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The Conventionally Armed Nuclear Submarine Program in the Context of Public Policies for Complex Problems

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ABSTRACT

National sovereignty remains a marginal issue on the agenda of Brazilian civil society. Understanding the strategic relevance of Brazil possessing its first Conventionally Armed Nuclear Submarine (SNCA) requires an analysis of the complexity involved in implementing this public policy, which stems from two governmental programs: the Submarine Development Program (PROSUB) and the Navy Nuclear Program (PNM). With this focus, the present study aims to discuss public policies, public goods, complex public problems, and public policy cycles in order to connect them to the SNCA Project/Program and, thus, demonstrate the importance of Brazil effectively building and operating its first Conventionally Armed Nuclear Submarine. The object of this research is the future SNCA, examined through the lens of public policy. The authors raise the question of whether the SNCA Program can be considered a complex public policy that addresses a complex public problem related to the creation of a public good, which simultaneously impacts the country's Defense, Energy, and Science, Technology & Innovation (ST&I) sectors. The methodology is based on qualitative research through a new literature review on public policies, proposing a definition of public policy to delimit the scope of the study. In conclusion, the SNCA is a necessary public good for the country, which faces the challenges of complex public policies for its realization.
Keywords: Nuclear Submarine; Public Policy; Complex Problems.

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INTRODUCTION

National sovereignty remains a marginal issue on the agenda of Brazilian civil society. Understanding the strategic relevance of Brazil possessing its first Conventionally Armed Nuclear Submarine (SNCA) [3]requires an analysis of the complexity involved in implementing this public policy, which stems from two governmental programs: the Submarine Development Program (PROSUB) and the Navy Nuclear Program (PNM). Public policies will be addressed considering the specific nature of the SNCA project/program[4], which intersects with the three most synergistic government sectors: Defense—as the submarine is a piece of equipment intended for use by the Brazilian Navy; Nuclear—as it features a propulsion system powered by a nuclear reactor; and Science, Technology, and Innovation (ST&I)—given the intrinsic need for the development of both the submarine and its propulsion system to be indigenous, since technology transfer in the nuclear field is virtually nonexistent. Additionally, Foreign Affairs and Diplomacy are affected by decisions in the realm of National Defense, and international bodies such as the International Atomic Energy Agency (IAEA) closely monitor developments related to nuclear technology.

The conventional submarines built under the scope of the Submarine Development Program (PROSUB), equipped with diesel-electric engines, also represent a technological and public policy challenge. However, for these non-nuclear-powered submarines, the technology transfer agreement has been far more comprehensive. This agreement, established in 2008 with France through the Naval Group—a French defense-oriented industrial group with majority ownership by the French government—has enabled broader cooperation. In the case of the SNCA, however, the agreement was limited to the design of the "non-nuclear section.":

> In the context of the technology transfer process

3 The Brazilian Nuclear Submarine, which will be named Almirante Álvaro Alberto (SN-BR), and the description Conventionally Armed Nuclear Propulsion Submarine (SCPN) are alternative names to the one currently (2024) adopted by the Brazilian Navy, Conventionally Armed Nuclear Submarine (SNCA).

4 The author chose to adopt the nomenclature SNCA project/program because initially the SNCA was a project, but as it progresses, it evolves into an independent program derived from the intersection between PROSUB and PNM.

> outlined in the bilateral agreement, Naval Group inaugurated a submarine design school in 2009 in Lorient, France, with the aim of assisting Brazil in designing the non-nuclear part (hull, structure, and all non-nuclear systems) of the SN-BR (IPEA, 2019, pp. 3–4).

Thus, the construction of the four conventional submarines under PROSUB (Brazilian Navy, 2012; 2014) does not attract as much external attention as the nuclear-powered submarine project, which is described as "conventionally armed," emphasizing that the nuclear component is solely related to the propulsion system's fuel (reactor):

> This propulsion system constitutes a "non-proscribed nuclear activity," considered a peaceful use (Rublee, 2010; Carlson, 2015; IAEA, 1994, art. 13), and its development is therefore the exercise of an inalienable right. However, there is a perception that it creates loopholes in the IAEA safeguards system (Costa, 2017; Carlson, 2021), potentially allowing for the diversion of fissile material for the possible production of nuclear weapons. This risk has helped align international security interests against such initiatives (Acton, 2021). Brazil is one of the few states that masters the nuclear fuel cycle, allowing it to meet part of its civilian needs and aim for self-sufficiency (INB, 2024), but this also makes the country a target of global concerns regarding nuclear weapons proliferation. Brazil has refused to accede to the Additional Protocol (AP), an instrument introduced by the IAEA in 1997 that makes nuclear safeguards significantly more stringent, and it has faced international pressure to join (Carlson, 2015; Carlson, 2021; Acton, 2021). In Brazil's case, adherence to the AP could help reduce the perceived risk associated with the SCPN [SNCA] program (DE MOURA & ALVES, 2024).

On the other hand, domestically in the country:

> Although political and expert elites debate whether Brazil should sign the IAEA Additional Protocol, there is little public discourse on the merits and challenges of a nuclear submarine program (Kassenova, 2014).

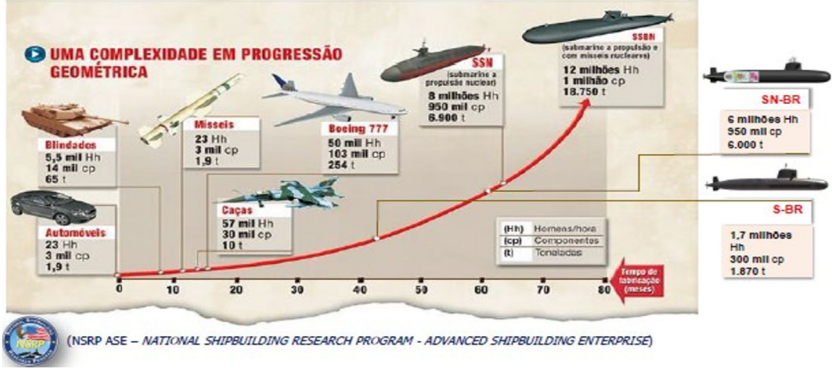
The debate begins with the question, "Why does Brazil want a nuclear submarine?" The strategic relevance of the SNCA can be summarized as follows:

> [...] the existence of the SCPN [SNCA] would provide Brazil's Naval Power with a true operational capability to protect natural resources, deterring potential adversarial forces from conducting hostile actions in the AJB [Brazilian Jurisdictional Waters];
> [...]
> The security of a nation and its legacy—enhanced by its maritime spaces and corresponding natural resources—requires the deployment of adequately prepared and compatible defense assets capable of countering external ambitions that could interfere with and threaten national sovereignty.
> This is justified by the fact that, in international relations, armed conflict continues to be used as a tool of power by actors and organizations in pursuit of objectives and the safeguarding of their own interests.
> [...] Therefore, this important operational asset stands as an appropriate and consistent instrument to fulfill the primary purpose of repelling attacks from the sea against national territory, protecting the country against superior naval forces that could threaten not only energy production facilities but also hinder the flow of maritime traffic, the supply chain, and Brazil's commercial trade routes (Messeder, Guimarães & Almeida, 2024).

