectors of national development" – and "permanent" – "fully utilize nuclear energy to peaceful ends, in all sectors of national activity," and "facilitate technical-scientific exchange

[43] "Comunicado conjunto: Stoltenberg," 2.
[44] José de Magalhães Pinto, Telegram to Artur Costa e Silva. April 2, 1969, 2. WCDA.

with other countries in the area of nuclear energy, *especially with more developed countries*."[45] In section 4.2.3, the aims of such agreements are made clear: "Brazil should sign agreements and contracts with highly developed countries and with international entities, with the aim of: ensuring resources such as equipment and instruments for existing nuclear installations and for future ones to be built; developing research projects within sectors."[46] Clearly, any such efforts would require close coordination with Itamaraty. The priorities for the "treaties, agreements and contracts" that outlined the details of coordination needed to "complement established programs [in ways] that would not be possible in Brazilian territory, [and] accelerate the implantation of nuclear infrastructure." Specific goals for the collaboration itself were the "formation/education of specialized personnel, use of radiation, projects of reactor component production, implantation of particle accelerators, [and] prospecting of minerals of interest in the nuclear area."[47]

Brazil's "counter-proposal" to the original West German proposal, as mentioned in Magalhães Pinto's telegram to Costa e Silva, was neither as confrontational nor major as the English translation of *contraproposta* might make it seem to be. The West German language that lent cooperation toward "nuclear research and development of nuclear technology" was simplified by the Brazilian interministerial work group to "nuclear energy," while the Germans' "space and air research" got a bit more specific in the Brazilian revision as "aeronautics and space activities." Oceanography and scientific documentation were left alone, but the Brazilian counter-proposal added electronic data processing and "other topics of mutual interest" to the potential fields of collaboration. A Brazilian diplomat later wrote that this change was

[45] Unknown author. "Brief Study of Draft of the General Agreement on Science and Technology between Brazil and West Germany." May 2, 1969. WCDA, in cooperation with National Archives of Brazil.
[46] "Brief Study," 8.
[47] "Brief Study," 6.

advantageous to his country, "as it eliminates the necessity of a new Agreement if a scientific-technological cooperation in a field not specified here may arise."[48] Section 4.2.2 of the "Brief Study" specifically accounts for the Brazilian changes to the original West German proposal: the title "does not have an explicit reference to the peaceful ends of the cooperation, as is usual in documents of this type, *but is made clear in the body of the Agreement*." This dispensation may have left more room for Brazilian military influence in the agreement than the West Germans had felt comfortable with. In the document, the absence of the explicit mention of peaceful ends is explained as a change to "not give emphasis to this intention [of peaceful nuclear use], nor to threaten it."[49]

In 1971, the creation of the Brazilian Company of Nuclear Technology (CBTN) helped to carry out the more ambitious nuclear power plans of the Costa e Silva and Médici presidencies. Responding to a 1970 Parliamentary Inquiry Commission that "concluded that Brazil had the need to engage strongly in a program of nuclear electric power generation,"[50] the CBTN would "research and mine deposits of nuclear minerals, promote development of nuclear technology for the treatment of minerals and production of fuel, as well as install a facility for the enrichment of uranium and components for reactors." The Dosimetry Laboratory, created in 1960, the Institute for Radioactive Research (IPR), and Nuclear Engineering Institute (IEN) were all incorporated into the CBTN in 1972 as well. In 1974, the CBTN was renamed Nuclebrás, and the division of labor between CNEN and the newly created state-owned enterprise that would manage nuclear power under the agreement with West Germany was codified in Lei Ordinária nº 6.189. The United States also announced in that year

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[48] "Brief Study," 15.
[49] "Brief Study," 15.
[50] Camargo, *O fogo dos deuses*, 271.

that it would be unable to fulfill its agreement to supply enriched uranium to Brazil, so the South American nation turned to other willing nuclear transfer partners.

A report to the Minister of State (Foreign Relations) written by Paulo Nogueira Batista in April 1971 went to the heart of the intersection between Brazilian sovereignty, nuclear nonproliferation, and peaceful exploitation of energy for economic development, and foreshadowed a similar communication in 1974 by Antônio Azeredo da Silveira. Of course, before Azeredo's memorandum, the stakes had gone up due to the immensity of the 1973 petroleum crisis. As Nogueira Batista's writing outlined a long-term forecast of Brazil's position vis-à-vis the developed "First World" countries of North America, Western Europe and Japan in uranium enrichment and a tightening supply of the nuclear fuel upon which the world's rapidly expanding peaceful – and military – programs and projects depended, it bears a substantial discussion here. By 1980, Nogueira Batista stated, the United States' uranium enrichment capacity via gaseous diffusion technology would be insufficient to meet the combined demands of nuclear reactors in its own country, Western Europe, and Japan; for this reason, American technicians were studying isotopic separation technology, while a triumvirate of European nations – West Germany, the Netherlands, and England[51] - began to explore centrifugation, an enrichment technology with far lower energy inputs than gaseous diffusion. Since the Paris Agreements of 1954, West Germany had been prohibited from enriching uranium on its own soil, so the proposed European project would use German-made centrifuges that would be operated in the Netherlands. Brazil, rather than be on the outside of a tightening uranium market – with few new suppliers to meet vastly increasing demand -- that would

[51] Nogueira Batista's report specifically mentions "Inglaterra," though probably the entire United Kingdom was implied.

"exceed one billion dollars annually, nearing the importance of the petroleum trade,"[52] would prefer to attempt to build in its territory "a uranium enrichment plant for supplying the global market, in association with another country possessing technology already proven on an industrial scale (gaseous diffusion)," or "associate ourselves with the development of a technology not yet proven industrially (ultracentrifuges or the 'nozzle process')…," also for world supply.

Making no small plans, Brazil sought to leap from importing enriched uranium sufficient for its own needs, primarily from the United States, to operating a foreign-built plant on its own soil capable of producing a substantial *excess* of the nuclear fuel to be exported to any willing buyer. If the energy-intensive gaseous diffusion option were to be chosen, Nogueira Batista suggested constructing a hydroelectric dam to provide Brazil's "quota of capital" in the form of inexpensive electricity to power the enrichment facility, in exchange for the technical assistance from a Western European partner, most likely France, given its experience with that type of enrichment technology.[53] One more disadvantage of gaseous diffusion was the enormous size of facilities required.[54] Were the Brazilians to make a deal to experiment with producing enriched uranium on an industrial scale with the jet nozzle process instead, West Germany would have been a "natural partner." However, Nogueira Batista warned, due to their participation in the tripartite agreement with the Netherlands and United Kingdom, the West Germans might not be able to give Brazil access to the information and process to enable the South Americans to build their own centrifuges. If the secrets of construction could not be

[52] Nogueira Batista, Paulo. "Informação para o Senhor Ministro do Estado: Enriquecimento do Urânio." April 19, 1971, 2. WCDA.
[53] Nogueira Batista, "Enriquecimento do Urânio," 3.
[54] The physical size of a gaseous diffusion enrichment plant must have been a significant factor in the Brazilians' calculus, as it is here mentioned twice in short succession.

shared, West German technicians could perhaps build the equipment in Europe and ship it to Brazil.

Nogueira Batista's tenth paragraph finally delivered, explicitly, the implied message of the rest of the document: "The idea would be to demonstrate to the Minister of Foreign Relations of the Federal Republic of Germany, upon his next visit to Brazil, that the Brazilian government is interested in entering the uranium enrichment race, and that we would like to consider the possibilities of German-Brazilian cooperation in this area."[55] West Germany's status as a signatory to the NPT should not have presented any problems, as the Brazilian representative stated "our willingness to apply IAEA safeguards to any joint enterprise." Any specifics would need to be hashed out with the particular German firms that would supply the technology, and their government would of course need to approve of the terms. "This kind of understanding will also be easier in light not only of the political-juridical restrictions weighing upon the Federal Republic of Germany on nuclear matters," Nogueira Batista concluded, "but also in the 'image' problems that Brazil today faces in the world." That remarkably candid admission of the poor reputation of Brazil's military government on the world stage by that nation's ambassador to West Germany did not cloud the last hopeful paragraph: "Beyond the high economic value to Brazil, the decision [to enrich uranium] would place the country in the vanguard of modern technology, in a step of perhaps greater significance to the Brazilian industrial process than the manufacture of steel." Nogueira Batista would convey much of the report above to the West German minister of foreign relations, Walter Scheel, in a wide-ranging conversation in mid-May 1971 that touched upon Brazilian relations with the European Economic Community, economic aid, scientific and technical (mostly nuclear)

[55] Nogueira Batista, "Enriquecimento do Urânio," 4.

cooperation, including the agreement between Brazil's CNPq and the Nuclear Research Center at Jülich, terrorism, and East-West German relations.[56]

The relationship between that center at Jülich and Brazil's CNEN, however, predated the Special Agreement by some time. At the end of April 1970, Ambassador Osiris Guillermo Villegas wrote a brief report on specialized courses to be given by Jülich personnel to Brazilian nuclear technicians. Ten professors would be responsible for teaching these courses at the Nuclear Energy Institute in Rio de Janeiro and Atomic Energy Institute in São Paulo, which would cover agricultural uses of nuclear energy, medicine, the mechanics of nuclear reactors, among other topics, over a two-month period in July and August.[57] Just over a year later, the extent of cooperation between CNEN and the West German nuclear research institution seemed to be much more extensive.

The "brief study" of the Special Agreement on Cooperation in Fields of Research and Technological Development between CNPq and the Jülich nuclear research center bears a striking resemblance in both format and content to the West German-Brazilian general agreement from 1969 on scientific and technical cooperation across six fields. As one of the "specific contracts" through which the 1969 agreement would be carried out, the Special Convention between CNEN and the Jülich Center was signed in April 1971 to encourage cooperation in various areas of research and nuclear development.[58] The earlier agreement prioritized "nuclear energy production, raw materials used in nuclear technology, fuels and fuel

[56] Nogueira Batista, Paulo. "Relações Brasil/RFA. Visita do Ministro Walter Scheel." Wilson Center/NPIHP Digital Archive. May 12, 1971.
[57] Guillermo Villegas, Osiris. "Informar sobre cursos especialistas ciencia nuclear y reservas de uranio en Brasil." Archivo MRECIC, Caja AH/0043, Departamento América del Sur, Serie 47, 1-2.
[58] Unknown author. "Estudo sucinto no. 076/SG-1/71." October 19, 1971, 2. WCDA.

cycles, production and application of radioisotopes, problems in formation of personnel, safety and protection against radiation, nuclear chemistry, nuclear physics, and systems analysis."[59]

The CNPq-Jülich contract appeared to move away from applied nuclear energy technology and more toward "pure" scientific research, proposing collaboration on "theoretical, experimental, and applied physics; organic, inorganic, and physical chemistry, both theoretical and experimental; geology, geophysics, and geochemistry; materials science; industrial technology; agriculture; veterinary science; biology, biochemistry and geochemistry; production and application of radioisotopes in science and technology; astronomy."[60] A side-by-side analysis, the author wrote, allowed the reader to see that they were indeed complementary agreements; any duplications in scientific areas or industrial sectors between the two ingredients could be "easily avoided through adjustments among the participating Brazilian entities."[61]

The Bilateral Relationship in the Post-Tlatelolco Era

The second half of this chapter, roughly, focuses on the diplomatic implications of nuclear (and hydroelectric) energy for the complex bilateral relationship. The gradual worsening – and near-fracture – in relations between the Southern Cone neighbors is obvious from a chronological analysis of the documents that show the effects of presidential personae and policies back at the foreign relations ministries of Itamaraty in Brasília and MRECIC in Buenos Aires.

On December 5, 1967, CNEN President Uriel da Costa Ribeiro wrote to his Argentine counterpart, Rear Admiral Oscar A. Quihillalt, accepting Quihillalt's invitation to visit Ezeiza for the inauguration of the atomic center there. Before detailing his flight plans from Rio de

[59] "Estudo sucinto no. 076," 4-5.
[60] "Estudo sucinto no. 076," 5. The double mention of geochemistry may be an error in the original document.
[61] "Estudo sucinto no. 076," 5.

Janeiro to Buenos Aires, Costa Ribeiro lavished praise on Argentina as a "beautiful brother country" to his native Brazil, and relished the "opportunity to attend the inauguration of one more center for atomic research in Latin America" as well as to "draw closer the bonds of friendship and cordial fraternity traditional between Argentines and Brazilians." Costa Ribeiro mentioned that he would be accompanied by Hervásio Guimarães de Carvalho, member of CNEN's Deliberative Commission and one of Brazil's leading physicists, as well as engineer Hélcio Modesto da Costa, professor Rômulo Ribeiro Pieroni, director of São Paulo's Institute of Atomic Energy (IEA), professor Milton Campos, director of the Institute of Radioactive Research in Minas Gerais, engineer Sergio Gorreta Mundim from Rio de Janeiro's Institute of Nuclear Engineering (IEN), and two more engineers who represented the Planning and Development Advisory Committee and the Administration of Monazite Production.[62]

At the beginning of 1968, an official in Argentina's foreign ministry (MRECIC) wrote a report on the nuclear energy program in his own country as well as in Brazil. Argentina was "five years ahead" of its neighbor in the area of nuclear energy research, and was ahead in industrial applications too, having completed feasibility studies and an international bidding process for its first nuclear power reactor while Brazil continued to develop its own feasibility study.[63] Brazil's recent increase in nuclear activities, the authors of the report argued, was a response to the widening gap between its own capabilities and those of Argentina, but also to the "growing international pressure to conclude agreements on nonproliferation." As evidence, the author pointed out "agreements on cooperation with France and Israel, the content of which, in agreement with technical opinions by Argentines, indicate the existence of an

[62] Uriel da Costa Ribeiro, Letter to the Director of the Argentine National Atomic Energy Commission (CNEA) Oscar A. Quihillalt. December 5, 1967. WCDA.

[63] "Energia Nuclear," author unknown, January 15, 1968, 1. WCDA in cooperation with Argentine Foreign Ministry Archive (AMRECIC).

ambitious plan of development." Within three to five years, "authorized Brazilian sources" claimed that they would "take over the atomic leadership of Latin America."[64] Brazil's plan for nuclear energy development was "seriously studied and with precise and clear objectives," with a budget allocation that had recently been tripled, according to the same anonymous sources. The second section of the document discussed bilateral relations between Argentina and Brazil, admitting "efforts in the past to ensure cooperation of both nations in the nuclear area have not produced positive results."[65] Brazil's aggressive actions in international nuclear diplomacy, intended to "obtain a maximum of benefits without offering corresponding measures [of their own]," had cost Argentina its "gentleman's agreement" to team up with Brazil to earn both nations a seat on the IAEA's Board of Governors. Worse yet, CNEA authorities had observed a "marked interest" in poaching Argentine technicians from across the border to accelerate the Brazilian nuclear program.

The Argentine MRECIC report was not finished with criticizing Brazilian diplomatic efforts to preserve the right to peaceful nuclear explosions in the worldwide Non-Proliferation Treaty and under the Treaty of Tlatelolco in force in Latin America and the Caribbean. Argentina, lacking a seat on the Eighteen-Nation Committee on Disarmament that had been debating the terms of the Non-Proliferation Treaty, had been able to "maintain a prudent silence" on the question of PNEs, though the Argentine delegation had ardently supported Brazil in persuading other nations to support the exclusion of PNEs from banned nuclear activities in the Treaty of Tlatelolco, a fact that the authors recall on page 9 of the report.[66] Brazil's staunch position in favor of peaceful nuclear explosions, the authors wrote, was "accompanied by an intense propaganda campaign arguing the necessity of Brazil 'nuclearizing'

[64] "Energia Nuclear," (1968, Argentina MRECIC), 2.
[65] "Energia Nuclear," (1968, Argentina MRECIC), 3.
[66] "Energía Nuclear," (1968, Argentina MRECIC), 8.

to accelerate its own economic development." This determination had so concerned the United States that the American ambassador offered "at cost… devices to carry out this type of explosions," a concession that did not succeed in muting Brazil's desire to develop and manufacture this technology on their own. As noted in the Argentine navy's twenty-page report earlier, the MRECIC official highlighted Itamaraty's growing relationship with France in nuclear energy cooperation as a way of diversifying their allies to include wealthy, industrial nations other than the mercurial United States.

From Brazil's support of the right of signatories to non-proliferation agreements to conduct peaceful nuclear explosions, a few other geopolitically consistent stances followed. On the ENDC, the Brazilian delegation, led by Antônio Azeredo da Silveira, sought also to "obligate the nuclear [weapon] powers to set aside funds for development, through a special fund at the United Nations, [taken from] a substantial part of financial resources freed by steps toward nuclear disarmament," to demand that nuclear-weapon states soon negotiate a treaty for the reduction, then elimination, of all nuclear arsenals and means for their transportation, and establish that the Non-Proliferation Treaty not interfere with the rights or obligations already set down in regional agreements to use nuclear energy exclusively for peaceful ends.[67] Argentina's top diplomats sought to put some diplomatic space between themselves and their neighbor, and anticipate some of Brazil's likely positions and talking points that country's Minister of Foreign Affairs, José de Magalhães Pinto, might broach in the near future.

On the question of Argentina's potential signature to a Non-Proliferation Treaty that did not satisfy the South Americans' desires regarding peaceful nuclear explosions, or of a definitive position on nonproliferation of weapons or contacts with nuclear-weapon states, a

[67] "Energía Nuclear," (1968, Argentina MRECIC), 9. Notably, only Brazil and Mexico among the ENCD members would have had any cause to insist on this provision during the negotiations of the NPT, as Tlatelolco was the first (and still, in 1968, only) such agreement in the world.

policy of noncommittal waiting, or of "avoiding any promise that separates us from the posture of prudence that we have assumed until now," was recommended as the best to follow.[68] In conclusion, the MRECIC leadership sought to keep Brazil in "close contact" with Argentina on matters of nuclear disarmament and nonproliferation being hashed out in Geneva. The Argentines found themselves in the uncomfortable position of outsiders looking in, yet fundamentally agreed with most of their neighbor's positions on nuclear energy and how to contain its destructive potential, and thus sought to have Brazil represent "Latin American" interests if Argentina could not secure a spot on the committee.

Brazil's membership on that committee, in fact, conferred a "status of upper hierarchy" on both it and Mexico in terms of international prestige and access to "negotiations and discussions of undeniable importance" on the future of peaceful and military uses for nuclear energy.[69] Argentina feared unacceptable restrictions on nuclear technology development that would fall upon states that did not possess nuclear weapons, "tangling" their progress in the field. When the Disarmament Committee's draft document would reach the General Assembly, an "alliance of countries that might consider themselves hurt by a document that institutionalizes the tutelage of current nuclear [weapon] states" including Argentina and Brazil would probably be required to moderate the most restrictive provisions, an opportunity for "interesting Argentine-Brazilian cooperation in defense of identical national interests."[70]

One immediate avenue for this potential alliance between Argentina and Brazil was in resolving some "friction" between the Costa e Silva administration and the United States. Despite Brazil's "fluid dialogue" with the hemispheric superpower and "solid commercial trade

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[68] "Energia Nuclear," (1968, Argentina MRECIC), 9-11.
[69] "Visita al Brasil de S.E. el Señor Canciller Doctor Nicanor Costa Mendez: Temario." Ministro de Relaciones Exteriores y Culto [Argentina], Caja AH/0124, Serie 47, Departamento América del Sur. January 1968, 3.
[70] "Visita al Brasil…," 4.

that exceeds $400 million [US dollars] in both directions," the United States had apparently expressed its concern to Brazil about a presumed (conventional) "arms race," exemplified by a spate of Latin American military governments that exceeded quotas of weapons purchases from industrialized nations that the US Department of State had deemed appropriate for the region of the Southern Cone. Argentina reiterated its support for Brazil on this matter and pledged to stick to its policy of "independence, balance, and mutual support," grounded in the "right of each nation to decide, in a sovereign way, on the acquisitions of equipment that its Armed Forces believe necessary for the appropriate training of their personnel."[71] However, in terms of nuclear energy diplomacy and relations with the United States, the final paragraph of the document put some space between the South American neighbors; Argentina refused to pursue "any commitment…that would unilaterally determine Argentina's position already clearly expressed upon signing the treaty of Mexico, or bind us to contacts with nuclear powers." Brazil may have perceived more value in some kind of agreement with the US to "alleviate its diplomatic actions on the matter of nonproliferation," but Argentina sought to continue its "framework of prudence followed up to the present moment," resisting close nuclear energy alliances with declared nuclear-weapon states.

Minister of Foreign Affairs Costa Mendez's visit to Brazil immediately followed that of his Brazilian counterpart, José de Magalhães Pinto, to the Argentine capital for a series of meetings. From the meeting notes and a Joint Declaration signed on January 25, 1968, a much clearer understanding emerges on other questions and issues in the bilateral relationship that surrounded the narrower problems of nuclear energy diplomacy. Both ministers restated their support for the principles of the Inter-American System and belief in the appropriateness of the

[71] "Visita al Brasil…," 8.

Organization of American States' Third American Extraordinary Conference, to be held in Buenos Aires the following month, to carry out reforms they believed to be imperative for the OAS. They sharply rebuked the Castro regime in Cuba for subverting the principle of non-intervention, "repudiating the threats of subversion and provocations emanating from the [1966] Tri-Continental Conference of Havana."[72] In another thinly veiled attack on growing Cold War division, the ministers inveighed against "the formation of blocs within the hemisphere," affirming instead that "development and progress of the American Nations has its irreplaceable basis in the union and solidarity of the continent." The joint statement then moved to matters closer to home. Argentina sought support for a meeting of its minister of foreign affairs and his counterparts in Bolivia, Brazil, Paraguay, and Uruguay to begin an overarching process of cooperative planning for the region, "necessary for the integration of the Plata river basin," through a Preparatory Commission that could begin its work immediately.[73]

The ministers announced their common support for paving a highway between Paraná in Entre Rios province, Argentina, and Porto Alegre, Rio Grande do Sul, Brazil, which, while less ambitious than the proposed projects in the La Plata basin, would ultimately "facilitate land-based communication between the Atlantic and Pacific Oceans." Magalhães then pledged that all official Brazilian maps and publications would refer to the Malvinas Islands as an Argentine possession. On economic cooperation, the two ministers found some common ground in playing a leadership role within ALALC (the Latin American Association of Free Trade). In terms of bilateral relations, the ministers agreed on the "total absence of conflict in matters of a political character between both countries," and to promote efforts to substantially increase bilateral trade, using the Special Commission on Brazilian-Argentine Cooperation (CEBAC) as

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[72] Juracy Magalhães and Nicanor Costa Mendez. "Comunicado Conjunto." Caja AH/0124, Departamento América del Sur, Serie 47. January 25, 1968, 1. AMRECIC.
[73] Magalhães and Costa Mendez, Comunicado Conjunto, 2.

a vehicle to accomplish economic integration and cooperation. Nuclear energy was barely mentioned except for a reiteration of support for a nonproliferation protocol that still protected the full range of peaceful uses.

In February 1970, Ambassador Osiris Guillermo Villegas of Argentina wrote a memorandum on Brazil's plans for a nuclear power plant. According to "higher officials" within CNEN, Brazil would finish construction of the plant in 1976, in an "undetermined location in the center-south of the country," with firms from Canada, the United Kingdom, Germany, and the US most interested in winning the bid. The maximum cost of the project would be 300 US dollars per kilowatt installed, or "approximately $150 million." Though the decision on natural vs. enriched uranium to be used as fuel had not been made yet, Brazilian nuclear technicians seemed to be covering all bases, having planned a pilot plant for the manufacture of heavy water (deuterium oxide), necessary as a neutron moderator in natural uranium power reactors. The pilot heavy water plant would have a maximum output of 4 tons annually and would be used to train nuclear technicians; a plant with sufficient capacity to supply a large nuclear power plant would take ten years to build.[74]

Other information from CNEN referred to studies by the Instituto de Energía Atómica on producing nuclear pure graphite, another possible neutron moderator for a natural uranium reactor, an analysis of possibilities for modifying the Argonaut reactor at Ilha do Fundão to be a zero-power fast reactor, and doubling the capacity of the IEA's pool reactor in São Paulo from 5 megawatts to 10 megawatts for irradiation. Within three weeks, Argentina's foreign ministry had learned quite a bit more about Brazil's reactor plans; the government had approved a budget of 236 million new cruzeiros – approximately US $103 million in 1970. The planned

[74] Osiris Guillermo Villegas, "Información sobre construcción de usina nuclear brasileña," Caja AH/0043, Departamento América del Sur, Serie 47. Feb. 4, 1970, 2. AMRECIC.

reactor would apparently pose "no contamination risk" due to its isolated location at Angra dos Reis and the surrounding mountains, a decision that was the outcome of one full year of studies kept secret "to avoid economic, political, and technological pressure."[75] Brazil's firm decision to build and finance a nuclear power plant represented "a decisive triumph for Brazilian technocrats and especially for CNEN within the surroundings of national administration." It seemed to be a defeat for economists and others who had urged the government to use Brazil's tremendous endowment of potential hydroelectric power by damming its vast rivers instead of incurring "the high costs of application" of nuclear energy and lack of "concrete experience in practical and economic results" of such an expensive – and, in their eyes, risky – investment.[76]

But with Brazil's energy use growing by an estimated 13 percent per year, as the memorandum quoted, and its nuclear technicians "visibly concerned" about their nation's nuclear energy lag behind Argentina, perhaps the price tag mattered less than the fact that initial and concrete plans for large-scale nuclear power were finally underway. Médici made no mention of the breakthrough in an April 24 speech on Brazilian foreign policy, instead dedicating his words to Brazil's continued opposition to Cold War "zones of influence" and support for an "independent foreign policy" in line with that of the first two military presidents. His only mention of nuclear energy was to repudiate the Non-Proliferation Treaty once again, as Brazil "refused to compromise its future by obligating itself to international frameworks in which rights are denied to it and constituted as the privilege of a few."[77]

The Spirit of Tlatelolco and Early Attempts Toward Nuclear Energy Agreement

[75] Osiris Guillermo Villegas, "Aprobación proyecto instalación central nuclear," Caja AH/0043, Departamento América del Sur, Serie 47. February 27, 1970, 2. AMRECIC.
[76] Guillermo Villegas, "Aprobación," 3.
[77] Osiris Guillermo Villegas, "Discurso del Presidente Garrastazu Médici sobre política exterior brasileña." Caja AH/0043, Departamento América del Sur, Serie 47. April 24, 1970, 3. AMRECIC.

A 1968 draft of a basic agreement between Brazil and Argentina on matters concerning peaceful use of nuclear energy, probably taken back by the Argentine delegation visiting Brazil from CNEA, seemed to indicate Brazil's desire for a bilateral accord that was broader in scope than what Argentina's foreign ministry seemed inclined to offer: either a "statement of overlap" of positions on the importance of peaceful nuclear energy for economic development or a reiteration of the points of agreement between the neighbors' delegations in the negotiation of the Treaty of Tlatelolco.[78] The draft agreement would "formalize and strengthen the links of collaboration" already established between the two countries, and benefit the region as well, "serving the needs of the inter-American community" through the would-be allies' participation in the hemispheric nuclear energy commission IANEC.[79]

Article 1 of that draft agreement pledged both countries' "broadest assistance and collaboration in all areas of peaceful application of nuclear energy," while Article 2 proposed an accord between CNEA and CNEN that would guarantee cooperation in "prospecting, exploration, processing, and nuclear purification" of minerals; radiological protection and safety measures; exchange of personnel and information; reciprocal use of equipment, installations, and "raw materials" pertaining to nuclear energy; sharing of studies on reactors, fabrication of fuel elements, and energy production; basic and applied research; and coordination of diplomatic activities related to nuclear energy within international and regional organizations. Article 3 guaranteed non-interference between the proposed agreement and existing domestic laws and international treaties, while the final article proposed the duration of ten years for the document's terms.

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[78] Unknown author. "Anteproyecto de acuerdo argentino-brasileño en el campo de los usos pacíficos de la energía nuclear." 1968. WCDA.
[79] "Anteproyecto de acuerdo", 1.

The generally close bilateral relations between the neighbors had not faded by the end of 1968, when an Argentine diplomat indicated his positive consideration of the request of Carlos Antonio Bettancourt Bueno, First Secretary of the Brazilian Embassy, for the sale of five tons of triuranium octoxide (better known as "yellowcake") to Brazil.[80] The uranium transfer was to be free from safeguards and made with "great discretion." The Argentine diplomat sought approval for the sale in light of "the spirit of goodwill that characterizes our relations with Brazil," but wrote that it would be delayed until the middle of 1969 in order to allow Argentina's uranium stock for the planned Atucha I power reactor to build up.[81] Three and a half months later, José Luís Alegría, head of the planning department of CNEA, and Oscar Quihillalt, that agency's president, responded to the Brazilian Minister of Foreign Affairs at greater length about the proposed uranium sale. CNEA sent to its own foreign ministry a document that essentially gave the green light to the uranium sale. Technical aspects (the small amount of the mineral requested would make a minimal dent in Argentina's stock), economic considerations (no net benefit to Argentina or its CNEA, but other types of considerations prevailed in the decision), and legal factors (CNEA was authorized to export 100 tons of non-concentrated uranium in the 3-year period beginning on January 1, 1968, and Brazil's request for five tons would not impede any other exports) all pointed to an affirmative answer from the nuclear energy agency for Brazil's uranium request.[82] Scarcely more than a month later, however, Alegría signed another letter, this time explaining to Quihillalt that the uranium sale to Brazil was in jeopardy because the Foreign Ministry would "have some objections" due to "difficulties of the diplomatic type with that country."[83]

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[80] "Yellowcake" is 84.8% uranium based on a mass percent calculation.
[81] Unknown author. "Ayuda Memoria – Asunto: venta de 5 t de U a Brasil." September 4, 1968. WCDA.
[82] José Luís Alegria and Oscar A. Quihillalt. CNEA report to the Argentine Ministry for Foreign Affairs (MRECIC) on Brazil's request for uranium. December 20, 1968, 1-2. WCDA.
[83] José Luís Alegria, Memorandum to Oscar A. Quihillalt, January 31, 1969. WCDA.

Though the uranium sale proposal had fallen through, the idea of a memorandum of understanding or some kind of joint communication on nuclear energy between the governments and/or commissions (CNEA and CNEN) of Argentina and Brazil was not dead, even in an environment of worsening bilateral relations. On December 15, 1969, the end of the same year that began with the failure of the uranium sale from Argentina to Brazil, CNEA President Quihillalt wrote to his Minister of Foreign Affairs to revive the conversation that had begun in Buenos Aires at the end of 1967 about "areas of greatest interest for exchange between the two institutions."[84] After sending a secret communication to MRECIC in April 1968 about possible avenues of cooperation with Brazil, Quihillalt believed it was an appropriate time to "formalize and guide relations [in the nuclear area] through the signature of a collaboration agreement…which could be from country to country or, better yet, from Commission to Commission. In our judgment, this latter option is the most efficient and will allow us to rapidly settle on an exchange program with the Brazilian commission." Quihillalt was nothing if not persistent on the idea of an agreement with Brazil on nuclear energy, writing on February 16, 1972 – over two years after his last attempt – that the "National Commission [CNEA] maintains its interest in signing an agreement that allows the growth and formalization of relations…, but for political reasons determined by the Ministry [of Foreign Relations] has been postponed until the present."[85] In 1970 and 1971, he wrote, ongoing conversations between the directors and officials in the Political Division of MRECIC about the possibility of this long-discussed accord with Brazil had sputtered. Quihillalt made no attempt, however, to budge MRECIC officials from their position that a nuclear energy cooperation agreement or memorandum of understanding would need to wait until a general

[84] Letter from Oscar A. Quihillalt to Minister of Foreign Relations Juan B. Martín, December 15, 1969, 1. WCDA.
[85] Letter from Oscar A. Quihillalt to MRECIC, Buenos Aires. February 16, 1972, 1. WCDA.

improvement in bilateral relations between Brazil and Argentina, reiterating CNEA's willingness to wait for any definitive instructions from Foreign Relations on the Brazilian proposal – essentially using it as a bargaining chip "given Brazil's demonstrated interest" in firming up such an agreement.[86] Nuclear energy cooperation thus seemed for the foreseeable future to be a non-starter at the beginning of the 1970s after an auspicious, but brief, period in the late 1960s, as the warm feelings from an alliance between Brazil and Argentina that had so tenaciously upheld sovereign national rights to pursue a full peaceful range of nuclear activities at Tlatelolco appeared to have cooled entirely.

Itaipu and the Diplomatic Costs of Brazilian Hydroelectric Progress

The final section of this chapter analyzes the diplomatic consequences of an internal pivot in Brazilian energy policy from the rejuvenated plans for commercial nuclear power under Artur Costa e Silva to the seemingly boundless potential for hydroelectric energy from the Itaipu Dam, to be constructed in collaboration with Paraguay. Argentina grew increasingly resentful at being left out of the agreement, and saw Médici's Brazil as a neighbor with dangerous great-power pretensions that threatened the stability and peace of South America, especially in the damage that the hydroelectric project threatened within the crucial bilateral relationship. Brazil's Itaipu dam would be constructed only a few miles from Argentina's planned Corpus dam, a proximity that ignited an acrimonious diplomatic disagreement about the planned height of the two hydroelectric dams.[87] Of the countries with territory in the La Plata basin – Paraguay, Uruguay, Bolivia, Argentina, and Brazil – the latter two had reached such an impasse that Argentina threatened to raise the level of the Corpus dam by 20 meters to

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[86] Quihillalt to MRECIC, 1972, 2.
[87] João Resende-Santos, "The Origins of Security Cooperation in the Southern Cone." *Latin American Politics and Society* 44, no. 4 (2002): 96.

flood Itaipu's turbines.[88] Argentina insisted that Brazil consult its neighbors on any proposed project that might harm them. When its officials tired of what they called Brazil's "successive delays," Argentina sought support for its claims in the United Nations, Non-Aligned Movement, and other forums for international cooperation and dispute resolution.[89]

In an informational memorandum dated March 21, 1973, Alberto Pugnalin, Minister-Counselor at Argentina's foreign ministry, forwarded and glossed some press comments about the Itaipu dam project to the Argentine embassy in Brazil.[90] Marcelo Sanchez Sorondo of Argentina's Justicialist Liberation Front had reiterated his Peronist party's promise to "destroy the Washington-Brasília axis to avoid the implementation of Brazilian hegemony in Latin America," and block Brazil from constructing the massive hydroelectric dam on the Paraná River. This move may have been a planned counter to Brazilian "subimperialism."[91] Brazil's press had reacted "in a violent and unbalanced way" against Sorondo's comments, including the "most influential newspapers in the country," *O Estado de São Paulo* and *O Jornal do Brasil*. Ulysses Guimarães, a parliamentary representative from São Paulo state and president of the opposition MDB party, briefly analyzed the status of Brazil's relations with Argentina in remarks reprinted in *Correio Braziliense*, the capital's leading daily newspaper, assailing the "indefensible behavior" of certain individuals, mostly Argentine politicians and journalists, concerning Brazil and the Itaipu dam plans. Guimarães was particularly upset that a

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[88] Resende-Santos, "Origins of Security Cooperation," 95.
[89] Resende-Santos, "Origins of Security Cooperation," 96.
[90] Alberto A. Pugnalin, "Comentarios periodísticos sobre Itaipu." Departamento América del Sur, Caja AH/0361. March 21, 1973, 1. AMRECIC. These meta-commentaries on press articles effectively show the bitterness and resentment that were building in Argentina, yet only touch the surface of underlying military and diplomatic concern in that country toward Brazil's foreign relations and energy ambitions.
[91] Brazilian economist Ruy Mauro Marini created the thesis of "subimperialism" in the early 1970s to argue that Brazil had reached an intermediate point between developed countries and those still in development. Its massive geographic size, population, and diversified economic profile meant that it could operate as a quasi-imperial power among its neighbors, but its incomplete economic development kept it dependent on foreign capital and "active collaboration with the imperial center." See Matthew Flynn, "Between Subimperialism and Globalization: A Case Study in the Internationalization of Brazilian Capital." *Latin American Perspectives* 34, no. 6 (2007): 11.

"prosperous and socially stable" Argentina should have been a reliable partner to Brazil, striving for "complementarity and not competition" with its neighbor.[92] Using the example of postwar European unity, he sought to illustrate a future where "countries like Brazil and Argentina have a destiny to be peacemaking agents, calming, exporters of security and the practice of true democracy." *O Globo* had carried a story about the Paraguayan Head of Ceremonies coming to meet with officials at Itamaraty to iron out details for the visit of President Stroessner to sign an agreement that would create a joint enterprise between Brazil and Paraguay to build the Itaipu dam. No other major Brazilian newspaper had even mentioned the Paraguayan official's presence, which the MRECIC digest of Brazilian news pointed out as a suspicious "absolute silence."

In fact, the Argentine voices "trumpeting that a mere river, the Paraná…would make the brother peoples [of Argentina and Brazil] incompatible," in the words of Guimarães, seemed to speak for a sizable faction within the foreign ministry. Yet not every hydroelectric energy project was doomed to sour the bilateral relationship; a project to dam the high River Uruguay between Argentine firm Hidrened and Brazil's Hidroservice had reached the point of a binational feasibility study. It was also a notable example of two military presidents (Alejandro Lanusse of Argentina and Emílio Médici of Brazil) agreeing on technical matters of cooperation toward mutual economic development. Similar projects to the Alto Río Uruguay hydroelectric plant would be the future "basis to attain, at the end of the century, the energy integration of all of South America."[93] The agreement, and the integration for which it held promise, showed both "Brazil's cooperative attitude toward Argentina…and the proof of good faith with which

[92] *Correio Braziliense*, March 21, 1973, 3. Retrieved online from search at Biblioteca Nacional Digital Brasil, Hemeroteca Digital Brasileira, http://memoria.bn.br/hdb/periodico.aspx.
[93] José María Alvarez de Toledo, "Comentarios editoriales sobre el Acuerdo Argentino-Brasileño para Estudio del Aprovechamiento Hidroeléctrico del Alto Uruguay y el Pepirí-Guaçú con referencia a las relaciones entre los dos paises." Departamento América del Sur, Caja AH/0361. April 11, 1973, 1. AMRECIC.

we are proceeding in the case of Itaipu," and the nation's "physical and spiritual integration" with its Spanish-speaking neighbors, according to an editorial writer in *O Jornal do Brasil*.[94] *O Estado de São Paulo* reminded its readers of the economic advantages of hydroelectric power over both thermal and nuclear sources, but that another "much more important" truth was behind the recent feasibility study agreement. "Notwithstanding the wishes of many people and the intrigues of newspapers, both of which show little judgment, there is still a dialogue maintained without problems between experts and diplomatic personnel from Brazil and Argentina." Solving the technical puzzles that could help supply "abundant and cheap" energy to 63 million inhabitants of the La Plata river basin area, the editorialist argued, provided an urgent drive for regional cooperation that should overpower "petty political dissensions."[95] Brazilian journalistic paeans to South American unity, exalting the benefits of economic development from triumphantly conquering technical challenges of large energy projects, were coldly dismissed by Argentina's ambassador José María Alvarez de Toledo. "It is appropriate to note here that, within certain limits and in certain ways, this country does not want to remain isolated from the Latin American process, an indication apparently quite contrary to that of the regime in Brasília."[96]

The president of Eletrobrás, a few days later, commented extensively on the necessity for, finances of, and progress toward the Itaipu hydroelectric dam, and the same Argentine ambassador, Alvarez de Toledo, came to similarly dark conclusions about his neighbor country's dogged pursuit of hydroelectric power at the expense of the collective welfare of nearby Southern Cone countries. Brazil's economic ascendancy to 10% annual growth by the mid-1970s was only the most obvious sign of a widening gap between that nation and

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[94] Alvarez de Toledo, "Comentarios editoriales," 2.
[95] Alvarez de Toledo, "Comentarios editoriales," 3.
[96] Alvarez de Toledo, "Comentarios editoriales," 5.

Argentina, compelling Argentine officials to use the conflict over Itaipu and the La Plata river basin to strengthen their own hand, seeking a "durable settlement that would preserve it some latitude and influence in the region."[97]

The Brazilian engineer, Mario Behring, at the head of Eletrobrás, reported that Itaipu would require an investment of $2 billion US dollars, would provide work for 20,000 people, and eventually provide a savings of $250 million in imported oil.[98] Behring saw the construction of Itaipu as a sort of live-drill training process, conferring both specialized labor and know-how that would facilitate the future installation of nuclear reactors in power plants. Itaipu was a crucial step away from dependency on imported petroleum, and the energy that it would provide would be "cheap, with great benefits for the southeast region of Brazil," the nation's largest in population. Brazil's Minister of Mines and Energy, Shigeaki Ueki, echoed the importance of replacing petroleum with hydroelectric (and less so, nuclear) energy sources in April 1974. Brazilians used an average of 8 kilograms per person per year of petroleum *equivalent* in 1973. Only half, however, was actually from hydrocarbon sources like petroleum or natural gas, while the rest of the world averaged 65% of its energy from those materials. Ueki seemed less bullish on nuclear energy than the expansive plans for hydroelectric plants; though Brazil had a thorium mineral reserve among the world's largest, the country of "limited capital resources" could not afford to be a global leader in the use of nuclear energy for steelmaking and other industrial ends.[99]

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[97] Resende-Santos, "Origins of Security Cooperation," 97.
[98] José María Alvarez de Toledo, "Ultimos comentarios referentes a la represa de Itaipu." Departamento América del Sur, Caja AH/0361. April 16, 1973. AMRECIC.
[99] José María Alvarez de Toledo, "Declaraciones del Director Financiero de la empresa binacional. Apreciaciones del Ministro de Minas y Energía Shigeaki Ueki." Caja AH/0326 1974/1977-1979, Brasília, Departamento America del Sur C75, A82, April 23, 1974. AMRECIC.