This study does not intend to delve into the motivations behind the SNCA Program, nor into the reasons for the government's decision,

up to the present moment, not to adopt the Additional Protocol[5]. These political decisions and the developments that have brought the project to its current stage are treated as preliminary data—already established facts. As previously mentioned, the SNCA involves issues directly related to the nuclear sector, defense, and matters of science, technology, and innovation. Defense and the nuclear sector are both connected to international[6] (diplomatic) relations, each in its own way; the nuclear sector, specifically, spans a broad technological spectrum and has applications across economic activities, particularly in the energy sector, healthcare (nuclear medicine), and is subject to continuous monitoring regarding environmental issues (mining, waste, decommissioning, operational safety, etc.). The implementation of the SNCA Program itself represents a significant advancement—a national milestone in science, technology, and innovation that draws the attention of other countries and international organizations. Figure 1 illustrates the complexity of a nuclear-powered submarine construction project in comparison to other projects with high technological complexity, even surpassing Boeing 777 aircraft:

Figure 1 – Complexity of Submarine Construction



Source: Naval Group[7].

5 According to Article III of the NPT, each non-nuclear-weapon state party must sign an agreement with the IAEA for the application of nuclear safeguards on all materials used, in all peaceful nuclear activities taking place within the territory of such a state, or under its jurisdiction, or those carried out under its control elsewhere (BRAZIL, 1998). Agreements with these characteristics are called Comprehensive Safeguards Agreements (CSA), as stated by (FONSECA, 2024, p. 35).

6 The debate on the schools of international relations is beyond the scope of the thesis.

7 Extracted from the presentation by Eric Bertthelot of the company Naval Group to the Foreign Relations and Defense Committee of the Chamber of Deputies on November 30, 2019.

Furthermore, the public policies related to the effective operation of the SNCA involve each of these sectors and engage with the aforementioned issues—but not exclusively. Consequently, the following sections will address key concepts related to public policies, prioritizing references that are immediately relevant to the scope of this research. International issues will serve as the "background" and will be mentioned and addressed as necessary.

The object of this research is the future SNCA, analyzed through the lens of public policy. The central question this study seeks to answer is: "What is the appropriate public policy approach for the SNCA Program?" As a hypothesis, we start from the premise that the construction of the SNCA constitutes a complex public problem. The methodology employed is based on qualitative research through a new literature review on public policy, which proposes a definition of public policy to delimit the scope of the study. The research process involved data collection from publications, books, articles, and both printed and digital documents, which served as the starting point for the bibliographic and documentary research. Various secondary sources were used to identify primary sources and seminal works.

Introduction to the Public Policy Literature Review

In 2006, researcher Celina Souza[8] published an article titled "Public Policies: A Literature Review." In it, the author presents the origins of the field of public policy in Europe and the United States, highlighting their differences:

> Thus, in Europe, the field of public policy emerged as an extension of works based on explanatory theories about the role of the State and one of its most important

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8 For more about Celina Souza, visit http://lattes.cnpq.br/5422025168210583. The article was published in 2006 in the journal Sociologias (UFRGS, Printed), which has an A1 classification in the CAPES Journal Evaluation (Sucupira) area.

> institutions—government—which is, by definition, the primary producer of public policies. In the United States, by contrast, the field emerged within academia without establishing connections to theoretical foundations on the role of the State, shifting directly to an emphasis on the study of governmental action. The analytical premise that guided the formation and consolidation of public policy studies is that, in stable democracies, what the government does or fails to do can (a) be scientifically formulated and (b) analyzed by independent researchers (Souza, 2006).

The field of public policy studies emerged as a subfield of political science, and in this sense, its objective is to understand how and why governments choose certain actions. One of its founding figures, Harold Dwight Lasswell (USA, 1902-1978), inaugurated this field of study in 1936 with his work "Politics: Who Gets What, When, How"[9], less than a decade after the 1929 economic crisis (Souza, 2006). In parallel, the term "public administration" emerged to differentiate itself from business administration during the period of the Great Depression in the United States, a time that "generated hostility toward businesses and contempt for their executives" (Drucker, 1999).

Three additional authors are often cited as co-founders of the public policy field. Herbert Alexander Simon (USA, 1916-2001), who published "Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations"[10] in 1947; Charles Edward Lindblom (USA, 1917-2018), whose key reference works are the articles "The Science of 'Muddling Through'" (1959) and "Still Muddling, Still Not Through"[11] (1979); and David Easton (Canada, 1917-2014), who published "A Framework for Political Analysis" in 1965 (Souza, 2006).

Influenced by these works, public and private organizations continued to evolve in their techniques during the 1950s and 1960s, adopting organizational and governmental planning, but at different paces. The delay in public administration incorporating strategic

9 Original title in English: Politics: Who Gets What, When, How.

10 Original title in English: Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization.

11 Original titles in English: The science of 'muddling through' and Still muddling, not yet through.

management and developing a more agile response capacity to the demands of a democratic society increasingly clashed with public participation demands:

> All of this led, throughout the 1980s, to the progressive strengthening of a more agile conception of governmental activity: action based on planning shifted towards the idea of public policy (Saravia, 2006, p. 26).

The author complements this with a citation from Ana Luiza Viana's[12] article.

> Indeed, from then on, "[...] the production of public policies seeks to analyze how the state apparatus functions, starting with the identification of the characteristics of the public agencies that 'make' policy; the actors involved in this process of 'making' policies; the interrelationships between these variables (agencies and actors); and the external variables that influence this process" (Saravia, 2006, p. 26; Viana, 1996).

And it makes a connection between the concept of public policy and political decision-making:

> But what is a public policy? It is a flow of public decisions aimed at maintaining social balance or introducing imbalances intended to modify that reality. Decisions conditioned by the very flow and by the reactions and changes they promote in the social fabric, as well as by the values, ideas, and views of those who adopt or influence the decision (p. 28).
> [...]
> Political decision-making takes into account variables that business decision-making does not consider (Saravia, 2006, p. 23).

12 The article had 628 citations on Google Scholar as of 09/30/2023.

Definition of Public Policies

Table 1 gathers classic definitions and some more recent initiatives in conceptualizing such a complex and broad term:

Table 1 – Classical and Contemporary Definitions of Public Policies

Definição de Políticas Públicas	Autor e Obra de Referência
Decisões e análises sobre política pública implicam responder às seguintes questões: quem ganha o quê, por que e que diferença faz.	LASWELL, H.D. Politics: **Who Gets What, When, How**. Cleveland, Meridian Books. 1936/1958.
Um conjunto de ações do governo que irão produzir efeitos específicos.	LYNN, L. E. **Designing Public Policy**: A Casebook on the Role of Policy Analysis. Santa Monica, Calif.: Goodyear. 1980.
Conjunto de ações do governo [que] considera a decisão de "não fazer" ou de "agir por inércia" – subentende política pública como "o que o governo escolhe fazer ou não fazer" ou, em outras palavras, agir ou não agir.	DYE, Thomas D. **Understanding Public Policy**. Englewood Cliffs, N.J.: Prentice-Hall. 1984.
Um campo dentro do estudo da política que analisa o governo à luz de grandes questões públicas.	MEAD, L. M. "Public Policy: Vision, Potential, Limits", **Policy Currents**, Fevereiro: 1-4. 1995.
É a soma das atividades dos governos, que agem diretamente ou através de delegação, e que influenciam a vida dos cidadãos.	PETERS, B. G. "Review: Understanding Governance: Policy Networks, Governance, Reflexivity and Accountability by R. W. Rhodes", **Public Administration** 76: 408-509. 1998.
Fluxo de decisões públicas, orientado a manter o equilíbrio social ou a introduzir desequilíbrios destinados a modificar essa realidade.	SARAVIA, Enrique; FERRAREZI, Elisabete. **Políticas Públicas**. Coletânea. 2 Volumes. Brasília: ENAP, 2006.
Políticas públicas configuram decisões de caráter geral que apontam rumos e linhas estratégicas de atuação governamental, reduzindo os efeitos da descontinuidade administrativa e potencializando os recursos disponíveis ao tornarem públicas, expressas e acessíveis à população e aos formadores de opinião as intenções do governo no planejamento de programas, projetos e atividades.	BRASIL. Ministério da Saúde. **Política nacional de plantas medicinais e fitoterápicos**. Brasília, 2006, p.9.
Campo do conhecimento que busca, ao mesmo tempo, "colocar o governo em ação" e/ou analisar essa ação (variável independente) e, quando necessário, propor mudanças no rumo ou curso dessas ações (variável dependente).	SOUZA, Celina. Políticas Públicas: uma revisão da literatura. **Sociologias**, [S. l.], v. 8, n. 16, 2006.
Estuda como leis, regulações e outras políticas [públicas] são formuladas, implementadas e avaliadas.	GRIGSBY, Ellen. **Analyzing Politics**: An introduction to political science. 4 ed. Wadsworth, Cengage Learning: Belmont, California, 2009.
[...] se trata do conjunto de ações implementadas pelo Estado e pelas autoridades governamentais em um sentido amplo. Trata-se do estudo do "Estado em ação" [...] portanto, estudar políticas é analisar por que e como o Estado age como age, dadas as condições que o cercam.	MARQUES, Eduardo. **As Políticas Públicas na Ciência Política**. In: MARQUES, E.; FARIA, Carlos Alberto Pimenta de. A Política Pública como Campo Multidisciplinar (org.) São Paulo: Ed. Unesp; Ed. Fiocruz, 2013. p. 24.
Política Pública é um conjunto de decisões e ações adotadas por órgãos públicos e organizações da sociedade, intencionalmente coerentes entre si, que, sob coordenação estatal, destinam-se a enfrentar um problema político.	SCHMIDT, João Pedro. Para estudar políticas públicas: aspectos conceituais, metodológicos e abordagens teóricas. **Revista do Direito**, v. 3, n. 56, p. 119-149, 2018. p. 127.

Source: Author's own elaboration.

For reference purposes in this research, the definitions by Lynn (1980), Dye (1984), and Marques (2013), which emphasize the state's role as the decision-maker and sponsor of public policies, are the author's choices. Thus, public policies are understood as "a set of government actions that will produce specific effects," meaning public policy is implicitly understood as "what the government chooses to do or not to do," or, in other words, to act or not to act, given the conditions surrounding it.

Below is a complementary summary of the concept[13] that spans the main definitions of public policies:

> Public policy is a response to a political problem. In the political science literature, there are numerous definitions, but one concept stands out: public policies are the responses of the public authority to political problems. That is, policies refer to initiatives by the State (governments and public powers) to address social demands related to political problems of public or collective order (Schmidt, 2019, p. 122).

As an extension, this didactic description in the form of questions deserves to be reproduced:

> This subfield [of Political Science, one of the main ones] closely examines questions such as: "What makes a public policy necessary?", "How can public policies be designed to effectively meet specific needs?", "What contributes to the effectiveness of public policies?", "Why do ineffective public policies remain instead of being discontinued?", "What should be the standards for evaluating public policies?" (Grigsby, 2009, p. 14, our translation).

Therefore, as illustrated in Figure 2, public policy is a subfield

13 "The distinction between concept and definition is made here. The concept expresses what is essential in a phenomenon; the definition elaborates and gives precise contours to the concept. In the case of public policies, there are multiple definitions of policies, but few concepts that differ in the essential" (SCHMIDT, 2019, p. 122).

of Political Science.

Figure 2 – Public Policies as One of the Main Subfields of Political Science

Source: Adapted from Grigsby (2009, p. 14, our translation), as per Guimarães (2019, p. 125).

In Kurian (2011), two main concepts are attributed to the term politics: politics as a sphere of action or space, and as an activity:

> The spatial concept of politics refers to the demarcation of the political sphere. [...] both diffuse in their boundaries and vague in their core. [...]
> The distinction between the public and private spheres

> forms the traditional core of the spatial concept of politics. [...]
> Considering politics as an arena, forum, stage, or theater establishes a distinction between the fluid concepts of sphere and activity, because these metaphors also allude to the performance of an activity [...] (Kurian, 2011, p. 1299-1301).

Then, public policies are defined based on the term "politics." Here, it is worth highlighting the mention of continuity and purpose (teleology), essential elements in the discussion of public policies.

> Public policy refers to a conception of politics emphasizing the continuity of simple measures. This allows some authors to distinguish between policies or denounce all opportunism. The core of public policy lies in the balance between teleological convenience and normative demands. [...]
> Different stages of the political process – including deliberation, commitment, or contestation – also offer an alternative theme for the conceptualization of politics (Kurian, 2011, p. 1300, our translation).

Additionally, Souza (2006, p. 26) describes how public policies manifest in practice:

> The design of public policies and the rules that govern their decisions, formulation, and implementation also influence the outcomes of the conflicts inherent in public policy decisions.
> [...]
> Public policies, once designed and formulated, unfold into plans, programs, projects, databases, or information systems and research. When put into action, they are implemented, and from that point, they are subject to monitoring and evaluation systems (Souza, 2006, p. 21; 26).

Schmidt (2019, p. 126) emphasizes the need for a set of actions to characterize a public policy:

> A policy consists of a set of actions. Isolated actions do not constitute a policy. No political problem can be solved by a single action or by a few fragmented actions.
> [...]
> A policy consists of a set of actions and initiatives that are generally coherent with each other and often involve several areas.
> (Schmidt, 2019, p. 126).

The aforementioned author also emphasizes that:

(i) Isolated actions, even if important, do not constitute a [public] policy, which is always a set of actions and decisions.

(ii) A set of decisions and actions only constitutes a [public] policy when they arise from the intention to solve a political problem; in practical execution, the coherence between actions may be fragile or even nonexistent, but there must be a prior intentionality to bring them together.

(iii) Actions can be carried out directly by the public authority or delegated to social or private organizations.

(iv) Public interest actions carried out by civil society only constitute a public policy if they are part of a set of actions coordinated by the State; it is not necessary for the State to execute the actions, but in a democracy, it is its role to coordinate and legitimize the political process (Schmidt, 2019, p. 127).