Argentina was exploring its own hydroelectric energy plans – the Corpus dam, 250 km from Itaipu, and Apipé-Yaciretá, 400 km from the planned Brazil-Paraguay venture – and Behring indicated his concerns that Corpus, because of the height of the waters planned for the dam, could flood the Itaipu installations and reduce its capacity. He then dismissed Argentina's "unfounded" concerns that Itaipu might flood Buenos Aires if Brazil were to open its lock gates, instead lauding the future benefits for his own country and Paraguay, "as they would enjoy a richness lost in the direction of the ocean," and Argentina "because it would enjoy a regulated river, without the risk of floods during the rainy season, and the ability to construct its dams with more safety and generating capacity."[100] Seventeen years in the future, in 1990 – it is unclear at this point in the memorandum whether Argentine ambassador Alvarez de Toledo was paraphrasing Behring or disseminating known information that did not need attribution – Brazil would have completely used its hydroelectric potential available in the south and southeast regions of the country, leaving a gap to be filled by its nuclear power production beginning at Angra dos Reis in 1980. The futures of Itaipu hydroelectric energy and Brazil's and Argentina's nuclear power ambitions were thus intertwined in yet another way.

Brazilian officials had derided Argentine critics of the Itaipu plans as "emotional," insisting on the dam as a "true imperative for the…continuity of Brazilian development." After an extended discussion of river levels for a number of planned hydroelectric dams along the Paraná River, and Argentina's efforts to delay Paraguay's assent to Brazil's plans for Itaipu, Alvarez de Toledo commented on a piece in *O Jornal do Brasil* by Carlos Castello Branco (1920-1993), one of Brazil's most famous and eminent columnists and writers. Castello Branco discussed the dual advantage of hydroelectric over nuclear power as he defended the

[100] Alvarez de Toledo, "Ultimos comentarios," 3.

hydroelectric installation against delays by Paraguay or diplomatic tensions with Argentina: "Brazil would suffer a violent impact on its projects [by delaying construction]; even though it has alternatives, they are extremely onerous, like thermonuclear power plants, which would demand double the investment of Itaipu and the mobilization of foreign know-how and primary materials."[101] In conclusion, Alvarez de Toledo wrote, both Paraguay and Brazil were playing a zero-sum diplomatic game, where Argentina played the role of gatekeeper to its Spanish-speaking neighbors. By allying with each other on Itaipu over the strenuous objections of Argentina, they risked "closing the door to cooperation and understanding with Argentina, and therefore with Hispanic America," but Médici and Stroessner could opt instead to "show their inclination toward dialogue and toward the integration of Latin America."

On April 24, Alvarez de Toledo continued commenting on press articles related to Itaipu, this one from a weekly periodical *Manchete*, with a "truly aggressive style in general and one offensive to our country," that openly called for Brazil to develop a nuclear weapon as one of its conclusions.[102] The article's author, whose name is not given, had apparently recently been decorated by President Médici, and argued that Brazil must "begin to execute a policy of a great power country." Apparently, Argentina's president Héctor Cámpora and the aging Juan Domingo Perón had urged Brazil, in the words of the "Manchete" author, towards an "integration and isolationism of Latin America to fight against the trusts and foreign imperialism," but the globalizing and rapidly developing Brazil would instead turn outward to show its enhanced status on the world stage. Most troubling was the author's assertion that Brazil would need a more sophisticated and destructive arsenal of weapons, and might possibly develop nuclear explosive devices "for scientific objectives and to open hydraulic channels,"

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[101] Alvarez de Toledo, "Ultimos comentarios," 7.
[102] "A Su Excelencia el Señor Ministro de Relaciones Exteriores y Culto, Brigadier Eduardo McLoughlin." Departamento América del Sur, Caja AH/0361. April 24, 1973, 1-2. AMRECIC.

which the Argentine diplomat saw as a thinly veiled call to develop nuclear weapons from high levels of the Brazilian government – naming specifically its foreign minister Gibson Barbosa and Ambassador Sergio Correa da Costa. Alvarez saved a special barb for the end, writing that Brazil's "relative backwardness in atomic energy makes one wonder if they will not consider getting special assistance in the field from some interested foreign power."

If the press and diplomatic war over Itaipu could get still more intense, Alvarez's countryman and fellow diplomat Alberto Pugnalin wrote a private memo to the Argentine embassy in Brazil, in which he assailed Argentina's neighbor for taking "frankly paternalistic postures toward its neighbors with little or no disguise."[103] This bristling response to a headline in *O Jornal do Brasil* that claimed that Argentina "might have lost the Second War of the Triple Alliance" and that incoming President Héctor Cámpora was going to have to handle his nation being on the outside of "a done deal that was difficult to annul." Much of an article quoted from *Correio Braziliense* attempted to dazzle its readers with the sheer size of the Itaipu project dimensions: "a plant whose dam extends 1,500 meters, with a maximum height of 170 meters, [with] 14 generating units of 765,000 kilowatts each, with no parallel in the world at present. It will allow 11 million kilowatts to be generated, with 60 billion kilowatts of annual production to divide between Paraguay and Brazil…"[104] Much of the rest of the press commentary focused on the fortunes of Paraguay, now able to "leave its isolated Mediterranean state and join the age of its industrialization."

On May 2, 1973, Alberto Pugnalin wrote a short memo from the Argentine Embassy in Brazil back to MRECIC headquarters on probable modifications in Itaipu's generative capacity. An article in *Folha de São Paulo* had upped the estimate of the project's eventual power output

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[103] Alberto A. Pugnalin, "Comentarios periodísticos sobre Acuerdo de Itaipu." Departamento América del Sur, Caja AH/0361. April 25, 1973, 4. AMRECIC.
[104] Pugnalin, "Comentarios," 3.

by 2 million kilowatts due to two new dams planned on the upper course of the Paraná River. The problem with this increased capacity was that the second dam would form "an immense artificial lake that would make the project uneconomical, because of the compensation to be claimed by the occupants of the flooded area." Itamaraty had carried out several studies showing the easiest and most economical locations to build hydroelectric dams and power plants on four parts of the river: lower Paraná, defined as "from the estuary [on the Rio de la Plata] to the city of Paraná [in Argentina]," low Paraná, from Paraná city to Apipé, Paraguay,[105] middle Paraná, from Apipe, Paraguay, to Sete Quedas, Brazil, a stretch on which an Argentine-Paraguayan collaboration would enable the channeling of the Paraná River toward the Uruguay River by way of the Aguapey River,[106] and the contentious Corpus dam to be constructed by Paraguay and Argentina, and Itaipu itself. On the high Paraná, entirely in Brazil, the colossal river wound through the states of Minas Gerais, Goiás, Mato Grosso, Paraná, and São Paulo.[107] Pugnalin closed by stating the astonishing figure of 48 plants having been planned for the Paraná River and its various tributaries, and made no further comment.

One year later, an extended set of comments from Argentina's embassy in Brasília to the Foreign Ministry's office in Buenos Aires – again from the pen of José María Alvarez de Toledo – had less to say about hydroelectric or nuclear energy than the earlier Argentine diplomatic communications, but offered an important analysis of the impact of Brazil's new military president, Ernesto Geisel, and the hope for a more accommodating approach to foreign policy than under predecessor Emílio Médici. Alvarez de Toledo warned of the American press's renewed antipathy toward Perón, in power once again after the fall of the 1966-1973 military

[105] I have translated the Spanish terms "inferior" as "lower" and "bajo" as "low," but this may be a somewhat confusing distinction.
[106] A double line appears to the left of this typewritten text with a handwritten "Versión paraguaya? [Paraguayan version?]" note.
[107] Pugnalin, "Comentarios," April 25, 1973.

dictatorship. A week prior to the diplomatic memo, in mid-April 1974, "various dispatches" from Washington had warned of a new "vast and energetic Argentine diplomatic offensive on the Continent, with a clear Latin American affirmation in the face of the United States."[108] This new Peronist foreign policy supposedly aligned with the diplomatic priorities of Mexico, Peru, and Panama, but decidedly against Brazil. According to Alvarez de Toledo, the Brazilian press alleged that Argentina had taken a newly "militant" stand in favor of Cuba, "in contrast with the 'ecumenical point of view' of the Brazilian government," in which Brazil's ambassador to Argentina, Antônio Azeredo da Silveira, sought broad international understanding of Brazil's policies within the region in return for his nation undertaking the same task of comprehension towards the alignments of other nations.[109] In attempting to make sure that Cuba would be represented at the next meeting of Latin American foreign ministers – and US Secretary of State Henry Kissinger – that was scheduled to take place in Buenos Aires, Argentina had taken a bold stance with significant Cold War implications that even Pinochet's Chile "accepted, but with reservations."

Azeredo da Silveira continued to lay out a renewed vision for Brazil's foreign policy under Geisel at a meeting of the OAS in Atlanta, the precise date of which is not given by Alvarez de Toledo. According to a commentary in *O Estado de São Paulo* on March 31, 1974, by Oliveiros Ferreira, Brazil was attempting to "return to the origins of its foreign policy drawn by Marshal Castelo Branco in 1964…based on a global strategy dictated by permanent national interests," not durable alliances with potentially fickle partners, nor "criteria endorsed in advance."[110] Geisel – and Azeredo – sought to steer Brazil toward "responsible pragmatism,"

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108 Alvarez de Toledo, José María. "Brasil – Argentina – America Latina," Caja AH/0361 A del Sur 1977/80/82-83/1973 Brasil 75 a 91, 1. AMRECIC.
109 Alvarez de Toledo, "Brasil – Argentina – America Latina," 1.
110 Alvarez de Toledo, "Brasil – Argentina – America Latina," 4, 6.

and away from "any pretension of leadership or rigid ideological assertion," thus redefining the image of an "emerging power." The authenticity of this shift seems both to have placated and convinced Alvarez, writing the memo to the Argentine foreign ministry, whose tone in discussing his neighbor's foreign policy was much more measured than in 1973's frenetic communications about Itaipu.

Geisel's *distensão* – relaxation of tensions – and Argentina's fragile return to nominally elective government following the *Revolución Argentina* under an ailing Juan Perón, 78 years of age, had opened a space for a "new Argentine-Brazilian dialogue," but his neighbors' new diplomatic outlook might have been nothing more than a "tactical move" to reach the objectives laid out by the military coup leaders in 1964. He closed on a more hopeful note from *O Jornal do Brasil*, quoting a statement that "The fundamental task of a developing nation is to develop…Brazil is focused on its growth and does not need anyone to direct its steps in order to reach it."[111]

On June 25, 1974, the Argentine embassy in Brasília sent notice to MRECIC that the Soviet ambassador Sergei Mikhailov, bidding farewell to President Geisel after nine years in Brazil, "would maintain contact with the technicians responsible for Itaipu, after construction has begun, to make an official proposal to sell turbines."[112] The ambassador touted Soviet success in building "the largest turbines in the world – hydraulic type of up to 800,000 kW and steam type of 1,000,000 kW each." But Mikhailov's purpose with the Brazilians was actually to convince them to install "small turbines of large capacity in a project of great importance like Itaipu."[113] General Costa Cavalcanti, president of the joint Paraguayan-Brazilian Itaipu firm,

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[111] Alvarez de Toledo, "Brasil – Argentina – America Latina," 10-11.
[112] Alvarez de Toledo, José María. "Embajador soviético afirma interés de su país en proveer turbinas para complejo hidroeléctrico sobre el Paraná." Archivo MRECIC, Departamento América del Sur, Caja AH/0326. June 25, 1974, 1-2.
[113] Alvarez de Toledo, "Embajador soviético afirma interés," 1.

announced that 60% of the costs of the massive hydroelectric project – US $2 billion -- would be applied to construction, and that the importation of heavy equipment for construction would require another 500 million dollars.[114]

In the next few days, Costa Cavalcanti added, local infrastructure work would begin to build access roads, supply energy, provide lodging for the workers "appropriate for work that necessitates the movement of 50,000 people, between laborers and their families." In addition to discussing Paraguayan displeasure at how Brazil's technicians, cities, and industries were taking over the lion's share of what was intended to be an even bilateral cooperation, the MRECIC memorandum closed with a harsh critique of Cavalcanti's handling of the project by a Brazilian engineer, Otávio Marcondes Ferraz. Marcondes Ferraz alleged that Cavalcanti did not have a fixed budget, that his project would depend on a "new form of long-term financing" that may or may not prove sound, and that, most troublingly, the "falls of the Paraná River and the Sete Quedas National Park will disappear without having studied any alternative to preserve these natural beauties."[115] Under Geisel, it seemed, internal dissent on the Itaipu plans was at least printed in the Brazilian press, if not outwardly tolerated by the government; no such frank assessments of Itaipu by Brazilians had appeared, at least in the files of Argentina's foreign ministry officials, under Médici's government.

Conclusion

At the end of 1974, Brazil's military government was unfolding a policy of *distensão*, relaxing the harshest aspects of the Médici presidency and pursuing a more inclusive foreign policy. Argentina was in a tense democratic interregnum under ailing Juan Perón, then his third wife, Isabel Martínez de Perón, after the transformative leader's death on July 1, 1974.

[114] Alvarez de Toledo, "Embajador soviético afirma interés," 2.
[115] Alvarez de Toledo, "Embajador soviético afirma interés," 4.

Argentina had one functioning nuclear power reactor – Atucha I, in Lima, Buenos Aires province, and had budgeted and contracted its second reactor, Embalse, by the end of 1973. Brazil was on the cusp of signing a massive deal with West Germany to build four to eight power reactors and transfer the technology needed to complete the full nuclear fuel cycle. The effects of the decision to substitute hydroelectric power (via the massive Itaipu dam project) for nuclear power in Brazil was absolutely fundamental both to Brazil's domestic energy policy planning and in intensifying the crisis of the bilateral relationship between Argentina and Brazil.

Once again, nuclear questions – and energy issues, more generally – were at the heart of a complex and dynamic push-and-pull between the most technologically advanced countries in South America, as the "identical national interests" coming out of the Tlatelolco negotiations, discussed in Chapter 2, had diverged widely by 1975, as each country began to pursue its own path toward autonomous and secretive nuclear technologies, analyzed in Chapters 4 and 5.

Chapter 4: Enrichment

Autonomous Nuclear Development in Argentina, 1975-1985

To examine the development of "autonomous" or "parallel" nuclear technologies in Brazil and Argentina in the late 1970s through much of the 1980s is to tell a fundamentally conflicted story: Sometimes, the South American neighbors stood by each other to defend the rights of developing nations to pursue a full range of nuclear technologies, including sensitive uranium enrichment and reprocessing, outside the strictures of international nuclear weapons proliferation measures. In other parts of the history of autonomous nuclear development, though, the Brazilian and Argentine militaries played out their main historical role on a global stage, each attempting to force a stalemate with the other, and stoking fears across the border of their neighborly rival's possibilities of building a weapon of mass destruction.

This chapter will discuss and analyze the motivations behind Argentina's autonomous nuclear development between 1975-1985, the technical means used to achieve the ambitious goals laid out by CNEA in 1975, and the diplomatic challenges from foreign governments and international organizations that spurred Argentine technicians and diplomats to turn inward to develop indigenous capabilities to span the full nuclear fuel cycle. The following chapter will cover the same time period and processes of nuclear development in Brazil, before closing the dissertation with Chapter 6, showing the long trajectory of bilateral nuclear energy relations that culminated in the Quadripartite Treaty of 1991, creating the bilateral nuclear verification and control organization ABACC.

In the second half of the 1970s, Argentina's level of innovation and development in nuclear energy technologies surpassed even that of Brazil. Argentina had recovered well from its early and expensive stumble, the Huemul Project, as its scientific community stepped in to repurpose the Huemul machines for ambitious nuclear technology research. Under 18 years of leadership by Oscar Quihillalt from 1955-1973, CNEA made significant steps forward between 1960-1975. In 1961, a uranium heap leaching facility, to extract the metal from ore, was opened in Salta province, and in 1962, CNEA signed new cooperation agreements with the US and Euratom, the European nuclear energy continental organization. Nuclear power was not far behind: in 1965, President Arturo Illia authorized technical and economic studies toward the nation's first nuclear power plant near the coast of Buenos Aires province.[1] Argentina's second research reactor at Constituyentes Atomic Center reached criticality the following year, and in 1967, Argentina signed cooperation agreements with Colombia and Paraguay, as CNEA's president Quihillalt was unanimously elected president of the IAEA Board of Governors for a two-year term.[2] In 1968, the first power plant became much closer to reality as CNEA signed a contract with the German firm Siemens to install a 313 MW-capacity pressurized heavy water reactor that would use natural uranium fuel.[3] The following year, Argentine technicians succeeded in chemically separating plutonium from spent fuel rods.

In 1970 and 1971, two more research reactors reached criticality, RA-0 in Córdoba and RA-4 in Rosario, Santa Fe, bringing the nation's total to five. Decree no. 4658 in 1972 outlined a plan for a second nuclear power plant, which was contracted from Atomic Energy of Canada Limited (AECL) to bring a 600 MW reactor, again using heavy water and natural uranium, to Embalse in Córdoba province.[4] In 1974, Atucha I reached criticality and was connected to the national electricity grid, beginning commercial operation three months later. Ten days after India's nuclear explosion, in May 1974, Argentina signed a peaceful energy use cooperation

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[1] "CNEA – Historia – Década 1960-1969," http://www.cnea.gov.ar/decada2, accessed Nov. 2, 2016. Hereafter, this source will be referred to as "CNEA timeline." 1965: 22 de enero.
[2] CNEA timeline, http://www.cnea.gov.ar/decada2, 1967.
[3] CNEA timeline, http://www.cnea.gov.ar/decada2, 1968.
[4] CNEA timeline, http://www.cnea.gov.ar/decada3, 1972-1973.

agreement with that country.[5] And toward the end of 1975, Argentina sent for the second time a CNEA president to lead the IAEA Board of Governors, this time Pedro Iralagoitía.[6] His successor, Carlos Castro Madero, was one of the primary figures behind landmark nuclear energy achievements while Argentines suffered their darkest decade.

On March 24, 1976, a military junta led by Jorge Rafael Videla overthrew the acting president, Isabel Perón, Juan Perón's third wife, who had been serving as head of state after her husband's death in July 1974. Videla's ruling junta called its government the *Proceso de Reorganización Nacional*, or National Reorganization Process, a benign title that gave little hint of the uncompromising and unprecedented brutality with which the military would rule until 1983. The actions and international reputation of the *Proceso* government explain the primary difference between Argentine and Brazilian nuclear energy development during this period. As there was no explicit military involvement in nuclear energy outside the auspices of Argentina's National Atomic Energy Commission (CNEA), as was present in the Brazilian Navy's *programa paralelo*, I have avoided using the "parallel" label on nuclear activities in Argentina that were secretive in nature, opting instead for "autonomous." CNEA President Castro Madero's insistence that Argentina's intentions for nuclear energy were entirely peaceful echoed the words of the ruling junta, but nuclear suppliers such as the United States did not trust these assurances, given the brutal and unpredictable nature of the junta, and Argentina's simmering rivalry with Brazil, also relatively advanced in nuclear energy technology. Yet Argentina continued to be abandoned by their key nuclear suppliers, such as the United States, Canada, and France. Argentina's eventual decision to develop an autonomous enrichment program (and press ahead with nuclear fuel reprocessing and the construction of a

[5] CNEA timeline, http://www.cnea.gov.ar/decada3, 1974.
[6] CNEA timeline, http://www.cnea.gov.ar/decada3, 1975.

heavy water plant), were not entirely products of its own decisions; India's successful nuclear test in 1974 alarmed the world's nuclear gatekeepers. Closer to Argentina, in 1975, Brazil negotiated to receive what was then the largest technology transfer in history, through a nuclear deal with West Germany. This chapter begins with these two international nuclear energy history landmarks, and ends in 1985. I argue here that the path of nuclear energy policy in Argentina, as formulated within CNEA and larger political priorities and strictures, remained largely unchanged throughout the decade. The nuclear energy budget expanded under military rule; that windfall, as well as key developments like the foundation of state technology company INVAP in 1976 surely facilitated achieving the nation's ambitious goals for self-sufficiency in nuclear energy and control of the full fuel cycle. But the underlying motivations, ideas, and priorities that shaped nuclear energy in Argentina before and after 1975 did not ultimately change much within the overarching goal of technological autonomy.

In developing an argument based on the essential continuity of Argentina's nuclear energy policy and goals from years prior to the 1976-1983 military government into the *Proceso* period, it would be both irresponsible and incomplete not to discuss the brutality of the regime and its catastrophic impact on the nation's scientific and technical communities and university system. The leaders of the second dictatorship, unfortunately, had an effective blueprint for intrusion into universities to root out "subversive" faculty and administrators, one drawn by their predecessors in the Onganía regime of 1966-1973 and discussed in Chapter 3. If the *Proceso* junta learned any caution from Onganía's experiences, it was to repress scientific intellectuals in a less obvious and headline-making fashion. "The military leaders generally viewed intellectual activities with distrust," and sent spies and informants to "systematically infiltrate the universities and identify students or professors with critical views."[7] Within the first few months after the coup, the regime dismissed or expelled 3,000 university professors, administrative personnel, and students from 28 state universities for political reasons; 150 were fired the day after the coup from INTI, the National Industrial Technology Institute, while 180 were dismissed and 20 arrested among employees of the INTA, the National Institute of Agricultural Technology.[8] Nuclear scientists and technicians fared no better; 25 CNEA members were kidnapped, and 15 are currently on the list of the regime's *desaparecidos*.[9]

On the day of the 1976 coup, a naval captain directed physicist Máximo Victoria and eight colleagues to be taken away from CNEA headquarters at gunpoint; these experts in fuel reprocessing and plutonium separation were "subjected to interrogation and torture" for twenty days aboard a ship, the *Bahía Aguirre*, transferred to another ship for two days, and then to maximum security in the Villa Devoto prison for four months.[10] Castro Madero's role in interceding on behalf of the scientists and technicians is difficult to discern. Many said that the president of CNEA had "taken efforts to protect the institution's personnel and had confronted military authorities on this matter" since the 1976 coup. But in the case of Máximo Victoria, Castro Madero seems to have delivered the INTI director directly to the control of military police by ordering the physicist to report to the "chief of logistics," the military captain waiting to march the nine CNEA employees away at gunpoint to certain detention and torture.[11] The agency in some of these cases is a bit unclear, but chemist Tomás Buch and engineer Domingo

[7] Wolfgang Bietenholz and Lilian Prado, "Revolutionary physics in reactionary Argentina." *Physics Today* 67, no. 2 (2014): 42. The Argentine physicists profiled in their article, Juan José Giambiagi and Carlos Guido Pollini, took refuge in Brazil during the 1976-1983 dictatorship, but being under the rule of a less repressive dictatorship than Argentina's was indeed cold comfort for some Brazilian scientists who ran afoul of the regime for "alleged involvement with communist conspiracies."
[8] Diego Hurtado, *El sueño de la Argentina atómica: Política, tecnología nuclear y desarrollo nacional (1945-2006)* (Buenos Aires: Edhasa, 2014), 179.
[9] Hurtado, *Sueño*, 180.
[10] Hurtado, *Sueño*, 180-181.
[11] Hurtado, *Sueño*, 180, 182.

Quilici had diametrically opposed accounts of Castro Madero's resistance to, or complicity with, Videla's regime. In Buch's account, Castro Madero did "all that he could" to protect his employees from repression, and did so in his case, letting him hide from the Secretariat of Intelligence of the State (SIDE) at INVAP after he was fired from his university position.[12] Quilici, however, wrote in an open letter to his colleagues that "Denying Carlos Castro Madero's responsibility in the consequences that *el Proceso* had within CNEA is impossible. He surely knew that his presidency came accompanied by ideological "cleanliness"… He had the chance to have acted, and did not do so."[13]

Even as the *Proceso* persecuted scientists within CNEA, and even as international nuclear suppliers recoiled from a government that terrorized its people and refused to accede to nuclear nonproliferation agreements, the key decisions that set nuclear energy events in motion had largely been made before the coup of March 1976. The lofty *Plan Nuclear 1975/1985* outlined $5 billion in nuclear energy spending, and envisioned constructing a "complete industry for the nuclear fuel cycle, in all its stages."[14] Five nuclear power reactors would be in operation by 1985; the four planned reactors would each have approximately 1⅔ times the capacity of the Atucha I plant in operation since 1974. After the construction of Atucha II, the first of four planned 600 MW plants to be built between 1975-1990, CNEA leaders anticipated the ability to "construct these reactors almost completely within the country, functioning with Argentine uranium and with fuel elements built by national industry."[15] The cost of the plan, as delivered to the Argentine Congress in the beginning of 1976, was US $5.5 billion, and outlined a plan for five nuclear power plants to be in operation by 1985: Atucha I, already operational

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[12] Hurtado, *Sueño*, 182.
[13] Hurtado, *Sueño*, 184.
[14] Quoted in Hurtado, *Sueño*, 168. The steps of the full nuclear fuel cycle are described briefly later in this chapter and illustrated in Figure 2.
[15] Hurtado, *Sueño*, 168.

(US $70 million, fueled by natural uranium and heavy water, with a capacity of 319 MW)[16], Embalse, with a capacity of 600 MW, and Atucha II, of the same higher capacity, due to open in 1979 and 1971, and two more of 600 MW capacity, one to be located in the region of Cuyo.[17] Castro Madero was counting on the national treasury to provide almost two-thirds of the total cost of the *Plan Nuclear*, with a further $1 billion coming from a "quite feasible" financing through loans, and the last $1 billion from "savings on petroleum…through production of electricity by Atucha and Embalse [nuclear power reactors.]"[18]

Argentina's resistance, and alliance with Brazil, against international nonproliferation agreements – the Treaty of Tlatelolco, and to a much greater extent, the NPT – stiffened, but certainly did not begin, under the junta's rule. Argentina's parallel uranium enrichment program was certainly not a foregone conclusion, especially under the cash-strapped dictatorship. However, given the country's degree of nuclear technological advancement, a massive spike in the budget for nuclear energy development under military government, and the impetus toward indigenous technology that indirectly came from the United States 1978 Nuclear Non-Proliferation Act, the enrichment efforts were not a complete surprise either. Spent fuel reprocessing and heavy water production, while not carried out with the same degree of secrecy as test- and industrial-scale uranium enrichment, will be treated in this chapter as "parallel-type" activities designed to circumvent the export restrictions at the heart of the international nonproliferation regime, increasingly seen by Argentines as punitive and discriminatory.

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[16] Hurtado, *Sueño*, 139. 1 MW = 1 megawatt = 1 million watts. For reference, a standard 60W household incandescent light bulb is rated by the power that it would use if left on continuously for one year; one megawatt of installed electrical capacity would power 16,667 such bulbs for one year.
[17] Hurtado, *Sueño*, 168.
[18] Carlos Castro Madero, quoted in Hurtado, *Sueño*, 175.

A corollary argument here, more developed in the chapter that follows on Brazil, is one that I hope will help shift the conversation about beginnings of nuclear energy cooperation between the South American neighbors back in time. As early as July 1, 1974, a high-ranking Brazilian foreign ministry official wrote a two-page account of a delegation from his nation's *Escola Superior da Guerra* to Argentina's Atucha I reactor site, and the friendly reception by engineer Jorge Cosentino.[19] Pinheiro, the official, notes that Cosentino opposed the use of enriched uranium in Argentina's nuclear power plants, and convinced General and President (1971-1973) Alejandro Lanusse to opt for a natural uranium plan. More importantly, Pinheiro devotes an entire paragraph near the end of the memo to Cosentino's "hope that Brazil and Argentina would come to work together in cooperation on nuclear energy matters."[20] Cosentino admitted that such collaborations had been "more formal than effective" in practice, but throughout the rest of the 1970s, diplomats from both countries would write more frequently and in greater detail about these plans for collaboration. Even after the *Proceso* ruling junta took power, and perhaps to match the spirit of Brazilian president Ernesto Geisel's relaxation of the most authoritarian and harshest manifestations of military rule, *distensão*, Argentine officials took part in these increasingly detailed discussions and plans, and there is little reason to think that they did so in bad faith. A detailed discussion of this cooperation appears in Chapter 6.

The autonomous activities and developments in nuclear energy in Argentina between 1975-1985 developed in the rest of this chapter are the contracting and construction of a heavy water plant, efforts to develop spent fuel reprocessing facilities, and the secret gaseous diffusion uranium enrichment plant tested at "Villa Golf" and built in the remote hamlet of Pilcaniyeu in

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[19] Pinheiro, "Visita de funcionário da Embaixada à Central Nuclear de Atucha." Memorandum to Brazilian Embassy in Buenos Aires, July 1, 1974. WCDA.
[20] Pinheiro, "Visita," 2.

the early 1980s. Again, the autonomous label that I am applying to these activities does *not* imply some kind of neat disconnect from official nuclear energy programs; they were part and parcel of CNEA's activities toward achieving the full nuclear fuel cycle, and included technologies that Argentina would legitimately need to develop both for its own peaceful uses and in order to fulfill its newly chosen promise to become an exporter of research reactors to other developing countries.

A brief outline of the regional and global crises that motivated the activities of CNEA in the last half of the 1970s follows. Within South America, a diplomatic crisis between Argentina and Brazil erupted in 1973 over the construction of the Itaipu hydroelectric dam, threatened to spiral into armed conflict, and reached both the General Assembly of the United Nations and the Summit of the Non-Aligned Movement.[21] In the Middle East, the surprise attacks on Israel by Egyptian and Syrian forces, armed in part by their Soviet allies, began the Yom Kippur War of October, 1973. US President Richard Nixon authorized a strategic airlift of military and supply aid to Israel, intended to counterbalance his Soviet rivals' support for the other side in the conflict. The coalition of Arab nations opposing Israel responded by raising the posted price of petroleum by 70% on October 16th and initiating an embargo on oil exports to the United States, United Kingdom, Canada, Japan, and the Netherlands.[22] Before the embargo ended in March 1974, the global price of oil had quadrupled, and would balloon to ten times its pre-Yom Kippur War value (closer to five times, when adjusted for US inflation) in the decade after the conflict.[23] The Itaipu conflict, Arab nations' oil embargo, a test of a nuclear explosive by India

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[21] Hurtado, *Sueño*, 167.
[22] Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power*. New York: Simon and Schuster, 2008.
[23] United States Department of State, "Oil Embargo, 1973-1974." https://history.state.gov/milestones/1969-1976/oil-embargo, and Historical Crude Oil Prices (Table). https://inflationdata.com/Inflation/Inflation_Rate/Historical_Oil_Prices_Table.asp

in 1974, and the Brazilian nuclear technology transfer deal with West Germany in 1975,[24] though spread across four continents, all centered upon the finiteness of energy resources and the centrality of energy in the geopolitics and conflicts of the global Cold War, and all would profoundly affect and decisively shape Argentina's plans for, and means of, developing nuclear energy capabilities.

On May 18, 1974, India's army conducted a successful nuclear explosion test in the northeastern province of Rajasthan in a 107-meter deep pit. How did an explosion nearly 10,000 miles from Buenos Aires shape nuclear energy developments in the following decade in the Southern Cone? In one blinding flash, India became the first country outside of the declared nuclear-weapon states of the Non-Proliferation Treaty of 1968 (the United States, United Kingdom, Soviet Union, France, and China) to have shown both the possibility of its intent and certainty of its capability to develop a nuclear weapon. Smiling Buddha had not only shaken the world's nascent and fragile nuclear nonproliferation regime, codified by the problematic Non-Proliferation Treaty (NPT), but also changed forever the relationship between Global North providers and Global South buyers of nuclear technology on the world market. Mario Báncora, head of CNEA's Reactors Division, said later in 1974 that "the only thing the Indian bomb did for us was complicate our lives terribly."[25]

Twenty years prior to the nuclear test, the Indian government had purchased a heavy water/natural uranium reactor from the Canadian government, and under the terms of Atoms for Peace technology transfers and aid, the United States had provided the heavy water (deuterium oxide) as a neutron moderator.[26] (Argentina's Atucha I nuclear power reactor,

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[24] These four events are chronologically linked in Hurtado's analysis, but he does not make the energy connection explicit.
[25] Quoted in Diego Hurtado, "Periferia y fronteras tecnológicas: Energia nuclear y dictadura militar en la Argentina (1976-1983)," *Revista Iberoamericana de Ciencia, Tecnología y Sociedad*, November 2009, 6.
[26] Gary Milhollin, "Stopping the Indian Bomb." *The American Journal of International Law* 81, no. 3 (1987): 595.

connected to the power grid two months prior to India's test, used a nearly identical combination of natural uranium fuel and heavy water moderator). The sale of the reactor from Canada to India in 1954 predated the creation of the IAEA, and so the transfer was made without safeguards. In the eyes of the United States and Canada, those two countries had only themselves to blame for India's capability to produce plutonium for "Smiling Buddha," and the fledgling non-proliferation regime needed further changes to accommodate the relationships of nuclear technology providers, like the US, Canada, and Germany, and buyers, like India, Argentina, and Brazil, without encouraging the development of nuclear weapons. Mario Báncora's words about India's test complicating Argentine nuclear activities proved prophetic; two years later, Jorge Sábato and Raúl Frydman wrote in the pages of *Estrategia*, an Argentine military journal, that "under the pretext of impeding the proliferation of nuclear weapons, [central countries] try, at any cost, to block developing countries from reaching full control of the techniques of [spent fuel] reprocessing and [uranium] enrichment."[27] (The mere existence of a secret uranium enrichment program in 1978 shows that any compromise on enrichment and reprocessing between the position of Argentina and that of its European and North American suppliers was absolutely impossible at the time).

The reaction of the industrial countries that furnished these technologies – the United States, USSR, United Kingdom, France, West Germany, Japan, and Canada – to the Indian nuclear test was somewhat delayed, as they added in late 1975 to the guidelines set up by the Zangger Committee between 1971-1974. The Zangger Committee had brought together representatives of fifteen nations to the IAEA headquarters in Vienna to develop a specific list of devices and technologies – called the "trigger list" because export of these devices "triggers"

[27] Hurtado, *Sueño*, 168.

the IAEA safeguards process – in compliance with Article III.2 of the Nuclear Non-Proliferation Treaty.[28] Besides identifying the equipment or material on the "trigger list," the committee also decided on conditions and procedures that complied with the terms of Article III.2 and also upheld the principles of fair commercial competition among supplying companies. NSG members also explicitly required IAEA safeguards to be applied to the items on the "trigger list." Importantly, the Zangger Committee made its conclusions in the form of non-binding guidelines, so the seven industrial nations above met in London from 1975-1978 to create more rigid and binding rules for export of nuclear technology and material that could potentially lead to a repeat scenario of nations like India developing a nuclear explosive device. These countries forming the Nuclear Suppliers Group, or NSG, met for the first time in November 1975.

In 1976-1977, eight more European nations joined the "London Club." (Argentina joined in 1994, to be followed two years later by its neighbor Brazil, after those two nations had concluded the ABACC agreement and placed all nuclear activities under IAEA safeguards). Four of the last 20 annual meetings have been held in those two nations, with Buenos Aires hosting the NSG in 1996 and 2014, Bariloche in 2015, and Brasília in 2006. Aside from the two South American countries, only three other nations in the Southern Hemisphere are members of the Nuclear Suppliers Group: South Africa, Australia, and New Zealand. But for the late 1970s and early 1980s, the NSG's members stood opposed to the autonomous and parallel nuclear development plans of Brazil and Argentina, either of which, in the eyes of highly developed, industrial, North Atlantic nations, could have become the next India, a Global South

[28] "Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, *unless the source or special fissionable material shall be subject to the safeguards required* by this Article."

non-signatory to the NPT successfully testing a nuclear explosive device. The combined effects of decisions by the London Club and United States Congress, when it passed the 1978 Nuclear Non-Proliferation Act, made it impossible for Argentina to rely on foreign technology and material suppliers in order to realize the goals of the ambitious *Plan Nuclear 1975/1985.*

Castro Madero's first year in his new post, 1976, was marked by developments appropriate to the budgetary and political weight that the military dictatorship granted to nuclear energy. Construction began on a pilot plant for autonomous fabrication of fuel elements for the two-year-old Atucha I power reactor. In September, the provincial government of Rio Negro passed Order 661/76 creating INVAP S.E. This state high technology firm that would very soon transform and accelerate Argentina's possibilities and plans for nuclear energy, most immediately in a secret project to enrich uranium and begin exporting research reactors to other developing countries.

INVAP was born of an idea by physicist Conrado Varotto to collect Argentina's most valuable resource, its "gray matter," putting it to use to compete in the global technology market with projects of "high value added."[29] Additionally, Varotto wanted the new firm to be a state enterprise and not a private corporation so that it would be less susceptible to the "abrupt turns of Argentine governments," who tended to judge decisions less harshly from state-linked firms than from private enterprise.[30] CNEA and Rio Negro provincial officials sought to take advantage of Law 20.705, passed in 1974, which granted equal status to "societies of the State" as to private corporations chartered as *sociedades anónimas*, and negotiated for almost two years to found INVAP. "a firm that would survive exclusively from the revenues generated by technological developments that were solutions to the real problems of clients."[31]Though the

[29] Olivia Grobocopatel Marra, "Caso INVAP." MA thesis, Universidad de San Andrés, 2016: 28.
[30] Grobocopatel Marra, "Caso INVAP," 29.
[31] *30 años INVAP: Tecnología argentina para el mundo.* Publisher and site of publication unknown. 2006, 24.

Province of Rio Negro and Government of Argentina own the corporation, it is operated like a private firm, without tax exemptions and without a budget from the government.[32] At first, INVAP depended exclusively on CNEA's demand for its nuclear products; the national nuclear energy agency both "absorbed the totality of its productive capacity" and allowed the young technology firm to thrive.[33] By 2013, its annual sales were in the range of 40-70 million US dollars, and it was one of the top five builders of research reactors in the world.[34]

INVAP's location on the southern shore of Lake Nahuel Huapi just east of Bariloche, the Argentine town transformed into a hub of scientific and technological activity by CNEA's activities there since 1950, calls to mind another high-technology area that inspired its founder, Varotto. The Argentine physicist had returned in 1972 from a visit to Stanford University and inspired by the San Francisco Bay Area's Silicon Valley technology corridor, and sought to transform the prestige of the Centro Atómico Bariloche (CAB) in basic physics research into applied physics and technology development.[35] Varotto's plan found a champion in the CAB's director, Hugo Erramuspe. His vision drew its intellectual strength from the ideas of Jorge A. Sábato, who envisioned technological firms born of state contracts, growing to serve the rest of industry, and return (with value added) in their mature, productive phases, the funds provided by the national government at their creation.[36] INVAP would play a key role in the near future nuclear development of Argentina, but most immediately, in building a research and radioisotope production reactor of 10 MW capacity to send to Peru in 1977-1978, and in the secret enrichment program begun in 1978.

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[32] Fabio Bustos, "INVAP SE Perfil de Empresa." Company slide presentation, 2013, 2. http://hpcday2013.hpclatam.org/files/INVAP.pdf
[33] Grobocopatel Marra, "Caso INVAP," 29; *30 Años INVAP* states that the corporation was always to be sustained entirely by its sales, which soon branched out to foreign governments.
[34] Bustos, 5.
[35] *30 años INVAP*, 24-25.
[36] *30 años INVAP*, 24.

Castro Madero accelerated CNEA's activities within the global nonproliferation and safeguards regime in order to expand Argentina's total energy capacity; in 1976, Atucha I provided just short of six percent of the nation's electrical power, or 340 MW of an estimated 6000 MW total capacity. It was his view that the nuclear industry would exert a multiplier effect on other industrial activities, and in so doing, merited the focus and efforts of personnel from "practically all the scientific and technological disciplines."[37] In 24 years, at the turn of the millennium, CNEA's new president estimated that nuclear power would need to provide 15,000 MW; in order to reach this figure, five 600 MW reactors would need to be built before 1990, with the remaining 12,000 MW capacity to be installed between 1990-2000. Castro Madero estimated the price tag for expanding Argentina's nuclear power by 44 times the capacity of Atucha I to be $30 billion; his neighbors in Brazil held similarly lofty aims for a future powered by the atom and spoke of 63 nuclear power plants.[38] Argentina had sufficient uranium reserves to fuel Atucha and six 600 MW power plants for thirty years, according to figures cited by Hurtado; retired Argentine general Juan E. Guglialmelli's numbers in 1979 were only slightly more optimistic.[39] If world prices for uranium jumped, Argentines would be wise to begin exporting uranium in larger quantities, but regardless of whether national reserves of uranium were used in Argentina's reactors or sold to other countries, it would be depleted rapidly if Castro Madero's plans for a tremendous expansion of nuclear power capacity were to become reality. One solution to this shortage would be to unlock the plutonium accumulated in spent

[37] Quoted in Hurtado, *Sueño*, 177.
[38] Hurtado, "Periferia," 6.
[39] Guglialmelli, Juan E., "Energía y geopolítica," *Estrategia*, 8-9. The author assumed that sufficient national uranium reserves existed, if a world price of US $80 or less held per kilogram, to fuel eight 600 MW power plants for a "useful life of 30 years" as well as Atucha I and Embalse, which would be commissioned in 1984.

reactor fuel elements by 2000 as a potential source of energy "equivalent to the total of our reserves in fossil and uraniferous minerals..." through reprocessing.[40]

The foundation of INVAP as a "society of the State" was arguably the key development to promote autonomous nuclear energy technology in 1976, but other developments that year are certainly notable: a pilot plant was built for producing fuel elements for Atucha I, and Argentina's government concluded peaceful use nuclear technology agreements with Canada and Chile. But Argentina's nuclear suppliers – most notably West Germany, Canada, and the United States – were increasingly restless about existing and future transfers of technology and material. After India's nuclear test, the West German government asked for safeguards applied to the Atucha I reactor to be extended to the entire useful life of the power plant as a condition to continue providing Argentina with its fuel elements; in December 1976, Canada began to insist on Argentina's adherence to the NPT and its acceptance of full-scope IAEA safeguards in order to carry out its existing contracts for nuclear transfers.[41] Hurtado argues that Canada essentially reneged on the terms of these transfer agreements by making *ex post facto* demands for safeguards, then added insult to injury by asking for more money to cover the "application of additional security measures" to these transfers.[42]

The United States' position against sales of nuclear technology to countries that remained outside the NPT and safeguards regime, similar to that taken by Canada, was becoming more rigid. President Jimmy Carter's hard line against such transfers led Canada to ban the sale of heavy water (a neutron moderator necessary in natural uranium power reactors)

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[40] Castro Madero as quoted in Hurtado, "Periferia," 6. After 1978 – the year of both the United States' Nuclear Non-Proliferation Act and the international reinforcement of the ideas and policies behind it, the IAEA's INFCIRC/254, reprocessing would be one-third of a trifecta of sensitive technologies and materials, which also included uranium enrichment and heavy water production, prohibited from being transferred to countries that had not signed and ratified the NPT.
[41] Hurtado, "Periferia," 7-8.
[42] Hurtado, "Periferia," 8.

for the Embalse power plant.[43] When US Secretary of State Cyrus Vance traveled to Argentina in November 1977 with two others in the administration, hoping to convince Castro Madero and the Argentines to ratify the Treaty of Tlatelolco, he was surprised to have the CNEA president propose a *quid pro quo* arrangement: if you sell us heavy water for our power reactors, and perhaps more, we'll ratify Tlatelolco. The month before, the US embassy in Buenos Aires had cabled back to Washington that "[ratification of Tlatelolco] cannot be done without heavy political cost to the [Argentine] government…and is variously seen as: a further encroachment on national sovereignty; a weakening of Argentina's position as a developing nuclear power vis-à-vis Brazil; unacceptable bending to US and foreign pressure; and a bargaining chip which should be used to extract better treatment from the US."[44]

Later in that same cable from Buenos Aires to Washington, Argentina's perception of the US' bargaining role with their Brazilian neighbors was highly illuminating. "[Argentina] sees the US making concessions and soft-pedalling on Brazilian human rights violations in order to influence that country's nuclear power program, and would like to use Tlatelolco in the same way. Others admire the Brazilian government's blunt negative reaction to US human rights pressure and advocate a similar aggressively non-cooperative attitude for Argentina on matters of US bilateral concern."[45] It is important to reiterate that even without any evidence that a secret bomb project was underway or planned, adherence to global and regional nuclear nonproliferation agreements gained no traction with Castro Madero or the military junta who kept him in the directorship of CNEA. 1977, after all, had been another banner year for Argentina's nuclear technology development. The Centro Atómico Constituyentes, at the

[43] Hurtado, "Periferia," 9.
[44] US State Department cable, October 18, 1977, from American Embassy, Buenos Aires, to Secretary of State in Washington DC. "Tlatelolco Treaty." DNSA.
[45] US State Department, "Tlatelolco Treaty."

northwestern edge of the city of Buenos Aires, inaugurated its National Institute of Non-Destructive Testing in March; the uranium concentration plant *Los Adobes* opened in the province of Chubut in August, and in September, another "sociedad del Estado" company, this time devoted to mining, began operations in Mendoza province. In November, CNEA and the Instituto Peruano de Energía Nuclear (IPEN) agreed that Argentina would provide the Nuclear Research Center in Peru with a research and radioisotope-producing reactor of 10 MW, a separate plant for the production of radioisotopes, and a Radiological Protection and Nuclear Safety Center.[46] Quietly, Argentina had marshaled its relatively new technological capacities through INVAP and become an exporter of nuclear technology.

In February and March 1978, a double blow arrived from Vienna, then Washington, threatening Argentina's prospects for autonomous development of nuclear technology and control of the full fuel cycle. Information Circular 254 of the International Atomic Energy Agency gave the texts of twelve letters from member states discussing "guidelines for the export of nuclear material, equipment, or technology," followed by an appendix reminding member states of and reinforcing guidelines for nuclear transfers. Under an underlined section header on safeguards, guideline 4 read as follows: "Suppliers should transfer trigger list items only when covered by IAEA safeguards, with duration and coverage provisions in conformance with the GOV/1621 guidelines." Below, a section titled "Safeguards triggered by the transfer of certain technology" specifically named reprocessing facilities, enrichment, and heavy-water production as items on the "trigger list", and thus subject to the guidelines listed above it.[47]

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[46] CNEA timeline, 1977.

[47] International Atomic Energy Agency, Information Circular INFCIRC/254. https://www.iaea.org/publications/documents/infcircs/communications-received-certain-member-states-regarding-guidelines-export-nuclear-material-equipment-or-technology, accessed Nov. 15, 2016. Annex A of the same information circular, on pages 12-15, contains the "trigger list" in full detail. Most pertinent to Argentina are the items listed in Part A, 2.2.1, "Deuterium and any deuterium compound in which the ratio of deuterium to hydrogen exceeds 1:5,000…in quantities exceeding 200 kg of deuterium atoms," 2.6.1, "Plants for the production

On March 10, 1978, US President Jimmy Carter signed the Nuclear Non-Proliferation Act (NNPA) into law, which required safeguards on all nuclear facilities in any country to which the US would transfer technology or fuel for civilian energy programs, and a promise by that country not to develop or acquire nuclear weapons. A particularly onerous provision of the NNPA required existing contracts between the United States and the countries to which it supplied nuclear fuel or technology to be renegotiated, a measure that "deteriorated commercial relations that were based on mutual confidence."[48] Many scholars and nonproliferation experts criticize the NNPA for having the opposite effect from its intention, a trend begun by misguided US policy earlier in the 1970s: "After learning of the US decision not to supply [low enriched uranium], the Brazilians promptly concluded a contract with the Germans to acquire a full nuclear fuel cycle [in 1975] while France concluded reprocessing plant contracts with Pakistan and South Korea."[49] Chauncey Starr puts it more starkly, but mistakes the level of progress on Argentina's enrichment plant (already completed and announced in 1984), writing that "the NNPA apparently has stimulated other countries to plan or create their own national fuel cycles, including uranium enrichment and fuel reprocessing facilities, for their national security. The recent announcement of Argentina on the start [sic] of its enrichment plant and the activities of Pakistan are evidence of such a response."[50] The most astute critique of the NNPA for the case of Argentina's nuclear development is perhaps that of Gerard Smith and George Rathjens, who argue that the greatest flaw in the 1978 law was "its emphasis on

of heavy water…," Part B, 2) a), "in the case of an isotope separation [enrichment] plant of the gaseous diffusion type: diffusion barrier," and 5) e), "a fuel reprocessing plant using the solvent extraction process."

[48] Chauncey Starr, "Uranium Power and Horizontal Proliferation of Nuclear Weapons." *Science* 224, no. 4652 (June 1, 1984): 955. Smith & Rathjens' 1981 article in *Foreign Affairs* makes this same point.

[49] Sharon Squassoni, "Looking back: The 1978 Nuclear Nonproliferation Act." *Arms Control Today* 38, no. 10 (2008): 64.

[50] Starr, "Uranium Power," 955.

unilateral denial of nuclear materials as a form of leverage to prevent proliferation."[51] They also identified Carter's linkage of civilian nuclear power programs to potential weapons proliferation as a problematic red herring, "since nations can build plants specifically for weapons programs, as all the present weapons states have done."[52]

To nuclear energy policymakers, military personnel, scientists, and technicians in Brazil and Argentina, these American scholarly criticisms of a harsh restriction on nuclear exports with the intention of stopping developing nations from building nuclear weapons may have seemed quite tame. In Argentina and Brazil, the NNPA only deepened the chasm of hypocrisy at the heart of the Non-Proliferation Treaty. As Robert Goheen wrote in 1983, "most Third World countries and other states that do not possess nuclear weapons consider proliferation and nonproliferation in terms of another, even more important dimension, which is vertical. It involves the piling up and ever more devastating refinement of nuclear armaments by the nuclear weapons states."[53] Fewer than six months after Carter signed the NNPA into law, Argentine nuclear planning officials began plotting a secret uranium enrichment facility to accomplish three aims: the nation would be one step closer to controlling the full nuclear fuel cycle, low enriched uranium could be combined with natural uranium fuel in Argentina's power reactors, but perhaps most importantly, Argentina could begin its new role as an exporter of (enriched uranium-fueled) reactors to other developing world countries. This chapter continues by briefly explaining the nuclear fuel cycle that Argentina successfully controlled by the end of this period, realizing a long-held goal of both CNEA and the nation's democratic and military governments, then recounts a brief history of Argentina's heavy water production plant at

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[51] Gerard Smith and George Rathjens, "Reassessing Nuclear Nonproliferation Policy." *Foreign Affairs* 59, no. 4 (1981): 885.
[52] Smith and Rathjens, "Reassessing," 875.
[53] Robert F. Goheen, "Problems of Proliferation: US Policy and the Third World." *World Politics* 35, no. 2 (1983): 194.

Arroyito before ending with an analysis of the test uranium enrichment plant, called "Villa Golf," and its industrial-scale counterpart at Pilcaniyeu.

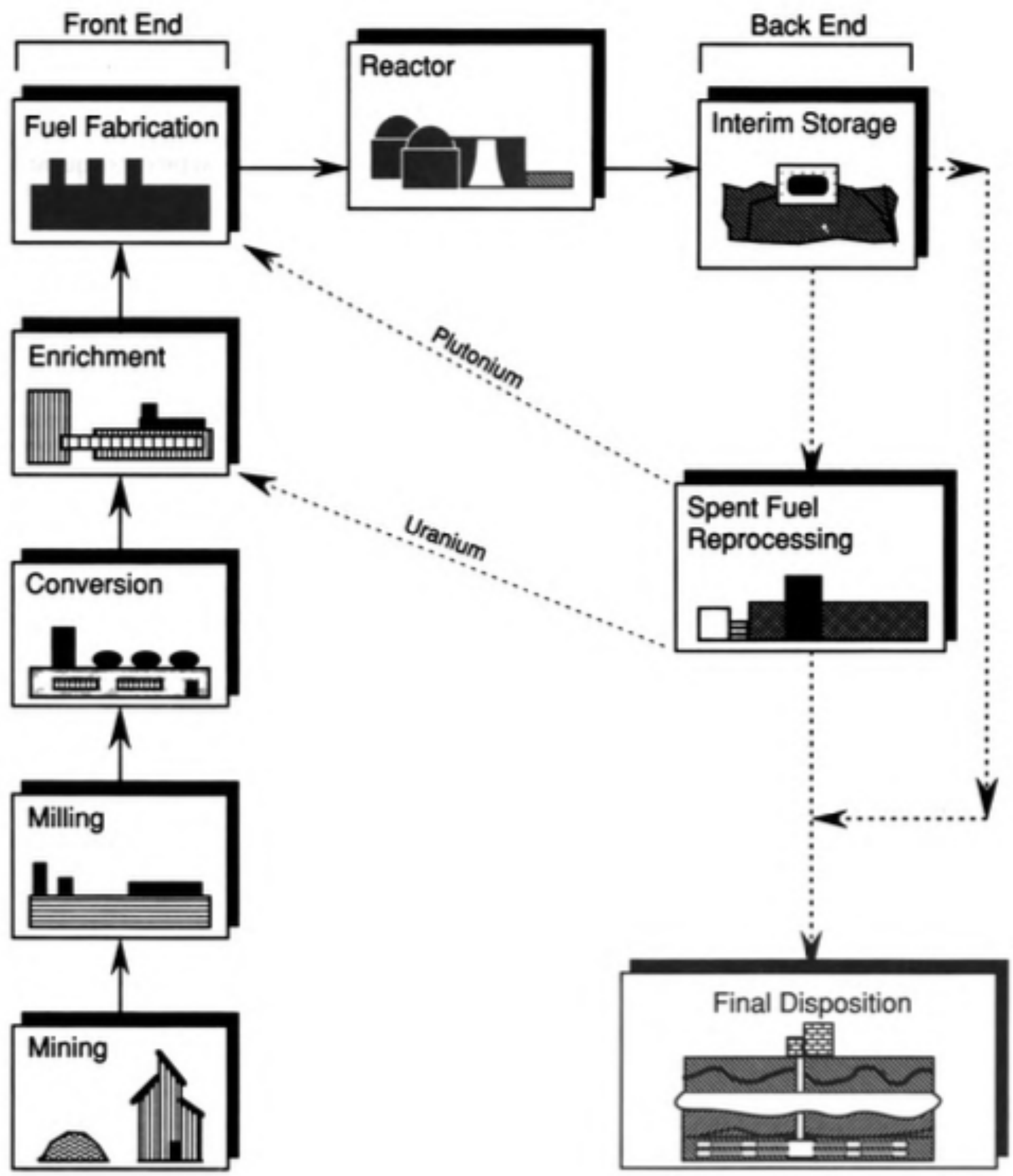
The nuclear fuel cycle

Argentina's capability to enrich uranium was not always sought by nuclear policy makers and experts in technology. Pressurized heavy water reactor (PHWR) technology was chosen for the Atucha I nuclear power plant because "it was believed that…the technology of uranium enrichment was beyond the reach of countries like ours."[54] Producing nuclear power involves one of two combinations: either enriched uranium and light water (H_2O) or natural uranium and some type of neutron moderator, often "heavy water." Heavy water, also known as deuterium oxide, replaces the protium isotope ^{1}H of hydrogen (with a nucleus containing only one proton) with the deuterium isotope, or ^{2}H, where a proton and neutron comprise the nucleus. In planning a series of reactors that used natural uranium as fuel and heavy water as a neutron moderator, Argentine nuclear policymakers and technicians essentially gambled on the fact that heavy water would be easier and cheaper to purchase on the international market than enriched uranium, and that this tradeoff would remain favorable to that original decision. The science of uranium enrichment, then, is explained most simply using the story of two isotopes: deuterium hydrogen (^{2}H) and fissile uranium (^{235}U). Uranium metal does not come out of the ground as a usable fuel, however, so first, the *front end* of the nuclear fuel cycle transforms uranium ore into fuel for nuclear reactions. See Figure 2 for a diagram of the nuclear fuel cycle from mining to final disposition of waste.

[54] Eduardo Santos, "Charla Pública 2.0.ppt," slide 5. Mr. Santos was president of CNEA in the mid-1990s and generously shared with me a copy of his digital archive of documents on the secret enrichment project, rapprochement with Brazil, and some of the first safeguards agreements made by Argentina in the ABACC (post-1991) period. His digital archive is noted hereafter by the initials ESDA.

Figure 2. The Nuclear Fuel Cycle

Note: For Argentina's *power* reactors, "enrichment" can essentially be skipped in the cycle depicted below, and the front end sequence proceeds from conversion to fuel fabrication. In reality, low enriched uranium, or LEU, has been added to the natural uranium fuel since Argentina mastered its enrichment technology on an industrial scale.



Source: "World Nuclear Fuel Cycle Requirements 1991," report by the U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, 41.

Exploration, mining, milling, conversion to UF_6 or uranium hexafluoride, and enrichment must all occur before the final step of the front end, which is fabrication of uranium dioxide fuel.[55] Bodies of uranium ore are found using drilling and other geological techniques. Once quantities and cost of production are known for particular deposits, those deposits are called reserves; uranium ore deposits that have not been proven or discovered, but are believed to exist, are known as potential resources. Uranium ore is then mined and milled to extract uranium oxide (U_3O_8), which occurs at percentages between 0.035% and 2.5%; uranium ores in the United States are often less rich in U_3O_8 than sources outside that country.[56] The product of milling is called "yellowcake," a colloquial name for uranium oxide that can actually range in color from yellow to orange to dark green, a variable that depends on the drying temperature and resulting level of impurities.[57] Argentina generally used a process called *heap leaching* to convert raw uranium ores into yellowcake; an acidic solution would be sprayed over a pile (or heap) of uncrushed ore, dissolving any uranium compounds into a solution that drained into pipes below the heap. A processing plant would then transfer this uranium-rich liquid solution to an ion-exchange system, which extracted and concentrated the uranium into the dry "yellowcake" – triuranium octoxide, or U_3O_8 – powder.[58]

Dissolution of the "yellowcake" in nitric acid yields uranyl nitrate, purified through solvent extraction. A subsequent reaction with ammonia produces ammonium diuranate, $(NH_4)_2U_2O_7$. This ammonium diuranate is reduced with hydrogen to produce uranium dioxide,

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[55] "World Nuclear Fuel Cycle Requirements 1991," report by the U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels (October 1991): 40.
[56] "World Nuclear Fuel Cycle Requirements 1991." Perhaps this is a reason that the United States continued to import uranium despite a sizable supply of its own.
[57] "United States Nuclear Regulatory Commission Glossary: Yellowcake," www.nrc.gov/reading-rm/basic-ref/glossary/yellowcake.html, accessed Nov. 14, 2016.
[58] "United States Nuclear Regulatory Commission Glossary: Heap Leaching and Ion-Exchange Facilities," www.nrc.gov/materials/uranium-recovery/extraction-methods/heap-leach-ion-exchange.html, accessed Nov. 14, 2016.

UO_2. Pellets of ceramic uranium dioxide are sealed into corrosion-resistant tubes made of zirconium alloy, in Argentina's case; these tubes are then mounted on special assemblies to be loaded into the reactor.[59] This step is called fuel element fabrication. At this point in the nuclear fuel cycle, natural uranium reactors with heavy water moderator, like those in Argentina, can be fueled with no problems, though today uranium metal enriched to 0.85% is added to the UO_2 in the fuel for Atucha I,[60] Latin America's first nuclear power reactor that has been in operation since 1974. A pilot plant for fabrication of fuel elements was built at the Centro Atómico Constituyentes in 1976; six years later, a full-size factory began production under the auspices of CONUAR S.A., a state-sponsored firm chartered at Centro Atómico Ezeiza in October 1981.[61] Uranium enrichment, again, is *not* necessary to fuel Argentina's power reactors, but when CNEA agreed in 1977 to build and transfer a 10 MW research and isotope production reactor to its Peruvian counterpart, IPEN, that reactor (and other similar reactors that would be constructed at INVAP and shipped to destination countries) would be fueled by enriched uranium. Small research reactors typically use highly enriched uranium (20% ^{235}U or higher) to allow their designs to remain compact yet allow for a high neutron flux, or rate of neutron flow through a given space.[62]

Uranium enrichment is simply the conversion of natural uranium – over 99% ^{238}U, which cannot support the fission chain reaction that give nuclei of atoms their immense potential power as nuclear energy – into higher percentages of the fissile ^{235}U isotope, in which

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[59] "World Nuclear Fuel Cycle…," 42.
[60] "Central Nuclear Atucha I," http://www.monografias.com/trabajos/atucha/atucha.shtml, accessed Nov. 14, 2016.
[61] CNEA timeline, 1976, 1982 (http://www.cnea.gov.ar/decada4) and http://www.conuar.com/quienes-somos/, accessed Nov. 24, 2016.
[62] Committee on the Current Status of and Progress Toward Eliminating Highly Enriched Uranium Use in Fuel for Civilian Research and Test Reactors, National Academy of Sciences, *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors.* (Washington, DC: The National Academies Press, 2016), 9-10.

chain reactions can be triggered by free neutrons. Many methods of enrichment were available to Argentina's CNEA in the late 1970s, and the reasons of its enrichment project leaders for choosing gaseous diffusion will be explained at greater length below. In brief, gaseous diffusion technology relies on the infinitesimal difference in mass between the lighter fissile uranium-235 isotope and heavier uranium-238, separating the two by pushing a stream of uranium hexafluoride gas through semipermeable membranes, which allow the smaller desired uranium atoms of mass 235 to pass through instead of the non-fissile atoms of mass 238. The design of these membranes would prove one of the knottiest technical challenges to the Argentine technicians and engineers that pioneered autonomous enrichment technology.[63] Because the difference in mass between the two uranium isotopes is so small, "cascades" of successive stages of enrichment must be used to obtain sufficient commercial quantities of the lighter fissile isotope. These cascades build upon the previous enrichment steps and make more efficient use of the depleted uranium stream, containing whatever "hex" gas was not forced through the membranes.

After an enriched uranium reactor's operating cycle is complete, fuel that has been used in the power reactor's core has been stripped of fissile ^{235}U, and what is called the "depleted uranium" left behind is predominantly uranium-238. The reactor shuts down for refueling, and "spent fuel" rods are stored in water, both to cool the fuel elements (where continual radioactive decay is producing additional heat) and to protect the environment from ionizing radiation. This step, called interim storage, occurs either at the reactor site or at a central storage location distant from reactors. Reprocessing, the next stage in the fuel cycle, separates fissile isotopes of uranium-235 and plutonium-239 from the spent fuel, as well as any fertile uranium-

[63] Personal communication from Eduardo Santos, CNEA's contractual representative to INVAP at the time the secret uranium enrichment project began, and later Chief of Operations of the Mock-Up enrichment module.

238 (fertile isotopes can be converted into fissile ones by absorbing a neutron and undergoing subsequent conversions of their nuclei).[64] Without reprocessing, there can be no recycling of uranium and plutonium as nuclear fuel, and so nations with nuclear power programs would be far more preoccupied with the finite quantities of uranium available for mining. (The CNEA timeline notes that construction began on a pilot plant for reprocessing at the Centro Atómico Ezeiza in February 1979, one of the audacious steps taken during this "autonomous decade").[65] Last in the nuclear fuel cycle is waste disposal. A brief account of Argentina's quest to produce heavy water – which slows down neutrons in order to increase the likelihood that they will react with fissile ^{235}U atoms, and not be absorbed by the heavier inert atoms of mass 238 – follows here.

A brief history of heavy water production in Argentina[66]

In the aftermath of the 1973 petroleum embargo crisis, as already discussed, CNEA's leaders drew up the *Plan Nuclear 1975/1985*. In addition to the more attention-grabbing nuclear power reactors and a stated intention to continue working toward 100% Argentine control and usage of the full nuclear fuel cycle, a less glamorous promise appeared: construction of a plant for the industrial production of heavy water. Though Heavy Water Projects attained the status of a department or division within CNEA as late as 1974, the initial work to separate deuterium oxide from standard H_2O or "light water" had begun in the first half of the 1950s.[67] Juan MacMillan, head of the stable isotopes laboratory, worked with Italian scientist Mario

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[64] Reprocessing is one of the most controversial steps of the nuclear fuel cycle in any discussion of nuclear weapons proliferation, because the resulting plutonium and fissile uranium can be diverted for use in a covert weapons program.
[65] CNEA timeline, 1979.
[66] After the strictures of both IAEA INFCIRC/254 and the US Nuclear Nonproliferation Act (NNPA) made the sale of heavy water to Argentina an illegal action under international law, CNEA's September 1979 contract for a "turnkey" heavy water production plant from Swiss firm Sulzer Brothers Ltd. may have seemed a radical departure from its traditional emphasis on autonomous, indigenous development of nuclear technology.
[67] Luis Fernando Conde Bidabehere, *Agua Pesada: Un proyecto original en la Patagonia Argentina* (Buenos Aires: Editorial Ciencia y Tecnologia, 2000), 28.

Marchetti to build a distillation column that relied on the difference in the boiling points of deuterium oxide (101.5° C) and light water (100° C). Barán and Cretella began to study isotope-exchange of deuterium in 1960, using hydrogen gas and water vapor, and measuring the catalytic activities of platinum and aluminum on that reaction. Conde notes that the glass distillation column (5.5 cm in diameter and 33 cm tall) that these scientists used for their catalysis experiments was the "real antecedent to the enormous [metal] ones existing today at Arroyito."[68] Cretella and Silberman, after talking to scientists in Europe, envisioned a heavy water plant in Argentina that would produce 20 tons annually, using a US-developed process of isotope exchange between H_2S – hydrogen sulfide – and water. This process would require a large amount of water with a high natural content of deuterium oxide, and natural gas as a source of heat, but avoided reliance on another chemical input, ammonia.

In 1970, as construction was beginning on Atucha I, Jorge Cosentino asked Aníbal Núñez, manager of the reactors division, to carry out a study on methods of heavy water production around the world.[69] Núñez and Cretella were also charged with updating the potential investment and operation costs for a heavy water plant capable of producing 400 tons per year. A permanent work group formed out of this fact-finding mission, which by the end of 1974 had grown to include 20 members. Conde notes that the entire transition of the heavy water project from work group to "area" to full department took place in the democratic interregnum of 1973-1976. The head of the division, Gerardo Videla (no relation to 1976-1981 dictator Jorge Rafael Videla), initiated contact with the Universidad Nacional del Litoral (in Santa Fe) to have its chemistry specialists in the Department of Engineering begin planning a pilot plant in 1975.

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[68] Conde Bidabehere, *Agua Pesada*, 29.
[69] Conde Bidabehere, *Agua Pesada*, 30.

Prior to Videla's contacts with the chemists, a feasibility study had analyzed "the world market, Argentine demand, methods of heavy water production, satisfaction of demand, location, domestic participation, possible schedules, economic and financial aspects, and methods of contracting," and arrived at a total estimate of 4000 tons of heavy water to furnish eight nuclear power plants running on natural uranium fuel through 1990.[70] Videla's official proposal to CNEA maintained the consistent emphasis on developing Argentine capabilities in all facets of nuclear technology and engineering: "*Acquisition* of an industrial plant based on exchange of SH_2/H_2O of 400 tons annual production, and at the same time, the installation of a pilot plant, *domestically built*, intended for the training, technical knowledge, and development of personnel prepared to operate the industrial plant, and also for *the design of new heavy water plants or expansion of the existing one*." In short: Argentina would buy its industrial-scale heavy water plant from another country, but that would be the end of its dependence on foreign physical capital and technical know-how in the vital field of heavy water production.

Videla and his team knew at the time of the feasibility study that heavy water was a rare commodity indeed; only four countries (Norway, the United States, India, and Canada) operated industrial-scale heavy water production plants. Only Canada could export any part of its deuterium oxide, since the other three nations used all of their heavy water for their own nuclear reactors. Hydrogen sulfide/light water exchange was chosen as the method of production because it would not require 5,000 tons of ammonia *daily*, as would an ammonia distillation, ammonia-hydrogen exchange, or aminomethane-hydrogen exchange (developed in Canada and planned for an industrial prototype, but scuttled in 1979).[71] The team rejected isotope exchange between hydrogen gas and water as expensive and having persistent

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[70] Conde Bidabehere, *Agua Pesada*, 34.

[71] A.I Miller, "Heavy Water: A Manufacturers' Guide for the Hydrogen Century." *Canadian Nuclear Society Bulletin*, 22, no. 1 (2001): 7.

unresolved problems with catalysis; distillation was attractive for the final step of increasing concentration of deuterium oxide, but not for the whole process on an industrial scale. Only the H_2S/H_2O exchange method offered "unlimited production capacity and a full and proven industrial [scale] development."[72] See Figure 3 for 1974 CNEA figures for projected demand of deuterium oxide/heavy water until 1990.

Figure 3. Demand for heavy water in the Argentine Republic projected through 1990 (Note: *x* axis proceeds chronologically by year, *y* axis by planned commissioning of nuclear power plants I-X).

DEMANDA DE AGUA PESADA EN LA REPUBLICA ARGENTINA (devolución CARGA CENTRAL NUCLEAR II) (TONELADAS)													
C.N.	AÑO	Potencia (MW)	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	TOTALES
I	1974	319			3	3	3	3	3	3	3	3	24
II	1980	600		5	5	5	5	5	5	5	475	5	45
III	1982	600		470		5	5	5	5	5	5	5	505
IV	1984	600				470		5	5	5	5	5	495
V	1985	600					470		5	5	5	5	490
VI	1987	600							470		5	5	480
VII VII	1988	2 X 600								940		10	950
IX X	1990	2 X 600										940	940
PARCIALES ANUALES			-	475	8	483	483	18	493	963	498	978	4399
TOTALES ACUMULADOS			-	475	483	966	1449	1467	1960	2923	3421	4399	

Source: *Agua Pesada*, Luis Fernando Conde Bidabehere, 2000.

The site of the industrial heavy water plant was the next matter for Gerardo Videla's study team to resolve, and their decision depended on three factors: availability of water and its natural concentration of deuterium oxide; supply of electrical power; and availability of fuel in the form of natural gas, fuel oil, or coal. The necessity of infrastructure for transporting large industrial building and plant components to the site, as well as availability of specialized labor during construction and operation, lodging and transportation for the plant's employees, health

[72] Conde Bidabehere, *Agua Pesada*, 51.

and education facilities, and communications limited the selection yet further. The team deemed six rivers suitable as possible sources of water: Santa Cruz, Chubut, Limay, Tercero, Bermejo, and Paraná, and using the criteria above, recommended construction of the plant along the River Limay in Neuquén province, in the town of Arroyito.[73] In 1976, under the new direction of Adm. Carlos Castro Madero as head of CNEA, Núñez, Cretella, and a new divisional director, Amilcar Funes, estimated Argentina's heavy water needs through the year 2000 at 10,600-11,000 tons, planned a pilot plant of 20 tons/year to begin operation in 1980, an industrial plant to begin operation in 1984. Their combined production over five years would be sufficient for the new Atucha II reactor planned for 1985.[74]

A new *Plan Nuclear* was launched in 1979, presumably taking into account the knowledge that the United States, Canada, and West Germany would no longer supply heavy water, enriched uranium, or any other nuclear materials found on the London Club's "trigger list," though Conde only mentions Canada's increasingly cold feet on the Embalse reactor negotiations and that country's provision of heavy water to the Argentine nuclear program. The Canadian firm AECL would only design the Argentine heavy water plant if CNEA agreed to that firm's construction of the four planned nuclear power reactors.[75] Canada's nuclear regulatory organization, the Atomic Energy Control Board, insisted on safeguards criteria and a "meticulous control" over information supplied by AECL before approving the export of the CANDU (Canadian deuterium) reactor to Argentina; AECL found itself in a politically weak position, knowing the Canadian government – which would need to sign off on any technology

[73] Conde Bidabehere, *Agua Pesada*, 59-60, 67.
[74] Conde Bidabehere, *Agua Pesada*, 72.
[75] Canada's increasing proximity to the US in terms of a policy refusing to sell potentially proliferative nuclear technologies or material to non-signatories to the NPT is well-documented in both Conde's book and the work of Diego Hurtado. I have chosen to emphasize Argentina's *responses* to a tightening nonproliferation regime in this chapter rather than the actions of the suppliers intended to implement that regime.

transfer or any formal AECL-CNEA collaboration under a joint firm – might refuse to do so out of either nonproliferation or human rights concerns. The Argentine military regime did not want to renew its relationship with a Canadian supplier that it saw as increasingly fickle, and opted instead to have KWU, a German firm, build the Atucha II reactor, and a Swiss firm, Sulzer Brothers Ltd., construct the heavy water plant.

The resistance of AECL and the Canadian government, and their Argentine purchasers' intransigence, cost the *Proceso* government and CNEA dearly. For the price of the German KWU reactor alone, AECL would have sold its own CANDU reactor *and* the heavy water plant, essentially a two-for-one package deal.[76] In addition, Sulzer's proposal for the heavy water plant involved ammonia/hydrogen exchange technology and required immense quantities of ammonia.[77] The Swiss firm's only experience in heavy water plant construction was in collaboration with a German corporation, UHDE, to build India's Talcher plant, with a capacity of 70 tons/year, less than ⅕ of the annual production that Argentina envisioned in its feasibility study from 1975. Conde wrote that Sulzer's engineers were never actually sure that their "*sui generis* design" would function properly, and did so "in some measure thanks to the incalculable contributions of the Argentine technicians who launched it."[78]

Sulzer's contract for the "turnkey" ammonia/hydrogen exchange plant would cost US $640 million, but fines, delays, misestimates, debt servicing, and indemnities ran the total to approximately $1 billion, three times the estimate from the feasibility study; in addition, the 48 percent of construction to be done by Argentine labor did not materialize. Beggars could not be choosers, however: Argentina's defiant stance toward a nuclear nonproliferation regime

[76] Conde Bidabehere, *Agua Pesada*, 79.
[77] Conde Bidabehere does not say whether the hydrogen sulfide/water technology that the Argentines desired for the heavy water plant was proprietary to AECL.
[78] Conde Bidabehere, *Agua Pesada*, 78. An analysis of the contributions of these Argentines would be a welcome addition to the nuclear history of South America.

dominated by rich, industrial countries, many of whom possessed nuclear weapons meant that any firm willing to sell a heavy water plant to that country could dictate many of the terms of the sale, construction, and installation. The Swiss government accepted safeguards that were limited to the Arroyito heavy water plant itself, on far more generous terms to Argentina than the Canadians likely would have, in a "unique case in the entire world."[79] The Arroyito plant would not actually begin production of heavy water until 1994. Because most of the reactors envisioned in the Plan Nuclear 1975/1985 were never built, Argentina's demand for heavy water was a small fraction of what enthusiastic planners thought it would have been nineteen years prior to the plant's opening.

In 2016, Argentina's facility for heavy water production, however far short it may have fallen at the time from the ideal that CNEA's nuclear planning team had outlined in 1975, however behind schedule it was completed, and however more expensive Sulzer's alternative was than the Canadian deal that fell through, would be the largest heavy water producer in the world at 200 (not 400, as the 1975 feasibility study sought) annual tons.

Secret Enrichment in the Andes: Villa Golf and Pilcaniyeu

The history of Argentina's uranium enrichment plant at Pilcaniyeu has a concrete beginning date, June 14, 1978, when CNEA leaders proposed the plant for the first time to the commission's president, Carlos Castro Madero. Ironically, Richter's original choice of location for his nuclear fusion experiments in the late 1940s and early 1950s would benefit the technicians working on the enrichment project almost thirty years later. Pilcaniyeu is a hamlet

[79] Conde Bidabehere is frustratingly vague on what he means by this. Argentina almost certainly would have been the first purchaser of a heavy water *plant* of foreign manufacture in the post-Zangger Committee "trigger list" era; as a non-nuclear weapon state, regardless of whether it was party to the NPT or not, the purchase of either heavy water or the physical capital to produce it would have "triggered" safeguards. Before the Zangger Committee developed this list, of course, only facilities capable of producing radioactive materials required safeguards in non-nuclear weapon states.

of under 1,000 inhabitants[80] located approximately 40 miles east of the ski resort town of San Carlos de Bariloche, along Ruta Nacional 23, a ribbon of highway that traverses the southern third of Argentina's mountainous Rio Negro province. Rio Negro is nestled between Neuquén, to its northwest, La Pampa, to its immediate north, and the panhandle of Buenos Aires province to its east; Chubut, the third southernmost province of Argentina, is its only neighbor to the south.

Of course, the political impetus for self-sufficiency in the full nuclear fuel cycle had antecedents long before the second military dictatorship; the 1964 feasibility study for Argentina's first nuclear power plant, Atucha I, mentioned the country's history of petroleum dependency as a motivation for energy independence moving forward.[81] Such a highly coveted technological advancement as autonomous uranium enrichment capability would not wait long for the director's blessing. Castro Madero, President of CNEA; Hugo Juan Erramuspe, CNEA's Director of Research and Development; Conrado Varotto, General and Technical Director of INVAP, later to be Principal Investigator of the enrichment project; Marrero, a naval captain and CNEA's director of planning; Eduardo Santos, CNEA's contractual representative to INVAP and chief of operations of the Mock-Up test enrichment module; Juan José Olcese, Director of CNEA's Centro Atómico Bariloche, where the semipermeable membranes for diffusion were built; and Renato Teriggi, accountant and Director of Administration for CNEA, signed the Act of Creation for the Pilcaniyeu enrichment facility on August 2, not even two months after CNEA personnel made their proposal.[82] A memo appended to Joint Resolution no. 252 from January 1978 listed the objectives of the secret project: to "develop materials,

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[80] 757, to be exact, according to Argentina's INDEC (Instituto Nacional de Estadística y Censos) census of 2010, just more than half its estimated size in 2011.
[81] Santos, "Charla 2.0.ppt," slide 3 of 60 [digital PowerPoint file], ESDA.
[82] Names and titles of the signers from personal email communication with Eduardo Santos, July 14, 2017. Neither he nor I know Marrero's first name.

processes and equipment, execute the detailed engineering[83], complete the assembly and begin operation of a gaseous diffusion uranium enrichment plant, with a capacity between 2,000 and 20,000 work units."[84] After the paragraph of quantities and technical information, the memo justifies the project as enabling "the capacity to produce [CNEA's] own enriched fuels for research reactors and/or the production of radioisotopes," and "acquiring, on behalf of the country, the capacity for international negotiation in an area sensitive for national security."

The *Acta de Creación* for the enrichment plant that would eventually be located at Pilcaniyeu outlined plans for a facility that would produce uranium enriched to 20% with an annual capacity for production between 50 and 500 kg. In a slide based upon a regional geology study from 1975, and a hypothetical analysis of the "maximum foreseeable [radiological] accident" in 1979, Pilcaniyeu was justified as a "site appropriate for nuclear power installations" based on its geology, climate, water available for cooling, a low population density (in case of a catastrophic radiological accident or nuclear error), nearby railroad access, Ruta Nacional 23 which 'would be paved within 3 years', gas and electricity able to be connected soon, and most intriguingly, "an isolated place, ideal for 'mysteriometry.'"[85] Work would take place under the guidance of the Program for Applied Research of the Centro Atómico Bariloche, nestled in the Andes almost 1,000 miles southwest of Buenos Aires. INVAP (*Investigaciones Aplicadas*, or "Applied Research"), the government-owned company that had spun off from CNEA in 1976, would assist with hiring of technicians and scientists for the new project.[86] Three titles of

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[83] The phrase *ingeniería de detalle* refers to a stage of engineering after *ingeniería básica* and refers to engineering during phases beyond basic and preliminary calculations, models, and cost-benefit analyses; construction begins after *ingeniería de detalle*.
[84] "Anexo a la DDG 1/78," reproduced in Eduardo Santos's PowerPoint file "Charla 2.ppt", created June 9, 2008. Separative work units are not a measure of energy, but rather the amount of isotopic separation of uranium performed by a given enrichment process or facility. ESDA.
[85] Santos, Charla Pública 2.0.ppt, slide 26. ESDA. (His "sic" might refer to a delay in asphalting Highway 23).
[86] The original Spanish is *contrataciones parciales*, and this may well have a more specific meaning than I have translated here.

individuals – Director of Research and Development, Chief of the Department of Planning, and Director of the Centro Atómico Bariloche - were given at the end of the document before one personal name, that of Dr. Conrado F. Varotto, the leading mind behind INVAP, as "recognizing an agreement" on the document above.[87]

On August 6, 1978, a small crew of CNEA leaders and technicians settled into Villa Golf, a name given by INVAP members to an enrichment test site approximately 25 km (15.5 mi) from Bariloche.[88] There, they inaugurated the "technological package," a two-part plan for autonomous, parallel nuclear development. This event is somewhat humorously noted in the calendar of events that would lead to the construction and operation of the full-scale Pilcaniyeu enrichment facility, approximately 60 km from Bariloche: "We had whiskey and breadsticks for lunch," presumably as an appropriately unadorned celebration for a planned high-technology site with such humble beginnings, as depicted in Figure 4.

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[87] The document, as Santos notes in his slide presentation from 2008, is signed by seven distinct individuals, which is the same number that he identified in the email from July 2017 explaining his answers to my questions. I do not know the reasons for this discrepancy.
[88] Hurtado, "Periferia," 17.

Figure 4. Sheep shearing shed at future Pilcaniyeu enrichment site, *c.* 1978. Source: ESDA.

At the Villa Golf laboratory, technicians would develop and try "basic processes," such as the production of uranium hexafluoride (UF_6) and fluoride gas as its byproduct, the production of aluminum oxide and membranes, passivation (the use of a protective material, such as a metal oxide, to create a shell against corrosion), and gaseous diffusion, the method by which CNEA leaders had chosen to enrich uranium. (See Figure 5 for Santos's chart comparing Argentina's suitability for diffusion vs. centrifugation processes). The second part of the plan was to design the industrial plant that would carry out the enrichment process.

Figure 5. Comparison of uranium enrichment technologies of gaseous diffusion and centrifugation. Table by Eduardo Santos, ESDA.

La Elección

	Difusión	Centrifugación
Elementos Esenciales de la Tecnología	Membranas Compresores	Rotores Válvulas especiales Cojinetes magnéticos
Resistente a la proliferación	Muy resistente	Poco resistente
Tecnología	Accesible en el país	No accesible en el país
Capacidad en CNEA	Cerámicos SI Vacío SI Ing. Química SI Control SI Ing. Mecánica SI	Maraging NO Fibras NO Cojinetes NO Ing Química SI Control SI Ing Mecánica SI

In an abbreviated account of the calculation of the most appropriate option for Argentina of the two options available to them for uranium enrichment, gaseous diffusion and centrifugation, Santos included a digest of information on diffusion that had been declassified by the US Department of Energy. Information left classified is typed in red on these slides. Under the category of physics, "basic theoretical work on [the] reflux separation process" without reference to diffusion cascades, and "basic theoretical work on cascade design, kinetic chemistry, and thermal diffusion" without revealing production methods in the diffusion plant" were available to the pioneers of Pilcaniyeu. Under the category of chemistry, "theoretical work on chemical kinetics such as [that] developed in connection with corrosion problems, without reference to the conditioning of barriers," and "analytical methods for materials used in the gaseous diffusion plant, except insofar as they may reveal plant practice[s] and production."[89]

Argentine nuclear experts would therefore be responsible for their own processes of anything classified above: developing diffusion cascades, production methods for the future plant, the "conditioning of barriers" – where piping and equipment may have been cleaned and prepared before installation,[90] specific "plant practices and production" for the planned facility, and the design of compressor shaft seals. A pilot enrichment plant used a 20-step cascade and "membranes made in the laboratory" successfully made a one-gram sample of enriched uranium on Feb. 23, 1981. Nine more tests were run, ending on May 17, 1982,[91] before the pilot plant was shuttered in February 1983. "For us, it was revenge for Malvinas," Santos notes somewhat cryptically of the relationship between successful uranium enrichment on a test scale and the 2½-month war launched by the Argentine military dictatorship and armed forces in 1982, intended to pry the Malvinas/Falkland Islands from the control of the United Kingdom.[92]

1979 and 1980 were eventful years in Argentina's nuclear development, both inside and outside Pilcaniyeu's secret enrichment facility. At the Villa Golf test enrichment site, on May 15, 1979, 10 kilograms of uranium hexafluoride gas, the necessary eventual input to the gaseous diffuser, were successfully produced.[93] Later that year, on October 4, nickel plating

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[89] In general information, the Department of Energy had declassified the fact that "US gaseous diffusion plant compressor shaft seals operate on the gas bearing principle," but without details on the design of the seals themselves.