Marta Arretche refers us to the object of study of public policies, relating it to the study of government programs:

> There is little doubt about the object of analysis in the subdiscipline of public policies. The analysis of the

> "State in action" [...] has as its specific object the study of government programs, particularly their conditions of emergence, their operational mechanisms, and their probable impacts on the social and economic order (Arretche, 2003, p. 8).

Therefore, there is a hierarchy, a logic within the propositions involving public policies. Table 2 presents useful definitions for such understanding:

Table 2 - Common Terminology in Government Planning, from the most general to the most specific

Termi-nologia	Descrição	Exemplos
Política (Política Pública)	Dispõe sobre princípios, objetivos e diretrizes relativas à gestão, **estabelece responsabilidades do poder público e da sociedade**, elenca meios e recursos, explicitando a forma de atuação governamental em determinada área.	Política Nacional de Defesa – PND Política Nuclear Brasileira (Decreto 9600 de 5 de dezembro de 2018) Política Nacional de Transição Energética – PNTE (2024) Política Nacional da Indústria de Defesa – PNID (2005) Política Nacional para os Recursos do Mar – PNRM (2005)
Plano	Detalha as diretrizes da política e, com base em um diagnóstico da situação, **estabelece estratégias e metas para um período temporal**.	Plano Estratégico da Marinha (PEM 2040) Plano Decenal de Expansão da Energia – 2034 (EPE) Plano Geral de Atividades do Setor Nuclear Brasileiro – 2023 Plano Nacional de Transição Energética 2024 (PLANTE)
Programa	Geralmente derivado ou associado a um plano, contém diretrizes, estratégias, objetivos e metas que **norteiam as ações públicas em um determinado "setor"**.	Programa de Submarinos – PROSUB Programa de **Aceleração** da Transição Energética – PATEN Programa Nuclear Brasileiro – PNB Programa Nuclear da Marinha – PNM **Programa do SNCA**
Projeto	É a menor unidade do processo de planejamento, que **detalha estratégias, ações, atividades e recursos para a operacionalização por parte de uma unidade de ação**.	Ciclo do Combustível Nuclear Laboratório de Geração Nucleoelétrica – LABGENE Projeto de Assistência Técnica dos Setores de Energia e Mineral – META Projeto de Implantação do Centro Tecnológico Nuclear e Ambiental – CENTENA **Projeto do SNCA**
Ação	É o nível mais concreto do planejamento governamental; **designa uma iniciativa** expressa em um plano, programa ou projeto.	Assinatura do PROSUB Construção do Estaleiro e Base Naval de Submarinos de Itaguaí (Execução das Obras) Criação dos GTs do CDPNB* Retomada das obras de Angra III Criação do Fundo Verde

* Brazilian Nuclear Program Development Committee

Source: Adapted from Schmidt (2019, p. 128)

Although in practice governments do not always follow the political – plan – program – project – action sequence, adopting this terminology has the advantage of helping to establish the concept of public policies as a set of actions aimed at solving a political problem, and not just any action of public management. In summary, a public policy will only exist if there are coherent governmental/state actions among themselves, including the deliberate decision not to act[14]. The specific effects generated, that is, the effectiveness of the public policy, are studied in the analysis of public policies, a component of the public policy cycle.

The public policy cycle seeks to explain how governmental actions are constructed through an idealized reference mechanism composed of a sequence of stages or phases. This approach, due to its didactic structure, was chosen to receive greater emphasis. However, it is worth mentioning in this literature review the presentation of typologies of public policies due to their effort to simplify through classification and synthesis.

Typologies of Public Policies

According to Leonardo Secchi[15]:

> A typology is a scheme for interpreting and analyzing a phenomenon based on variables and analytical categories.
> [...]
> Public policy typologies are ways of classifying the

14 As of the present date (09/19/2023), the creation of the ANSN – National Nuclear Security Agency represents only a "public policy in progress," as despite the publication of decrees/laws XYZ, it has not yet produced effects, remaining "on paper." In short, the previous and centralized public policy, characterized by the accumulation of functions in the CNEN, remains in effect.

15 According to the CNPQ Lattes Platform, Leonardo Secchi is a full professor at the State University of Santa Catarina (Udesc/Esag), affiliated with the Department of Public Administration and the master's and doctoral programs in Administration (PPGA/Esag/Udesc). His reference book "Políticas Públicas: conceitos, casos práticos e questões de concurso" is in its 3rd edition and is part of the syllabus for Public Policy courses at institutions such as USP (see: https://edisciplinas.usp.br/course/view.php?id=73515) and UFPR (see: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://politicaspublicas.weebly.com/uploads/5/3/9/6/5396788/programa_2023-1_-_an%C3%A1lise_de_pol%C3%ADticas_p%C3%BAblicas.pdf). Accessed on: November 3, 2023.

contents, actors, styles, and institutions in a public policy process (Secchi, 2020, pp. 30-1).

The table below summarizes some of the most relevant "content typologies":

Table 3 – Content Typologies of Public Policies

Nome da Tipologia	Tipos de Políticas Públicas	Critério de Referência	Breve Descrição
Tipologia de Lowi (Theodore J. Lowi, 1964)	1. Políticas regulatórias 2. Políticas distributivas 3. Políticas redistributivas 4. Políticas constitutivas	"impacto esperado na sociedade"	As fronteiras entre as políticas não são claras; útil para estudos de política comparada.
Tipologia de Rittel e Webber (1973) / Alford e Head (2017)	1. Políticas para Problemas Domáveis (*tame problems)* 2. Políticas para Problemas Complexos (*wicked problems)* 3. Políticas para Problemas Super / Muito Complexos (*very wicked / super-wicked problems*)	"diferenciação entre políticas que lidam com problemas públicos com diferentes graus de complexidade"	Políticas para *tame problems* são políticas de efeito conhecido capazes de mitigar ou extinguir um problema público. Políticas para *wicked problems* lidam com problemas de difícil solução, mitigáveis apenas no longo prazo e que geram *trade-offs* na sua aplicação. O termo *super-wicked* (*very wicked*) enfatiza a gravidade e a extensão do problema.
Tipologia de Wilson (James Quinn Wilson, 1983)	1. Políticas clientelistas (=distributivas de Lowi) 2. Políticas de grupos de interesse (=redistributivas de Lowi) 3. Políticas empreendedoras 4. Políticas majoriárias	"distribuição dos custos e benefícios de uma política pública na sociedade"	Os custos considerados não são necessariamente financeiros, podendo ser materiais, simbólicos, de liberdade de decisão etc.
Tipologia de Gormley (1986)	1. Políticas de sala operatória (*operating room politics*) 2. Políticas de audiência (*hearing room politics*) 3. Políticas de salas de reunião (*board room politics*) 4. Políticas de baixo escalão (*street level politics*)	"nível de saliência – capacidade de afetar e chamar a atenção do público em geral; e o nível de complexidade (necessidade de conhecimento especializado para sua formulação e implementação)"	Um assunto é saliente quando afeta um grande número de pessoas de modo significativo e é complexo quando "levanta questões fatuais que não podem ser respondidas por generalistas e amadores"
Tipologia de Gustafsson (1983)	1. Políticas reais 2. Políticas simbólicas 3. Pseudopolíticas 4. Políticas sem sentido	"o conhecimento e a intenção do formulador de políticas públicas (*policymaker*)"	É possível que uma política pública possua elementos de dois ou mais tipos, dependendo da sua complexidade.
Tipologia de Bozeman e Pandey (2004)	1. Políticas de conteúdo essencialmente político 2. Políticas de conteúdo essencialmente técnico	"distinção entre conteúdo técnico e conteúdo político"	Políticas públicas geralmente possuem predominância de um dos tipos, podendo inclusive mudar esse % de participação conforme o momento[16] em que a política se encontra.