[90] Conditioning seems to refer to a broad set of processes to prevent the negative effects of corrosive uranium hexafluoride gas on metals in the enrichment plant, including nickel-plating of iron and steel parts. See, for example, http://www.k-25virtualmuseum.org/site-tour/the-war-effort-in-east-tennessee.html, accessed Nov. 26, 2016.

[91] Calendar entries for "Experiencia en DDG." ESDA.

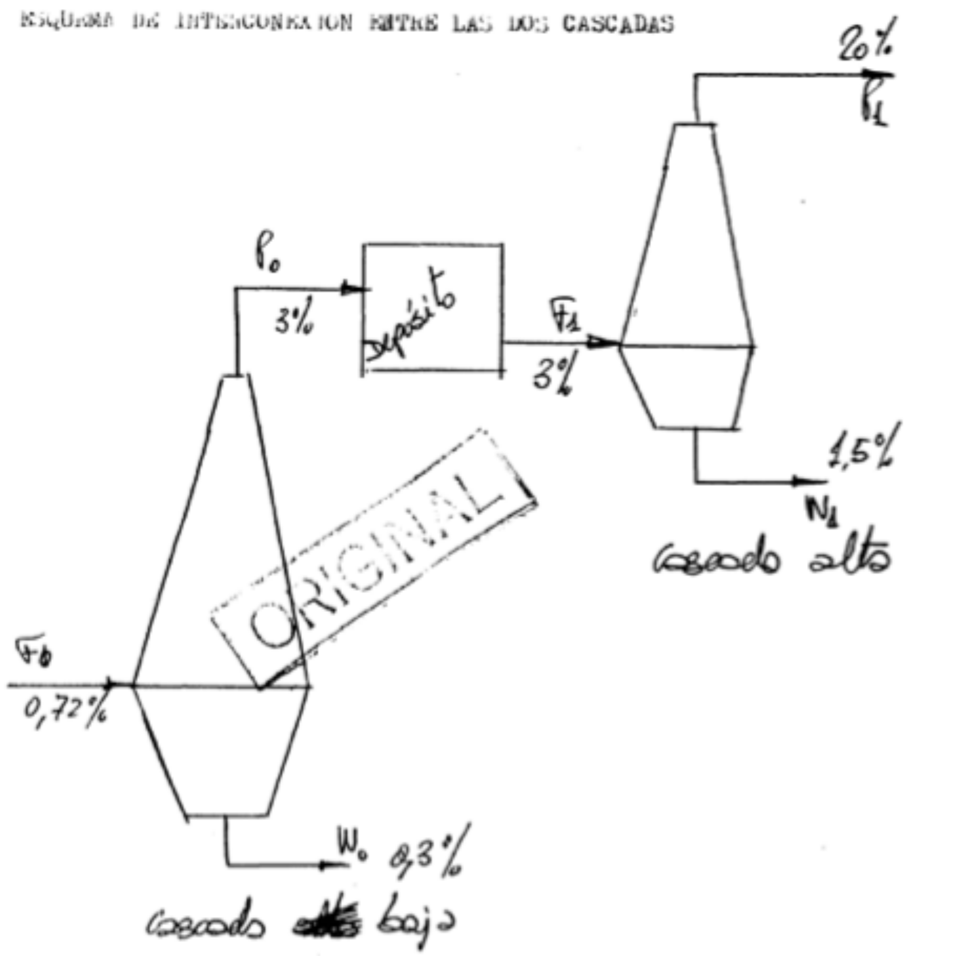
[92] The Malvinas conflict had an immense impact on nuclear technologies and nonproliferation ideas in Argentina. As the proverbial straw that broke the camel's back of the military *Proceso* regime, its aftermath threatened both developments inside and outside the auspices of the global nuclear nonproliferation regime. Also, the open question of whether Britain had violated the terms of the Treaty of Tlatelolco by sending a nuclear submarine to the disputed islands (and whether Argentina was entitled to its protections without the agreement having formally entered into force there) remained a contentious issue for years to come.

[93] Pilcaniyeu Enrichment Calendar, ESDA.

arrived, presumably for conditioning any metal parts from the corrosive effects of uranium hexafluoride gas. Assembly of the test diffusion setup was completed on May 2, 1980, one month before the contract for PEMIN (an amusingly vague acronym for “Experimental Plant for Materials of Nuclear Interest) was approved. PEMIN would develop graphite anodes for uranium enrichment at extremely high temperatures, presumably for use as a reducing agent to transform uranium oxides into uranium metal.[94] A conceptual design for two interconnected diffusion cascades outlined a first cascade fueled by natural uranium, intended to produce 9,120 kg per year of uranium enriched to 3% ^{235}U, and leave a depleted uranium “tail” enriched to 0.3%; the second cascade, fueled by the 3% enriched uranium from the first cascade, would produce 50 kg/year of 20% enriched uranium, leaving a tail depleted to 1.5%, as shown in Figure 6.[95]

[94] https://www.cab.cnea.gov.ar/index.php/es/areas/tecnologia-nuclear-innovativa, and Willit, J.L., W.E. Miller, and J.E. Battles, “Electrorefining of uranium and plutonium – A literature review.” *Journal of Nuclear Materials* 195 (1992): 231.
[95] Charla Pública 2.0.ppt, slide 24, ESDA.

Figure 6. Graphical representation of two interconnected diffusion enrichment cascades as designed in 1979.



Source: Eduardo Santos PowerPoint presentation slide, ESDA.

Having agreed on the technical details of its plan, CNEA officially acquired the Pilcaniyeu site for construction of the plant, began a "massive competition to recruit people" to the secret enrichment project, signed a contract with INVAP to build the installations at the new site on October 2, then "burned the ships," officially moving operations away from Villa Golf to Pilcaniyeu on October 10.[96]

[96] Pilcaniyeu Enrichment Calendar, ESDA.

In 1981-1982, as the uranium enrichment team conducted ten experimental runs of gaseous diffusion at Pilcaniyeu, Santos notes the civil engineering accomplishments in construction of the Mock-Up (a test plant to operate the full diffusion process on an industrial scale, including a facility to treat the surfaces of diffusion mechanism components with anti-corrosive coating; see Figure 7), PEMIN, the facility for the production of semipermeable diffusion membranes, and workshops.[97]

Figure 7: Construction of A1/"Mock-Up" 1:1 scale pilot for first enrichment phase.

Source: Eduardo Santos PowerPoint slide, ESDA.

The Mock-Up's trial-and-error name actually belied its complexity. At first, engineers on the enrichment project had hoped to build a nonfunctional wood and plastic model to resolve any potential problems with pipes, but opted instead to construct a module that would run 20

[97] The TECNIN page also explains the function of the Mock-Up, the topic of many 1982-1983 entries on Santos' calendar. https://www.cab.cnea.gov.ar/index.php/areas/tecnologia-nuclear-innovativa, accessed Nov. 24, 2016.

steps of uranium enrichment and "used it to resolve technical problems in the most efficient and economic way."[98] By July 20, 1982, Pilcaniyeu had a 500-kilogram stash of uranium hexafluoride gas to provide the stream for diffusion. In 1982, Santos explains, CNEA leaders expanded the goals for the enrichment work to meet the fuel needs of a nuclear propulsion reactor for a submarine. By 1985, enrichment on an industrial scale had been successful enough that they sought to supply Atucha I and II with low enriched uranium.[99]

But few Argentines had their minds on celebrating unprecedented national achievements in nuclear energy at that time. In April 1982, General Leopoldo Galtieri (leader of the "third junta," after Jorge Videla's and Roberto Viola's rule) made the fatal misstep that would bring the *Proceso* military regime to its end. The Malvinas, or Falkland Islands, roughly 300 miles from the southern coast of Argentina, had been a possession of the British Crown since 1841; Galtieri and his advisers calculated that a war to retake possession of the Malvinas, South Georgia, and South Sandwich Islands might motivate patriotism in the Argentine public, distracting them from the regime's economic turmoil and widespread systematic abuses of human and civil rights. The militarily superior United Kingdom defended the islands with relative ease, and the Argentine retreat laid bare a dual humiliation of the military as soldiers and as a governing body. The Malvinas War also had quite significant, but under-explored, implications for military and peaceful uses of nuclear energy in Latin America, and briefly thrust the Treaty of Tlatelolco and OPANAL organization to center stage in responding to a particularly bitter episode of the conflict.

Whether British forces had planned to ever use nuclear weapons in the brief but bitter Malvinas conflict is certainly up for debate, but in Kingston, Jamaica, at the 1983 General

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[98] Eduardo Santos personal communication via email, July 2017.
[99] Charla Pública 2.ppt, slide 28; Charla Pública 2.0.ppt, slide 9. ESDA.

Conference meeting of OPANAL, Argentine observer Altilio Molteni suggested exactly that, based on Margaret Thatcher's words at the Second UN General Conference on Disarmament that nonproliferation promises were "never able to be reliable" in the environment of war.[100] However, the primary controversy around Tlatelolco and Malvinas had to do with *Britain's* commitments to the Latin American nonproliferation agreement as a nuclear-weapon-state, as ratified on Dec. 11, 1969, not to employ nuclear power for warlike purposes within the Tlatelolco zone. Argentina's claim that their military opponents had violated that agreement stemmed from the British having deployed nuclear submarines to the treaty zone. On May 2, the nuclear submarine *HMS Conqueror* fired three torpedoes at Argentina's light cruiser *ARA General Belgrano*. The two hits at 4:00 pm sank the *Belgrano*, and 323 Argentine crew died, representing half of Argentina's fatalities from the three-month conflict.[101] Britain maintained in its two-pronged defense that nuclear submarines were not explicitly prohibited as weapons under the Tlatelolco Treaty, and that Argentina had no rights to claim under that treaty, as they had never ratified and waived Article 28 to bring it into force.

In 1982, later revealed in *Clarín* and other news outlets, the Argentine military came as close as they ever had to constructing a nuclear weapon.[102] Under the direct orders of Galtieri, then head of state, a group of engineers and physicists were working on designs for a laboratory to make metallic plutonium and a neutron reflector, useful in preventing a fission chain reaction from destroying the weapon itself while it is detonating.[103] The primary designer

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[100] Ryan A. Musto, "Tlatelolco Tested: The Falklands/Malvinas War and Latin America's Nuclear Weapon Free Zone." NPIHP Working Paper #7, Woodrow Wilson International Center for Scholars, July 2015, 10.

[101] Rosana Guber, "Crucero ARA 'General Belgrano' in memóriam. Linajes político-navales en las memorias de Malvinas." *Iberoamericana* 8, no. 30 (2008): 8-9.

[102] Daniel Santoro, "El plan de Galtieri para hacer la bomba atómica." *Clarín*, January 8, 2006.

[103] The journalist incorrectly states that neutron reflectors can only be used in nuclear weapons; they are often also used in reactor cores of power plants. But Rapacioli's later statements contradict any peaceful use intentions for the laboratory's activities.

of the laboratory was Ricardo Rapacioli, army colonel and holder of a doctorate in physics, with whom Galtieri had been in contact since the general toured the Centro Atómico Bariloche in 1976.[104] Rapacioli unequivocally referred to the secret activities as military in nature in a resumé from 1989 that he sought to support his promotion to general. The article states that this secret program existed from 1980-1982; presumably, it ended sometime during or after Argentina's disastrous defeat in the Malvinas War, though the journalist does not say so.

1983 opened on a somber note back at Pilcaniyeu. Santos noted alarmingly that "the Mock-Up is leaking like a sieve" in an entry from Jan. 20, 1983. Six months later, when the Mock-Up was first put to the test, it failed miserably: "Todo se rompe!!" (Everything breaks!)[105] The Mock-Up had been plagued by problems, and thus could only run for short periods. Everything from insufficient instrumentation to poor heat extraction demanded a trial and error process to fix the issue.[106] But on July 15, the Mock-Up ran for nine hours according to plan; a "large fraction" of natural uranium hexafluoride gas "decomposed" into 5 units "full of low enriched uranium."[107] The second trial of the Mock-Up ran for four days at the end of July, and a third from August 26-31. Little information is given about either of these trials in Santos' slides. A final test, with the Mock-Up connected to the A1 module where the diffusion cascades would run, was intended to produce 1 kg of uranium hexafluoride enriched to 0.80% with a 60-step cascade. This test ran from November 10-18, 1983. Due to malfunction of the seals in four compressors of Module 1, the resulting 0.781% share of uranium-235 fell just short of the goal of 0.80. The very next day, Argentine newspaper *Clarín* carried Castro Madero's public announcement that Argentina had mastered uranium enrichment with the banner headline

[104] Santoro, "El plan de Galtieri," *Clarín*.
[105] Pilcaniyeu Enrichment Calendar, ESDA.
[106] Eduardo Santos email correspondence, July 2017.
[107] Charla 2.ppt, slide 55. ESDA. This part of Santos' archive is rich in technical information on the trial runs at the Mock-Up and their relative degrees of success in separating the two isotopes of uranium.

"Argentina produce ya su propio uranio enriquecido" (Argentina now produces its own enriched uranium).[108] Castro Madero had secretly met with president-elect Raúl Alfonsín on November 11 to inform him of the secret project and its successful outcome. In 1985-1986, after what Santos called the "economic disaster" of 1984, technicians finished developing and improving the compressors in the enrichment plant; a failure rate of 1 per 10,000 hours of operation seemed to confirm that the problems that had plagued their efforts in 1983 had been solved.

Coda: Enriched uranium, depleted Argentina

The history of parallel and authorized nuclear development in Argentina between 1975-1985 is inseparable from domestic politics and an international tightening on markets for technology and material for nuclear power plants. The push during this decade to restrict nuclear transfers came primarily from the wealthy industrial nations of the Global North. The United States and its allies, frightened by India's successful nuclear test explosion of 1974, were determined not to have another nation obtain nuclear weapons capabilities as the South Asian nation had, though the nuclear weapon capabilities of India and Israel were by then open secrets. The trifecta of "trigger-list" technologies – heavy water production, spent fuel reprocessing, and uranium enrichment – developed by Argentina in this decade stand to this day as sources of immense national pride in scientific achievement. That pride stands in sharp relief to the economic, military, and human rights nightmare years under the authoritarian *Proceso de Reorganización Nacional.* A human symbol of this jarring contrast might well be Carlos Castro Madero, the ambitious naval admiral who led CNEA as president for most of this period. Castro Madero oversaw Argentina's transition to being an exporter of advanced nuclear

[108] The reasons for the timing of Castro Madero's announcement mere days before the transfer of power from Reynaldo Bignone, leader of the "fourth junta" to democratically elected president-elect Raúl Alfonsín are both curious and intensely debated. Image of front page of November 19, 1983 *Clarín* thanks to Eduardo Santos.

technology in the same years that he took an ambiguous stand toward the brutal repression of the military and police bent on rooting out "subversion" in intellectual centers around the country.

One last example of the sort of juxtaposition that fills the nuclear energy history of this decade in Argentina is somewhat less heavy than the topic of mass state terror, but still puzzling: On February 3, 1983, Eduardo Santos, one of the pioneers of uranium enrichment at Villa Golf and Pilcaniyeu, noted on his calendar that the facility, an astounding example of technological autonomy in its sheer complexity and advancement, still did not have a telephone connection. Argentina's motivations and means for remaining on the path toward ever more advanced nuclear technology development did not change, even as they navigated around the obstacles that a nonproliferation regime seen as an onerous intrusion on national sovereignty threw onto that path.

Chapter 5: Fabrication

Parallel Nuclear Development in Brazil, 1975-1990

In the mid-1970s, the divergence between Argentine and Brazilian policymakers, technicians, and diplomats on nuclear energy policy continued to widen from the late 1960s, when the relationship was closer and warmer in the post-Treaty of Tlatelolco years. As seen in Chapter 4, Argentina's military government massively increased funding to its nuclear energy program in 1976, hoping to attain domestic control of the full nuclear fuel cycle, and helping to position the nation as an exporter of advanced nuclear technology equipment built by the state-operated INVAP firm to other developing, non-aligned countries. Where Argentina's *Proceso* generals became secretive and turned inward to achieve their nuclear energy aims, Brazil's leaders, particularly Gen. Ernesto Geisel, instead looked outside the nation's borders, building on six years of close trans-Atlantic technical cooperation with West Germany to craft a massive agreement in 1975 that would bring two large nuclear power reactors to Brazil, along with a heavy components facility, a pilot nuclear fuel element fabrication plant, jet-nozzle uranium enrichment capability, and a small fuel reprocessing plant.[1] The Brazilian Navy began to expand its outsized role in nuclear energy activities, running a "parallel program" starting in 1979 with the cooperation of the Army and Air Force and CNEN itself.[2] The parallel program's objectives included completing the full nuclear fuel cycle and building a nuclear submarine, and may have led an effort – abandoned in very early stages – to conduct a nuclear explosion test.

Because the parallel program was conducted in secret, this chapter cannot offer much new evidence on it beyond a discussion of its aims and its considerable achievements, official actions taken afterward (the fourth and final nuclear parliamentary inquiry commission of

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[1] William W. Lowrance, "Nuclear Futures for Sale: To Brazil from West Germany, 1975." *International Security*, 1(2), Fall 1976, 151-152.
[2] Togzhan Kassenova, *Brazil's Nuclear Kaleidoscope*, 23.

1990), and accounts by some of its participants from an oral history conference in Rio de Janeiro in 2012. The 1979 launch of the parallel program was a direct response to the Brazilian armed forces being "disillusioned with the outcomes of cooperation with West Germany."[3] This chapter proceeds in four main parts. The first examines the logic and diplomacy that supported the 1975 technology transfer agreement between the governments of Brazil and West Germany and the IAEA, as well as the text of the agreement itself. The second details the numerous arguments against that agreement by the nuclear physics and engineering communities. The third examines the rise and activities of the parallel program under the auspices of the Brazilian Navy (and coordinated efforts by the other two branches of the armed forces), and the last section will explain the aftermath of the parallel program – and the question of whether a secret nuclear explosive project was underway – in the first years of the return to democratic rule in Brazil.

In a confidential memo dated April 2, 1974, Foreign Minister Antonio Azeredo da Silveira detailed Brazil's outlook for uranium enrichment technology to Ernesto Geisel, who had been president of the Republic for just over two weeks. After stating that natural uranium is over 99% U_{238}, and that the much rarer 235 isotope was "the only fissile material found in a natural state and constitutes the point of departure for any nuclear fuel cycle,"[4] Azeredo noted that more than 80% of civilian nuclear power reactors, whether installed or planned, used low-enriched uranium, or LEU; Canada, India, and "recently" Argentina were among the few nations using natural uranium in reactors moderated by deuterium oxide, or heavy water. Their reasons for opting for natural uranium – and the path-dependent accompanying technologies and materials that came with it – were summarized by Azeredo as granting them

[3] Kassenova, *Kaleidoscope*, 23.

[4] Paulo Nogueira Batista, Memorandum, "Enriquecimento de Urânio," April 2, 1974, AMREB, via Wilson Center Digital Archive, 1.

"independence in the face of the virtual monopoly of the superpowers in the field of uranium enrichment." Indeed, only three known processes could enrich uranium at the time: gaseous diffusion, centrifugation, and the "jet nozzle" process.

Azeredo identified the six nations that possessed uranium enrichment technologies – the US, USSR, UK, France, Netherlands, and West Germany – and which ones they used. Notably, the West Germans were the only ones using the "jet nozzle" process; this technology, unproven on an industrial scale, would prove several times a sticking point between the Brazilian scientific community, in particular, and their European nuclear technology partners. Azeredo's proposal to enter into a collaboration with one or more European countries with the infrastructure and know-how to enrich uranium would put Brazil in an increasingly crowded field, which much of the rest of the memo covers in detail.

The rest of Azeredo's memorandum, indeed, betrays a deep uncertainty about what the actions and positions of the United States, by far the leading provider and user of enriched uranium, would mean for the rest of the world's -- primarily western Europe's – rapidly growing needs for the nuclear fuel for civilian power reactors. Brazilian foreign officers and scientists, therefore, were highly attuned to developments in Europe to collaborate and ensure a steady continental supply of enriched uranium, and kept up with the rapid pace of technological change and cooperation on the other side of the Atlantic. In the face of uncertainty regarding future American policy on providing enriched uranium, the UK, Netherlands, and West Germany had banded together in 1970, "for economic reasons and increasingly for political ones," to develop the new ultracentrifugation technology, which used one-tenth the energy input of gaseous diffusion and required plants only one-fifth the size of those devoted to that older enrichment process.[5] The URENCO firm was to be incorporated in England – where it still stands, in Stoke Poges, Buckinghamshire – for this exploratory work.

The partnership's initial capacity estimate for the plant of 360,000 separative work units (SWU) was increased more than eightfold to a revised goal of 3,000,000 SWU.[6] Countries that were outside looking in at URENCO did not take long to encourage different (or expanded) collaboration efforts for uranium enrichment: In 1971, France dropped plans to build natural uranium reactors and opted for enriched uranium fuel instead, hoping that its European partners might be interested in a continental collaboration for gaseous diffusion enrichment. At the Fourth Conference on Peaceful Uses of Nuclear Energy in July 1971, the US offered *access* to gaseous diffusion technology to a carefully-chosen set of transfer partners, including Western European nations, Japan, Australia, New Zealand, and Canada. At this Washington, DC meeting, attended officially by Brazil in an observer role, the Americans discouraged the construction of enrichment plants in other countries, but offered "know-how and equipment" for gaseous diffusion enrichment for "multinational projects" in exchange for a guarantee of peaceful use, secrecy of technical information, and acceptance of IAEA safeguards.[7] American officials envisioned five of these multinational collaborations with a "capacity of 2 million SWU per year, which should not affect the promises already made with the American reactors," but Azeredo did not seem so sure, interpreting the inconclusive results of the Washington meeting as the Americans' "creating obstacles to European solutions under consideration."

In February 1972, more possible European solutions would further complicate the picture. Belgium, Italy, Spain, and Sweden joined France and the three URENCO countries in

[5] Nogueira Batista, "Enriquecimento," 2.
[6] Uranium enrichment is measured in "separative work units," which are *not* units of energy. The mathematics behind the formula for SWU are complex, but the SWU, a measure of work done by an enrichment process, is proportional to both the total energy input and the mass of uranium metal processed.
[7] Nogueira Batista, "Enriquecimento," 3-4.

an alliance called EURODIF, which incorporated as a firm at the end of 1973 to construct a commercial gaseous diffusion enrichment plant. But the original URENCO countries balked at France's insistence that the plant be built within that country; Sweden also exited EURODIF for reasons that Azeredo does not explain. The URENCO nations remained interested in exploring opportunities for centrifugation enrichment processes, joining with Australia and Japan in London in 1973 to "study and evaluate any material related to uranium enrichment by centrifuges." This obscure and now almost forgotten association, the Association for Centrifuge Enrichment (ACE), was analyzed in considerable detail by Stephen Salaff in 1978.[8] Azeredo drew a historical arc between Brazil's contemporary exploration of enrichment possibilities and its refusal to sign the Non-Proliferation Treaty six years before; in "deciding…to intensify its nuclear program and make use of the rights that it did not want to renounce," Brazil had begun feasibility studies for its first power reactor and agreed to the terms of its construction, to begin operation in 1976; the US would provide the enriched uranium for Angra I in exchange for IAEA safeguards on its operation.[9]

Power reactors – particularly those using enriched uranium and light water – were far less controversial in terms of potential weapons proliferation than other technologies and capabilities Brazil wanted for its nuclear program: "not only uranium enrichment, but also the reprocessing of fissile and fertile materials that result from the consumption of U_{238} in power reactors." Since 1969, Brazilian officials had been considering steps in this direction, and in 1971, the West German foreign minister's visit to South America began a series of "diplomatic and technical contacts" resulting in plans to install a uranium enrichment plant of 1.5 million [separative work units] in the São Francisco River valley. Eventually, the French would be

[8] Stephen Salaff, "Bar Sinister: The Anglo-Dutch-West German Consortium for the Enrichment of Uranium," *Current Research on Peace and Violence*, 1(3/4), 1978, 154-176.
[9] Nogueira Batista, "Enriquecimento," 4.

involved in this particular proposal, as "their gaseous diffusion technology would be used in a first stage [of enrichment,]"[10] but West German representatives fought to keep the ultracentrifuge technology on the table, developed in Jülich, and rely on American technology for gaseous diffusion. (In January 1972, CNEN asked the Ministry of Mines and Energy to direct the President to authorize a first feasibility study of a plan more along the West German line of a multinational coalition). Brazil continued to move toward this latter plan in May 1973, when CNEN communicated its interest in a collaboration with West Germany to the Ministry of Foreign Relations and applied for an official government endorsement for its association with ACE, one of many competing European collaboration plans for uranium enrichment that also involved Australia and Japan.

What brought Brazil to this point? Azeredo painted a picture of Argentina's emerging leadership in nuclear power within the Latin American region, and gestured toward a technological competition where Brazil's action on a trifecta of nuclear activities could no longer be delayed. "Keeping in mind that Argentina has an operational 300 MWe natural uranium reactor that yields 150 kg of plutonium-239 per year, and also possesses a reprocessing plant to treat that plutonium," Brazilian nuclear planners urgently needed to turn to "the problem of the second reactor," a possible uranium enrichment plant, and increasing mining efforts for the nuclear metal. The pressure on the Brazilians was intensified by diplomatic difficulties with the United States in obtaining enriched uranium "given the fact that we are not signatories to the NPT, the legal restrictions surrounding the US Atomic Energy Commission, and the demands that they will exact from us on petroleum." Goaded into a competition for leadership in nuclear technology in Latin America by their Argentine

[10] Nogueira Batista, "Enriquecimento," 5.

neighbors, Brazil thus opted for European partnerships to develop and expand their capacities. In turning away from the United States as an overly restrictive potential partner, Brazil saw West Germany as an ideal replacement, as its "political-military limitations made it more open to cooperation."[11]

Yet in the four steps Azeredo outlined at the end of his memorandum, he kept the door open for French cooperation on a gaseous diffusion project by urging Geisel to establish diplomatic and technical contacts with that country. His directive on West Germany was more specific, suggesting that a technical mission be sent to study the viability of centrifugation and the "jet nozzle" uranium enrichment process. The other two recommendations were internal to the Brazilian government: to give official endorsement to CNEN to participate in the ACE uranium enrichment coalition in London through Brazil's embassy there, and to designate a confidential work group between the Ministry of Mines and Energy and Ministry of Foreign Relations to strategize on foreign technical cooperation to jumpstart Brazil's own uranium enrichment program.[12]

A memorandum written from Secretary General of the National Security Council, Hugo de Andrade Abreu, to Azeredo in August 1974 serves as a sort of progress report on Azeredo's suggestions made above in April, and reveals a longer history of technical and nuclear cooperation with West Germany than Azeredo had previously made explicit. Recalling the 1967 Guidelines for National Policy on Nuclear Energy – "to stimulate and broaden industrial infrastructure, aiming for more intensive participation in reactor construction programs" and "to expedite technical-scientific exchange with other countries in the nuclear area, especially the more developed ones", Abreu framed his remarks within the context of the 1969 General

[11] Nogueira Batista, "Enriquecimento," 6.
[12] Nogueira Batista, "Enriquecimento," 7.

Agreement with West Germany on scientific research and technological development collaboration. In Minas Gerais and Espírito Santo states, an agreement on geological and geophysical research cooperation had been in effect since 1970; the Jülich Nuclear Research Center in Germany had signed separate cooperation contracts with Brazil's CNEN and CNPq.[13]

Between Azeredo's memorandum of April and Abreu's communication to the President in August, Abreu had written another statement approved by Geisel in which he named enrichment as "a stage of utmost importance in the nuclear fuel cycle, and a matter of the highest importance for the interests of National Security."[14] The Ministry of Mines and Energy's recommendation to proceed with a uranium enrichment plant, Abreu noted, implied an eventual choice for enriched uranium power reactors, but also demanded an examination of "promising possibilities of cooperation that would allow [uranium enrichment] to be expanded from the scientific and research arena, already in development, to industry." Construction and operation of this proposed plant would be "a joint enterprise…installed in Brazilian territory," according to a memorandum of understanding from April 23. Brazil's preliminary negotiations with West German officials and firms had been the most auspicious toward this end, leading Abreu to predict that "Brazil will have reached, in a relatively short time, a highly satisfactory solution for the problem of profiting from nuclear energy."[15]

Geisel's first year as president coincided with the first – and most acute – phase of the global petroleum crisis, "when the price of a barrel abruptly rose from US $3.88 to $12.55, the

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[13] AAS.1974.08.15/pn, "Exposição de Motivos Nº 055/74," 2. ACPDOC. As a reminder, CNPq is the National Council on Scientific and Technological Development discussed at more length in Chapter 1.
[14] AAS.1974.08.15/pn, 2.
[15] AAS.1974.08.15/pn, 3.

price adopted by [the Organization of Petroleum Exporting Countries.]"[16] Brazil suffered economically as a major importer of oil, and Geisel made it a key priority of his government to lessen dependency on foreign energy sources and expand the usage of domestic alternatives. His efforts were certainly not limited to nuclear energy, as he also sought to "maximize the use of mineral coal, and industrialize the production of oil from bituminous shale, as well as optimize the use of resources of hydraulic origin."[17] In terms of expanding Brazil's commitment to and plans for nuclear energy, Geisel's government would use a revamped state-owned enterprise, Nuclebrás (from [Empresas] Nucleares Brasileiras, S.A.), to operate directly under the Ministry of Mines and Energy, with 51% of its shares held by the federal government of Brazil.[18]. Nuclebrás – rebranded from the *Companhia Brasileira de Tecnologia Nuclear* by the Brazilian Senate at the end of 1974 – would be the organizational face of the effort to carry forward Médici's (and Geisel's) ambitious plans for Brazilian control of the full nuclear fuel cycle and construction of reactor components for nuclear power installations.

When the US Atomic Energy announced in June 1974 that it would not continue to supply enriched uranium to Brazil after India's successful nuclear test, the 1971 agreement negotiated under Médici's presidency between CNEN and Westinghouse to provide the power reactor at the planned Angra dos Reis site was functionally void. In that same month of June 1974, Geisel authorized a second reactor to be installed at the Álvaro Alberto nuclear power plant in Angra dos Reis, but "Angra II" was not even Geisel's first energy priority. That distinction fell to a program to vastly increase Brazil's hydroelectric energy output, where the 16,919 installed MW were only slightly more than one-tenth of the "150 million kW potential",

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[16] República Federativa do Brasil. *Diario do Congresso Nacional: Suplemento ao Nº 104. Seção II: Suplemento.* August 17, 1982. "A questão nuclear: Relatório da Comissão Parlamentar do Inquérito do Senado Federal," 106. This document contains the full text of the CPI report as published in August 1982.
[17] "A questão nuclear," 106.
[18] http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=98581&norma=122613

80% of which had been called "economically usable," and a plan to decrease the ratio between Brazil's oil imports and domestic petroleum production – approximately 4:1 in 1974.[19] These ambitious plans appeared in the Second National Plan for Development, or II PND, which called explicitly for increased production of minerals related to nuclear energy but left out bigger plans for reactors and peaceful nuclear cooperation.[20]

One year before the Agreement on Cooperation in the Area of Peaceful Uses of Nuclear Energy of 1975, a smaller-scale collaboration with Germany, called the Protocol of Brasília, set up the negotiations that would lead to the blockbuster agreement in Bonn. In October 1974, Shigeaki Ueki, Minister of Mines and Energy, would accept this preliminary agreement that outlined six broad areas of future cooperation between Brazil and Germany: manufacture of nuclear reactors, prospecting and exploration of uranium, conversion to UF_6 (uranium hexafluoride) gas, uranium enrichment, fabrication of nuclear fuel elements, and reprocessing of spent nuclear fuel.[21] The wide-ranging Protocol of Brasília "would come to cover all the steps of development of nuclear technology, from mining through the construction of 1.35 gigawatt nuclear power plants."[22]

In the Protocol of Brasília, Brazilian leaders sought to build on a close scientific and technological cooperation relationship with West Germany, dating back to 1969, when CNPq and CNEN had made arrangements with the Jülich Nuclear Research Center in Karlsruhe, as discussed in Chapter 3. A "consortium between German and Brazilian firms" would help to develop an industrial capacity in Brazil for manufacturing heavy components, turbo-generators and high technology components for pressurized water reactors (PWR) that used enriched

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[19] "A questão nuclear," 106.
[20] "A questão nuclear," 106.
[21] "A questão nuclear," 116-117.
[22] Vargas, José Israel, *Ciência em tempo de crise, 1974-2007*. 196.

uranium fuel and light water moderator, and Brazil had the option to place orders for eight more power reactors of 1,200 MW each before 1990.[23] The nuclear fuel cycle collaboration was no less ambitious: CBTN/Nuclebrás would receive technical assistance to operate a uranium treatment plant to begin operation in 1980, a binational consortium would begin work on converting "yellowcake" triuranium octoxide (U_3O_8) to hexafluoride gas (UF_6) with the target capacity of 3,000 tons per year, while the physical infrastructure for two methods to enrich uranium – centrifugation and the "jet nozzle process," the latter still untested on an industrial scale – would be financed and built.

It was particularly this jet nozzle process that would motivate the Brazilian Senate's Parliamentary Inquiry Commission, established in 1978 by Resolution no. 69. In the first paragraphs of the CPI report explaining the commission's reasons for being, the official reporter of the proceedings, Senator Milton Cabral, decried the state's making important decisions about nuclear energy without "the maximum amount of information being continuously shared with the community."[24] The central objective, Cabral's report continued, of the parliamentary inquiry was to examine "the conception of the Agreement with Germany and the execution of the Nuclear Program," to see if the government's action would "in fact make possible technological autonomy in the nuclear sector."[25]

The West Germans had specifically pledged assistance in training of Brazilian nuclear personnel as part of the text of the agreement, especially in "sensitive areas" such as reprocessing spent fuel and the uranium enrichment techniques mentioned above; a German-built demonstration unit for the jet-nozzle process of 100 SWU was promised in another clause

[23] "A questão nuclear," 117.
[24] "A questão nuclear," 2.
[25] "A questão nuclear," 2. The phrase "autonomia tecnológica" is indeed used in this sentence.

of the contract.[26] Brazil's German partners would also aid in the earliest steps in the nuclear fuel cycle, prospecting, mining, treatment, and manufacture of uranium concentrates, and at the cycle's end, with promised training for Brazilian technicians in "non-industrial" fuel reprocessing activities. Lastly, the Protocol of Brasília guaranteed cooperation in manufacturing fuel elements for reactors, "satisfying Brazilian needs for initial [fuel] charges, recharges, and possibly for exportation," with training to plan, install, and operate a pilot fuel manufacturing plant to produce 25 tons per year. In keeping with the spirit of an agreement intended to develop gradual Brazilian self-sufficiency in nuclear fuel production and the complex technologies by which that fuel would be used, a chart appears in the 1982 CPI showing gradually increasing shares of "nationalization of components" across the planned series of eight nuclear power plants to be installed and operated under the agreement. Many components – such as ventilation and air conditioning, cranes, and tanks – were planned to be 100% Brazilian before the construction of the third nuclear power reactor; only turbo-generators, pumps, and "special components of the reactor" were at or below sixty percent nationalized by the time of the planned ninth reactor.[27]

The Protocol of Brasília predated the more (in)famous Agreement on Cooperation with West Germany by almost a year, but it made a legal reality out of two key Brazilian positions, both drawn from extensive international experience in trying to gain autonomy in nuclear energy technologies. First, among potential nuclear transfer partners that were sufficiently technologically advanced, only West Germany would "offer conditions for the transfer of technology in sensitive areas" to their Brazilian counterparts. Second, Brazil's leaders believed it "indispensable to implement in the Nation an integrated nuclear industry with advanced

[26] "A questão nuclear," 118.
[27] "A questão nuclear," 120.

technology."[28] The West German negotiators had their own conditions: they wished to secure a reliable supply of nuclear raw materials, abundant on Brazilian soil, to develop alternative industries overseas, and pursue suitable partners for scientific and technological cooperation. Those were the primary reasons to enter into the deal on the German side; in this chapter, we learn much more about the motivating factors on Brazil's side.

The 1975 agreement had three important antecedents, two of which have already been discussed above, and all of which are referenced in the preamble discussing "friendly relations" between the two nations: the 1969 "Jülich" agreement, formally titled the Agreement on Cooperation in the Sectors of Scientific Research and Technological Development, the 1972 Agreement of Cooperation on Peaceful Uses of Atomic Energy between Brazil and EURATOM, the European Community of Atomic Energy,[29] and the 1974 Protocol of Brasília, formally, "Guidelines for the Industrial Cooperation between Brazil and Germany." In eleven succinct articles, West German foreign minister Hans Dietrich Genscher and his Brazilian counterpart Antônio Azeredo da Silveira pledged cooperation across the full nuclear fuel cycle, from uranium prospecting to spent fuel reprocessing, "including necessary technological information." This last phrase was particularly important to the Brazilians, who had been locked out of "restricted data" on uranium enrichment and spent fuel reprocessing for two decades in their nuclear cooperation agreements with the United States. Article II simply stated that "the Contracting Parties declare themselves supporters of the principle of nonproliferation of nuclear weapons."[30] The ambiguity of this statement led international critics to charge that the massive deal was a covert transfer of everything Brazil needed to

[28] "A questão nuclear," 120.
[29] This was an amendment to an agreement between the same parties from June 1961; the 1975 bilateral agreement refers in its preamble to this original, and not to the 1972 amendment.
[30] República Federativa do Brasil. *O Programa Nuclear Brasileiro.* Brasília, 1977.

construct a nuclear weapon.[31] Articles III and IV pledged both parties to authorize exports for the "development of special fertile and fissile material, equipment, and materials intended or prepared for the production, utilization, or processing of special fissile material," and allowed the re-exportation of any such material to a third party that was a signatory to the NPT once safeguards had been concluded, but only if the party supplying had given its consent.[32] (Likewise, Article IX stated that West Germany's commitments under Euratom and the European Economic Community would not be affected by the Agreement with Brazil).[33] The final article stated that the agreement would be valid for 15 years, and that safeguards and physical protection measures did not depend on that period of validity.

The safeguards contract that accompanied the Agreement came almost seven months later, and does not need much comment here. However, its terms reached 29 articles, covering definitions, commitments of the governing parties and the [International Atomic Energy] Agency, "Inventories, Lists, and Notifications" to be kept for the purposes of records upon which safeguards were to be based, Proceedings for Safeguards, Inspectors from the Agency, Physical Protection, Finances, Interpretation and Application of the Agreement and Solution of Controversies, and Final Clauses.[34]

In the months following the drafting of the Agreement, it remained for the officials most invested in it to persuade the Chamber of Deputies to support it. Deputy Nogueira Rezende said on the morning of September 10, 1975, that "the incorporation of technology, by

[31] Most famously, Norman Gall inveighed against the deal in *Foreign Policy* 23 (1976): 155-201 in a lengthy piece entitled "Atoms for Brazil, Dangers for All," jointly published by *The Bulletin of the Atomic Scientists*, arguing that the insufficiency of "knowhow" safeguards, policed by an IAEA with no enforcement power, to prevent potential Brazilian nuclear weapons development imperiled global security and the nonproliferation project after the Germans had delivered promised enrichment and reprocessing machinery to Brazil.
[32] República Federativa do Brasil, *O Programa Nuclear Brasileiro*, 32.
[33] República Federativa do Brasil, *O Programa Nuclear Brasileiro*, 33.
[34] República Federativa do Brasil, *O Programa Nuclear Brasileiro*, 37-51.

itself, justifies the approval of this Agreement, and Germany proposes to transfer its technology to us."[35] Other deputies, like Blota Júnior, sought to uphold Brazil's peaceful traditions and scuttle worries about weapons proliferation: "It is never too much to highlight the emphasis given to the expression of Peaceful Uses, which demonstrates well that the Brazilian government, conscious of the challenges of the technological age, maintains itself in the line of its best historical tradition, which is that of peace and development."[36] Minister of Mines and Energy Shigeaki Ueki was mindful that Brazilian leaders not "repeat the error committed with the hydroelectric turbines (a true example [of the effects] of all the manufacturers in the world, with different rules, specifications, controls, etc.)," and instead sought to vest one national energy company – Nuclebrás – with the responsibilities and duties to carry out a uniform and coherent policy of technology development.[37]

Ueki continued to name what Brazil would gain by the deal: technology for complete construction of reactors, the transfer of basic engineering, technology to concentrate uranium and manufacture "yellowcake," technology for fabricating fuel elements, uranium enrichment capability, and technology to reprocess irradiated uranium. Ueki and Ambassador Paulo Nogueira Batista tangled a bit on the implications of the agreement with Germany for Brazil's stance on nonproliferation of nuclear weapons. Nogueira Batista did not see the same conflict that Ueki perceived between the agreement's Article II, supporting nonproliferation, and the Treaty of Tlatelolco's Article 18, allowing for nuclear explosions with peaceful ends. Nogueira Batista maintained that the Tlatelolco text and spirit distinguished between a nuclear weapon and a nuclear explosion, and that supporting the right to carry out peaceful nuclear explosions posed no conflict with the "constant" of Brazil's commitment to nonproliferation. Still,

[35] "A questão nuclear," 121.
[36] "A questão nuclear," 121.
[37] "A questão nuclear," 122.

Nogueira Batista warned, safeguards applied to technology transfers from Germany, as the Agreement required, did not apply to nuclear activities that remained outside the scope of that bilateral arrangement.[38]

In 1976, construction began on the Angra II reactor alongside Angra I in Rio de Janeiro state. Perhaps more importantly for the maintenance of technical knowledge among the scientific community, CNEN, the Ministry of Education and Culture, Nuclebrás, and CNPq launched the Program of Human Resources for the Nuclear Sector "with the end of promoting the formation and development of Human Resources to meet the needs of the National Nuclear Energy Policy."[39] Such a specific emphasis on education and advanced training in the history of Brazilian laws on nuclear energy was somewhat unusual, but can be viewed as part of the obsession with technological autonomy and tighter inter-agency cooperation. CNEN, Nuclebrás, CNPq, and the Department of University Matters of the Ministry of Education and Culture would combine their efforts to "guarantee the full success of the Brazilian nuclear program with respect to availability of human resources, educate and develop an adequate number of national human resources, at the middle and upper levels, specialized in the area of nuclear technology and similar areas, [and] institute a group of professionals to ensure, for the Nation, sufficient incorporation of nuclear technology and to effect a growing expertise in scientific knowledge in this sector."[40] CNEN and Ministry of Education and Culture personnel working under a general coordinator would compose the Group on Planning and Coordination, and Brazil's universities, national technical schools, institutions linked to nuclear research, and

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[38] "A questão nuclear," 122.
[39] Senado da República Federativa do Brasil. Decree no. 77977, July 7, 1976. http://legis.senado.leg.br/legislacao/ListaTextoSigen.action?norma=500617&id=14325327&idBinario=15706323
[40] Decree no. 77977, July 7, 1976.

"other organizations or public and private entities" were to carry out the activities and programs of education and training.

In 1977 and 1978, two important documents justified (Geisel's "White Book," addressed simply "To the Brazilians"), and investigated (through the beginning of a parliamentary inquiry commission, or CPI) the effects of the Brazil-Federal Republic of Germany agreement on the country's finances, international relations, and scientific/technological infrastructure.[41] In August 1977, the national reserve of nuclear minerals – established legally in Article 14 as a presidential prerogative in Law 6.189, and noted above in the discussion of Nuclebrás and its many subsidiaries – took shape as three polygons in Brazil's center and south. Within these boundaries, all nuclear minerals, concentrates, or chemical compounds were subjected to the national reserve requirement; outside them, 80% of the production of the same classes of mining products would go to the state's "stock necessary for the national nuclear energy program," never to be less than "the demand of special fertile and fissile materials," as part of a calculation that would be repeated annually.[42] The other significant piece of nuclear energy legislation that year defined the legal terms of, and assigned civil and criminal responsibility in potential cases of nuclear energy accidents or deliberate harm, roughly a year and a half before the Three Mile Island accident in Pennsylvania.[43] Not until the Goiânia radiation accident of September 1987, discussed later in this chapter, was this law invoked in a substantial way.

On Nov. 19, 1976, the US Embassy in Brasília forwarded to Secretary of State Kissinger and other embassies, missions, and consulates in Europe and South America a defiant and brief

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[41] *O Programa Nuclear Brasileiro* is the document colloquially known as the "White Book," while "A questão nuclear" was the short name for the summary report of the late-1970s CPI.
[42] Senado da República Federativa do Brasil, Decreto nº 80.266, Aug. 31, 1977. http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=194768&norma=209097
[43] Senado da República Federativa do Brasil, Lei nº 6.453, Oct. 17, 1977. http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=100608

statement from "an unidentified high source of the Ministry of Mines and Energy" made in *O Estado de São Paulo* eight days prior.[44] This diplomatic cable quoted the high official as saying "We know how to resist any and all US pressures because Brazil also tried, in a friendly way, to reach an agreement with the United States. At the start of 1974, between January and March, we tried to explain that the US could do good business if it helped us in our program," an approach that was so controversial among various factions in Brasília that apparently "the subject was taboo for a period of eight months" as the government feared that these overtures to the United States might be made public.[45] This brief, but fundamental, diplomatic failure reinforced, for the Brazilians, the double standard implicit in the Non-Proliferation Treaty and made explicit in the US' differential treatment of its nuclear allies and those countries deemed too dangerous to possess certain technologies, such as uranium enrichment. The incoming Carter administration, too, would soon take on countries like Brazil, advanced in nuclear technology but not a signatory to the NPT, as a threat to proliferate nuclear weapons.

Much of the controversy outside of the two countries involved in the 1975 nuclear deal with West Germany centered on the fact that Brazil would be able to enrich uranium,[46] which renewed concerns, primarily outside the nation's borders, of the possibility of building nuclear weapons. Within the Brazilian scientific community, the disagreement was much more focused on the *type* of uranium enrichment technology – the jet nozzle process – that had not been proven to work on an industrial scale. A short description of this technology from a November 1975 paper should assist in understanding many of the problems that scientists saw in the nuclear deal. "Isotope separation [of fissile uranium-235 from fertile uranium-238] is effected

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[44] "Brazilian Public Reactions to US Nuclear Policies." Unclassified diplomatic cable, Nov. 19, 1976. Wilson Center Digital Archive/NPIHP.
[45] "Brazilian reactions to US nuclear policies," Nov. 19, 1976. Wilson Center Digital Archive.
[46] "A questão nuclear," 123.

by the same basic mechanism as in the centrifuge method. However, the serious mechanical problems of highly stressed rotating machines are avoided" by having the enrichment occur via a high-speed jet, where uranium hexafluoride (UF_6) is mixed with a "light auxiliary gas."[47] The German firm STEAG had been developing the nozzle enrichment technology for five years before the landmark deal with Brazil. A gas mixture of 95% hydrogen and 5% uranium hexafluoride "expands along a curved fixed wall," and the uranium isotopes are separated into a light (fissile) fraction and a heavy (depleted) fraction by a mechanical skimmer. Smaller nozzles worked better for an efficient separation of isotopes, the scientists wrote, because the "optimum operating pressure of the nozzle system is inversely proportional to its characteristic dimensions."[48]In an industrial machine described in the paper, ten slit-shaped nozzles were placed around an extruded aluminum tube. The separation nozzle system itself was made up of the ten deflection grooves machined into the aluminum tube and skimmer strips; deflection grooves normally "had a radius of curvature of 1/10 mm."[49]

In a dogged quest to miniaturize the separation elements even further – and enhance the efficiency of the process, "Siemens…[had] developed another method for the commercial production of separation elements for further possible reductions in the equipment size. The method is based on the stacking of photo-etched metal foils."[50] In Siemens' improvement to the process, a large number of separation nozzle structures would be photo-etched at the edges of a metal foil strip, then these strips would be stacked in multiples of approximately 100, as a photo in the paper showed. These stacks would be covered with plates and clamped together, creating a "compact separation nozzle chip" from which the light uranium-235 gas fraction could exit

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[47] Becker, et al. "Uranium Enrichment by the Separation Nozzle Process," Institut für Kernverfahrenstechnik, paper number KFK 2235, November 1975.
[48] Becker, et al. "Separation Nozzle Process," 3.
[49] Becker, et al. "Separation Nozzle Process," 3-4.
[50] Becker, et al. "Separation Nozzle Process," 6.

both sides. Roughly 100 chips would be inserted into a tube of 50 mm diameter; the two tube halves then introduced the 95/5 "feed gas" mix and removed the heavy or depleted fraction, while the desired light fraction left the separation element tube between the two halves. When this separation process was run "about 500" times, a cascade design to produce uranium enriched to 3% U_{235} proved successful; in conclusion, Becker and his fellow authors justified building the demonstration plant for nozzle enrichment in Brazil as "the implementation of an enrichment process which combines a reliable and comparatively simple technology with a high potential for further improvements."[51]

Members of the Brazilian scientific community seized on points that Becker et al had mentioned but minimized in the "Uranium Separation" paper – an extremely high rate of power consumption, even compared to the diffusion enrichment process – and Brazil's role as guinea pig for the first large-scale nozzle enrichment plant in the world – as only part of their vociferous objections to the West Germany agreement. "The question raised on this matter," from multiple members of an unnamed group of Brazilian technocrats and authorities, "was if Brazil would be the owner of a technology, or of a research project."[52] Despite Ueki's insistence that CNEN and Nuclebrás, two entities closely involved in the negotiations with West Germany, "were not constituted by bureaucrats," and had employed "numerous physicists and nuclear engineers trained in the leading universities of the world," many of Brazil's scientists and technicians were infuriated that the government and ardent backers of an ambitious nuclear energy plan justified the exclusion of the scientific community by claiming the need for secrecy. "The Agreement, as Virgílio Távora emphasized, could only have been negotiated in secret. Given its financial size and the interests in play, the execution of 36 industrial contracts

[51] Becker et al, 20.
[52] "A questão nuclear," 123.

to be carried out in Germany by Nuclebrás and STEAG…"[53] Senator Franco Montoro spoke on behalf of the scientific community, distilling their complaints into two main categories: the negotiations should have featured more participation by scientists, and they were concerned about the risks of adopting the jet nozzle process for uranium enrichment.[54] Physicist José Israel Vargas was surprisingly sanguine about the experimental jet nozzle uranium enrichment portion of the agreement, seeing a net positive in "the first time that we have been associated, whether abroad or here at home, in the development of a technological process, leaving our traditional position of transferring technology by sending scholars to foreign countries."[55] Vargas warned, however, that all the effectiveness of the deal hinged on "our capacity to absorb technology," citing a disconnect between university scientific research and the nuclear program. Vargas was one speaker who underscored the need to increase the numbers of highly trained physicists and engineers to cope with the demands of implementing the terms and technologies of the agreement; Brazil, according to him, would need to graduate 50-60 Ph.D.s in physics per year. To develop scientific research capacity in Brazil, Vargas noted, "the necessary thing in this whole issue is the capacity to formulate projects. It is more important than carrying them out."[56]

José Goldemberg, another prominent Brazilian physicist known as "the most constant critic of the Nuclear Agreement with Germany" by the time of the 1982 CPI, attacked CNEN for its "low representativeness" in the technical and scientific communities as well as in government policies. CNEN's original sin, to Goldemberg, was purchasing the "turnkey" reactor from Westinghouse, the original provider for Angra I, without interest in transferring

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[53] "A questão nuclear," 130.
[54] Montoro's comment also took issue with the absence of an organization with an illegible 4-letter acronym from the negotiations.
[55] "A questão nuclear," 127.
[56] "A questão nuclear," 127.

the technology as a step toward greater autonomy.[57] (Later in the CPI, he stated that the choice of enriched uranium reactors added to Brazil's technological dependency, making it "completely dependent" on some method of enriching the nuclear metal). In his eyes, the national nuclear energy commission was reactionary, "immobilist," and ended up being "defeated by the facts." CNEN's lack of internal criticism, and poor external outreach to the scientific community that should sustain the organization, led to a "closed decision process that left Nuclebrás and the Government few alternatives." In sentiments that echoed those of Vargas on the power of scientific problems to motivate authentic progress and growing autonomy, Goldemberg stated that "what scientists want is to control the technology, and for that it is essential to build a complete nuclear reactor, with Brazilian technical methods."[58] The physicist's prescription for the intellectual sickness that Vargas had diagnosed – the disconnection between the nuclear power program and the physics community that should have supported it – was to place CNEN in charge of Nuclebrás' activities in order to "broaden the vision" of the state-run company, or else to "leave CNEN as it is, and grant CNPq the tasks of coordinating nuclear science research, including at the existing institutions."[59]

In another section of the CPI, depositions collected indicated displeasure with the terms of the deal far beyond what Goldemberg and Vargas had to say about the lack of linkage between the nuclear program (or negotiation of the Brazil-West Germany agreement) and the nation's scientific communities. Joaquim de Carvalho, ex-director of the Nuclebrás subsidiary responsible for engineering power plants, wrote in 1980 in *Jornal do Brasil* that Brazil chose the path of least resistance in its technology transfer agreement, and that by "absorbing and disseminating, within local industry, the scientific and technological advancements of other

[57] "A questão nuclear," 127.
[58] "A questão nuclear," 128.
[59] "A questão nuclear," 128.

countries," the developing nation ran a significant risk of not mastering the knowledge and technology of the PWR reactors included in the deal, and that the reallocation of scarce funds to the nuclear program threatened the development of hydroelectric and traditional thermal power. Brazil's fragile institutions of scientific research, too – "IPI, IPEN, CESP, [Universidade de Campinas], CODETEC, the Universities of São Carlos, Santa Catarina, Rio Grande do Sul, Rio de Janeiro, and Paraíba" – would see their "serious and important efforts…frustrated" as more and more money went to carrying out the technology transfer from Germany.[60]

Prof. Lucas Nogueira Garrez, with a long resumé in government and management of electric utilities (São Paulo's state power utility and the Itaipu hydroelectric plant, for example) and power projects, favored the "deceleration" of the nuclear power program in an April 1981 editorial.[61] Brazilians had erroneously conflated the technology transfer agreement with the nuclear program itself, as well: "The Agreement refers to the transfer of technology and not the construction of nuclear power plants, and regarding the technology to be obtained through the Agreement, it is not sufficiently controlled [by its Brazilian recipients.]"[62] Frederico Magalhães Gomes wrote that the Agreement itself was not flawed, but that its timetable made the primary Brazilian goal in the deal – absorption and internalization of the technology transferred – impossible. "Instead of being part of a plan of installing large power plants, we would be simply testing this technology, developing it and trying to absorb it at the level of the laboratory, in experimental settings of a smaller scale, lower cost, and possibly, technologies even more favorable *when they become necessary*."[63] (emphasis added) Kurt Mirow, director of

[60] "A questão nuclear," 157.
[61] "A questão nuclear," 157.
[62] "A questão nuclear," 157.
[63] "A questão nuclear," 157.

"electromechanical firm" CODIMA, and ex-director of the Brazilian Association of Electric and Electronic Industry, criticized the costs of the nuclear program – "between 25 and 45 billion US dollars" – the unreliability of reactors manufactured by KWU, the German firm that was building them for Brazil, Germany's lack of suitable spent fuel reprocessing technology, and most interestingly, KWU's membership in an "international cartel of electrical equipment."[64]

Mirow continued with a deposition seemingly long on allegations and short on facts. Brazil was being cheated, purchasing reactors from KWU at prices 20% higher than those available from the United States. Charging higher than market price was cartelistic behavior; in the eyes of the author of "Dictatorship of the Cartels," the difference between KWU's price and market price was being funneled into bribes to change the German government's orientation. Mirow had suffered a personal loss through his electricity business through the Government's policy in the national machining sector. Political leaders sought to stimulate the growth of the electromechanical sector; by encouraging the entry of new firms, Mirow alleged, an internal competition began that threatened small firms most of all. He somewhat backed off of a charge that "contracts resulting from the Nuclear Agreement were being subordinated to the orders of the cartel," then ended by strangely praising United States laws against firms joining cartels, seemingly unaware of why Brazil could not follow through with its planned purchase of a Westinghouse reactor for a better price.

A trio of scientific experts and critics of the Brazil-West Germany agreement – physics professor Luiz Pinguelli Rosa, nuclear physics theory professor Mário Schenberg, and ex-technical assistant to the president of regional power utility Furnas – used the stage provided by the CPI to question the need for nuclear power in Brazil at all, and to attack the

[64] "A questão nuclear," 157.

determination of technologies and expenses that was the necessary price of doing business with the Brazilians' new West German partners. Pinguelli Rosa questioned the very notion that Brazil needed nuclear energy at all in the late 1970s, and in his deposition, gave a damning account of the Nuclear Agreement that he argued was "based on a series of doubtful premises and incorrect data." The government, or at least the brokers of the deal, had overestimated the demand for electric power in the coming decades, and underestimated the potential to meet that demand from non-nuclear sources, given incorrect numbers on Brazil's tremendous hydroelectric potential and the true costs of nuclear power plants, and chosen the wrong kind of reactor – as José Goldemberg had also argued – locking the nation into an experimental and extremely energy-intensive uranium enrichment process to realize the benefits of the agreement.[65] Moreover, the government had misevaluated the actual feasibility of the technology transfer from West Germany, and badly miscalculated the strategy to attain greater energy and technology independence, overlooking potentially fruitful South American cooperation partnerships in rushing toward the German firms. Pinguelli Rosa shared Magalhães Gomes's concerns above with the timetable for carrying out the deal, stating that Brazil had ample enough hydroelectric potential to run the country on river power alone until 2010, and use the coming three decades to "develop nuclear technology more appropriate to the Nation than what is being implemented."[66]

Another physicist, Mário Schenberg, assailed the Agreement on its cost alone. Spending "so many millions of dollars," he argued, could not be justified on the basis of either peaceful (electrical energy) or military ends (a hypothetical nuclear bomb project). Schenberg was not advocating for a bomb or insinuating that one was being developed, but echoed many of his

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[65] "A questão nuclear," 157.
[66] "A questão nuclear," 158.

fellow scientists' concerns that providing the same amount of nuclear power could be done with much lower costs without German enriched-uranium reactors. He also did not know "what Germany's intentions were" in striking the deal with Brazil in 1975, a concern that "worries the entire world."[67]

Lastly, a veteran of the negotiations between Furnas and KWU, David Neiva Simon, leveled his criticisms of the agreement that he had helped to arrange. Simon spoke of a "near unanimity among the scientific community about criticisms of the Nuclear Agreement, with the exception of a shrinking minority of 'expert nucleocrats'…on the following points."[68] First, the ambitious nuclear constructions could wait until 1990 because of Brazil's abundant and cheap hydroelectric power potential. Second, installing the reprocessing reactor, so ardently sought by Geisel and his ministers in the negotiations to control the full nuclear fuel cycle in Brazil, was inadvisable on economic grounds alone. Third, the burgeoning problem of nuclear waste was a dangerous side effect of the rapid acceleration in reactor building and technology transfer, and one on which no consensus yet had been reached.[69] Simon echoed Goldemberg's and Vargas's concerns about the lack of a meaningful connection between the national scientific community and nuclear officials, particularly when transfer of technology was under discussion. Safety concerns were catching up to the architects of the original agreement; a "collapse" in global contracts for nuclear reactors, from 1975 onward, indicated to scientists a "serious crisis of confidence on the part of buyers." Sixth, the concerns of the scientific community about the jet nozzle uranium enrichment process had only grown over time; were the process to remain unproven on an industrial scale, Brazil's chance at nuclear fuel cycle independence was shot

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[67] "A questão nuclear," 158.
[68] "A questão nuclear," 158. It is difficult to know whether these "expert nucleocrats" were blindly loyal to Geisel, ardent supporters of the German technology transfer deal, but it is certainly an entertaining characterization of a scientist's opponents.
[69] "A questão nuclear," 158.

without the crucial step of uranium enrichment. At the organizational level, CNEN, Nuclebrás, and Eletrobrás had taken on "frequently conflicting responsibilities," and Simon urged that CNEN be placed under a different authority from the two state-sponsored energy firms.[70] Lastly, the transfer of technological know-how for manufacturing some reactor components – namely, turbo generators – had not occurred, and forced Brazil to keep importing some of these parts from their German partners, maintaining their technological dependency on European suppliers.

The growing opposition of the scientific community to the 1975 West Germany agreement, especially as it continued to bear less fruit than hoped in terms of nationalizing technology and the long-sought autonomy in nuclear energy, was quite significant; the intensity of disagreement with the document's terms and implementation, and resentment at the government having left out some of the most important experts and stakeholders in nuclear energy, can certainly be perceived in the discussion above. But it was the Brazilian military's disappointment with the West Germany cooperation that would grab the attention of CNEN in 1979, who agreed to coordinate and support a "parallel program," whereby military forces sought to develop the full nuclear fuel cycle using Brazilian ingenuity and materials. The air force began trying to enrich uranium with lasers; the navy's two parallel program projects, Ciclone and Remo, sought to develop a fuel cycle and implement naval nuclear propulsion for submarines, respectively.[71] Meanwhile, the army sought to develop a graphite-gas reactor to meet its needs for uranium metal and graphite; had it succeeded, that reactor may have produced plutonium.[72]

[70] "A questão nuclear," 158.
[71] Kassenova, *Kaleidoscope*, 23. José Goldemberg confirms this division of labor among the three branches of the armed forces in "Lessons from the Denuclearization of Brazil and Argentina," *Arms Control Today*, April 2006, 41.
[72] Kassenova, *Kaleidoscope*, 23.

The nominal goal of the parallel program – to develop indigenous nuclear propulsion technology – was actually one shared by the Geisel government and stated to be a goal of the official Brazilian nuclear program.[73] In 1976, German officials communicated to Paulo Nogueira Batista, president of Nuclebrás – against the official terms of the 1975 Agreement, prohibiting military uses of any transferred technology – their willingness to share technical knowledge about nuclear propulsion. Admiral Maximiano da Fonseca asked Lt. Captain Othon Luiz Pinheiro da Silva in 1978 to evaluate Brazil's outlook for nuclear propulsion technology. Silva had just completed a doctorate in nuclear engineering at MIT, and was highly conscious of his status as a foreigner because of his professors' unwillingness to discuss certain 'off-limits' topics with him.[74] He accepted Fonseca's challenge, and laid out a two-part plan in his results, directing Brazil's efforts first to completing the nuclear fuel cycle[75] – that is, enrichment and reprocessing, the "sensitive steps" that the German technology transfers had not given them – then focus on constructing a pilot reactor for tests. In 1976, with the goals of mastering conventional submarine technology, stimulating the production of domestic industry, and finally designing nuclear submarines, Brazil's navy contracted four Type 209 conventional submarines, or "Tupi-class" subs, from Howaldtswerke-Deutsche Werft (HDW), a German firm.[76] The agreement between West Germany and Brazil on submarines, like that on nuclear energy technology, failed to live up to its promise to develop native expertise in the South American nation, as the index of nationalization for the HDW submarines fell shy of 30 percent.[77]

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[73] Andrea de Sá. "Brazil's Nuclear Submarine Program: Navigating the Uncharted Waters of the Non-Proliferation Treaty." Unpublished senior thesis, Woodrow Wilson School of Public and International Affairs, April 16, 2013.
[74] Sá, "Nuclear Submarine," 37.
[75] Sá, "Nuclear Submarine," 37.
[76] Sá, "Nuclear Submarine," 39.
[77] Sá, "Nuclear Submarine," 40.

Only sixty engineers and 120 technicians worked on the navy's parallel program.[78] Before the 'official' Brazil-West Germany deal had been in effect for six years, the navy constructed two uranium enrichment centrifuges, expanding that total to nine in 1984. The naval program was the only "successful" one among the three branches of the armed forces under the coordinated parallel program, continuing "unabated by the dramatic changes in the political landscape of Brazil." [79] Much of the story of the Brazilian parallel program comes from scholars such as Michael Barletta, whose late-1990s article "The Military Nuclear Program in Brazil" is detailed, concise, and based on dozens of interviews with participants and leaders of the program. Barletta calls the parallel program a "product of failure," reflecting its direct (and intended corrective) relationship to the "official program" as laid out in the agreement with West Germany.[80]

Opposition to the official program encompassed wide swaths of Brazilian society, even beyond the scientists and technicians named above in the CPI; industrial groups, the media, and certain political sectors joined the military and scientific communities in rebuking the outcome of "a narrow bureaucratic and policy coalition, which proved unable to overcome criticism and resource constraints."[81] Financing for the parallel program came from the military services themselves, the National Security Council, and CNEN, which had been upstaged by Nuclebrás' dominance in executing the nuclear power portion of the West Germany agreement. Rex

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[78] Kassenova, *Kaleidoscope*, 23.
[79] Kassenova, *Kaleidoscope*, 24.
[80] Barletta, Michael. "The Military Nuclear Program in Brazil." Center for International Study and Arms Control, Stanford University, 1997, 4. The secrecy of these parallel nuclear activities has made it extremely difficult, even now, for scholars to get access to these documents; CNEN President José Luiz de Santana Carvalho wrote in 2006 that his predecessor distributed "the bulk of the documents" on the nuclear weapons program through the armed forces' intelligence services "in order to shield those involved in the program and the nature of Brazil's plans from public disclosure." More disturbingly, when he took office in 1990, all sensitive documentation on the weapons program had "suddenly disappeared from the files of the Nuclear Commission" the night before he was to succeed to the presidency of CNEN. *Arms Control Today* 36, no. 2 (2006), 51.
[81] Barletta, "Military Nuclear Program in Brazil," 5.

Nazaré Alves, president of CNEN, opened a series of bank accounts in 1981 to channel federal and military money toward the secret nuclear projects.[82] Toward the end of the Geisel administration, in December 1978, the Navy Ministry approved the objective of developing a nuclear submarine. The Navy's successful uranium enrichment efforts under the leadership of Lt. Colonel Othon Luiz Pinheiro da Silva represent a landmark achievement on the way to the concrete technological aim of nuclear propulsion.[83] The Brazilian navy began to work on centrifuges based on a Soviet "Zippe" model, having given up on the German jet nozzle process entirely. Sá writes that the navy used publicly available information on designs of centrifuges and brought in Brazilian experts trained in the official program or abroad to build them.[84]

The initiation of the parallel enrichment and nuclear technology efforts came directly from the pen of President João Figueiredo, and the PATN (*Programa Autônomo de Tecnologia Nuclear*) competed for financial and human resources with the "official" program from its very beginning. (Surprisingly, accounts by CNEN President, and unofficial overseer of the parallel program, Rex Nazaré Alves, said that four factors were paramount in shifting scarce resources from the official to the autonomous program: a growing awareness that hydroelectric resources were less limited than thought previously, knowledge that crucial hexafluoride gas technology would not be provided by Germany through the official program, realization that the jet nozzle enrichment process would not reach industrial viability, and a tightening currency crunch that made imports untenably expensive, encouraging domestic alternatives such as autonomous technology).[85] Not only financial and physical resources were shifted, but also human capital was directed into the parallel program in staggering numbers. Beginning in 1982, under

[82] Sá, "Nuclear Submarine," 41.
[83] Barletta, "Military Nuclear Program in Brazil," 7-8.
[84] Sá, "Nuclear Submarine," 45.
[85] Barletta, "Military Nuclear Program in Brazil," 14.

Nazaré's control of CNEN, more than 3,000 scientists and technicians were hired and trained to participate in the parallel program; Nazaré's CNEN became the research institution with the highest percentage of Ph.D. holders in Brazil.[86]

Brazil's first successful isotopic enrichment of uranium occurred in September 1982 as the Navy's centrifuge process proved most successful among those tried by the three branches of the military; five years later, IPEN had successfully produced several kilograms of uranium-235 enriched to 1.2%.[87] The navy's success vis-à-vis the other two branches may, somewhat paradoxically, be explained by its lack of a branch-specific technical university, which the army and air force did have. The navy thus "actively sought out civilian expertise from…four civilian research institutions," while their counterparts in the army and air force worked "in relative isolation from civilian specialists."[88]

Not all of the reasons behind starting and developing the autonomous nuclear program in Brazil were about technology; Barletta notes that "the more fundamental and enduring motivation for the PATN was that it was viewed by military officers as a means to realize their ambition to enhance Brazil's international stature."[89] In doing so, these military personnel sought to "attain the technological requisites" appropriate to Brazil's aspirations to great-power status. Barletta noted that a secret *Exposição de Motivos* – essentially a communication written to the President by a high Brazilian official – explicitly mentioned in February 1985 a desire to share the technology developed in the parallel program with other Latin American countries. The combination of the document's secrecy and succinctness suggested to Barletta that

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[86] José Luiz de Santana Carvalho, "Ending Brazil's Nuclear Weapons Programm" *Arms Control Today* 36, no. 2 (2006), 51. Santana's higher numbers of parallel program employees seem to dispute Kassenova's much lower figures; hers may be limited to the Navy program only.
[87] Barletta, "Military Nuclear Program in Brazil," 6.
[88] Barletta, "Military Nuclear Program in Brazil,", 10-11.
[89] Barletta, "Military Nuclear Program in Brazil," 16.

"decision makers' approval of the PATN was based on an understanding that political prestige would be acquired through technological mastery. In their vision, *technological capability served as a latent asset in bolstering political prestige*, rather than as an operational tool employed as force."[90]

The argument for political prestige through technological mastery as the primary motivator for parallel nuclear development project in Brazil explains another strange circumstance: the PATN did *not* stop when Brazil returned to civilian rule. Several officials in José Sarney's government (1985-89) supported the parallel program, and the president himself approved all existing projects continuing.[91] Barletta notes that this support by Sarney may have been "less enthusiastic than acquiescent," and the pervasive remaining influence of the military on the first civilian administrations after 1985 may not have given him much other choice. Astonishingly, the Air Force restarted its laser enrichment program at the Aerospace Technology Center in São José dos Campos as the 1980s were coming to a close; its leaders may have secretly imported rotors and other equipment from an "American specialist," according to journalist Tania Malheiros's *A bomba oculta* (1993).[92]

Tracing Parallels: Official Program and Diplomatic Progress

Within the first two years of the 1980s, Brazil's nuclear energy program entered into cooperation agreements with Iraq, Colombia, Peru, and most importantly, Argentina, for reasons that are discussed extensively in Chapter 6. Another Nuclebrás subsidiary, Nucon, was created by presidential decree with the "specific goal of constructing nuclear electric power plants…and objective of global supply for all engineering services, equipment, and necessary

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[90] Barletta, "Military Nuclear Program in Brazil," 16. Barletta writes in a footnote that the secret document "was made available to [him] in a context that left no doubt as to its content or authenticity." Emphasis is mine.
[91] Barletta, "Military Nuclear Program in Brazil," 10.
[92] Sá, "Nuclear Submarine," 43.

materials for the construction, installation, and commissioning of [these] facilities."[93] In December 1982, the Brazilian government centralized still more control over nuclear energy activities, as Figueiredo declared the "development of research in the nuclear energy area to be under the exclusive control of the Union…and can be carried out through agreement with CNEN, Nuclebrás, or its subsidiaries." Only the nuclear activities mentioned in Law 4.118 from August 1962 – research and working of deposits of nuclear minerals in Brazilian territory, sale or trade of said minerals, concentrates, fissile and fertile nuclear materials, artificial radioisotopes and radioactive substances, and the production and industrialization of nuclear materials – or those under the "monopoly of the Union" were subject to the legal restriction instituted 20 years later. CNEN also relieved the State of São Paulo of its responsibility for IPEN, putting its (often secret) activities under the umbrella of the National Nuclear Energy Program. Angra I had its first successful chain reaction as well, three years before it would enter into commercial operation in 1985.

From 1983-1985, the last years of the 21-year military regime, Brazil's nuclear energy progress looked to be mostly diplomatic, as far as the official, and not parallel, program was concerned. Cooperation agreements with Venezuela, Spain, and the People's Republic of China were all concluded within one year. On September 2, 1985, new civilian president José Sarney created the Commission to Evaluate the Brazilian Nuclear Program. Its seventeen members – twelve "representative of society and possessing notable knowledge of the sector," and five governmental/nuclear institution personnel, including persons sent from the Ministry of Foreign Relations and the Ministry of Science and Technology as well as the National Security Council – were given a wide berth of potential contacts and institutional representatives to

[93] Senado da República Federativa do Brasil, Decreto nº 85.290, Oct. 23, 1980. http://legis.senado.leg.br/legislacao/ListaTextoIntegral.action?id=199695

interview and a technical assistance team provided by MME.[94] José Israel Vargas chaired a committee with such prominent names of Brazilian physics and engineering as Marcelo Damy de Souza Santos, representing IEA and USP, and José Leite Lopes of the Brazilian Center for Physics Research and the Ministry of Science and Technology.

Eleven of the committee's recommendations, originally published in 1990 by the Brazilian Academy of Sciences, were briefly summarized in the December-January 2006-07 issue of *Economia e Energia*.[95] Taken as a whole, they are an important assessment of Brazil's nuclear energy progress and deficiencies at a crucial time of transition to civilian government. The first justifies the nuclear program's trajectory in light of the strategic importance of "full and autonomous" control of nuclear energy to provide electrical power and increase its benefits when applied to peaceful ends. (This overarching goal implies what is stated explicitly later in the document, that full domestic fuel cycle capabilities remained a highly desired goal for the planning authorities). The second recommendation seeks, somewhat poetically, to align the "rhythm" of the nuclear program with national energy demand and increased power costs, in part by maintaining cooperative relations with Germany. The committee focused on Argentina – and Brazil's growing cooperation with its neighbor since the 1980 agreement between two military presidents – in urging the "gradual establishment of a mechanism of mutual inspection of nuclear activities," while asking authorities to support research and development efforts directed toward an increased degree of nationalization in nuclear energy. Brazil's ambitious nuclear power plans received a mixed review; the committee supported continued construction on Angra II and III and manufacture of heavy components (at a pace appropriate to the progress of the reactors, and seeking sales in "complementary markets" for any surplus) but

[94] Senado da República Federativa do Brasil, Decreto nº 91.606, Sep. 2, 1985. http://legis.senado.leg.br/legislacao/ListaPublicacoes.action?id=219026
[95] *Economia e Energia*, 59 (Dec. 2006-Jan. 2007), 3-4.

sought to delay the decision on whether (and where) to build any power reactors beyond the nation's third.

The committee's next recommendations focused on mining and nuclear fuel. In mining, the abundant resources of Poços de Caldas would sustain Brazil through feasibility studies of the mines of Itatiaia and Lagoa Real; these explorations could be funded with "public or private funds, repaying the investments through commercialization of uranium in the international market." For nuclear fuel fabrication, the committee took a strong position in favor of autonomy, seeking to replace a contract for the Pechney-Ugine-Kuhlmann firm's patented process for uranium dioxide conversion with IPEN's indigenous technology. The report urged the government and nuclear technicians to conclude building an "experimental jet-centrifuge enrichment cascade," and to support research for other uranium enrichment methods already being attempted, with the goal for choosing the most appropriate industrial scale technology for the country within three years.

The Goiânia Cesium-137 Radiation Accident

Not every threat to safety and security from nuclear energy activities came from the potential of weapons proliferation or autonomous technology development, however. In Brazil, one of the oldest and least controversial applications of nuclear technology – the development and maintenance of radioactive isotopes of certain elements for cancer treatment – led to an ironic and tragic chain of events that killed four people and made hundreds ill.

On September 13, 1987, in the city of Goiânia, the state capital of Goiás, one of "the most serious radiological accidents to have occurred to date" led to the death of three adults and a six-year-old girl, and sickened and injured hundreds of others with radiation exposure.[96]

[96] International Atomic Energy Agency, *The Radiological Accident in Goiânia.* Vienna: IAEA, 1988. Foreword.

CNEN monitored approximately 112,000 people for such exposure over a three-month span at an ad hoc facility in Goiânia's Olympic Stadium, finding that 249 individuals showed external or internal doses of radioactivity that indicated contamination from the accident.[97] Its proximity in time to the catastrophic power reactor meltdown at Chernobyl, now Ukraine, in April 1986, heightened the psychological impact of the Goiânia accident on the Brazilian population;[98] the economic impact of the accident was similarly dire, as sales of Goiás's primary agricultural products, cotton, grains, and cattle, fell by one-quarter in the months afterward.[99] A private medical radiotherapy institute, the *Instituto Goiano de Radioterapia*, had obtained CNEN's approval to import a cesium-137 source in June 1971, but ceased operation in late 1985.[100] Though a similar teletherapy unit with the cobalt-60 radioisotope was moved to a new facility, the cesium chloride unit was not; personnel responsible for the abandoned radiotherapy institute did not notify CNEN about the "significant change in the status of equipment or facilities," as they were required to do in the terms of their license.[101] At the time of its manufacture, probably at Oak Ridge National Laboratories in Tennessee,[102] the cesium-137 source had 2,000 curies of radioactivity; by the time it was stolen from the former site of the teletherapy institute (see Figure 8) in September 1987, 1,375 curies of activity were still present.[103]

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[97] IAEA, *Radiological Accident*, 133-134.
[98] IAEA, *Radiological Accident*, 115.
[99] IAEA, *Radiological Accident*, 115.
[100] IAEA, *Radiological Accident*, 18.
[101] IAEA, *Radiological Accident*, 18.
[102] IAEA, *Radiological Accident*, 21.
[103] Weber Borges, *Eu também sou vítima.* Goiânia, Brazil: Editora Kelps, 2003, 26-27.

Figure 8. Radiotherapy clinic in Goiânia from which cesium source was taken.

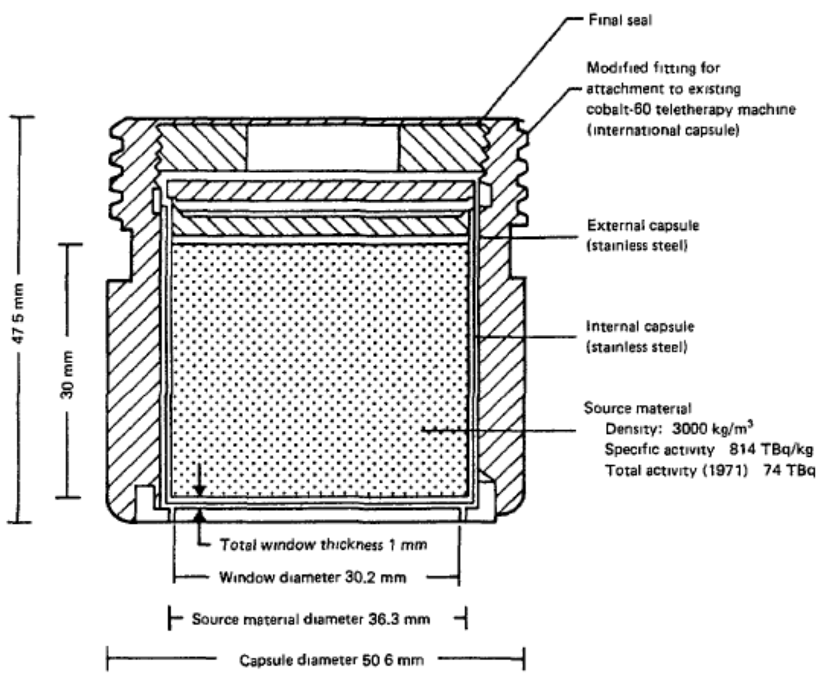
Source: IAEA, *The Radiological Accident in Goiânia*, 95.

In the timeline that the IAEA reconstructed after the accident, a local man, Roberto dos Santos Alves, had heard rumors around September 10, 1987, that valuable equipment remained at the dilapidated former IGR clinic site at the intersection of Avenida Tocantins and Avenida Paranaíba,[104] and went with a friend, Wagner Mota Pereira, to attempt to dismantle the cesium-137 teletherapy unit with simple tools, eventually succeeding in removing the rotating assembly.[105] The two men believed the shiny stainless steel casing might be valuable, and took it to Roberto dos Santos Alves's home in a wheelbarrow.[106] Over the next week, the men vomited and had symptoms of diarrhea, but Wagner Pereira's maladies were diagnosed as a reaction to bad food. They succeeded in opening the cesium-137 source itself, with either a

[104] Borges, *Eu também sou vítima*, 27.
[105] IAEA, *Radiological Accident*, 23.
[106] IAEA, *Radiological Accident*, 23.

hammer or a screwdriver,[107] and sold the pieces of the rotating assembly, with a captivating gunpowder-like substance then visible inside the radioisotope source, to a junkyard dealer, Devair Ferreira.[108] See Figure 9 for a schematic diagram of the type of capsule stolen.

Figure 9. Cross-section diagram of an international standard radioactive capsule.



Source: IAEA, *The Radiological Accident in Goiânia*, 21.

Ferreira noticed a curious blue glow in the garage, where he had placed the capsule, and brought it into his home, where he invited various neighbors, relatives, and acquaintances to come see it; his wife Gabriela became sick approximately three days, but was dismissed by doctors who believed she had similar food poisoning symptoms to Pereira.[109] Many of Devair's visitors daubed the radioactive cesium powder on their skin, "as with the glitter used at

[107] The IAEA reports that a screwdriver was used, while Weber Borges claims that a hammer shattered the capsule "in the shade of two mango trees" at Santos Alves's home.
[108] IAEA, *Radiological Accident*, 24, and Borges, *Eu também sou vítima*, 27.
[109] IAEA, *Radiological Accident*, 24.

Carnaval time."[110] Two of Devair's employees, Israel Baptista dos Santos and Admilson Alves de Souza, were hired to extract the lead from the capsule's rotating assembly, both later dying after massive radiation doses.[111] His wife would also die in October from radiation exposure, as would his six-year-old niece Leide, who had handled some of the cesium fragments that had previously been given to Devair's brother while she ate.[112] Devair's wife Gabriela had become convinced by late September that the mysterious powder was "killing her family," and had one of her husband's employees put the remaining source assembly in a bag to take to the Vigilância Sanitaria, which he carried on his shoulder, causing a "significant radiation burn."[113] The source remained on a doctor's desk "for some time," but he soon moved it to a courtyard and placed it on a chair, concerned about its contents.[114]

On September 28, a doctor at the Tropical Diseases Hospital suspected that Devair's wife and the man who had carried the source to the Vigilância Sanitaria were not suffering from a tropical disease, but in fact had skin lesions consistent with damage from radiation exposure.[115] This physician, called by his initials R.P. in the IAEA account, and his colleague, "A.M.," who had been contacted independently about the suspicious bag left at the Vigilância Sanitaria, contacted another doctor working for Goiás state's Department of the Environment; this state doctor knew that a medical physicist, Walter Ferreira, was visiting Goiânia and would better understand the bag's contents.[116] Ferreira, fortunately, arrived at the Vigilância

[110] IAEA, *Radiological Accident*, 24.
[111] IAEA, *Radiological Accident*, 24.
[112] IAEA, *Radiological Accident*, 24; on pages 49-50 of the same report, each clinical half-page description of the autopsies of the four victims starkly reveals the devastating effects of large-scale radiation exposure on the human body.
[113] IAEA, *Radiological Accident*, 25-26.
[114] IAEA, *Radiological Accident*, 26.
[115] IAEA, *Radiological Accident*, 26.
[116] IAEA, *Radiological Accident*, 26. Weber Borges calls Ferreira "the hero of the beginning" of the Goiânia accident narrative in his account, as his detective work both proved correct and launched CNEN and health authorities into a comprehensive plan to combat the effects of radiation spreading quickly through the Goiânia population.