16 It refers to the phase or stage in the public policy cycle, which will be presented later.

Meny e Thoenig	Políticas universais e políticas focalizadas	"escopo e direcionamento das políticas – universais e focalizadas"	*Políticas universais* afirmam direitos para o conjunto dos cidadãos. *Políticas focalizadas* destinam-se a alguns setores sociais e frequentemente assumem caráter assistencial.
T. H. Marshall	Políticas sociais e políticas econômicas	"escopo das políticas – econômico x social"	As *políticas sociais* dizem respeito às medidas e ações de proteção social, especialmente nos campos da saúde, educação, habitação, seguridade e assistência social. As *políticas econômicas* incluem fundamentalmente política fiscal, política monetária, incentivos e controles sobre setores da economia e comércio internacional.
Bucci (2013)	Políticas de governo e políticas de estado[17].	"grau de institucionalização, legitimação política"	*Políticas de governo* expressam opções de um governo ou de governos com a mesma orientação ideológica; estão menos enraizadas na institucionalidade estatal e menos legitimadas pelo conjunto das forças políticas. *Políticas de estado* expressam opções amplamente respaldadas pelas forças políticas e sociais, têm previsão legal e contam com mecanismos e regulamentações para a sua implementação.

Source: Author's own elaboration based on Secchi (2020, pp. 29-39), Schmidt (2019, pp. 128-130), and aforementioned sources.

Table 3 does not present an exhaustive list, highlighting some of the possible classification approaches for research in public policies, including the possibility of creating a new, specific typology. A typology is always a model, an attempt at explanation, and therefore limiting within its self-established criteria. The classifications above may be conveniently used throughout the work, but none of them will

17 According to Schmidt (2018): "This distinction, highly controversial in Brazilian debates [...]. Innovative policies often begin as government policies, and it is the successful confrontation of the challenges of institutionalization and political-social legitimation that elevates them to the status of state policies, which 'transcend' governments of different ideological orientations because they are deeply embedded in the state apparatus and have broad legitimacy. Characterizing a policy as 'state policy' is not to assign it a qualifier of ethical-political excellence, but rather to recognize that it meets the conditions to endure over time. Government policies tend to be temporary; state policies, enduring."

be adopted in isolation.

Differentiating Policies from Public Policies

According to Frey (2000), in Brazil, the study of national public policies was still in its early stages in the 1990s, with its focus alternating between the analysis of structures and institutions and the characterization of the negotiation processes of specific sectoral policies. From the perspective of public policy (policy) as one of the three dimensions of politics, the following definition—regarding the content of policy—is linked to the understanding of the other political dimensions—political institutions (polity) and political processes (politics):

> • the institutional dimension polity refers to the order of the political system, outlined by the legal system, and the institutional structure of the political-administrative system;
> • in the framework of the procedural dimension politics, the focus is on the political process, often of a conflictual nature, concerning the imposition of objectives, content, and distribution decisions;
> • the material dimension policy refers to the concrete contents, that is, the configuration of political programs, technical problems, and the material content of political decisions.
> [...]
> In political reality, these dimensions are intertwined and influence each other (Frey, 2000, pp. 214-217).

Souza (2006) separates politics into four elements: public policy (policy) itself, which is responsible for identifying the type of problem it aims to correct; politics (politics), which receives the political problem; political society (polity), which here appears separate from the institutions where public policies are decided, designed, and implemented. These institutions or rules would shape the decision and implementation of public policy. It is important to highlight how Souza (2006) defines the

term institutions:

> Institutions are formal and informal rules that shape the behavior of actors. How do institutions influence the outcomes of public policies, and what is the importance of institutional variables in explaining public policy results? The answer lies in the assumption that institutions make the course of certain policies easier than others. Moreover, institutions and their rules redefine political alternatives and change the relative position of actors. In general, institutions are associated with inertia, but much public policy is formulated and implemented (Souza, 2006, p. 38).

However, the definition of institutions, far from being unanimous, can also be presented as:

> The legal [academic] doctrine understands institutions as material structures. They are constitutions, cabinets, parliaments, bureaucracies, courts, armies [armed forces], federal systems, or autonomous regimes, and, in some cases, party systems. The materialist definition is accepted by a large number of new institutionalists.
> [...]
> Rational choice institutionalists deviate slightly from this definition, focusing more directly on the "rules of the political game," which tend to be associated with material structures but represent, in themselves, less tangible parameters.
>
> A more significant deviation from the materialist definition consists of conceptualizing institutions in terms of norms and values (Kurian, 2011, p. 1107, our translation).

Moreover, another author had already provided an even more fluid and abstract definition:

> Institutions are logical structures; they are trees of logical compositions that, depending on the form and degree of formalization they adopt, can be laws, can be norms, and, when not explicitly stated, can be habits or regularities of behavior.
> Some authors argue that laws, norms, and customs are objectifications of values. Laws, in general, are written; norms and codes are also. But an institution does not require such written formalization: even non-literate societies have codes, but they are transmitted verbally or practically, without appearing in any document (Barembitt, 2002, p. 25).

The diversity of definitions of institutions highlights a complexity for the approach of new institutionalism – widely used in comparative research and comparative politics, another subfield of political science.

> [...] each analytical perspective on policies was inspired by theories about the nature, functioning, and characteristics of the state. Among these perspectives, pluralism, Marxism, elite theory, and new institutionalism are the most prominent.
> [...]
> In general, however, the public policy literature up until the 1970s was pluralist in nature, although with occasional influences from Marxism and elite theory. From the 1980s onwards, new institutionalism increasingly influenced analyses, but in various recent perspectives, pluralist roots can still be felt (Marques, 2013, p. 24).

Political pluralism[18] is present in the 1988 Constitution as a fundamental principle. In this way, we can consider it diluted in the political debate to a greater or lesser extent. Although Marxism and elite theory may contribute theoretical elements, their premises and approaches are outside the scope of this research.

The new institutionalist approach is widely present in public policy analysis texts, as shown below:

> Unlike approaches such as pluralism or elitism, which view the state as an arena where conflicts over economic and social interests are established, the new institutionalist perspective discusses the importance of state institutions in the process of defining and formulating policies. The assumption is that the institutional structures of the state affect the goals, capabilities, and alliances among political groups, and consequently influence the outcome of policies.
>
> New institutionalism posits that social actors in the political arena do not act solely based on personal interests, but their behavior in decision-making processes is also influenced by state institutions (Lima, 2010, p. 103).