Sanitaria in time to convince the Goiânia fire brigade not to carry out their original plan to pick up the radioactive capsule and throw it in a river. On September 30, people woke up to find areas of Goiânia near the junkyard and Vigilância Sanitaria cordoned off without explanation, as a mere five scientists (including Ferreira and the physicist from the *Instituto Goiano de Radioterapia*) struggled to handle the state's and city's initial response from the medical standpoint before more experts arrived.[117]

Ten countries, including Argentina, the World Health Organization, and the IAEA itself would end up contributing material and expertise to the international effort to treat the victims of radiation poisoning in Goiânia, decontaminate sites that were widely dispersed around the city, and assist in radiation protection and waste disposal.[118] Though the Goiânia accident is not typically considered a landmark event in strengthening nuclear cooperation between Brazil and Argentina, Roberto Ornstein, Argentina's nuclear energy commission director of international affairs, mentioned that two of the country's "best specialists" in the effects of ionizing radiation were dispatched immediately to Goiânia, along with another expert in managing radioactive waste.[119] In Ornstein's comments, he downplayed the "good neighbor" implications of this assistance, and stated that Argentine nuclear authorities were simply complying with the inter-commission agreement on aid in case of a nuclear accident.[120] The severity of the Goiânia accident, as noted above, was considerably exacerbated by the lack of monitoring of radiological sources that made the initial theft possible, the two-week lapse

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Ferreira's smoking gun was an interview with Carlos Bezerril, the owner of the defunct cancer treatment clinic, who revealed that a cesium-137 source had been left in the decaying building.

[117] IAEA, *Radiological Accident*, 35.

[118] IAEA, *Radiological Accident*, 111-113.

[119] Mallea, Spektor, and Wheeler, eds. *The Origins of Nuclear Cooperation: A Critical Oral History of Argentina and Brazil*, 167.

[120] Mallea et al, *Origins of Nuclear Cooperation*, 167. Presciently, as noted on *Origins* page 199, the two governments had indeed signed a protocol on "prompt notification of nuclear accidents and mutual assistance in case of a nuclear accident or radiological emergency" in July 1986.

between initial exposure by the victims and knowledge of medical and scientific authorities of what had transpired and in which places, and the general ignorance of the surrounding population of both the radioactivity of the cesium source and its potential for serious or fatal damage to the human body. From the disaster that unfolded in September 1987 in Goiânia, CNEN learned 15 "lessons," listed in an appendix to the IAEA's report; the most significant of these concerned mitigating the non-physical effects on human populations through an "adequate system of information" and "social and psychological support" for the public after another potential incident, knowledge of the physical and chemical properties of any radioactive source and consideration of those properties in licensing for manufacture, a clear decision-making hierarchy for working teams after any radiological accident, and a robust program of inspection of facilities like the IGR paired with an enforcement system for assigning civil or professional liability in the licensing of radioactive sources.[121]

In the same month as the Goiânia radiation disaster, Brazilian President José Sarney would announce the success of the parallel program in enriching uranium by centrifugation.[122] Though CNEN, Brazilian military leaders, and many politicians claimed a triumph in the Navy's successful project, it might well have led to the potential for a disaster far beyond even that of the Goiânia accident, as serious discussions continued about constructing a nuclear weapon.

Brazil's Bomb: Evidence For (and Against)

On October 9, 1990, a *New York Times* story ran with the placeline "Brasília, October 5," restating Brazilian Minister of Science and Technology José Goldemberg's declaration that Fernando Collor de Mello's newly-inaugurated government had uncovered a secret military

[121] IAEA, *Radiological Accident*, 120-122.
[122] Mallea et al, *Origins*, 208.

program to build a nuclear weapon.[123] Apparently, Goldemberg, a long-time opponent of the government's colossal expenditures on nuclear energy at the expense of "other, more acceptable energy alternatives,"[124] had needed some convincing that the evidence pointed definitively to a weapons program.[125] In September of that year, Collor had reportedly received a 50-page classified report on the project, but this report has never surfaced, according to Mark Hibbs, senior associate at Carnegie's Nuclear Policy Program.[126]

Much of the evidence for the existence of a covert nuclear weapons program in Brazil, oddly enough, came from the actions of the president himself, when he flew to the Cachimbo mountain range in the Amazon, in a remote part of the state of Pará, to "throw a symbolic shovelful of cement into a hole four feet in diameter and 1,050 feet deep."[127] But Collor's own officials had inspected the shafts and found that they would be useless for nuclear explosive tests. "There was no cabling or other support infrastructure, and the bottom of the holes was full of water."[128] In addition, there was nothing new or especially surprising to anyone in government circles about the holes or shafts as their existence had been known since 1986.[129] What was indeed novel was the public acknowledgement by the government of the Air Force's (conventional) weapons testing facility in the Amazon, and its attempt to tie it to a nuclear

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[123] James Brooke, "Brazil Uncovers Plan by Military to Build Atom Bomb and Stops It." *The New York Times*, Oct. 9, 1990.
[124] José Goldemberg, "Lessons from the Denuclearization of Brazil and Argentina," *Arms Control Today* 36, no. 3 (2006), 41.
[125] Barletta references an "internal debate" about the purported bomb project among the Brazilian Physical Society, where Goldemberg and physics professor Anselmo Páschoa held that the evidence was not strong enough. When they were adequately convinced, the society released a technical report "concluding that the Aramar enrichment plant could enrich uranium to 90%" and that a bomb might be a month away.
[126] Mark Hibbs, "Looking Back at Brazil's Boreholes." April 22, 2014. http://www.armscontrolwonk.com/archive/1102670/looking-back-at-brazils-boreholes/
[127] James Brooke, "Brazil Uncovers Plan by Military to Build Atom Bomb and Stops It." *The New York Times*, Oct. 9, 1990. http://www.nytimes.com/1990/10/09/world/brazil-uncovers-plan-by-military-to-build-atom-bomb-and-stops-it.html
[128] Hibbs, "Looking Back."
[129] Ken Conca, "Technology, the Military, and Democracy in Brazil," *Journal of Interamerican Studies and World Affairs* 34, no. 1 (1992): 172.

bomb development project.[130] Much as Perón's motivations for supporting the fusion research at Huemul Island in Chapter 1 were explored by later scholars, Collor's actions have now had 27 years to be analyzed in light of what he knew at the time; he may have sought to demonstrate to the United States and Argentina, with whom a landmark bilateral nuclear verification agreement had just been concluded (Chapter 6) that Brazil would be a trustworthy partner,[131] or he may have been seeking to consolidate his government's power over a still-powerful military with an unmistakably symbolic gesture.[132]

One last piece of evidence in favor of some kind of secret nuclear weapons project having existed in Brazil comes from José Luiz de Santana Carvalho, president of CNEN from 1990-1993. Santana wrote in 2006 that all sensitive documentation about Brazil's nuclear weapons program "suddenly disappeared from the files of the Nuclear Commission" the night before he took office in 1990, and the few documents that were intercepted from those smuggling them out of CNEN headquarters now are under an "Ultra Secret" classification by Brazil's civilian intelligence agency.[133] Hibbs' examination of the bomb controversy, too, closes with a "qualified yes" on the question of preliminary nuclear weapons development, with an unnamed government advisor identifying a "secret project, but at a very preliminary stage" in 1990.[134] If what this advisor says is true, the project was probably not close to readiness for a test, nor does it seem from contemporary and later descriptions of the famous Cachimbo shafts in Amazonian Pará that Brazil had any suitable facilities for such an undertaking.

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[130] Conca, "Technology," 172.
[131] Hibbs, "Looking Back."
[132] José Goldemberg and Harold A. Feiveson, "Denuclearization in Argentina and Brazil," *Arms Control Today* 24, no. 2 (1994), 13.
[133] José Luis Santana Carvalho, "Ending Brazil's Nuclear Weapons Program," *Arms Control Today* 36, no. 2 (2006): 51.
[134] Hibbs, "Looking Back."

Coda: Brazil's Parallel Path to Autonomous Nuclear Success

The 1970s began in Brazil amid the years of repressive rule by Gen. Emílio Garrastazu Médici, who sought to continue the policies of his predecessor, Artur Costa e Silva, in expanding the goals and budget of the nuclear program, setting his sights on nuclear power and concluding an agreement with US contractor Westinghouse to build the nation's first nuclear power plant, Angra I, while finalizing agreements with Paraguay on what is still the world's second-largest hydroelectric dam at Itaipu. Médici's successor, Gen. Ernesto Geisel, concluded the "deal of the century" with West Germany to bring eight nuclear power plants into operation on Brazilian soil by 1990, and "absorb" and gradually nationalize the technologies that would allow Brazil to control the full nuclear fuel cycle and build its own reactors in the future.

A broad variety of sectors of Brazilian society, however, including the scientific and technical community excluded from its negotiation, condemned the German deal in the press and in the 1978-82 CPI as expensive, secretive, and bringing the country no closer to its goal of nuclear energy self-sufficiency or "technological autonomy." The secret "parallel program," under the auspices of CNEN and the three branches of the armed forces, launched in 1979, delivered enrichment capabilities intended, in part, to aid the navy in developing a nuclear submarine. The architects of the parallel program sought national greatness through technical proficiency, one conclusion of their willingness to share the technologies developed outside the auspices of the "official program" with other Latin American nations. Another conclusion is that the military still retained a significant amount of power and influence after the return to civilian rule. While some generals within the Air Force sought to use parallel technologies to construct a "Brazilian bomb," the parallel program had also brought Brazil's peaceful nuclear capabilities more in line with those of its neighbor Argentina.

In the final chapter of this dissertation, “Plowshares,” I show how political leaders, scientists, and diplomats from Brazil and Argentina came together to craft an innovative, and still unprecedented, legal mechanism that pledged both parties to peaceful use of nuclear energy indefinitely.

Chapter 6: Plowshares

ABACC and the Evolution of Nuclear Verification between Argentina and Brazil, 1974–1992

> "I believe that this race between Brazil and Argentina was not something that involved the whole country. I believe it was very much concentrated at the military level."[1]
>
> –Sebastião do Rego Barros, retired Brazilian Foreign Ministry official

This concluding chapter will trace how and why Brazil and Argentina created a bilateral regime with technicians responsible for nuclear facility inspections and accounting of materials in the Quadripartite Agreement of 1991. It will also analyze multiple interpretations for the historical sequence of events that led to a legal framework that is still unprecedented in the history of global nuclear legislation. The South American neighbors possessed, by far, the most developed infrastructures for nuclear energy research and power generation in Latin America. The "London Club" of supplier nations, led by an increasingly rigid United States concerned about weapons proliferation in the developing world, had largely frozen Argentina and Brazil out of international nuclear transfer markets.[2] In Buenos Aires and Brasília in the late 1970s, the London Club's tightening restriction on nuclear technology trades to countries remaining outside the Non-Proliferation Treaty was viewed as a continuation of discriminatory policies that interfered with the right of sovereign nations to pursue peaceful nuclear energy use for economic development. Paradoxically, this hard-line approach from the US and its European allies sparked a no-expense-spared quest in each nation to complete the nuclear fuel cycle using indigenous technology wherever possible, discussed at length in Chapters 4 and 5. By the mid-1980s, Argentine nuclear experts had succeeded in autonomous uranium

[1] Mallea et al, *The Origins of Nuclear Cooperation.* Rio de Janeiro: Fundação Getúlio Vargas, 2015, 187.
[2] See, for example, Ana Maria Ribeiro de Andrade, "Átomos na política internacional," *Revista CTS* 7, no. 21 (2012): 129, or Tatiana Coutto, "An International History of the Brazilian-Argentine Rapprochement," *The International History Review* 36, no. 2 (2014): 311 for the London Club's actions to restrict nuclear technology and fuel transfers to the South American neighbors.

enrichment at a secret gaseous diffusion facility at Pilcaniyeu, and the Brazilian navy had won an inter-branch race to do the same, using Soviet-designed ultracentrifuges at IPEN in São Paulo.

Brazil and Argentina also shared an exceptional, complex, and long bilateral relationship that had been forever changed by the first three decades of the Atomic Age, though nuclear energy was but one contentious issue between the two military forces that held power simultaneously in both nations for 14 of the 20 years between 1965 and 1985. The boundary between the modern countries once (roughly) separated the Portuguese Empire from that of Spain. After independence, Argentina and Brazil had expanded their national territories and incorporated resistant local populations into rapidly growing and centralizing nation-states. The two governments generally vied with each other for regional dominance and influence as their military forces served to keep the other in check, but expressing the complexity of the bilateral relationship requires attention to both its cooperative as well as conflictive periods. A long history of attempts at high-level bilateral coordination and cooperation between Brazil and Argentina bridging the War of the Triple Alliance and the final years of the Cold War is traced by Gian Luca Gardini, drawing on interviews with Oscar Camilión and Ramiro Saraiva Guerreiro, the ministers of foreign affairs of Argentina and Brazil, respectively, instrumental in the nuclear cooperation negotiations at the heart of this chapter, as well as five foreign ministry officials and one professor.[3] Despite an accelerating, and persistent, record of efforts to mend fences between Brazil and Argentina, including "attempts by Rio Branco in the early twentieth century, by Aranha and Pinedo in 1941, the understanding for an ABC [Argentina-Brazil-Chile] Pact between Vargas and Perón in the 1960s, the agreements of Uruguayana in 1961,

[3] Gian Luca Gardini, "Making Sense of Rapprochement between Argentina and Brazil, 1979-1982," *European Review of Latin American and Caribbean Studies* 80 (2006).

and the proposal for a sectoral customs union under Castelo Branco in 1967,"[4] Gardini cautioned against extrapolating any durable project or lasting political will to improve the bilateral relationship or increase overall integration and cooperation from any of these single events.

I argue in this chapter that meaningful attempts at bilateral cooperation on nuclear energy from both Argentine and Brazilian authorities stretch back into the late 1960s, particularly during the negotiations of the Treaty of Tlatelolco and the overtures of Artur Costa e Silva toward Argentina in early 1967.[5] Nevertheless, these efforts, like those discussed by Gardini, proved ephemeral as the acrimonious disputes over the La Plata river basin and Itaipú hydroelectric dam plans, "the height of geopolitical competition between the two states,"[6] evaporated whatever progress was made toward cooperative nuclear policy during and immediately after the negotiations of the Tlatelolco Treaty in Mexico City. Many authors correctly identify the resolution in October 1979 of the Itaipú-Corpus dispute over river levels in the La Plata basin, via the signature of the Tripartite Agreement by Argentina, Brazil, and Paraguay, as a fundamental event in a more general rapprochement between Brazil and Argentina, and a watershed in their bilateral negotiations on nuclear energy.[7] I argue in this chapter that a timeline for nuclear cooperation starting in 1979 does not go back far enough, without accepting the contention advanced by Argentine diplomat Julio Cesar Carasales that an essentially unbroken line of diplomatic and legal cooperation on nuclear matters stretches back

[4] Gardini, "Making Sense," 57.
[5] Coutto discusses Costa e Silva's visit to Buenos Aires in March 1967 and the surprising agreements on trade and nuclear politics and nonproliferation questions that belied a period of general tension in the bilateral relationship in "An International History of the Brazilian-Argentine Rapprochement," Tatiana Coutto, *The International History Review* 36, no. 2 (2014): 305-306.
[6] Mallea et al, *Origins*, 33-34.
[7] See Gardini, "Making Sense" (2006), João Resende-Santos, "The Origins of Security Cooperation in the Southern Cone" (2002), Rodrigo Mallea, "La cuestión nuclear en la relación argentina-brasileña" (2012), Coutto, "An International History" (2014).

to 1962, when the two countries agreed to rotate Latin America's seat on the IAEA Board of Governors between their two delegations.[8] The Itaipu crisis was far too contentious to allow for an unbroken path of growing nuclear energy cooperation from 1962-1991. Still, the bilateral relationship, even at its most strained points in the 1970s, was "not one of pure, unremitting rivalry, but one sprinkled with episodes of cooperation and mutual adjustment,"[9] events that would accelerate in frequency, formality, and specificity after the landmark negotiations between Jorge Rafael Videla and João Figueiredo of May 1980.

Many of the technical intricacies of nuclear energy cooperation that would anchor the formal legal and diplomatic structures built in the second half of the 1980s, in fact, find their earliest antecedents in the mid-1970s. In 1974, the year that India tested its nuclear explosion, exacerbating its tensions with neighbors China and Pakistan, Argentine engineer Jorge Cosentino expressed his sincere interest in exchanging technical information and experience with Brazilian nuclear officials and technicians, and a delegation from Brazil's Superior War College visited Argentina's Atucha nuclear power plant.[10] The latest impetus for nuclear cooperation in the Southern Cone had come about, in part, to battle the strong headwinds of renewed nonproliferation concern among North Atlantic countries after India's test; the United

[8] The key events in Carasales's chronology of early nuclear cooperation between Argentina and Brazil are the following: 1) Resolution of a competition for Latin America's representation on the IAEA Board of Governors as the "most advanced" nuclear nation in 1962 with a compromise that the two countries would alternate the seat; 2) tight coordination between the Southern Cone neighbors' delegations on positions and arguments at the meetings of COPREDAL (1964-1967) leading to the Treaty of Tlatelolco; 3) Argentina's ideological alignment with Brazil's professed goal to pursue full nuclear technology development through its 1975 power reactor and enrichment transfer agreement with West Germany, an event that could have heightened tensions around nuclear energy but instead brought the two governments and foreign ministries together.

[9] Resende-Santos, "Origins of Security Cooperation," 91. Carasales would certainly agree with this more positive assessment of Argentine-Brazilian relations, even going so far as to use quote marks around the word "rivalry" in one of his chapter titles in *De rivales a socios.* His central role in the negotiations with Brazil, however, may have led him to underplay the gravity of the Itaipu damper on the fragile bilateral efforts in his account.

[10] Mallea et al, *Origins*, 201, and diplomatic communications from Antônio Azeredo da Silveira to Ernesto Geisel, in translation, May 21, 1974, "Report from Brazilian Foreign Ministry to President Ernesto Geisel, The Indian Nuclear Test," Itamaraty official Pinheiro on July 1, 1974, "Visita de funcionário da Embaixada à Central Nuclear de Atucha," and Sept. 8-11 1974, "Exposição de motivos no. 062/74" and "Aviso no. 288/74," all from WCDA.

States responded to that shock, in part, by making exports of nuclear fuel conditional on American assessments of its availability after July 1974, prior agreements like Brazil's notwithstanding.[11] From 1974-1980, Argentina increased the power output from its newly operational Atucha reactor as Brazil slowly navigated the safety, regulatory, and financial hurdles toward its Angra I power reactor purchased from West Germany. Both national nuclear energy commissions began serious and ambitious autonomous fuel cycle projects in this six-year period as the Itaipu diplomatic crisis gradually receded from its tense apex from December 1976-September 1979.[12] Argentina's brinkmanship with Chile over the Beagle Channel occupied most of the Videla government's diplomatic attention, while the Brazilian military government's *abertura* policy under Ernesto Geisel aimed to defuse tensions in foreign relations as part of a broader goal of marginalizing the military's extremists and restoring the professionalism of the armed forces.[13]

However, Geisel's foreign policy orientations were far from ideal for a major improvement in relations with Argentina. In concert with his foreign minister Antônio Azeredo da Silveira, Geisel sought to isolate his southwestern neighbor by concluding agreements with Uruguay, Paraguay, and Bolivia,[14] and reached north and west to conclude the Amazon Cooperation Treaty in 1978 with Andean nations and Venezuela, Guyana, and Suriname. The Amazon treaty represented an effort, in part, to counteract Argentina's closer relationship with the Andean Pact countries (Colombia, Ecuador, Bolivia, and Peru) as Brazil sought to mend its relations with neighbors that it had largely spurned in the 1960s in favor of

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[11] Mallea et al, *Origins*, 201.
[12] Resende-Santos, "Origins of Security Cooperation," 97.
[13] Resende-Santos, "Origins of Security Cooperation," 100.
[14] Leslie Bethell and Celso Castro, "Politics in Brazil under Military Rule, 1964-1985." *Cambridge History of Latin America*, vol. 9, 2008, 208.

the United States.[15] Argentina, riven by dizzying inflation, and spiraling violence between extreme leftist *Montoneros* who had turned on Juan Perón's wife and vice president, Isabel, who assumed the presidency upon Perón's death on July 1, 1974, and the far-right *Triple A* (Argentine Anticommunist Alliance) death squad, faced such chaos that a foreign policy as coherent as Brazil's was impossible. [16] The Triple A's leader, José López Rega, had earned the confidence of the late Perón, serving as his Minister of Social Welfare; his widow Isabel, as president, openly courted López Rega's support to eliminate *Montoneros* and shore up her fragile power with the backing of the (civilian) authoritarian right and the military in an open and obvious betrayal of leftist Peronists.[17] Yet against the background of this political chaos, the beginnings of a *persistent and durable* effort toward technical and diplomatic coordination on nuclear energy and cooperation between Argentina and Brazil began in a quite simple way, when a delegation of Brazilian military officers and Argentine nuclear energy personnel each visited an important nuclear energy facility across the border in 1974.

Engineer Jorge Cosentino, the director of Argentina's Atucha nuclear power reactor facility, traveled to Brazil in June 1974 to indicate his interest in exchanging nuclear expertise and information between the two countries. A delegation from Brazil's military academy, the Escola Superior de Guerra, then visited the Atucha power plant in Argentina in July 1974. There, Cosentino was remarkably frank about the specifics and goals of Argentina's nuclear program, where the conversations mostly centered on the recently inaugurated Atucha power

[15] Elizabeth G. Ferris, "The Andean Pact and the Amazon Treaty: Reflections of Changing Latin American Relations." *Journal of Interamerican Studies and World Affairs* 23, no. 2 (1981): 159.
[16] Juan Carlos Torre and Liliana de Riz, "Argentina, 1930-46." *Cambridge History of Latin America*, vol. 8, 1991, 155. From June-August 1975, consumer prices rose 102%, a rate of monthly inflation three to five times that of the previous thirty years.
[17] David Rock, "Argentina since 1946," in *Cambridge History of Latin America*, vol. 8, 153.

plant.[18] It is interesting that Atucha's existence and operation served as a physical reminder to Brazil of Argentina's considerable lead in nuclear energy technology in the mid-1970s, itself an outcome of CNEA leaders' decision to use natural uranium in Argentina's power reactors,[19] and yet did not seem to exacerbate the tensions between the two countries.[20] Cosentino took on a didactic role as he explained the intricacies of Argentina's power reactor to his visitors, who learned, for instance, that CNEA had imported 327.08 tons of heavy water from the United States and West Germany to operate Atucha.[21] The engineer continued by discussing the plutonium that was a byproduct of Atucha's operation, and said that the Atucha facility was under safeguards (so the plutonium produced could not be diverted to use in a weapon)[22] and there were no plans to reprocess the plutonium to use as fuel.[23] He invited Brazilian technicians "without any reservation" to come learn "whichever details they wished to know" about the

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[18] Pinheiro, "Visita de funcionario da Embaixada à Central Nuclear de Atucha." Memorandum to Brazilian Embassy in Buenos Aires. July 1, 1974. WCDA.

[19] Paul L. Leventhal and Sharon Tanzer, eds. *Averting a Latin American nuclear arms race: new prospects and challenges for Argentine-Brazil nuclear co-operation* (New York: St. Martin's Press, 1992), 217. Leventhal and Tanzer's book is a series of transcripts and summaries of the Conference on Latin American Nuclear Cooperation held in Montevideo, Uruguay, from October 11-13, 1989, funded by the Ford Foundation and under the auspices of the Washington, DC-based Nuclear Control Institute. While the funding and leadership from American sources creates potential problems of bias in the selection of panelists and topics, the book remains an invaluable snapshot of a key moment late in the chronology of nuclear cooperation between Brazil and Argentina when the form and substance of the outcome of the long, complex trajectory were still very much in doubt.

[20] Lampreia's 2012 oral history account of the effects of the Corpus-Itaipu dispute on Brazil's worsening relationship with Argentina indeed places most of the emphasis on the hydroelectric energy debate and not the one involving nuclear technology (Mallea et al, *Origins*, 58). While their joint resistance to the perceived excesses of the nuclear nonproliferation regime and stringent United States policies on exports provided a common basis for nuclear diplomacy between the two South American neighbors, the Brazilian diplomat saw the Itaipu dispute as a fraught path with many potential bad endings, where the presence of a third country, Paraguay, created "a strategic situation that could have gone awry." (*Origins*, 60).

[21] The amusing exactitude of this figure in fact had a reason behind it, as Pinheiro explained that 27.08 tons of deuterium oxide had been imported from Germany to replace the "daily loss of around 600 grams" of the neutron moderator material.

[22] The safeguards agreement does not specifically mention plutonium, but it is covered in the requirement for an accurate inventory of "nuclear material that is being or has been produced in the Nuclear Facility" in Part V, Inventory and Notifications, Section 8 (a), and Part V, Section 10, Reports on Produced Nuclear Material, as "any special fissionable material produced during the period covered by the report." International Atomic Energy Agency, "Information Circular 168: The Text of the Agreement Between the Agency and Argentina for the Application of Safeguards to the Atucha Power Reactor Facility." October 3, 1972. Downloaded from https://www.iaea.org/publications/documents/infcircs/text-agreement-between-agency-and-argentina-application-safeguards-atucha-power-reactor-facility.

[23] Pinheiro, 2.

Argentine program, and told them that he hoped the two countries would come to cooperate more closely on nuclear energy matters because of the "two distinct experiences" of running power programs based on natural vs. enriched uranium.[24] Brazilian Ambassador to Argentina Luiz Castro Neves recounted a humorous anecdote about these Escola Superior de Guerra visitors, as well, whom he welcomed to Atucha in his official capacity as a representative of the country. Brazilian technicians had apparently sent Castro Neves a long and detailed questionnaire, to be used by the ambassador to quiz Cosentino on the Argentine facility's technical details.[25] When Castro Neves "started to ask about the time of the burning of uranium-238 and the intervals of replacement of the fuel, etc.," the Argentine engineer turned to him and said "You don't need to worry, we're not building the bomb!"[26]

On September 8, 1974, Hugo de Andrade Abreu, President Ernesto Geisel's chief of staff, wrote a memorandum to the president to update him on the prospects of an agreement with Argentina on nuclear energy for peaceful ends. Brazil, according to its objectives under the 1967 Guidelines for National Nuclear Energy Policy, had signed various agreements on nuclear energy with other countries, and Abreu referenced the last attempt that the government had made to conclude a similar document with Argentina in September 1967.[27] At that time, President Costa e Silva had authorized "preliminary conversations, with an eye toward putting the formal negotiation process in motion…"[28] Despite Brazilian efforts to contact persons in the Argentine nuclear sector prior to any definitive moves in the direction of a bilateral treaty, "there did not seem to be, despite the initial receptivity shown, more interest

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[24] Pinheiro, 2.
[25] Mallea et al, *Origins*, 74.
[26] Mallea et al, *Origins*, 75.
[27] Letter from Hugo de Andrade Abreu to President Ernesto Geisel (*Exposição de Motivos*), AAS 1974.09.11 mre/pn, Sep. 8, 1974, 2. WCDA.
[28] Abreu to Geisel, Sep. 8, 1974, 1.

from the parties in deepening understanding through a formalization of the Agreement."[29] In 1970, the Ministry of Foreign Relations believed the political conditions to be favorable to resuming negotiations with Argentina, and the National Security Council concurred that "the project of the Agreement, which earned the approval of the Ministry of Mines and Energy, is of undeniable merit for the high interests of National Security."

When trainees at Brazil's Superior War College had traveled to Argentina's Atucha power reactor, the director of that facility, Jorge Cosentino, had reiterated his interest in a nuclear information exchange with Brazil, supported by "another Argentine scientist holding a position of distinction" in the nuclear energy field.[30] Itamaraty responded favorably to this olive branch, claiming that such an agreement would "separate us from the malicious assertion made in certain international circles about a race between the two countries for the fabrication of the 'bomb'."[31] Whether or not there was any truth to these speculations from outside nations, Abreu argued, they could only hurt Brazil in terms of the nuclear energy aid that other countries would be willing to provide it, so a "discreet dialogue on the topic, through diplomatic channels" should be restarted with the Argentine government. Shigeaki Ueki, Geisel's Minister of Mines and Energy, agreed with Itamaraty's position from a rather practical standpoint: the exchange of information and experiences would be "quite useful," and from a diplomatic angle, would confer political and technical advantages in expanding the range of options that peaceful nuclear cooperation could take in Argentina and Brazil.[32]

Three days later, on September 11, 1974, Abreu wrote another brief memorandum, this time to Ambassador Antônio Azeredo da Silveira, referencing the Explanatory Statement from

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[29] Abreu to Geisel, Sep. 8, 1974, 2.
[30] Abreu to Geisel, Sep. 8, 1974, 2-3; this scientist is not named.
[31] Abreu to Geisel, Sep. 8, 1974, 3.
[32] Abreu to Geisel, Sep. 8, 1974, 4.

President Geisel on another attempt at an elusive nuclear energy agreement with Argentina. As "various pending issues" between the neighbors, including the river levels allowed around the Itaipú hydroelectric dam, weighed on the bilateral relationship, Geisel had suggested that "a possible agreement on cooperation regarding nuclear energy could be negotiated given the opportunity in which the above matters could also be addressed."[33] The president recommended that the Brazilian authorities wait for the most opportune time for such an accord, but continue their studies and preparation in the meantime, including drafting the document to be proposed.[34] (Eventually, Geisel's position would become more rigid, requiring the Itaipu question to be settled in a manner that satisfied the Brazilian side before agreeing to negotiate any official nuclear cooperation with Argentina).[35] The intersection of Brazil's cautious détente that mostly excluded Argentina while reopening toward the rest of its continental neighbors, and Argentina's sharp authoritarian turn inward, however, was hardly auspicious for the two military governments to craft a new understanding around nuclear energy. Luiz Felipe Lampreia stated in 2012 that the dominant bilateral energy issues between Argentina and Brazil from 1975-1985 – nuclear policy and Itaipu – were intricately linked and carried a high risk of damaging the troubled relationship between the two nations even further.[36] Brazil's military had been trained to believe that Argentina would be its most likely opponent in a hypothetical war, as part of a scenario known as the "Beta Plan," as officials of the two foreign ministries continued their traditional competition for influence in the continent and region.[37] Whereas one might logically expect that the 1975 West Germany-Brazil power reactors and fuel cycle technology transfer deal might have further destabilized this tense

[33] Abreu to Antônio Azeredo da Silveira. Sep. 11, 1974. WCDA.
[34] Abreu to Silveira.
[35] Coutto, "An International History of the Brazilian-Argentine Rapprochement," 309.
[36] Mallea et al, *Origins*, 49.
[37] Mallea et al, *Origins*, 49.

bilateral relationship, Oscar Camilión, soon to be Argentina's ambassador to Brazil,[38] recalled that Argentine officials saw no military potential in their neighbor's technology transfer, and perceived echoes of their own negotiations concluded with Germany in 1968 for the Siemens-built heavy water and natural uranium Atucha reactor.[39]

Paulo Nogueira Batista, as president of Nuclebrás, wrote notes during a meeting at Itamaraty in November 1976 that indicated some of the difficulties within Brazilian official circles in negotiating any potential agreement with Argentina. CNEA President Carlos Castro Madero had proposed a joint declaration with Brazil on nuclear energy during the 21st IAEA conference in Rio de Janeiro two months before, but the officials with whom Nogueira spoke in November seemed entirely unfavorable to the idea.[40] The nuclear transfer agreement with West Germany occupied a great deal of diplomatic space, making the others in the room – notably Itamaraty's diplomats Paulo Cabral de Mello and Luiz Felipe Lampreia – hesitant to support efforts toward a prospective nuclear energy cooperation agreement that might be better channeled into the extant German collaboration.[41] An intra-Latin American agreement between the region's two leading nuclear energy programs might limit CNEN, an agency that sought international significance and had put a great amount of conceptual weight on the German agreement and its application to Nuclebrás. There was also doubt regarding the financial benefit to Brazil of a potential neighborly agreement, as "the guarantee of markets for future exports will not come from [Argentina]."[42] Minister of Mines and Energy Shigeaki Ueki

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[38] Mallea et al, *Origins*, 12. Camilión was deputy foreign minister under Arturo Frondizi (1958-1962), ambassador to Brazil (1976-1981), Foreign Minister (1981) and Defense Minister (1993-1996).
[39] Mallea et al, *Origins*, 61, 195.
[40] Notes from the President of Nuclebrás Paulo Nogueira Batista to the Brazilian Ministry of Foreign Relations. PNB pn a 1974.07.01, WCDA via Paulo Nogueira Batista Archive/CPDOC, Rio de Janeiro, November 24, 1976; Mallea et al, *Origins*, 78, 202.
[41] Paulo Nogueira Batista, "Notes," November 24, 1976.
[42] Paulo Nogueira Batista, "Notes," November 24, 1976.

directed diplomat Paulo Cabral to communicate that the Ministry of Mines and Energy would not support any nuclear agreement with Argentina, and that the Brazilians would only listen to proposals initiated from the Argentine side.[43] (In the eighth month of military rule by the *Proceso* junta in Argentina, this would have been a rather unlikely offer to be made).

Despite the misgivings in some circles of the Argentine military and government regarding the Brazilian agreement with West Germany, in early 1977, Itamaraty received a cable from Brazil's embassy in Ottawa. The cable stated that Argentina's ambassador to Brazil, Esteban Takacs, had used the occasion of his visit to Canada to urge the Argentine government to show support for Brazil's technology transfer. This solidarity was especially important in light of the Carter administration's crackdown on nuclear proliferation, one hallmark of his foreign policy.[44] "If the US were to succeed in impeding or limiting the German-Brazilian agreement, their next objective would be the sabotage of the Argentine nuclear program."[45] Takacs also expressed his irritation with the Canadians on the stalled negotiation to purchase a heavy-water CANDU reactor (discussed in chapter 4) and indicated that Argentina would look to West Germany instead for its third nuclear power reactor, seemingly a sign of approval that Brazil had chosen its most recent and important nuclear partner well.

The initiative from Argentina's side that Ueki had been seeking at the meeting in November 1976 for any potential agreement with Brazil, in fact, reappeared surprisingly quickly in March 1977. Argentina's ambassador to Brazil, Oscar Camilión, had begun meeting with military and political officials in Brasília in May 1976 to negotiate the Itaipu dispute, and related in 2012 that they had been working behind the scenes "between 1975 and 1977" to

[43] Paulo Nogueira Batista, "Notes," November 24, 1976.
[44] Silos, "Energia nuclear. Acordo Brasil-RFA. Posição da Argentina," telegram to Brazilian embassy in Ottawa, Canada. February 11, 1977, WCDA.
[45] Silos, "Acordo Brasil-RFA." February 11, 1977.

establish a mechanism to build trust between the neighbors on matters of nuclear energy applications or "possible temptations."[46] These meetings began to bear fruit in early 1977, when Camilión told Brazilian naval admiral (and the armed forces' vice-chief of staff) José Calvente Aranda of Argentina's "complete solidarity" with Brazil and desire to strengthen the bonds of friendship between the two nations. The Argentine ambassador then surprised his interlocutor with the news that Jorge Rafael Videla wished to visit Brazil, a revelation by Argentina's head of state that had caught even his own foreign ministry off guard.[47] The bilateral dispute between the neighbors over the Itaipú hydroelectric plant, Camilión maintained, was now of lesser importance, and even perhaps a matter best left within the internal politics of Argentina.[48] Then Camilión added that the moment might be propitious for the long-debated nuclear energy agreement with Brazil, which would "strengthen the position of both countries and remove the stain of any insinuation with respect to the fabrication of the bomb."[49]

Argentina's military government knew well about Camilión's openness to rapprochement with Brazil, and sent him to Brasília to negotiate a diplomatic settlement on Itaipu rather than retrenching for a military fight.[50] Whether this move was a tacit admission that Brazil was the dominant regional power,[51] or a recognition of Camilión's long history of working with Brazilian officials from his earliest days as minister-counselor of the Argentine embassy in Rio in the late 1950s,[52] or motivated by other factors entirely, is difficult to argue. What we know for certain is that his efforts would not pay off in the form of a concrete

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[46] Mallea et al, *Origins*, 67-68. Presumably the "temptations" are a reference to possible development of a nuclear weapon in either country, but Camilión is not explicit on this point in the transcript.
[47] Unknown author, letter to Hugo Abreu from Brasília. March 22, 1977, WCDA.
[48] Letter to Abreu from Brasília, 1.
[49] Letter to Abreu from Brasília, 2.
[50] Mallea et al, *Origins*, 41-42.
[51] Amarildo Silveira, "As relações Brasil-Argentina durante o governo Figueiredo (1979-1985): as etapas de um projeto necessário," Faculdades Porto-Alegrenses, 2006: 146-162.
[52] Mallea et al, *Origins*, 51.

agreement on Itaipu until Geisel's successor as president, João Figueiredo, had taken power, and brought in with him a new foreign minister in March 1979, Ramiro Saraiva Guerreiro, to replace the harder-line Silveira.[53] This delayed reaction is a reminder of the absolutely fundamental role of individual personalities throughout the sixteen years of gradual *rapprochement*, and how much bilateral progress depended upon the presence and actions of like-minded officials, scientists, and diplomats in Argentina and Brazil. Despite his genuine desire to do so, Camilión was unable to effect a significant and lasting change on Itaipu or nuclear energy cooperation without sufficient support from Itamaraty or the executive, Ernesto Geisel. Yet even before 1979, he found these like-minded Brazilian officials in other positions besides head of state or chief diplomat.

In 1977, a close personal relationship between the heads of CNEA and CNEN – Carlos Castro Madero and Hervásio de Carvalho, respectively – continued to develop, built on the solid foundation of collegiality shared when both were on the IAEA Board of Governors.[54] Castro Madero's and Carvalho's positions atop the two national nuclear energy commissions helped to bring both formality and institutional permanence to a meaningful, but fragile, improvement of the Brazil-Argentina relationship centered on nuclear energy. Roberto Ornstein of Argentina noted the importance of Castro Madero's warm relationship with Carvalho within the broader rapprochement timeline.[55] Another Brazilian, Paulo Nogueira Batista, formed the third leg of an unlikely trio of high-level collaborators on nuclear matters.

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[53] Mallea et al, *Origins*, 69. Azeredo da Silveira, according to Luiz Felipe Lampreia, did not want to sign the Itaipu agreement with Argentina, and had a troubled relationship with his Argentine counterpart, foreign minister Carlos Pastor. Camilión himself speculated that Silveira's resentment toward Argentina may have stemmed from his five years in Buenos Aires as ambassador, 1969-1974 (*Origins*, 99).

[54] Mallea et al, *Origins*, 73. Roberto Ornstein, CNEA's head of International Affairs from 1979-1995, notes the warm relationship between the two nuclear energy commission presidents twice in different areas of the transcript from 2012.

[55] Mallea et al, *Origins*, 34.

Though Oscar Camilión, Argentina's ambassador to Brazil between 1976 and 1981, admitted later that Nogueira Batista was "not easy to deal with," the Nuclebrás president shared a close relationship with Castro Madero as well.[56] Castro Madero had advised Nogueira Batista against the sheer difficulty of building a massive 1350-megawatt nuclear power plant without any tests, as the agreement with West Germany had promised. Argentina's chief nuclear energy official also expressed more general reservations about Brazil's plan to develop a viable nuclear power program along the lines of that 1975 negotiation.[57] As conflicting plans for hydroelectric energy continued to drive a wedge between Argentina and Brazil until 1979, the positive developments in an unlikely relationship among Carlos Castro Madero, Hervásio de Carvalho, and Paulo Nogueira Batista seemed to offer a way forward on another knotty set of stalemated energy and security debates.

And from the United States, that same year, a new idea on nuclear control policy in the Southern Cone came from an unlikely source. Illinois Representative Paul Findley, a Republican from Jacksonville who served in the House from 1961-1983, sponsored 201 bills during his legislative career,[58] roughly half of which were referred to the Ways and Means, Education and the Workforce, or Agriculture committees.[59] Near the end of his first decade in Congress, however, his interests had moved toward foreign affairs; he was an early opponent of the Vietnam War, and later became a central and controversial voice in opposing the centrality

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[56] Mallea et al, *Origins*, 73.
[57] Mallea et al, *Origins*, 62. Camilión, in the transcript, interpreted Castro Madero's advice not as an unfriendly critique of the energy policy of a neighbor and rival, but rather as manifesting the "goodwill and constructive spirit" between high nuclear energy officials from Argentina and Brazil; it is not clear when this conversation took place, but the identities of the individuals involved indicate that it was sometime between 1976 and early 1979.
[58] "Paul Findley. Congress.gov. Library of Congress." https://www.congress.gov/member/paul-findley/F000123. This total excludes resolutions, joint resolutions, concurrent resolutions, and amendments, as well as legislation cosponsored by Findley (i.e. where he was not the lead sponsor).
[59] 103 of 201 bills that Findley authored ended up in these three committees. The primacy of foreign affairs among his interests emerges as a slight plurality, however, among committee referrals when other types of legislation are counted (53 of 304 bills, resolutions, or amendments), a percentage that is maintained when cosponsored legislation is added in (169 of 954 bills, resolutions, or amendments).

of Israel in United States foreign policy in the Middle East.[60] Findley toured Brazil, Argentina, Chile, Peru, Ecuador, and Colombia as part of a Congressional Study Mission in August 1977, his fifteenth year in Congress.[61] His travels and "discussions with top officials" in these countries led him to propose a bilateral verification mechanism that took concrete (and nearly identical) form almost 14 years later as the Common System of Accounting and Control, shortly transformed into ABACC by the Quadripartite Agreement of 1991.[62] Findley had arranged to speak with Brazilian Vice President Adalberto Pereira dos Santos when Pereira visited Washington, DC, as part of the delegation to attend the September 7, 1977 signing ceremony for the new Panama Canal agreements.[63] The vice president of Brazil demurred after hearing Findley's proposal, assuring the Illinois congressional representative that "Brazil was not concerned with obtaining weapons, but rather energy, essential to its development."[64] Yet Findley's idea had repercussions in the American capital, where his proposal was printed in the *Washington Post* in September 1977.[65] His proposal had ramifications on nonproliferation policy as well, since US officials began to consider abandoning hard-line diplomatic tactics toward the South American nuclear programs in favor of a system of inspections like that proposed by the congressman, particularly when the CIA reported that neither Brazil nor Argentina was building nuclear weapons.[66]

[60] "General Interest: Findley, Paul." https://www.illinois.gov/alplm/library/collections/oralhistory/illinoisstatecraft/general/Pages/FindleyPaul.aspx

[61] Paul Findley letter to General Pereira dos Santos, Wilson Center/NPIHP Digital Archive, Sept. 6, 1977, 1.

[62] It is not clear whether Findley traveled alone, but neither his letter nor the discussion of his visit to South America in *The Origins of Nuclear Cooperation* mention any companions.

[63] Adalberto Pereira dos Santos, "Relatório Apresentado pelo Exmº Sr. Vice-Presidente da República ao Excelentissimo Senhor Presidente da República." Sept. 7, 1977, 1, WCDA.

[64] Pereira dos Santos, "Relatório," 2.

[65] *Origins*, 202.

[66] Mallea et al, *Origins of Nuclear Cooperation*, 26.

In the Sept. 6 meeting with the vice president of Brazil, Findley stressed that his initiative was "strictly personal" and did not carry the official recommendation or support of the United States government. He referred to an earlier meeting with a high official of Brazil's ministry of foreign relations (whom he did not name) before handing a letter to Pereira, dated September 6, 1977, which the vice president attached in his communication to Geisel. Findley clearly stated there that his idea was "formulated entirely by myself, without consultation or knowledge of the White House or Department of State," on the basis of his experiences traveling in Latin America for two weeks during August 1977.[67] Findley's visit was very much secondary in importance, at least in Brasília, to the diplomatic activity around the signature of the Torrijos-Carter treaties that would begin the handover of the Panama Canal from US to Panamanian control, and the "transcendental step" for Western hemispheric relations in resolving the matter of control over the Canal.[68]

What Findley proposed in his September 1977 letter was essentially *exactly* what would take shape as ABACC fourteen years later, as codified under the Quadripartite Treaty, discussed near the end of this chapter. The congressman wrote succinctly and directly: "A bilateral, on-site nuclear verification agreement between Argentina and Brazil could help to arrest mounting concern over the character of each country's ultimate nuclear aspirations."[69] In travels that included meetings with top officials in the two countries of interest as well as four Andean nations, Findley called on the Brazilian and Argentine governments to "renounce any intention of developing a nuclear explosive device and agree to accept continuing, mutual, on-site monitoring of their respective nuclear facilities." Characterizing the relationship between the two countries as one of "natural competitors over the years" that would probably "remain

[67] Paul Findley letter to General Pereira dos Santos, Sept. 6, 1977, 1, WCDA.
[68] Pereira dos Santos, "Relatório," 2.
[69] Findley letter to Pereira dos Santos, 1.

so in the future," Findley did not trust the frequent disavowals of nuclear weapons development coming from Buenos Aires and Brasília "in the absence of solid safeguards."[70]

If either Argentina or Brazil were to opt to develop a nuclear weapon, Findley wrote, the other would certainly follow suit, possibly unleashing a "chain reaction" of nuclear weaponization in South America. Findley did not intend his plan to substitute for IAEA safeguards, but rather to supplement them, providing "an important additional element of assurance and protection," to "strengthen the web of checks and decrease any incentive for abuse and diversion."[71] The congressman concluded by offering three advantages to his idea: likely worldwide approval for a decisive move toward nuclear nonproliferation "without participation or pressure by the nuclear weapons state,"[72] a landmark agreement between Brazil and Argentina in a time of bilateral division, where those were quite infrequent, and a low (or nonexistent) political cost to both nations, where, Findley noted, "a cordial, informal, cooperative relationship among their nuclear officials" stood out as a harmonious example in what was otherwise a conflictive, tense, and complex bilateral environment.[73]

Findley got the chance to personally present his idea to some of the highest-ranking political officials in the two countries, including Argentina's president Videla, Brazilian Deputy Foreign Minister Geraldo Holanda Cavalcanti, and Vice President Pereira, as mentioned above, and mentioned that he had felt "great receptivity to this positive, cooperative step" in conversations with officials in both countries.[74] Despite having his plan "discarded on the spot" by officials at Itamaraty, Findley did find more open ears in Argentina, where ministers were

[70] Findley letter to Pereira dos Santos, 1-2.
[71] Findley letter to Pereira dos Santos, 2.
[72] Findley letter, 3; it is impossible to know if Findley meant "states," plural, or meant the "nuclear weapons state" to refer to the United States itself.
[73] Findley letter to Pereira dos Santos, 3.
[74] Findley letter, to Pereira dos Santos 3.

interested in finding "new points of departure for a bilateral relationship that was deteriorated."[75]

Two months after Findley's visit, a more consequential American politician would come to Brasília, Secretary of State Cyrus Vance. Vance caused a minor scandal by inadvertently leaving some preparatory notes at the headquarters of the foreign ministry. Brazilian Foreign Minister Silveira's four-page analysis of the note begins by mentioning its disclosure of official US positions on human rights in Brazil and nuclear energy in South America; as such, the note had "important diplomatic implications that deserve to be duly evaluated." Human rights apparently were not discussed, an omission from the conversation that Silveira explained as Vance's reluctance to "surpass the limits of the most extreme generality" and thus risk a "serious incident" between the US and Brazil.[76]

What followed in Silveira's letter was a damning indictment of a covert agreement on nuclear energy that the United States had apparently reached with Argentine officials. A basic *quid pro quo* arrangement – Argentina would ratify the Treaty of Tlatelolco and accept safeguards on all its nuclear activities in exchange for "significant assistance" from the Americans in the nuclear area, except for technology for manufacturing deuterium oxide, or heavy water – hid a serious plot twist in the second paragraph, where Argentina had offered to postpone the construction of its spent fuel reprocessing plant if Brazil would do the same.[77] Silveira accused the Americans of using the secret agreement with Argentina to pressure Brazil into renouncing advanced nuclear technologies and processes that US officials believed might lead to weapons proliferation.[78] Vance's pressure strategy relied on Brazil's supposed

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[75] Mallea et al, *Origins*, 26.
[76] Antônio Azeredo da Silveira to President Ernesto Geisel, "Visita do Secretário de Estado Cyrus Vance. Roteiro norte-americano para as conversações." Nov. 30, 1977, 1, WCDA.
[77] Silveira to Geisel, "Visita," 2.
[78] Silveira to Geisel, "Visita," 2.

"nervousness" about closer relations between Argentina and the United States, and on the possibility of urging France to help check the Federal Republic of Germany in its nuclear cooperation with Brazil, Silveira wrote.[79] This was all part of a careful strategy to "erode the Brazilian position" – in which the foreign minister praised President Geisel's "personal attitude" as a source of its strength in the eyes of American policymakers – and offer positive incentives in the thorium fuel program once that erosion began to take effect.[80]

Silveira saw a United States desperate to re-insert itself in the nuclear energy policies of Latin American countries, eager to draw up a new "tripartite agreement" with the US, Brazil, and West Germany, or perhaps the US, Brazil, and Argentina, as a way of undermining the 1975 agreement between Brazil and West Germany that had caused so much proliferation concern among Carter and his top officials. The other part of the United States' long game strategy, Silveira argued, was to stoke the nuclear energy rivalry between Brazil and Argentina in order to force Brazil to helplessly give up its nuclear plans before an inexorably tightening relationship between Argentina and the US, a "totally irresponsible" approach in its policy toward the region.[81] In Silveira's eyes, the US had shown its hand, in actuality uninterested in appropriate safeguards and nuclear nonproliferation, and using the latter a mere façade for a plan to block Brazil's right to access nuclear technology and expertise.

In the document that Vance left behind, the US does not appear to be as blithely unconcerned with Argentina's potential for nuclear proliferation as Silveira's account made it

[79] Silveira to Geisel, "Visita," 2-3.
[80] Silveira to Geisel, "Visita," 2-3. Presumably, the American administration preferred to incentivize Brazil's thorium program, still in its infancy, because it was considered a lower risk for the proliferation of weapons than the German collaboration.
[81] Silveira to Geisel, "Visita," 4. Vance and his team seemed to be either ignorant or dismissive of the close relationship between Carvalho, Castro Madero, and Batista, and offered the standard (and simplistic) narrative of technologically advanced rivals for regional power that drove nonproliferation efforts from the United States under Carter's administration.

out to be. "It is our judgment that Argentina has the technical capability, and now the motivation, to move ahead rapidly with a sizeable autonomous reprocessing program. But this is not yet inevitable."[82] Argentina's concern with maintaining "regional equilibrium" produced language that Vance would repeat to the Brazilians (in the talking points for presentation that the Secretary of State never gave, the author includes the same phrase in quotation marks) in urging the new tripartite agreement.[83] But Silveira's thinly veiled fury in his analysis of the talking points left behind at Itamaraty was not unexpected by the Americans either, and the Brazilian foreign minister quite correctly perceived that Argentina had gained the upper hand over its neighbor in US foreign policymaking circles. "Brazil will also be extremely uncomfortable with the implications of the US/Argentine communiqué, which suggest strong US support for Argentina's domestic power program and export potential…We need not press these points beyond ensuring that they are aware of the communiqué; it should do its own work in unsettling Geisel's complacency with the German deal."[84]

Three landmark events in the two years that followed would have a profound effect on the energy policies of Argentina and Brazil: In 1978, the United States Nuclear Non-Proliferation Act became law, curtailing transfers of nuclear reactors, machinery or parts, and fuel to nations that were not signatories to the Non-Proliferation Treaty, as discussed in Chapter 4. (As a reminder, in this same year, the nuclear programs and military forces of Argentina and Brazil began to seriously pursue autonomous enrichment technology, spent fuel reprocessing, and even ballistic missile projects).[85] On March 15, 1979, João Figueiredo took power as Brazil's fifth military president, a transition that had been in the making since Geisel

[82] US Department of State, "Confidential: Brazil Scope Paper – Implications of the Argentine Visit." Wilson Center/NPIHP Digital Archive, undated [but likely late 1977], 3.
[83] US Department of State, "Brazil Scope Paper," 2.
[84] US Department of State, "Brazil Scope Paper," 2.
[85] Mallea et al, *Origins*, 23.

had accelerated his promotion from a three-star to four-star general in December 1977.[86] Figueiredo had been a central figure in the military government for a long time, acting under Médici as head of the Casa Militar and as Geisel's chief of the SNI, the National Intelligence Service, a history that "represented a guarantee that, even in the midst of strategic changes, the core interests of the 1964 Revolution and unity and discipline in the Armed Forces would be protected."[87] Under Figueiredo, the stalled project to improve nuclear energy cooperation with Argentina received an important supporter and patron; his "innate sympathy toward Argentina," born of living there with his exiled father at the age of fifteen,[88] had given him, in the words of Camilión, a "global vision" and a strategic viewpoint on the Brazil-Argentina relationship, in which each country needed the support of the other in order to hold its important position within global and South American relations.[89] And in October 1979, the Brazilian military, having taken over negotiations of the Tripartite Agreement (Treaty of Asunción) after diplomatic efforts had stalled out, could claim a fundamental success when the treaty concluded the long-simmering dispute about river levels for hydroelectric dam projects, particularly the colossal Itaipu construction that would benefit Brazil and Paraguay.[90]

In August 1979 – the same year that Brazil's navy launched its "parallel program" to develop nuclear propulsion technology and enrichment and reprocessing capability – Luiz Augusto de Castro Neves, from Itamaraty's newly-minted Division of Energy and Mineral Resources,[91] met with Raúl Estrada Oyuela of the Argentine Embassy in Brasília. Oyuela had spent the previous week in contact with authorities in Buenos Aires to test the waters, again, on

[86] Bethell and Castro, "Politics in Brazil under Military Rule," 209.
[87] Bethell and Castro, "Politics in Brazil under Military Rule," 209.
[88] Mallea et al, *Origins*, 97.
[89] Mallea et al, *Origins*, 98.
[90] Bethell and Castro, "Politics in Brazil under Military Rule," 200.
[91] Mallea et al, *Origins*, 47.

some kind of nuclear energy cooperation agreement.[92] For several years, Oyuela told Castro Neves, Argentine leaders had sought some kind of initiative with their neighbor, but had gotten a cold shoulder from the government of Brazil under Geisel's government. Though he had no specific instructions from superiors, Oyuela had considered possible forums for approaching the topic with his Brazilian counterparts, and discussed this possibility with Castro Neves, suggesting the next Special Commission on Brazilian-Argentine Cooperation (CEBAC) meeting to be held in September in Buenos Aires as an auspicious forum.[93] Whatever eventual nuclear energy cooperation between the two nations might result, though, should have a "markedly economic and commercial quality," seeking to use each country's comparative advantage to expand the range of possibilities in goods and services for the nuclear and nuclear-electric industries in both countries."[94]

The most specific prescription yet for potential cooperation on nuclear energy between Argentina and Brazil came from the Argentine foreign ministry's Department of Latin America in August 1979.[95] Argentina's ambassador Héctor Subiza wrote that "clearly a change has occurred in the Brazilian government's disposition to cooperate with other nations on nuclear energy," based on a recently concluded Brazil-Venezuela agreement.[96] Historically, Brazil had been 'reticent' on the matter, but after the agreement with West Germany in 1975, its inclination to cooperation had become more evident. In 1976, at the 20th General Conference of the IAEA in Rio de Janeiro, the need for Brazil to direct all of its available technical personnel

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[92] Luiz Augusto de Castro Neves, "Brasil-Argentina: Possibilidades de cooperação nuclear." August 20, 1979, 1, WCDA.
[93] Castro Neves, "Brasil-Argentina," 2.
[94] Original is "complementação," which seems to have a connotation of termination or finality in most definitions. Memorandum, "Brasil-Argentina: Possibilidades de cooperação nuclear." June-August 1979. WCDA via Brazilian Foreign Ministry Archives, Brasília.
[95] Héctor A. Subiza, "Cooperación con Brasil en el area nuclear," August 23, 1979. WCDA via AMRECIC, Buenos Aires.
[96] Subiza, "Cooperación con Brasil," 1.

toward the "realization of the ambitious program launched with West Germany" opened a new series of actions toward cooperation.[97] The transition between military presidents Ernesto Geisel and João Figueiredo in March 1979, Subiza wrote, had touched off this marked change in policy, but it reflected several longer-standing historical developments: first, the Brazilian nuclear (power) program was in a state of "deceleration," so nuclear technicians and installations were suddenly available and underutilized.[98]

Second, a large part of the criticism of Brazil's nuclear program from within, such as the reaction of the scientific community and military described in Chapter 5, had its source in doubts that West Germany would actually carry out its promised transfers of technology.[99] Lastly, after 1976, Brazil had carried the intense weight of American pressure to change the terms of its 1975 agreement with West Germany, as only Argentina among its fellow South American nations seemed to offer even lukewarm support of Brazil's nuclear autonomy goals, drawn from "the circumstantial partnership of interests."[100] Brazil needed regional allies on nuclear energy, and Subiza indicated that Argentina was ready to play that role, particularly if an agreement could be reached on "specific aspects of the fuel cycle."[101] CNEN and CNEA were in close, if informal, contact, due to the "excellent personal relationship" between their respective chairs, Hervásio Carvalho and Carlos Castro Madero. Though the neighbors had chosen different nuclear technologies and types of uranium to develop their fuel cycle capabilities, "there were innumerable points of contact" between the two programs.[102] Brazil was interested in Argentina's zircaloy and fuel element manufacturing technology, while

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[97] Subiza, "Cooperación con Brasil," 1.
[98] Subiza, "Cooperación con Brasil," 2.
[99] Subiza, "Cooperación con Brasil," 2.
[100] Subiza, "Cooperación con Brasil," 2.
[101] Subiza, "Cooperación con Brasil," 2-3.
[102] Subiza, 3.

Argentina wished to know more about Nuclebrás uranium exploration and mining technology that the Brazilians had developed independent of German cooperation.[103] In the IAEA, too, Argentina and Brazil had supported each other on the issue of safeguards, and created the basis for a system to allow concurrent, allied positions that defied the London Club of nuclear supplier nations. Not all of the neighbors' international actions on nuclear energy as the 1970s ended reflected a greater tendency toward openness, rapprochement, or cooperation, however.

Luiz Augusto de Castro Neves, the Deputy Chief of Itamaraty's Energy and Mineral Resources Division from 1979-82, noted that the conclusion of the 1970s had left Brazil in dire straits as the peak of the oil crisis six years earlier had boomeranged back as a colossal foreign debt.[104] As Brazil only produced 16-20% of its own annual petroleum consumption and had "but a few weeks' stock of oil" in 1979, a diplomatic mission was sent to Iraq – including CNEN President Rex Nazaré Alves and headed by Paulo Nogueira Batista – to negotiate a transfer of uranium dioxide to Iraq to be paid with an "extremely high price…debited in part from the petroleum account."[105] Essentially, this was a yellowcake-for-oil deal designed to pay down Brazil's mushrooming foreign debt. As an NPT signatory, Iraq was obligated to declare to the IAEA how the "yellowcake" from Brazil would be used, but Brazil had no obligation to declare anything as an NPT non-signatory transferring non-sensitive material.[106] Castro Neves' "strong impression that the money [from the petroleum account] was also used to feed the parallel program" during dire budget restrictions indicates that both Brazil (the parallel program and yellowcake-for-oil agreement with Iraq)[107] and Argentina (autonomous diffusion

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[103] Subiza, 3.
[104] Mallea et al, *Origins*, 105.
[105] Mallea et al, *Origins*, 105.
[106] Mallea et al, *Origins*, 105.
[107] The final agreement was signed on January 16, 1980, according to the CNEN timeline.

enrichment at Pilcaniyeu) were engaged in covert nuclear development at the same time that they sought greater overt cooperation with each other.

In January 1980, CNEA President Carlos Castro Madero indicated his willingness to visit Brazil along with his colleagues Jorge A. Coll, his secretary-general, and Roberto Ornstein, head of CNEA's department of international organizations.[108] The Argentine nuclear energy commission president believed that the United States would soon gain support from other key Western countries on strict nonproliferation measures, and thus sought to convince global leaders that neither nation possessed a military nuclear energy program nor harbored hopes of creating one.[109] (More practical and immediate needs drove Castro Madero's project, as well; Ornstein mentioned that he had traveled to the Soviet Union to negotiate a purchase of enriched uranium under safeguards, while other CNEA officials had gone to China to buy a small amount of heavy water.[110] Brazil's negotiations with Iraq to trade yellowcake for petroleum had a similar impetus, but the scarcity in question was not of a nuclear material, rather of potential trade partners).

Castro Madero noted his good relationship with the Brazilian nuclear energy leaders, as well as the overlap of the two countries' positions on the issue in the international arena, and closed with a strong recommendation to formalize a peaceful nuclear energy use agreement between the neighbors soon in order to "undo the American accusations of a supposed arms race between Brazil and Argentina."[111] This trip, occurring at the end of January, included visits to the Poços de Caldas uranium mine, NUCLEP's installations in Itaguaí, the Angra dos

[108] Carlos F. Duarte, "Visita do Almirante Castro Madero ao Brasil." January 28, 1980, WCDA.
[109] Mallea et al, *Origins*, 84.
[110] Mallea et al, *Origins*, 84.
[111] Duarte, "Visita do Almirante Castro Madero," 1.

Reis nuclear power plant, and CNEN headquarters for a meeting with Hervásio Carvalho.[112] Preliminary conversations about the long-debated agreement on Brazil-Argentina cooperation in nuclear energy finally took shape when Castro Madero presented a list of possible technological specialties or areas most appropriate for such an agreement "to be analyzed by the competent authorities."[113] Most intriguingly, nuclear authorities in both countries had discussed the possibility of NUCLEP, Brazil's heavy nuclear equipment manufacturer for Nuclebrás, manufacturing and supplying some components of Argentina's second power reactor, Atucha II. This revelation of potential cooperation was one to which the press had been allowed access.[114] But Carvalho and Castro Madero sought to temper expectations, reminding journalists that contacts were in a very early stage and would be "developed in the future." At the end of the visit, Castro Madero extended an invitation to his highest-level Brazilian hosts – the presidents of CNEN and its incorporated firms Nuclebrás and Furnas - to visit Argentina in March.[115]

Roberto Ornstein, instrumental in the early 1980 meetings between nuclear officials, discussed the four pieces of the proposed Protocol of Industrial Cooperation, which he characterized as two successes and two failures. A simple transfer of natural uranium to CNEN, a renewable one-year agreement payable in "uranium interest,"[116] put Argentina's excess uranium to use in benefitting its neighbor, marked the first success; the second was NUCLEP's involvement in building the lower part of the pressure vessel for Atucha II. Siemens, the

[112] Foreign Ministry of Brazil (Itamaraty), "Energia nuclear. Cooperação Brasil-Argentina. Visita do Presidente da CNEA." Wilson Center/NPIHP Digital Archive, February 12, 1980, 1.
[113] Itamaraty, "Energia nuclear. Cooperação," 1.
[114] Itamaraty, "Energia nuclear. Cooperação," 2.
[115] Itamaraty, "Energia nuclear. Cooperação," 2.
[116] Mallea et al, *Origins*, 85; "uranium interest" worked exactly as a loan of money might, with the borrower paying back the original loan (in this case, mass of uranium) with a slightly higher amount before the due date for repayment.

German firm that had built the reactor, reportedly took a significant amount of convincing to transfer responsibility for constructing the largest nuclear reactor pressure vessel in the world.[117]

The two failures of the industrial cooperation agreement arose from unexpected differences in the supply and organization of the nuclear program in Brazil as opposed to that of Argentina. Argentina had offered "a few million dollars" of technology for uranium purification, yet the heap leaching technique developed there did not work on Brazilian uranium deposits at Poços de Caldas; uranium deposits were composed of different minerals in the soils of Minas Gerais, and Argentina's heap leaching method was not effective in extracting yellowcake uranium dioxide.[118] That part of the agreement failed "in a context of honesty,"[119] but the other failure was a more serious misunderstanding that threatened to halt (or reverse) the efforts toward cooperation.[120] In agreeing to accept CNEA's offer of zircaloy pipes to make fuel elements for Brazil's Angra I reactor, Nuclebrás's negotiators had apparently forgotten that another firm named Furnas operated the reactor and thus had the authority to approve and certify the supply of pipes; Nuclebrás's offer to CNEA was therefore superseded by this earlier agreement involving Furnas.[121] Enriched uranium reactors require a much smaller number of zircaloy pipes in their fuel elements,[122] a fact that seemed to catch the Argentines off guard and indicated the level of ignorance about even basic technical details of the vastly different nuclear technologies on the Brazilian side. For any kind of serious attempt at nuclear energy

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[117] Mallea et al, *Origins*, 86. The pressure vessel weighs 1,200 tons in total, and the cover alone weighs "200 or 300 tons," according to Ornstein. No single place could make such a massive construction, so manufacturers in Spain, Germany, and Brazil collaborated to build the entire vessel and have it ready to assemble in Argentina.
[118] Mallea et al, *Origins*, 85-86.
[119] Mallea et al, *Origins*, 86.
[120] Mallea et al, *Origins*, 86-87.
[121] Mallea et al, *Origins*, 86. Another conclusion from Ornstein's story is that Brazil's nuclear power program was by 1980 fragmented into a near-comical number of state-owned firms with overlapping responsibilities.
[122] Mallea et al, *Origins*, 87.

cooperation to work on the diplomatic or political levels, the basic technical details of Argentina's and Brazil's reactor technologies would first need to be known on the other side. The early 1980 visits of Nogueira Batista's delegation to Argentina and Castro Madero's to Brazil were as significant as they were unprecedented, and the lack of basic knowledge about nuclear activities in Brazil among Argentines, and vice versa, offers a plausible reason for why both men's reports were so full of technical details on possible avenues for cooperation.

In March 1980, Nogueira Batista reported at great length on his visits to Argentina's "main nuclear installations," including mineral treatment plants as well as the Ezeiza pilot fuel reprocessing plant, still under construction.[123] He praised the "climate of great cordiality and frankness" in all contacts with his hosts.[124] Like the Brazilian press during Castro Madero's travels, Argentine journalists had shown a great interest in the Brazilian nuclear officials' visit to Buenos Aires, and were hoping for some official word on a nuclear energy agreement to be signed during the presidential visit planned for May. Carvalho and Nogueira Batista stuck to the script, though, by reminding their interlocutors that the visit was only of a technical and preliminary nature.[125] Outside of the official itinerary, Castro Madero had arranged a meeting with Argentine foreign minister Carlos Pastor, which Nogueira Batista attended with CNEN's president Hervásio de Carvalho and Brazil's ambassador Carlos Duarte. Castro Madero's objective seemed to be winding up the technical-level talks between the nuclear energy authorities, then placing the next step in the hands of the foreign ministries to work out the political and diplomatic details of any potential agreement. Carlos Pastor, speaking for the Argentine foreign ministry, believed the agreement with Brazil to be "a fundamental issue in

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[123] Paulo Nogueira Batista, "Relatório enviado ao Ministro das Relações Exteriores. Assunto: Viagem a Buenos Aires." Paulo Nogueira Batista Archive/CPDOC via Wilson Center/NPIHP Digital Archive, March 23, 1980.
[124] Nogueira Batista, "Buenos Aires," 1.
[125] Nogueira Batista, "Buenos Aires," 1.

a…strategy of greater political and economic stability in the region, to the extent that both countries are improving conditions to collaborate with their neighbors,"[126] an explanation that excluded the United States' push for allies on its strict interpretation of the 1978 Nuclear Non-Proliferation Act and 1968 Non-Proliferation Treaty as noted by Castro Madero.

Nogueira Batista expressed his annoyance with what he saw as an excessively broad list of topics left by Castro Madero in Rio de Janeiro, "out of rhythm with the format and depth of its treatment of quite a heterogeneity of topics," to the most pressing and realistic areas for nuclear energy cooperation.[127] The president of Nuclebrás argued that five potential projects deserved greater study. Argentina would share three materials and technologies with its neighbor: heap leaching techniques for uranium treatment, "leasing" its uranium concentrates to Brazil, and manufacture of Zircaloy tubes for Brazil's nuclear installations.[128] Brazil, in exchange, would send to Argentina heavy nuclear components for its Atucha II power reactor, and enrich uranium up to 20% for research reactors.[129] Nogueira Batista quickly made clear, after giving his prioritized list of areas for cooperation, that "Nuclebrás was not present in Buenos Aires in the position of a vendor of services and materials, but simply as an instrument of Brazilian cooperation with the Argentine nuclear program."[130] Both countries remained committed to the long-term goal of "broad autonomy" in the nuclear sector, but Nogueira Batista sought to fine-tune the proposed cooperation to help both nations "optimize their investments and reduce dependency on third-party countries."[131] For instance, he mentioned that Brazil might defer decisions on whether to invest in technology to manufacture Zircaloy

[126] Nogueira Batista, "Buenos Aires," 2.
[127] Nogueira Batista, "Buenos Aires," 3.
[128] Nogueira Batista, "Buenos Aires," 3-4.
[129] Nogueira Batista, "Buenos Aires," 3-4. Ornstein did not mention uranium enrichment as a potential avenue for technical cooperation.
[130] Nogueira Batista, "Buenos Aires," 4.
[131] Nogueira Batista, "Buenos Aires," 4.

until domestic demand increased sufficiently to create economies of scale; likewise, Argentina could postpone "premature investment" in heavy component construction technology if Brazilian-manufactured components could fill in for the short term.[132] To Nogueira Batista, Castro Madero did not seem ready for this discussion, but the Brazilian offered to turn the final group work session into a private meeting with the two of them and Hervásio de Carvalho, as the old trio of unlikely nuclear energy collaborators began to unite again, to pursue the comparative advantage angles on nuclear cooperation that Nogueira Batista had proposed.[133] By drawing up "guidelines" for each of the five proposed areas of technical cooperation, a preliminary agreement *on the scope of the overall nuclear energy sharing arrangement* might be possible between the two governments, a conclusion that Castro Madero fed to the curious press.[134]

Nogueira Batista was concerned that Castro Madero sought maximum short-term advantages to Argentina at the obvious expense of Brazil; a more general political agreement, rather than the carefully chosen exchanges of technologies and materials that enabled each country to employ its comparative advantage to positive ends for both parties, would "obviously allow Argentina to reap the bigger prizes, especially in the short term, before the conclusion of negotiations with the Federal Republic of Germany and the IAEA on safeguards."[135] The issue of safeguards for Argentine nuclear installations was of high interest to Nogueira Batista at the conclusion of the account of his travels to Buenos Aires, and it is important to remember that the Nuclebrás president was engaging in some speculation as to

[132] Nogueira Batista, "Buenos Aires," 4.
[133] This is consonant with Castro Madero's rush to conclude some kind of cooperation agreement with Brazil, and entirely consistent with not wanting to wait to explore the best ways to employ each nuclear program's comparative advantages over the other.
[134] The original Portuguese is *acordo-quadro*, which appears to be a preliminary agreement that defines the limits of a diplomatic or political issue.
[135] Nogueira Batista, "Buenos Aires," 6.

Castro Madero's future actions and motives.[136] Castro Madero had declared to the United States, once again, that Argentina would not accept "*de facto* full scope safeguards," and as a result of that position, CNEA had run into problems with their West German technology transfer partners refusing to "go outside the rules of the London Club" of nuclear suppliers. It was possible that Argentina might ratify the Treaty of Tlatelolco, even with the "same reservations that Brazil had shared" on the 1967 agreement. As a last resort, Nogueira Batista believed, nuclear energy authorities in Argentina and West Germany had concocted the idea of a German "unilateral declaration" that Argentina had precautions in place that were, in essence, the same as full-scope safeguards. This statement, its creators thought, might allow the proposed transfer of technology to bypass Argentina's refusal to sign a document indicating acceptance of official safeguards under the auspices of the IAEA.[137]

In May 1980, a watershed event in high-level bilateral relations between Argentina and Brazil – and one that many credit with beginning the official high-level bilateral rapprochement around nuclear energy – took place in Buenos Aires. President Gen. João Figueiredo, the first Brazilian head of state to visit Argentina in forty-five years, and his Argentine counterpart, Jorge Rafael Videla, worked with their foreign ministers to hammer out the first nuclear cooperation agreement between the neighbors.[138] ABACC planning officials Orpet Peixoto (Brazil) and Sónia Fernández Moreno (Argentina) used the phrase "classic political will" to describe the 1980 agreement between the presidents,[139] which stated that "the Parties will cooperate toward the development and application of peaceful uses of nuclear energy, according

[136] Nogueira Batista, "Buenos Aires," 6-7.
[137] Nogueira Batista, "Buenos Aires," 7.
[138] Mallea et al, *Origins*, 35.
[139] Interview, Orpet Peixoto and Sónia Fernández Moreno. Sede ABACC, Rio de Janeiro, December 18, 2014. Ornstein would agree with this characterization of a top-down implementation, having said in 2012 that "the two Presidents somehow imposed it because above all both were military men and had overcome the internal opposition that had come up." (Mallea et al, *Origins*, 84).

to the needs and priorities of their respective national nuclear energy programs…"[140] Argentina had come to the negotiating table with Brazil at a decided advantage in nuclear energy negotiations, wrote Monica Hirst and Hector Eduardo Bocco, because they had adopted natural uranium as fuel for their power reactor program.[141] Brazil had steadfastly opted to carry out the terms of its deal with Germany in the face of opposition from the scientific community and military leadership,[142] spurning Argentina's offers to collaborate with Brazil and other Latin American countries to supply the lucrative international market for research reactors.[143] The beginning of Brazil's secret parallel program was a direct response to the inadequacies of the 1975 deal with Germany, and Hirst and Bocco note that the timing of the parallel program's inception in 1979 and official receptive stance toward nuclear collaboration with Argentina in 1980 was probably not coincidental: Brazil and Argentina could benefit from each other's knowledge of sensitive technologies as well as specialized expertise in nuclear power production.[144] In addition, Brazilian nuclear officials saw a chance to invigorate a sluggish industry by building the pressure vessel component for Argentina's Atucha II reactor, and anticipated the possibility of collaborating on 250 and 300 MW modular reactors more appropriate to the energy needs of, and lower costs to, developing countries.[145] Argentina stood to gain less than Brazil did from potential cooperation, but would gain access to Brazil's Computerized Information Center in addition to offers of materials more specific to nuclear energy, including enriched uranium for research reactors.[146]

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[140] Carlos W. Pastor and Ramiro Saraiva Guerreiro, "Acuerdo de Cooperación entre el Gobierno de la República Argentina y el Gobierno de la República Federativa del Brasil para el Desarrollo y la Aplicación de los Usos Pacíficos de la Energía Nuclear." Article I. "InfoLEG – Información Administrativa [Argentina]," http://servicios.infoleg.gob.ar/infolegInternet/anexos/205000-209999/206224/norma.htm
[141] Leventhal and Tanzer, *Nuclear Arms Race*, 216-217.
[142] See Chapter 5 on Brazil's autonomous nuclear energy efforts.
[143] Leventhal and Tanzer, *Nuclear Arms Race*, 217.
[144] Leventhal and Tanzer, *Nuclear Arms Race*, 218.
[145] Leventhal and Tanzer, *Nuclear Arms Race*, 219.
[146] Leventhal and Tanzer, *Nuclear Arms Race*, 220.

In the early 1980s, after Videla and Figueiredo had concluded the landmark nuclear energy cooperation agreement, Brazilian and Argentine technicians began to cross the border to carry out its rather specific terms. These tentative meetings of technicians grew in frequency and number, shaping what ABACC planning executives Peixoto and Fernández called a sort of "mini-IAEA." This inchoate gathering of technicians, not yet an organization, bridged the gap between that 1980 presidential summit of military rulers and the Foz do Iguaçú agreement of 1985 made between civilian presidents Raúl Alfonsín and José Sarney. In hindsight, the fortuitous timing of the 1980 agreement was crucial within the longer trajectory of the bilateral nuclear rapprochement: until 1983, there was a diplomatic and technological lull on nuclear matters, as both nations faced more grave matters.[147] Argentina's war with the United Kingdom in 1982 and collapse of the military regime absorbed all of its attention, while Brazil faced an acute economic crisis.

The construction director for NUCLEN, Brazil's state enterprise that designed, built, and commissioned nuclear power plants, said in 1989 that the earlier economic crisis had effectively curtailed the ambitious nuclear program as new reactor construction was canceled and ongoing projects became plagued by delays.[148] Economic motives were at the heart of that official's explanation of the path toward nuclear cooperation, as the "high cost of developing indigenous nuclear technology" pushed Argentina and Brazil toward regional coordination at the end of the decade.[149] A later Brazilian participant questioned the relevance of economic motives at all; Brazil's official nuclear collaboration with West Germany was, in his or her

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[147] Sara Kutchesfahani, "Politics & The Bomb: Exploring the Role of Epistemic Communities in Nuclear Non-Proliferation Outcomes." PhD diss., University College London, 2010: 115.
[148] Leventhal and Tanzer, *Nuclear Arms Race*, 19.
[149] Leventhal and Tanzer, *Nuclear Arms Race*, 18.

view, an inherently poor response to the nation's problems.[150] A mining executive had rightly pointed out that Argentina and Brazil had in fact taken on these high costs in their use of "scarce economic resources to re-invent the wheel"[151] rather than adhere to safeguards and gain access to the lower-cost international market for nuclear technologies. Economic decline might have explained some of the impetus to cooperation between Brazil and Argentina in the 1980s, but experts in Montevideo did not agree at all that it was of fundamental importance to the process.[152]

The 1980-1985 period between landmark bilateral presidential agreements in Buenos Aires and Foz do Iguaçú, respectively, while marked by sharp economic decline in both Brazil and Argentina, was not devoid of activities in nuclear energy technology and diplomatic efforts. In December 1982, Brazil purchased highly enriched uranium from China, when Argentina also made another purchase of heavy water from the same country, both decisive moves along a path that turned away from the US-led network of suppliers of nuclear technology and material in the North Atlantic.[153] In 1983, Argentina inaugurated its Embalse reactor in May, and in the same month, finally obtained the consent of the United States Ambassador, Richard Kennedy, for his government to ship heavy water to Argentine nuclear power facilities.[154] In August 1983, Dário Gomes of Nuclebrás and Rex Nazaré Alves of CNEN visited nuclear facilities in

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[150] Leventhal and Tanzer, *Nuclear Arms Race*, 21. (The "Brazilian participant" is unnamed in the rapporteur's summary).
[151] Leventhal and Tanzer, *Nuclear Arms Race*, 20.
[152] Leventhal and Tanzer, *Nuclear Arms Race*, 17-22.
[153] Mallea et al, *Origins*, 204.
[154] Kennedy had, in fact, been visiting Brazil and Argentina since 1978 or 1979, according to Luiz Augusto de Castro Neves' statements in 2012 (*Origins*, 93). Both nations maintained their steadfast opposition to his overtures to adhere to nonproliferation norms and place more nuclear facilities under safeguards, particularly Brazil in a working group that Kennedy created with the United States. Castro Neves saw Kennedy's actions as efforts to "co-opt Brazil somehow," and the Brazil-US working group as a "defensive instrument" that allowed CNEN officials to maintain that one IAEA statute (INFCIRC 66) applied to them as a non-signatory to the NPT, and not INFCIRC 153, as Kennedy wished. In essence, Castro Neves says, Kennedy's actions moved the needle very little in terms of unified resistance on the part of Brazil and Argentina. (*Origins*, 94).