Although here the centrality of the state is considered:

> In the new institutionalist perspective, the state is considered an actor independent of

18 Marques (2013, p. 27; 4) contributes to the understanding of pluralism: "It would not be possible to describe pluralism in detail here, but to situate readers (I would not assume that every political scientist knows what pluralism is), it is enough to say that it refers to a broad set of authors and fields of analysis developed particularly in the United States starting in the 1950s, all of which shared the consideration of interest groups as the basic unit of political action. Politics would concern the conflicts between such groups for control of the government, so that it could implement policies in their favor. Modern democratic institutions and contemporary societies would be structured in such a way that no group could exercise control over the entirety of government matters in a stable way, resulting in a regime of power alternation between groups and allowing the existence of democracy (actually polyarchies), even in the face of significant social and economic inequalities. A large part of the subsequent literature on policy analysis is inspired by pluralism, even if implicitly."

> civil society, capable of autonomy through external influences. [...] The state's possibility of autonomy comes from its institutional characteristics. [...] Relative autonomy gives rise to certain capabilities that create the conditions for implementing policy objectives. [...] The state's capacity to act is directly linked to its structural robustness. [...] Structural robustness refers to an effective and stable institutional structure that allows the state to expand its action spectrum, making it effectively capable of influencing political processes in a relatively autonomous manner (Lima, 2010, p. 105-6).

As will be presented later, the object of this study is not the analysis of public policies, but rather "the other end" under discussion – the identification of the public problem, its inclusion in the public agenda, its formulation, and implementation. Institutions certainly play a relevant role – according to new institutionalists, a determining role – in the study of public policies. However, here we make two critical considerations regarding new institutionalism for this work: the Brazilian state is not considered autonomous and independent of civil society – nor does the structural robustness of an institution necessarily translate into the capacity to influence public policies. This research considers these statements to be particularly true within the nuclear and defense areas in Brazil, thus opting to exclude the new institutionalist approach here.

It is important to highlight certain considerations regarding the reference sources:

> The policy analyst cannot overlook the subtext of specialized literature, which reflects the scenario of countries in the central capitalist system in which it was developed.
> [...]
> The analyst faces the challenge of selecting categories and methodologies appropriate to their object of study, capable of detecting the

> connections between policies and their socio-historical context, avoiding the uncritical assimilation of conceptual frameworks from foreign contexts, as well as the naturalization of liberal schemes that are not relevant to the realities of much of the planet (SCHMIDT, 2019, p. 121).

And about the relationship between the continuity of public policies and institutions:

> [...] administrative discontinuity often leads to the abandonment of current guidelines in areas of great relevance and the creation of others, quite distinct and often contradictory in relation to the previous ones, resulting in a waste of energy and financial resources. Institutionalized policies prevent excessive discontinuity (SCHMIDT, 2019, p. 127).

In turn, Defense, Nuclear, and S&T projects such as the SNCA are traditionally long-term plans that extend beyond government mandates. The periodic renewal of government leaders is a concern and represents a risk to the continuity of public policies. Therefore, institutions play a key role in maintaining certain public policies, especially state policies (BUCCI, 2013) that encompass "permanent" projects and programs.

Thus, for the purposes of this research, the definition adopted for institution will be the most formal one described above, i.e., material structures. The polity dimension will refer to companies, agencies, government bodies, committees, and other collegial bodies, as well as other public administration structures, referred to here as political institutions. The rules and norms will form the content of public policies, effectively public policy or simply policy. The Public Policy Cycle approach will be the structural reference foundation for this work.

Public Policy Cycle

The Public Policy Cycle was first introduced by Lasswell in his seminal work of 1936:

> The process of public policy formulation (policy-making process) is also known as the public policy cycle (policy cycle). This is a visualization and interpretation framework that organizes the life of a public policy into sequential and interdependent phases. Its precursor was Harold D. Lasswell in the book The Decision Process (1956) [...] (SECCHI, 2020, p. 55).

Marques (2013) highlights the transition from Lasswell's (and Simon's) approach to Easton's perspective on the public policy cycle:

> Although the idea of the cycle was already present in Lasswell and Simon, the more widely disseminated formulation later was established by Easton. For him, the idea of the cycle was associated with explaining the dynamics of policies, as well as their integration into the broader functioning of other social systems.
> Once again, the production of the policy itself was left aside in the description of the cycle, being presented, in fact, as a black box with unexplained functioning. The focus of the analysis was on the interaction between this black box and other systems, with the stages of the cycle being considered as discrete and subsequent. (MARQUES, 2013, p. 27).

The Public Policy Cycle can be understood as a methodology or methodological approach for academic investigations of public policies, which is recognized for having some virtues:

> [...] it offers a simple framework for analyzing public action, which favors the intelligibility of

> complex and seemingly uncoordinated actions and decisions; prevents politics from being perceived as a mere consequence of a legal mechanism or the will of an elected official; and is compatible with different theoretical approaches (SCHMIDT, 2019, p. 130).

The number of phases or stages and their designation vary depending on the author's perspective:

> I propose distinguishing between the following phases: problem perception and definition, agenda-setting, program formulation and decision-making, policy implementation, and finally, policy evaluation and the eventual correction of action (FREY, 2000, p. 226).

> Despite the various versions already developed for visualizing the public policy cycle, we restrict the model to the seven main phases: 1) problem identification; 2) agenda formation; 3) formulation of alternatives; 4) decision-making; 5) implementation; 6) evaluation; and 7) termination (SECCHI, 2020, p. 55).

> The cycle theory lists five phases that help understand how a policy arises and develops: (i) perception and definition of the problem; (ii) insertion into the political agenda; (iii) formulation; (iv) implementation; and (v) evaluation.
> [...]
> There are variants in the literature regarding the number and denomination of the phases, which does not alter the general meaning. Some combine problem constitution and agenda construction into a single phase; others separate formulation into decision-making and selection

> of alternatives. For illustration, Fernández (2006) lists the following stages: a) identification of the problem; b) formulation of a solution; c) decision-making; d) action application; e) evaluation of results [5 phases]. Howlett, Ramesh, and Perl (2013, p. 16) suggest these: a) agenda-setting; b) formulation; c) decision-making; d) implementation; e) evaluation [6 phases] (SCHMIDT, 2019, p. 131).

Unlike typologies, an exhaustive list of possibilities for the phases or stages of the public policy cycle does not add significant value to justify the effort. In Theories of the Public Policy Cycle, Werner Jann and Kai Wegrich describe the framework or perspective of the cycle as a basic model (template) useful for various approaches and discussions. According to the authors, the conventional model relies on five stages: agenda-setting, policy formulation, decision-making, implementation, and evaluation—which may or may not culminate in the termination of the public policy (JANN; WEGRICH, 2007, p. 43).

Like all approaches and typologies of public policies, the public policy cycle has both supporters and critics. Secchi (2020, p. 55) agrees with other authors regarding this approach's departure from the "real dynamics or life of a public policy." For Jann & Wegrich (2007), the first question is the treatment of the public policy process through separate and sequential stages. In the implementation process, for example, there would not be, in practice, a clear distinction between the formulation and implementation of a public policy—neither in terms of chronological or hierarchical sequence nor in terms of the actors involved. The stages would not be accurate, unable to provide a causal explanation for the transition between phases—the dividing line between them, where one ends and another begins. In short, it would be an overly simplistic framework for the complexity surrounding public policies.

Despite the validity of the critical points raised, the public policy cycle has proven to be an excellent heuristic tool, through which one can expand the understanding of complex preconditions, central influencing factors, and the results achieved related to public policies, in addition to occupying a significant space in the field's literature. Thus,

the utility of the public policy cycle approach remains valid, especially because it does not close in on itself, interacting and complementing other approaches, such as the pluralist, elitist, and neoinstitutionalist perspectives, previously mentioned (JANN; WEGRICH, 2007, pp. 55-58).

The phases adopted in this research follow the scheme proposed by Diana M. DiNitto, in which the Policymaking Process involves a combination of five phases, namely: Identifying Policy Problems, Formulating Policy Proposals, Legitimizing Public Policy, Implementing Public Policy, and Evaluating Policy (DINITTO, 2011, p. 13-17; GUIMARÃES, 2019). It is important to note that one of the main contributions of this article lies in the preparation for a future Policy Proposal Formulation to enable the effective operation of the SNCA. The issues involving the subsequent phases—Legitimization, Implementation, and Evaluation—are not within the scope of this article, merely indicating an expected path of continuity within the adopted public policy cycle.

Figure 3 – The Public Policy Formulation Process – Policymaking

Source: Adapted from DiNitto (2011, p. 13-17), as per Guimarães (2019).

Figure 3 – Elements of the Public Policy Formulation Process

Source: Adapted from DiNitto (2011, p. 13-17), as per

Guimarães (2019).

Again, despite the criticisms of the public policy cycle model, it still proves to be quite useful and widely used to organize and systematize ideas, especially as a starting point in this research.

A public problem is an issue to be resolved. The protection of the country, the need for deterrence against external aggression to national sovereignty, is a public problem that seems extremely distant for most Brazilians. However, it is a constant concern for the Armed Forces and the Ministry of Defense. The ongoing need for base energy to supply the country's energy needs is another public problem. The Energy Research Company (EPE) was created precisely to provide the Ministry of Mines and Energy (MME) with information to identify the main energy issues in the country across different time horizons, in order to support its actions.

The recognition of a public problem involves competition among issues for the formation of a political agenda. Therefore, the formulation of proposals should aim not only at the design of a public policy that solves the public problem but also at providing the proposal with the necessary legitimacy to move forward and be materialized. From the reverse perspective, legitimization starts from the competition among proposals, analyzing the alternatives raised until the definition of the Public Policy, or its preliminary design. It is closely related to agenda-setting, that is, the ability to include the issue on the political agenda to be seen, known, analyzed, discussed, and, finally, made feasible.

It is important to note that the design of the public policy to be implemented often differs from the formulation previously proposed, and at this point, we emphasize that the public policy cycle is a model. Policymakers, decision-makers, political actors and agents, and parties with interests in the public policy (as well as those opposed to it, with other interests) will influence the content of the proposals to a greater or lesser degree, in the so-called political arena. The political arena has become increasingly complex in the process of agenda formation and its implementation:

> [...] many shifts have occurred over the last fifty years in this literature, reducing the importance

> of rationality and the decision-making process in policy formulation, bringing other moments of the policy production cycle, such as agenda formation and its implementation, to the center of analysis.
>
> [...] if I could highlight a single element that summarizes these shifts, it would be the increasing politicization of the policy production process, which is increasingly understood as a complex process, shaped by various power dynamics, although constantly interacting with the institutional, relational, and cognitive environments that surround them—environments that are also actively constructed by the actors (MARQUES, 2013).

Marques (2013) points out, in the history of public policy conceptualization, Herbert Simon's focus on the centrality of decision-making:

> In fact, the centrality of decision-making in his conceptual framework is so significant that for him [Herbert Simon] the policy cycle, or the set of phases into which the policy production process can be divided, would include only "intelligence, design, and choice," thus ending even before the actual production of policies begins, and being restricted to preparation and decision-making (MARQUES, 2013, pp. 26-27).

It is from legitimization that decision-making is reached. The process of implementation, evaluation (and termination, when applicable) are discussions that go beyond the scope of this article.

The Basic Triad of Public Policies of the SNCA

In 1954, the United States launched the first nuclear-powered

submarine, the USS Nautilus. At the time, the Brazilian Navy already envisioned having such equipment in its portfolio. In 1979, a project was launched that, although secret, materialized this vision. To achieve nuclear propulsion, it was necessary, first and foremost, to master the nuclear fuel cycle – that is, uranium enrichment, a milestone achieved in the 1980s.

Only during the Lula administrations (2003-2006; 2007-2010) did a favorable context arise with government support for the PROSUB, which would not only facilitate the modernization of Brazil's conventional diesel-electric submarine fleet but also make the construction of the SNCA project feasible. During the Dilma administrations (2011-2014; 2015-2016), it was possible to establish AMAZUL[19], a public company aimed at promoting, developing, transferring, and maintaining technologies related to the PNM, PROSUB, and PNB activities. Its main goal is the realization of Brazil's first nuclear-powered submarine (VETTORAZZI, 2017).

With the partnership of the Naval Group, the basic design of the SNCA was completed in 2017, and the development of the nuclear propulsion motor prototype (reactor) is being executed at LABGENE.

The value of peaceful deterrence, the idea of sovereignty, the vision of a Blue Amazon[20] that needs to be preserved and protected, due to its national wealth and strategic importance, influenced the government's political decision to continue with PROSUB and the PNM. It can be inferred that the SNCA is part of a public defense policy. However, the structural design of the submarine is linked to research institutes such as the Institute of Nuclear and Energy Research – IPEN, also having a clear interface with a public CT&I policy.

The indigenous development of a nuclear propulsion reactor

19 AMAZUL is a public company, whose establishment was authorized by Law No. 12,706, dated 08/08/2012, and created by Decree No. 7,898, dated 01/02/2013 (BRAZIL, 2013). It is linked to the Ministry of Defense through the Navy Command, with the purpose of promoting, developing, transferring, and maintaining technologies related to the activities of the Navy's Nuclear Program (PNM), the Submarine Development Program (PROSUB), and the Brazilian Nuclear Program (PNB). Its primary mission is to develop and apply technologies and manage the projects and processes necessary for the development of nuclear-powered submarines, contributing to greater scientific autonomy and technological independence for the country (VETTORAZZI, 2017).

20 The Blue Amazon is a political-strategic concept that encompasses the Territorial Sea, the Exclusive Economic Zone, the Continental Shelf, inland waterways, and other internal waters of Brazil. In its maritime portion, it contains the oil reserves and production structures that account for a high percentage of the country's consumption.

combines the two aforementioned public policy areas with energy public policy. In fact, the nuclear propulsion reactor is essentially a compact reactor, for which there is a technological pathway to make it modular (Small Modular Reactor – SMR). Its use in hard-to-reach areas can provide base energy and promote social benefits, enabling economic development in regions currently deficient in electricity availability (AMAZUL, 2023).

There are significant impacts around the country due to the concerns of other South American countries about Brazil's technological advancement, as well as international demands from the IAEA and members of the Atomic Club[21], whose nuclear exclusivity has been gradually challenged by Brazil's insistence on developing in this sector. There is also an international market that the country can access with these new technologies.