Argentina.[155] Only months later, in November, Argentina's first civilian president in seven years, Raúl Alfonsín, would officially announce that CNEA engineers and technicians had successfully enriched uranium in the remote hamlet of Pilcaniyeu by the gaseous diffusion process, as discussed in Chapter 4. (There is no indication that the CNEN officials had been allowed to see the still-secret Pilcaniyeu facility in August preceding the official announcement). In December 1983, the foreign ministers of Brazil and Argentina, Ramiro Saraiva Guerreiro and Dante Caputo, met and pledged to write a joint declaration that would mitigate the suspicion of both nations' nuclear energy programs as potential proliferators of weapons.[156] This particular agreement never came into existence; five years would pass between any significant bilateral agreements on nuclear energy, bracketed by the 1980 Cooperation Agreement between Brazil and Argentina for the Development and Application of the Peaceful Uses of Nuclear Energy and the 1985 Joint Declaration on Nuclear Policy, also known as the Declaration of Iguaçú.[157]

Seventeen years after Argentina and Brazil had successfully battled to maintain permission for peaceful nuclear explosions in the Treaty of Tlatelolco negotiations in Mexico City, Brazilian diplomat Roberto Abdenur proposed to Jorge Sábato in May 1984 that the two countries jointly renounce the right to carry out these explosions.[158] In the political environment of Argentina's return to electoral government under Raúl Alfonsín, and Brazil's weakening military dictatorship, the ideas and positions of diplomats like Abdenur seemed to

[155] Mallea et al, *Origins*, 204. In July 1987, Brazilian president José Sarney visited Argentina's enrichment installations, and invited Alfonsín to do the same (*Origins*, 208).
[156] Mallea et al, *Origins*, 205.
[157] Somewhat curiously, the 1983 pledge between the foreign ministers does not appear in ABACC's collection of significant bilateral agreements, either.
[158] Mallea et al, *Origins*, 205.

carry more weight.[159] Also in May 1984, Brazil's chief diplomat, foreign minister Ramiro Saraiva Guerreiro, warned the Figueiredo administration that proposed budget cuts to Brazil's nuclear program would harm its standing in comparison to its neighbor Argentina.[160] In the following year, the bilateral debate about the method and extent of legal constraints that Brazil and Argentina were prepared to offer the international community grew more intense. Brazil's first civilian head of state in twenty-one years, president-elect Tancredo Neves, who died before he could take office, had proposed a "regional safeguards system" to Raúl Alfonsín in February 1985 as a way to show commitment to the letter and spirit of the Treaty of Tlatelolco.[161]

By the end of the year, however, after Tancredo Neves's death, his successor José Sarney had begun to seek a less restrictive and formal arrangement for controls on the country's nuclear energy activities. Sarney apparently convinced Alfonsín to postpone his concrete commitment to the idea of bilateral safeguards – slyly coded in the Declaration of Iguaçú as "mechanisms that assure the superior interests of peace, security, and the development of the region"[162] – in favor of the less stringent solution that Brazilian nuclear officials preferred, a "joint working group under the responsibility of the Argentine and Brazilian foreign affairs ministries, composed of representatives of the respective nuclear commissions and firms…"[163] However, Sarney moved decisively on nuclear energy in ways that

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[159] Adolfo Saracho, retired Argentine ambassador, remarked in 2012 that the country's return to civilian government had brought about a reassertion of civilian power over nuclear issues, and a delegation of international relations and diplomatic activity – above all with Brazil – to the Ministry of Foreign Affairs, and not CNEA. (*Origins*, 49-50).
[160] Mallea et al, *Origins*, 205.
[161] Argentine Foreign Minister Dante Caputo had indicated his willingness to consider adhering to the Latin American nuclear nonproliferation agreement in front of the UN Disarmament Commission in February 1984. (*Origins*, 205).
[162] Within the nuclear energy and diplomatic histories of Brazil and Argentina, Foz de Iguaçú, in the Brazilian state of Paraná, has played a more significant role than its equivalent in Argentina, Puerto Iguazú. For this reason, I use the Portuguese spelling of the name, though the symbolism of this location – a town that overlooks one of the world's most spectacular waterfalls and marks an important border crossing between the regionally dominant neighbors – should be quite clear.
[163] "Declaración conjunta sobre política nuclear," Nov. 30, 1985, at ABACC "Agreements and Statements," https://www.abacc.org.br/en/agreements-and-statements/.

upset the military and CNEN leadership as well, convening a commission to evaluate the Brazilian nuclear program (*Comissão de Avaliação do Programa Nuclear*, or CAPN), which led CNEN's president Rex Nazaré Alves to protest that the timing for a bilateral mechanism with Argentina was inappropriate.[164] Still, the will of Alfonsín and Sarney seemed to be solidly in favor of continuing to build efforts toward cooperation, though their relationship was described as one without "much intensity," impeded by a language barrier, and consisting of little written communication outside of encounters in person.[165] Roberto Ornstein characterized their actions as helping to compensate for the fact that the 1980 agreements between Videla and Figueiredo had failed to produce any significant concrete results, and responding to Alfonsín's perceived "need to intensify cooperation and…to implement a policy in which all would be transparent."[166]

In July 1986, this working group met for the first time, and Sarney and Alfonsín drafted twelve specific protocols to institutionalize cooperation on nuclear energy in the Act for Brazilian-Argentine Integration. In December, the two heads of state revisited the commitments made at Foz do Iguaçú two years prior as part of the Joint Declaration on Nuclear Policy, signing Protocol No. 17, which laid out seven specific collaborative and advanced research projects in nuclear energy, facilitating their completion through the bilateral supply agreements provided in Videla's and Figueiredo's landmark accord from 1980.[167]

A memorandum from the Argentine General Directorate of Nuclear Affairs and Disarmament, dated May 13, 1985, sought to provide guidance on nuclear cooperation for a planned meeting of Brazil's and Argentina's foreign ministers. In terms of technical and

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[164] Mallea et al, *Origins*, 97.
[165] Mallea et al, *Origins*, 141.
[166] Mallea et al, *Origins*, 95.
[167] "Protocolo Nº 17: Cooperação Nuclear," Brasília, December 1986, at ABACC "Agreements and Statements," https://www.abacc.org.br/en/agreements-and-statements/.

political cooperation, the author of the document placed the highest priority agreement on a system of mutual guarantees of peaceful use of nuclear energy materials, equipment, and installations.[168] However, this system should not replicate the IAEA's safeguards model, the author argued, as the reciprocal and open exchange of design and other technical information mandated by the IAEA would compromise the industrial secrets of "significant economic value" in both nations.[169] Across the border in Brazil, intrusive safeguards were viewed as compromising industrial secrets, and also as having the potential to create "suspicion, not confidence."[170] A bilateral safeguards system, moreover, would necessitate "high costs to include regular and periodic inspections" and measures of control over all nuclear materials and installations, some of which were, by their nature, apparently completely unusable in the building of a potential nuclear weapon.[171] A meticulous effort to follow IAEA safeguards would thus create a situation where the costs far outweighed "adequate compensation in terms of efficiency." Instead, Brazil and Argentina's bilateral cooperation should be framed within existing structures of collaboration, and include a joint declaration on the peaceful character of both nuclear programs, as well as periodic meetings to exchange information on nuclear activities with the secondary objective of carrying out an up-to-date analysis of concrete possibilities for cooperation.[172] The national nuclear energy programs would commit to inform each other about new nuclear installations and significant changes to existing ones, and create a structure that would allow visits by officials and technicians from the other country "with the

[168] Dirección Nacional de Asuntos Nucleares y Desarme. "Cooperación en el campo de los usos pacíficos de la energía nuclear con Brasil." May 13, 1985, 1, WCDA.
[169] "Cooperación en el campo de los usos pacíficos," 1.
[170] Leventhal and Tanzer, *Nuclear Arms Race*, 27. The themes of cooperation, confidence, and control run throughout the Montevideo conference of 1989, where many participants held a similar suspicion of safeguards and their potential to erode, not fortify, relations between Argentina and Brazil around nuclear energy.
[171] "Cooperación en el campo de los usos pacíficos," 1.
[172] "Cooperación en el campo de los usos pacíficos," 1-2.

goal of being able to fulfill the purpose of this agreement and also protect technological developments by each party."[173] The element of international visibility of the proposed agreement remained paramount: "through the eventual accord with Brazil, we aspire to design a mechanism of mutual guarantees that can oppose arguments of a supposed nuclear arms race between Brazil and Argentina."[174]

Still, any potential path to this mechanism would not be smooth; in September 1985, Argentina's ambassador Rafael Vazquez sought an audience with Brazil's foreign minister, Olavo Setubal, to discuss a *Correio Braziliense* article in which Army General Leonidas Pires had spoken in support of a Brazilian nuclear weapon. Setubal had responded that Gen. Pires had denied these statements, but that the news article had mentioned support from the President of the Senate and "various legislators," and even if these statements were denied or refuted, they would "complicate the international scene for Brazil and Argentina."[175] Vazquez inquired whether the situation might be useful to advance conversations about a joint agreement on peaceful use of nuclear energy, noting that the reaction of the "highest Brazilian authorities" was the key variable in how this revelation would impact the bilateral relationship, and the degree of trust that Brazil's political leaders could inspire on the Argentine side in light of this breach.

Career diplomat Rubens Ricupero served as special advisor to President Sarney during this incident,[176] and recalled that Sarney had always been proud of the fact that he fought an uphill battle toward nuclear integration with Argentina.[177] In the words of both Ricupero and

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[173] "Cooperación en el campo de los usos pacíficos," 2.
[174] "Cooperación en el campo de los usos pacíficos," 2.
[175] Cable from Rafael Vazquez, Argentine Ambassador to Brazil, Requesting Meeting with the Brazilian Foreign Minister. Sep. 2, 1985. WCDA via AMRECIC, Caja Brasil h0005B.
[176] Mallea et al, *Origins*, 13.
[177] Mallea et al, *Origins*, 126.

his countryman Sebastião do Rego Barros, active as a nuclear negotiator in the mid-1980s, Pires was actually in agreement with the idea of rapprochement with Argentina.[178] By using an imagined security threat of an Argentine nuclear bomb, Pires sought to stoke the competitive instincts of the Brazilian military so that they would not fall behind, and to command greater resources for the nuclear program. Pires was apparently influential enough – and represented a military force whose power had not waned significantly yet – that had he been opposed to rapprochement, Sarney would have backed off of the diplomatic aim of improving Brazil's nuclear energy relationship with Argentina.[179]

Brazil's Minister of Foreign Affairs, Setubal, wrote a detailed account of nuclear cooperation to President Sarney just nineteen days after the communication regarding a suspected Brazilian military overflight of Argentina's Pilcaniyeu enrichment facility.[180] Setúbal discussed "a group of suggestions on initiatives that we could take in the [nuclear] area" that would allow Argentina and Brazil to follow their "independent lines" on peaceful nuclear energy use, including an "unequivocal" joint declaration expressing the intention to continue this independent posture outside the legal strictures of the Non-Proliferation Treaty.[181] Setúbal wrote shortly before the upcoming 1985 Review Conference for that treaty, and believed that occasion combined with the upcoming presidential meeting between Sarney and Alfonsín provided the appropriate "conditions to consider initiatives that reaffirm the good understanding between Brazil and Argentina" on nuclear energy matters.[182] The foreign affairs minister anticipated another tightening by nuclear supplier nations on transfers to countries

[178] Mallea et al, *Origins*, 126-127.
[179] Mallea et al, *Origins*, 127.
[180] The alleged overflight is detailed in Adolfo Saracho's memorandum "Sobrevuelo de avión militar brasileño a la planta de uranio enriquecido de Pilcaniyeu," Oct. 10, 1985, WCDA via AMRECIC.
[181] Olavo Setúbal to President José Sarney, "Brasil-Argentina. Cooperação no campo da energia nuclear." Wilson Center Digital Archive/NPIHP, Oct. 29, 1985, 1.
[182] Setúbal, "Cooperação," 1.

remaining outside the NPT, paradoxically falling on countries like the South American neighbors that took advantage of nuclear trade and cooperation with the highly developed nations of the North Atlantic.[183] In that geopolitical dynamic, Setúbal saw a clear reaffirmation of peaceful nuclear cooperation in the Southern Cone as a way to buy international goodwill from supplier nations. He specifically mentioned the United States' hesitation to sell a "measurement device" to CNEN, likening it to a recent transfer of a computer to the Technological Research Institute that had also fallen through, while France had made "unacceptable demands" on the sale of compressors to NUCLEI. Argentina, he knew, had faced similar problems.[184] In Setúbal's characterization, France and the United States – the supplier nations – were those acting in bad faith, not the developing nations that imported nuclear technology but refused to sign the NPT.

Aside from signing and ratifying the NPT, which remained impossible in the political environments of both Argentina and Brazil, Setúbal recommended developing and announcing "joint initiatives that will reaffirm the inclination of both countries to tighten their nuclear cooperation and the peaceful purposes of their respective programs."[185] The declaration would condemn the proliferation of nuclear weapons, and reiterate the "inalienable right" of both countries to fully control nuclear technology, but it was a delicate matter. It could not imply a "unilateral concession" in the face of pressure to accept international control of Brazil's and Argentina's autonomous programs, a point particularly salient to Setúbal as it held open the possibility of relative parity with Argentina, still regarded as "more advanced than us in this field."[186]

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[183] Setubal, "Cooperação," 2.
[184] Setúbal, "Cooperação," 2.
[185] Setúbal, "Cooperação," 2.
[186] Setúbal, "Cooperação," 3.

In addition to the joint declaration that would restate the peaceful character of both programs, Setúbal proposed creating a working group, "in the context of the agreement signed in 1981, of a political-diplomatic and technical character," to make the promised cooperation into practical reality.[187] This working group would operate under the shared leadership of representatives of the two foreign ministries, and be composed of technicians, members of the two national nuclear energy commissions, and employees of state-sponsored nuclear technology firms. It would be more difficult, he stated with no supporting arguments, for Brazil and Argentina to create an initiative of this kind than other countries in rivalries such as the Arab nations and Israel, or India and Pakistan, and such an arrangement would be unprecedented among "threshold countries," or those with a viable path to a nuclear weapon due to their knowhow and technological capabilities.[188] The proposed group would have its greatest importance in its political implications, allowing for a "regular dialogue between the two countries in a sensitive and controversial area like nuclear [energy.]"[189] The visibility of the group's meetings in the press would reinforce the positive relationship between the two neighbors in the peaceful use of nuclear energy, and Setúbal believed that the Argentines would be receptive to such a collaboration in an area where there seemed to be numerous opportunities for improving the bilateral relationship, which "does not always occur in other sectors."[190] Itamaraty's next step would be to contact the National Security Council and CNEN to draft the declaration's text and begin to shape the working group.

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[187] Setúbal, "Cooperação," 3.
[188] "Threshold countries" is left in English inside quotation marks; Setúbal's argument that Argentina and Brazil have entirely peaceful intentions is thus somewhat undermined by lifting this term from the assessments of nuclear weapon states and London Club members as to the overt and covert ranges of technology available to the Brazilian and Argentine nuclear programs. Also, unlike Argentina's diplomat Carasales, Setúbal does not use scare quotes around the term *rivalry*, seeming to accept it as a characteristic feature of Argentine-Brazilian relations.
[189] Setúbal, "Cooperação," 4.
[190] Setúbal, "Cooperação," 4.

An undated memorandum written sometime after Nov. 12, 1985, reported the events of the nuclear energy cooperation meeting of foreign ministry representatives to Sarney. The Argentine delegation had presented a draft of a joint declaration that supported a "system of mutual guarantees," an idea supported by five primary arguments. Most importantly, the agreement would uphold and "prove in a concrete manner" that Argentina and Brazil would not develop or produce nuclear weapons, "*preserving peaceful uses within the limitations contained in the systems foreseen by the NPT and the Treaty of Tlatelolco*."[191] The time for such a far-reaching agreement on a sensitive matter of technology and sovereignty was ideal, as bilateral relations were excellent; other Latin American nations would be drawn to be a part of Argentina's and Brazil's exemplary (but still hypothetical) agreement to ban the existence or possibility of obtaining nuclear weapons.[192] Curiously, Setúbal's communication holds tightly to existing nonproliferation agreements like Tlatelolco and the NPT. The former head of OPANAL, the organization that oversaw adherence to Tlatelolco, Hector Gros Espiell, was the Uruguayan foreign minister at the time of the 1989 Montevideo conference. Espiell took care to note that any bilateral arrangement between Argentina and Brazil would need to be made subject to some system of international controls, but this did not have to have a basis in Tlatelolco or any other existing treaty.[193]

Returning to Setúbal's series of points, Brazil's goal to develop nuclear propulsion technology for an eventual submarine would still be allowed, as the new controls would be

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[191] November 1985, Memorandum to President Sarney, "Brasil-Argentina: Cooperação no campo nuclear," 1. The emphasis is mine; this is one of the first documents, chronologically, that I can recall any Brazilian or Argentinian officials mentioning the NPT in a positive light, and certainly seemed to show Argentina's support for stronger nonproliferation measures than Brazil wished at the time to codify as law or bilateral agreement.
[192] By this date, only ten nations had not deposited a waiver of Article 28/29 of the Treaty of Tlatelolco, and thus had not completed the step that officially bound the country to abide by its terms. In other words, it was somewhat unlikely that small nations would rush to join Argentina and Brazil in a mostly redundant agreement to the landmark 1967 treaty. Of these ten holdout nations in 1985, only Argentina, Chile, Brazil, and Cuba had or have populations over one million (2017).
[193] Leventhal and Tanzer, *Nuclear Arms Race*, 14.

"applied mostly to…sensitive materials (plutonium and enriched uranium)," and not inhibit other peaceful technology developments in the nuclear area.[194] Fourth, the proposed bilateral measure presented the possibility of avoiding "sensationalist versions" of Brazilian and Argentine nuclear activities within the international community, and lastly, the system would create not only a better environment for "confronting the problems that affect their respective nuclear programs," but also might open an economic space for Brazil and Argentina to trade with other Latin American countries.[195] Setúbal expressed concern that while the Argentine proposal was "acceptable in broad terms," a bilateral system of guarantees might have the undesirable consequence of *increasing* international pressure on Brazil's and Argentina's nuclear energy programs, thus "limiting their freedom of action in these matters."[196] The Argentine delegation insisted that the Brazilians consider carefully their proposal, the "fruit of a developed plan by the foreign ministry," which Setúbal insisted they would, while urging that the Brazilian proposal of a working group be equally studied by the Argentine side.

At the end of November, 1985, the first bilateral declaration on nuclear energy in five years between the heads of state of Argentina and Brazil, Raúl Alfonsín and José Sarney, respectively, marked one of the signature achievements of the presidential summit at Foz de Iguaçú. "Nuclear science and technology are marked by transcendental value in the life of any modern country," the document opened, then detailed the years of effort and enormous monetary investments by both governments in research and study of peaceful use of nuclear energy.[197] The next paragraph brought the commonalities in nuclear history and diplomacy between the neighboring countries to the fore. "Cooperation between Argentina and Brazil will

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[194] November 1985 Memorandum to Sarney, 2.
[195] November 1985 Memorandum to Sarney, 1-2.
[196] November 1985 Memorandum to Sarney, 2.
[197] Declaración Conjunta sobre Política Nuclear, Foz de Iguaçú. Nov. 30, 1985.
https://www.abacc.org.br/en/agreements-and-statements/

constitute a multiplier of the benefits that can be obtained reciprocally through the peaceful use of nuclear energy." Additionally, a closer relationship around nuclear energy would create in both countries better conditions to "face the growing difficulties encountered in the international supply of nuclear equipment and materials." To this end, the Declaration of Foz de Iguaçú officially inaugurated the bilateral nuclear energy working group to "develop relations between the two nations in this area," promote technological development, and begin to construct the cryptically worded "mechanisms that assure the superior interests of peace…without endangerment of the technical aspects of nuclear cooperation."[198] Lastly, a meeting of the working group scheduled within 120 days would serve as another check of accountability to "examine the proceedings leading to the implementation of the present declaration."

Sarney and Alfonsín also signed the Joint Declaration on Nuclear Policy in Brasília in December 1986, a sort of accountability check between the heads of state on the broader goals identified in the Declaration of Foz de Iguaçú of one year prior. In that document, the presidents recognized the achievements of the Working Group while urging still closer cooperation, particularly through "joint projects in the longer term," a somewhat nebulous plan that would continue building mutual trust while adding to each nation's technological abilities.[199] Rhetorically, in its article 3, the declaration sought to transform advanced nuclear energy swords into plowshares, seeking to make nuclear science and technology "effective factors in the reaffirmation of our interests of peace, security, and development," and practically, in article 4, highlighted the power of frequent contacts between technical organizations responsible for nuclear energy in each country in fortifying a lofty diplomatic and

[198] "Declaración Conjunta," Nov. 30, 1985, 3.
[199] "Declaração Conjunta sobre Política Nuclear," Dec. 10, 1986, Secretaría de Estado das Relações Exteriores, Brasília, via ABACC "Statements and Agreements" page, www.abacc.org.br/en/agreements-and-statements/.

philosophical goal laid out in the preceding article. Articles 5 and 6 pledged to strengthen the bilateral technical and diplomatic relationship through mutual visits and sharing of information and advice, and to defend Argentina's and Brazil's common interests in nuclear policy in international forums, particularly in keeping their region free of nuclear weapons.[200] Lastly, the heads of state called on the business community to contribute fully to "industrial projects linked to the nuclear area, of interest to the two countries."

The accompanying Protocol No. 17 to the Declaration of Brasília (December 1986) aimed to increase cooperation in nuclear energy research, particularly in high density fuel elements, nuclear detectors and electronics, enrichment of stable isotopes, nuclear and plasma physics research, non-destructive testing, safeguards, and perhaps most ambitiously, proposed a feasibility study for a demonstration-scale fast breeder reactor.[201] Article 8 of Protocol No. 17 gestured to the agreement six years earlier between Figueiredo and Videla, establishing a "reciprocal supply, whether through loan, lease, sale, or another mode of transfer of equipment, material and services necessary for the realization of joint programs, to be governed by Article VI of the Agreement of Cooperation [of 1980]." In 2014, Sonia Fernández, then one of ABACC's two Planning and Evaluation Officers, mentioned her own work on Protocol 17 of December 1986, the preliminary nuclear cooperation agreement that shaped later and more specific nuclear energy projects that the two countries might develop cooperatively.[202] Concurrently, the first concentrated effort to develop safeguards (on facilities that had

[200] Curiously, the geographical extent of "the region" is not specified, nor is the Treaty of Tlatelolco or any other specific disarmament or nonproliferation law mentioned in the brief declaration.
[201] Protocolo nº 17, December 1986. Safeguards were not explicitly mentioned in the Joint Declaration signed on Nov. 30, 1985, at Foz de Iguaçú, so the undeniable appearance of "salvaguardas" in article 5 of Protocol No. 17 is both a significant moment and contradicts Carasales's statement in *Averting a Latin American Arms Race* (p. 11) that no document signed by Argentina and Brazil (through the conference's date in 1989) mentions safeguards or a mutual inspection system. www.abacc.org.br/en/agreements-and-statements/.
[202] Interview, Sonia Fernández Moreno and Orpet Peixoto, December 18, 2014.

obviously been operating outside IAEA verification and control) was drafted in 1981. Its enforcement began in 1984, a development that she said "did not happen by chance, and there was a big discussion with Brazil about it." These safeguards did not include Argentina's uranium enrichment facility at Pilcaniyeu, completed in 1983, and Fernández noted that the political pressure from outside nations for Argentina and Brazil to join the NPT as non-nuclear weapon states from outside nations only intensified when the two countries returned to democratic government in 1983 and 1985, respectively.

The budding nuclear energy cooperation between Brazil and Argentina grew in both specificity and the mutual confidence in the text of the Declaration of Viedma, signed on July 17, 1987. Viedma was the first joint declaration to acknowledge Brazil's official knowledge of the existence (and visit by its president Sarney) of the Pilcaniyeu uranium enrichment facility, held up as "a source of legitimate pride for Argentine science and technology."[203] The presidents highlighted the achievements in "improving the legal and technical aspects of nuclear cooperation," then drew attention in the brief declaration's final article to the importance of meetings among business and industry leaders as "evidence of active participation by public and private firms in the process of nuclear connection," widening the path for cooperation through integrating the industrial sectors of Brazil and Argentina.

The Declaration of Iperó (in São Paulo state, Brazil) of April 1988, mirrored in at least one way the Declaration of Viedma from the year before. Brazil had officially announced its own capacity to enrich uranium at the Experimental Center of Aramar, a facility that Argentina's president had visited in 1987 as his Brazilian counterpart had done with Pilcaniyeu. The document explicitly noted this parallel fact of parity in nuclear achievement, a likely

[203] "Declaração Conjunta sobre Política Nuclear [Viedma]," July 17, 1987. ABACC "Agreements and Statements."

concession to Brazil's nuclear energy program that it had "caught up" with its neighbor.[204] The Iperó document spent a significant amount of text naming and recapitulating prior agreements – Protocols no. 11 and 17, and the Declarations of Iguaçú, Brasília, and Viedma – before noting the "advancements in bilateral cooperation in the nuclear area, with special emphasis on safeguards techniques, nuclear safety, fast breeder reactors, and exchanges, with a view to complementarity between the nuclear sectors of the two nations."[205]

For the first time in the Declaration of Iperó, the presidents credited a growing number and network of informal contacts between political officials and technical personnel in the two neighbor countries with "the consolidation of mutual trust" through important exchanges of information, and on the diplomatic level, the "full agreement of the Brazilian and Argentine positions on the most important international matters of the nuclear energy field." Sarney and Alfonsín concluded the document by urging a still greater number of exchange visits in order to broaden the knowledge of each country's nuclear program by individuals on the other side for reasons of technological parity and mutual trust, but saved their biggest gesture for last. The final article made the 1985 Joint Working Group into a Permanent Committee to coordinate political, technical, and business-oriented initiatives in nuclear energy policy, and formalized what was already a standard practice of a meeting every 3 months, with the setting alternating between Brazil and Argentina.

The Argentine and Brazilian governments did not negotiate any official joint declarations or treaties until both countries had new presidents. Carlos Menem took office on July 8, 1989, and Fernando Collor de Mello succeeded José Sarney on March 15, 1990. The

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[204] "Declaração de Iperó / Declaração Conjunta sobre Política Nuclear." April 8, 1988. ABACC "Agreements and Statements." Even in 2010 at the oral history conference in Rio, Brazilian participants routinely discussed their consistent feeling of lagging behind Argentina in their nuclear development.
[205] "Declaração de Iperó," 2.

new leaders' Joint Communiqué [Comunicado Conjunto], drafted during Collor's official visit to Argentina in early July, 1990, revealed the constellation of bilateral integration and cooperation initiatives, within which nuclear energy was just one issue. The opening articles pledged tighter economic and business integration, and noted in Article 5 the construction of another international bridge between São Borja, Rio Grande do Sul, and Santo Tomé, Corrientes, as a tangible symbol of efforts to collaborate on infrastructure projects.[206] Article 7 explicitly mentioned the two nuclear energy programs as a matter of "great importance," and the necessity of "continuing and deepening" the cooperation established over the course of the preceding decade, with the overall goal of "joint development…and integration between the two countries,"[207] reiterating the open invitation to other Latin American countries inclined to join the increasingly institutionalized and formalized cooperation on peaceful nuclear energy use.[208] (This could be interpreted as an end run around the Treaty of Tlatelolco, a document that is not referenced in any of the bilateral agreements until the November 1990 Declaration on Common Nuclear Policy).

In a nod to the Treaty of Tlatelolco, the presidents recognized the work of the Permanent Committee, especially in creating a "common list of products added to Protocol 17 of the Plan of Integration, to be used in the nuclear power plants under construction in both countries." This sentence's importance is difficult to overstate; to my knowledge, it is the first mention in a bilateral agreement between Argentina and Brazil of *any* kind of reciprocal knowledge or accounting of materials used in the construction or included in the physical capital of any nuclear installation.

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[206] "Comunicado Conjunto," Buenos Aires, July 6, 1990. ABACC "Agreements and Statements."
[207] "Comunicado Conjunto," 2.
[208] "Declaração sobre política nuclear comum brasileiro-argentina," November 28, 1990. ABACC Agreements and Statements, https://www.abacc.org.br/en/agreements-and-statements/.

The articles that followed remained roughly in the territory of science and technology, pledging cooperation on aerospace research, hydroelectric energy, and environmental protection within a broad conception of the South Atlantic that included policy coordination on Antarctica. The document closed with articles 13-15, promising increased efforts to fight drug trafficking and related violence, equal treatment of and benefits for Brazilian and Argentine workers under the labor laws of each country, and praising US President George H. W. Bush's "Initiative for the Americas" and its potential for economic development and increased free trade in the hemisphere.[209]

Five months after the wide-ranging plan for broad bilateral integration, Collor and Menem signed the last treaty on nuclear cooperation before the landmark ABACC treaty, the Quadripartite Agreement, of 1991. The document opened by naming the bilateral nuclear energy agreements that had become an annual November event by 1990: Foz do Iguaçú, 1985; Brasília, 1986; Viedma, 1987; Iperó, 1988, and Ezeiza, also 1988, and reaffirmed the promises made in July 1990. The traditional update on the Permanent Committee's achievements – increased cooperation in research, information exchange, industrial integration, trade of nuclear materials, and development of common projects and policies – had a new twist at the end, describing the committee's "mechanisms of control over the nuclear activities of the two nations," which, in turn, "establish common criteria of categorization for nuclear materials and installations, and *anticipate reciprocal inspections on all nuclear facilities*." (emphasis added) The four signers of the document approved the Common System of Accountancy and Control (SCCC in Portuguese and Spanish), which gave 45 days to both governments and nuclear energy agencies to exchange "descriptive lists of all nuclear installations, …initial inventories

[209] Comunicado Conjunto, 1990, 3-4.

of nuclear materials existing in each country, first mutual inspections of centralized record systems," and submit to the IAEA all records and reports included in the SCCC so that the international agency could reconcile those with materials already submitted by Brazil and Argentina in accordance with safeguards requirements.

Once new safeguards had been concluded that met the requirements of the SCCC, the presidents of Argentina and Brazil promised in the last article to "take steps leading to full entry into force of the Tlatelolco Treaty…including measures toward the revision and improvement of its text." By 1990, Brazil and Argentina had, in many ways, merged into one entity on nuclear affairs, a characterization underscored by Roberto Ornstein's statement that "cooperation in the political field on nuclear issues was so great between 1990 and 1994, the year I was in Vienna, that we were a single delegation [at the IAEA.] Interventions at the IAEA were read in rotation by the Argentinian governor and by the Brazilian one on behalf of the two countries."[210]

The Quadripartite Treaty, signed in Vienna on Dec. 13, 1991, just over a year after the Declaration on Common Nuclear Policy, now reads as somewhat anticlimactic. The innovative system of bilateral nuclear control and verification had been outlined in significant detail by the 1990 date of the previous Declaration, and neither document accounted for the formal and informal, technical and political, diplomatic and military aspects of the eighteen years of bilateral and international interactions that had both preceded and shaped its existence. Much of the document hashes out the division of labor between the International Atomic Energy Agency and the bilateral ABACC (really, a renamed SCCC that both was easier to pronounce and included the names of the countries party to it) that had been created by the Quadripartite

[210] *Origins of Nuclear Cooperation*, 175.

Agreement itself. Article 1 is notable for its categorical and absolute insistence on nuclear energy controls that, as recently as 1989 (at the Montevideo conference) had been unacceptable or at least considered with a great deal of skepticism by major actors or representatives of key stakeholders in any potential agreement:

> The States Parties undertake to accept safeguards, in accordance with the terms of this Agreement, on all nuclear material in all nuclear activities within their territories, under their jurisdiction or carried out in their control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other explosive devices.[211]

Nearly a quarter century after Brazil and Argentina had defiantly insisted on their right to make nuclear swords, and less than a decade after they had begun to forge them, in 1991, their nuclear energy technicians, political officials, and militaries had finally agreed to beat those swords into plowshares. The governments of Argentina and Brazil finally accepted full-scope IAEA safeguards on the same day that ABACC was formally created, in an agreement signed in Vienna between Presidents Menem and Collor and IAEA Director-General Hans Blix.[212] The scramble to include the two South American countries, recently pledged to exclusively peaceful use of nuclear energy, in the global safeguards infrastructure was estimated to cost $2 million for startup and familiarization, and half a million dollars annually for regular operations to begin in 1994.[213]

In summary of the complex process that Argentina and Brazil invented and navigated on political, diplomatic, legal, and technical levels between the Indian nuclear explosion test of 1974 and the durable commitment to mutually verifying the exclusive peaceful use of nuclear energy under ABACC in 1991, the illuminating words of Adolfo Saracho may help.[214] "I believe

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[211] Quadripartite Agreement. Dec. 13, 1991, Vienna, 2. ABACC "Agreements and Statements."
[212] "News Briefs: Argentina and Brazil Accept IAEA Safeguards," *Arms Control Today* 22, no. 1 (1992): 51.
[213] "News Briefs," 51.
[214] Saracho was the director of Argentina's foreign ministry division of Nuclear Affairs and Disarmament from 1983-1987. (Mallea et al, *Origins*, 12).

we can say that currently there is no significant difference between Brazil and Argentina in terms of nuclear development. Both Argentina and Brazil are fully aware of each other's plans and we believe that we are seeking together the development of nuclear energy for peaceful purposes that will bring only benefits to both peoples. I am convinced that this will go on."[215]

Brazil and Argentina had indeed gone their own way together in the eighteen final years of the Cold War, arriving at a durable stasis (ABACC) at the end of 1991 that not even many of those closest to the process could have imagined in Montevideo two years before.

[215] Mallea et al, *Origins*, 172.

Conclusion

The atom sits at the core of a historical transition defined by two intangible pairs of spaces and ideas: Argentina and Brazil, technology and diplomacy, a contested and volatile period that I have called a parallel power play. Parallelism does not sum up the entire bilateral relationship between Brazil and Argentina, but the guiding image of non-intersecting lines roughly approximates, at least for the fifty years of history at the focus of this dissertation, the improbable good fortune (and shrewd diplomacy) that kept the two regional powers from going to war as they chased technological autonomy, or domestic control over the supply and technologies supporting the full nuclear fuel cycle.

"Parallel" also describes the temporal overlap of most phases of nuclear energy technology development as well as political history in the two countries: Developmentalist postwar leaders, seeking a rapid boost in their national industrial capacities, bet big on atomic energy after 1945. In the early 1950s, scientific communities, motivated by a massive flow of state investment into an unprecedented set of opportunities and challenges, began a wave of institutionalization of scientific practice and research; new atomic energy commissions whose precise tasks and purposes were intensely debated among various sectors of society, including the military, took flight (Chapter 1). The military upended elected heads of state in 1964 in Brazil, and in 1966 in Argentina, and sought to develop nuclear power capabilities, purchasing reactors from North Atlantic firms as the global nuclear nonproliferation regime was constructed around them. Diplomatic delegations from the South American neighbors were very much aligned, almost indistinguishable, at the negotiations for the first treaty that banned nuclear weapons from a specific geographical region of the world. The technicalities of the treaty and its byzantine process for going into force allowed Argentina and Brazil to uphold the rhetoric of nonproliferation by signing the treaty, but without any obligation to obey the letter of its law (Chapter 2).

The parallel play was stretched almost to its breaking point in the decade that followed the negotiation of the Tlatelolco Treaty. Argentine officials, under military dictator Juan Carlos Onganía and his *Revolución Argentina* regime, resented what they saw as blatant attempts to establish hegemony in the region through two pharaonic energy projects. One was the construction of the colossal Itaipú dam in cooperation with Paraguay, impinged on Argentina's own plans for hydroelectric power. The other, a landmark nuclear technology transfer deal from West Germany to help Brazil complete the nuclear fuel cycle, also ended up exposing an internal rift between the Brazilian government, on one side, and scientists and the military, on the other, who did not think the German deal was delivering as promised. Two meanings of "power," too, are explored here as both nations took decisive steps between 1966-1974 to establish nuclear electricity capabilities and enterprises, while their military forces continued to play their historical role of jockeying for regional influence at each other's expense (Chapter 3).

Between 1975-1985, both nations pursued autonomous control of the nuclear fuel cycle after being locked out of international technology markets, still steadfastly opposed to the Non-Proliferation Treaty. Argentina embarked on a top-secret project to enrich uranium using the gaseous diffusion method, in part, to fuel reactors that it had promised to build and ship to other developing countries (Chapter 4). Brazil's military, fed up with lack of progress toward technological autonomy in the "official program" with West Germany, began a "parallel program" – essentially a race between the three branches to enrich uranium via different technologies. The parallel program was so successful that in many ways, Brazil's nuclear energy achievements had caught up to those of Argentina. However, in these years, a fifteen-year project to develop a nuclear weapon may have been underway (Chapter 5). Lastly, the dissertation explored the varied motivations for the neighbor countries moving from a steadfast opposition to nonproliferation measures, toward mutual confidence, and finally agreeing to verify and control the peaceful use of all nuclear facilities in Brazil and Argentina via an innovative mechanism of mutual visits and inspections (Chapter 6).

In 2017, nuclear power contributes roughly 3% to the total electrical power supply of both Brazil and Argentina. It is an appropriate data point, one last commonality, to finish a dissertation that has traced the parallel actions, ideologies, and motivations of South America's most advanced nuclear energy programs from their beginnings in 1945. Yet it is also a red herring, a meager number that obscures more than it reveals. What the atom built in Brazil and Argentina, I have argued, was far more than three-hundredths of either nation's energy resources. The South Americans' engagement with nuclear technology and diplomacy offers an extraordinary mosaic depicting a politically fraught technological project with global implications. As declassification clears away more secrecy of sources in the future, researchers will have a better picture of how Argentina and Brazil made nuclear energy, and how nuclear energy made modern Brazil and Argentina. These two countries also offer important historical lessons for the rest of the world in how technology and diplomacy can be placed in each other's service. Five concluding arguments may show how we can read and extend these lessons to other spaces, times, and fields of knowledge.

First, one hypothesis that motivated this dissertation, it turns out, was only partially correct. Preliminary research had suggested that there might be some kind of durable binational and transnational scientific community, perhaps formed as Brazilian and Argentine scientists and technicians received advanced training abroad, that quietly grew throughout the second half of the twentieth century before finally becoming apparent in the late 1970s and early 1980s. Yet many of my interlocutors in both countries were unequivocal on this point: no persistent collaboration or cooperation occurred between nuclear energy authorities or technicians for some time. As Argentina and Brazil began atomic energy programs in earnest in the early 1950s, national governments were too busy building the physical, legal, or institutional capital to support ambitious nuclear energy development goals for experts to connect across the border. Moreover, the relationship between the two was still marked by what Andrea Oelsner called a "cold peace," where absence of war but also absence of trust marked relations around sensitive matters of the utmost importance to both economic development and national security. Only at Tlatelolco in the mid-1960s did any kind of collaboration ensue between these communities, and it was more an alignment between the two countries' diplomats and foreign service personnel than among individuals in an epistemic or knowledge community specialized in nuclear physics, engineering, or energy. Even the record from 1967-1974 is spotty and halting in terms of bilateral progress.

Second, understanding the period that spans the end of World War II and the Cuban Missile Crisis is fundamental to the richer history of the technology and diplomacy of nuclear energy development that scholars, including me, have recently begun to tell. In those years, I found a colonial paradigm that the actors in this history worked hard to destabilize: Brazil and Argentina, at first, depended on the United States to provide nuclear technology and knowhow while the South American countries shipped newly valuable minerals to aid the peaceful (and military) nuclear development of the hemispheric and global hegemon. Out of this glaring inequality arose what I call the "spirit of Tlatelolco," a determination shared by authorities in Argentina and Brazil to use nuclear energy in order to carve out a larger role in global geopolitics almost completely dominated by the United States and Soviet Union. Given the false starts on nuclear energy in both Argentina and Brazil, albeit for rather different reasons as argued in Chapter 1, it is crucially important that both nations developed educational, legal, and diplomatic infrastructure to the extent that they became the unquestioned leaders in nuclear energy in the region, even before the Cuban Missile Crisis made nuclear energy an issue that suddenly affected all of Latin America and the Caribbean.

Third, even though the story of Brazilian and Argentine nuclear energy development is largely one of bureaucratic rationality taking hold through national nuclear energy commissions, then running smoothly over the din of political chaos, particularly in Argentina, individual personalities and characters still matter a great deal. Every nation that has developed advanced programs for peaceful and/or military use of nuclear energy has had its mad scientists, its determined administrators, often a few resolute military generals, and activists determined to expose the environmental and human costs of nuclear energy. Whether heroes or outcasts, their names – Robert Oppenheimer in the US, Homi Bhabha in India, Abdul Qadeer Khan in Pakistan, Carlos Castro Madero and Jorge Sábato in Argentina, Álvaro Alberto and Othon Pinheiro da Silva in Brazil – are engraved forever in these national and global histories of nuclear energy. I have dwelt little on the importance of individual motivations and strategies of heads of state over the five decades of political history that structure this dissertation, yet their centrality is undeniable. The expansive visions of Juan Domingo Perón, Getúlio Vargas, and Juscelino Kubitschek launched Argentina and Brazil into the Atomic Age, while unlikely diplomatic overtures from dictator Jorge Rafael Videla toward his Brazilian neighbors at the end of the 1970s helped to sustain autonomous nuclear development projects well underway in both countries in the face of enormous international pressure to comply with the NPT's "three pillars" of the nonproliferation regime. Personal histories matter, too: the affinity that Brazilian president João Figueiredo (1979-1985) felt toward Argentina from his time there as a teenager with his exiled father almost certainly played a role in the gradual *rapprochement* that began to take shape during his presidency, after the friendly binational trio of Paulo Nogueira Batista, Hervásio de Carvalho, and Carlos Castro Madero had managed complex technological and diplomatic maneuvers to maintain nuclear energy progress during the Itaipu standoff of the mid- and late 1970s. These are mere samples, not inclusive, of the personalities, contingencies, and historical accidents upon which the grinding bureaucratic rationality of the nuclear energy programs depended.

Fourth, though the dissertation is organized by the idea that Brazil's and Argentina's nuclear energy programs ran essentially in parallel, any overemphasis of the similarities between the technological and diplomatic approaches to the challenges that each nation faced in developing it has been unintentional. In fact, the gradual and continuous rapprochement between Brazil and Argentina around nuclear energy discussed in Chapter 6 *would not have been possible* without the basic technological differences between natural uranium and enriched uranium fuel technologies, and the possibilities for complementarity and comparative advantage that these distinctions offered toward potential collaboration and cooperation. Brazil and Argentina's parallel paths, in fact, had to diverge widely before coming back together in a comprehensive collaboration that finally pulled in political leaders, diplomatic personnel, and the scientific and technical communities after 1985. Nuclear energy was far from the only issue that divided Brazil and Argentina, but diplomatically and politically speaking, and leaving aside technology for a moment, it was an opportunity to show visible and tangible bilateral progress on a set of issues that potentially threatened regional and global security.

Lastly, in researching and writing the dissertation, I hope that I have in some measure "de-exoticized" or normalized nuclear energy as a technological project for middle-power nations like Argentina and Brazil. I agree with Itty Abraham's conclusions from 2006 on nuclear histories and ambivalence: the obsession of scholars with nuclear weapons and proliferation obscures useful research and writing on nuclear programs,[1] which Abraham argues are "best understood as one of a larger family of public technology projects, not all of which are weapons related or have destructive ends." Robust nuclear diplomacy – whether to gain technological capital from foreign nations, or to mitigate fears of weapons proliferation on a nuclear-weapon-free continent, or renegotiate a peaceful nuclear sharing agreement with a fellow developing nation – was the necessary *byproduct* – and not the cause of – ambitious nuclear energy programs with peaceful ends, legitimately aimed at developing cheap nuclear power and improving medicine and agriculture through the properties of radioactivity and nuclear physics, chemistry, and engineering. Nuclear energy in Brazil and Argentina began, in the immediate aftermath of World War II, as an exceptional technology, or "imported magic," a concept borrowed from a 2014 collection of Latin Americanist history and anthropology of science.[2] But by 1995, the South American neighbors had made it their own.

[1] Itty Abraham, "The Ambivalence of Nuclear Histories," *Osiris* 21, no. 1 (2006), 51.
[2] Eden Medina, Ivan da Costa Marques, and Christina Holmes, eds. *Beyond Imported Magic: Essays on Science, Technology, and Society in Latin America*. Cambridge, MA: The MIT Press, 2014.

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ACPDOC	Database of Personal Archives, Fundação Getúlio Vargas/Centro de Pesquisa e Documentação de História Contemporânea do Brasil (CPDOC), http://cpdoc.fgv.br/acervo/arquivospessoais/base
AICTP	Abdus Salam Archive at the International Center for Theoretical Physics, Trieste, Italy
AMREB	Foreign Relations Archive, Ministério das Relações Exteriores, Brasília, Brazil
AMRECIC	Foreign Relations Archive, Ministerio de Relaciones Exteriores y Culto, Buenos Aires, Argentina
ASABACC	Agreements and Statements (Bilateral and Quadripartite), https://www.abacc.org.br/en/agreements-and-statements/
BCAB	Library at Centro Atómico Bariloche [Biblioteca Leo Falicov], CNEA, Bariloche, Argentina
BCAC	Library of Centro Atómico Constituyentes, CNEA, Buenos Aires, Argentina
BSBPC	Library of the Sociedade Brasileira para o Progresso da Ciência, São Paulo, Brazil
CONICET	Consejo Nacional de Investigaciones Científicas y Técnicas Library, Buenos Aires, Argentina
DNSA	Digital National Security Archive, http://nsarchive.chadwyck.com/home.do
ESDA	Personal digital archive of Eduardo Santos, ex-president of CNEA. (Not available online).
LOCM	Library of Congress Manuscripts, Washington, DC
NARA	National Archives II, College Park, Maryland
NSecA	National Security Archive, George Washington University, Washington, DC
WCDA	Wilson Center Digital Archive/Nuclear Proliferation International History Project/Cold War International History Project, http://digitalarchive.wilsoncenter.org/

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