The public policy defined as a flow of political decisions involves a complexity of nuances, actors, interests, perspectives, developments, and articulations. The fact is that there is a set of public policies "for national sovereignty" within the scope of defense; another set of public policies involving CT&I issues; and public policies related to the national energy matrix. But there are many other proposals for defining public policies, which we will explore next.

Before proceeding, it is worth briefly highlighting two aspects related to public policies for the effective operation of the SNCA: a) Energy and Defense can be considered "public goods[22]"; b) The Positive Externalities of Advances in the Energy and Defense Sectors based on Science, Technology, and Innovation. As described below:

> They are called "public goods" those goods and services that are not produced due to the existence of a competitive market; on the contrary, they are actually a classic example of

21 The term "Atomic Club" emerged during the Cold War and refers to the five countries that have a permanent seat on the UN Security Council, and are also the first nations to possess nuclear weapons: the United States, Russia (formerly the USSR), the United Kingdom, France, and China.

22 Schmidt (2019, p. 124) classifies the distinction between public and private goods, widely adopted in the literature, as unsatisfactory. The author refers us to the work "Public Policies: Their Cycles and Subsystems," which presents his perspective on the subject (HOWLETT; RAMESH; PERL, 2013, p. 27). This debate and level of detail fall outside the scope of this research.

> market failures. They are goods (and services) consumed by all individuals and cannot be restricted to benefit only one or a few groups of buyers. Therefore, there is no interest from individuals or firms acting in isolation in producing these goods, since there will not be a consumer who individually would be willing to pay for a good that is enjoyed by everyone.
> [...] public goods are characterized by the lack of interest from firms or individuals in producing them. It is necessary that funds be collected from society through fees, taxes, or other means to finance the production of these goods (JANNUZZI, 2000, p. 3-4).

In order to illustrate the compatibility of the public goods concept with issues related to the SNCA, we present the examples below in the maritime, defense, and energy areas:

> [...] consider the use of a lighthouse by a ship. As long as the lighthouse is built and operating, its use by an additional vessel would not add any operational cost.
> [...]
> A good is non-excludable when people cannot be excluded from its consumption. Consequently, it becomes difficult or impossible to charge for the use of products with this characteristic – they can be enjoyed without the need for direct payment. An example of a non-excludable good is national defense.
> [...]
> An ocean or a large lake is a non-excludable good, however, fishing is a rival good because it imposes costs on others: the more fish are caught, the less is available for other fishermen[23].

23 On predatory fishing, see Varian (2006, p. 690-692).

> [...]
> Public goods that are both non-rival and non-excludable provide benefits to people at a zero marginal cost, and no one can be excluded from the possibility of enjoying them. A classic example of a public good is national defense. As we have seen, it is non-excludable and also non-rival, because the marginal cost of its service to an additional person is zero. The previously mentioned lighthouse is also a public good because it is both non-excludable and non-rival, that is, it would be difficult to charge ships for the benefit derived from using the lighthouse (PINDYCK; RUBINFELD, 1999, p. 729-731).

Thus, it is understood that the construction of the conventionally armed submarine with nuclear propulsion, an intersection of PROSUB and PNM, constitutes the creation of a public good. Here, we are not referring to the materiality of the good, which belongs to the Union, which designates the Brazilian Navy as the responsible manager for the equipment. The SNCA is characterized as a public good based on the effects produced from the announcement of its construction to its actual commissioning and beyond. Especially in the international sphere, the possession of the operationally effective SNCA catapults the country to the status of a holder of technological dominance and a naval resource restricted to few nations (6 in total), in addition to adding a differentiated projection of power that can evolve as Brazil progresses in the construction of other units, forming a class of submarines, with technological innovations expected in the new equipment.

The diffuse interest of Brazilian society and its detachment from issues of sovereignty and defense makes it more challenging for public policy makers to propose and implement budgetary proposals for the viability of the SNCA. One of the main reasons is the alienation regarding its beneficial externalities, starting from the very concept:

> Externalities (External Economies): when the production or consumption of a good results in effects on other individuals, and these costs are

> not reflected in prices (PINHO; VASCONCELOS, 2006, p. 583).
>
> Externalities (or external economies) can be defined as the changes in costs and benefits to society derived from the production of firms, or also as the changes in costs and revenues of the firm due to external factors.
> We have a positive externality[24] (or external economy) when an economic unit creates benefits for others without receiving payment for it (GARCIA; VASCONCELOS, 2004, p. 71).
>
> There are two situations in which the government can increase the total welfare of consumers and producers in a market, which could be considered competitive, through government intervention. The first situation occurs when the actions of consumers or producers result in costs or benefits that are not reflected in the market price. These costs and benefits are called externalities[25] because they are "external" to the market (PINDYCK; RUBINFELD, 1999, p. 315).

As an expected result for a set of successful CT&I public policies, the success in national technological development includes the achievement of the initial goal of LABGENE, enabling the construction of a nuclear reactor for naval propulsion with indigenous technology. The next challenge lies in the continuity of this public policy, as a single reactor produced would only be an artisanal item. It is necessary

24 For completeness of the concept: "We have a negative externality (or external diseconomy) when an economic unit creates costs for others, without paying for it. For example, pollution and congestion caused by cars, trucks, and buses [...]" (Garcia & Vasconcellos, 2004, p. 72).

25 "An externality occurs when some production or consumption activity has an indirect effect on other consumption and production activities (PINHO; VASCONCELOS, 2006, p. 663)." [...] A similar case is that of the fishing company that is concerned about the amount of pollutants discharged into its operating area, since pollution negatively impacts its catching capacity. [...] It is not difficult to perceive the [negative] externality here: the fishing company cares about pollution but has no control over it." A detailed description of this case of negative externality can be found in Varian (PINHO; VASCONCELOS, 2006, p. 677-687).

for this reactor to become a FOAK – first of a kind – the first model of an industrial series. In this way, the SNCA could become the first of a class of national nuclear submarines, with continuous improvements in subsequent versions. A positive externality linked to the energy sector unfolds in the domain of technology for the construction of small modular reactors (SMRs).

It is relevant to mention COP 28[26], specifically because it was the stage for the commitment of 22 countries to triple the use of nuclear energy in order to meet the goal of zero carbon emissions by 2050. This outcome represents the continuation of the Atoms4NetZero initiative, presented by the IAEA at COP 27, which highlighted the potential of innovative nuclear technologies, such as the aforementioned SMRs (COP 28 closes, 2024; IAEA, 2024).

The Complexity of Public Problems and the Brazilian Nuclear Sector

Antinuclear movements are sometimes fueled by opinion leaders with a Dunning-Kruger bias, whose ignorance allows them to vehemently assert things they deeply do not understand[27]. The choice of location for a nuclear power plant, a political decision clearly supported technically, is often refuted by fear driven by ignorance, with civil society representatives joining forces to prevent its implementation, as seen in the protests in the city of Itacuruba, Pernambuco[28].

It is clear that the major nuclear accidents, the existence of weapons of mass destruction, and the entire nuclear geopolitics confer inherent complexity to the acceptance of nuclear energy. However, nuclear technology remains present in diagnostic and treatment medicine, in the irradiation of food, crops, and seeds, in material sterilization, and in water desalination technology – facts unknown

26 COP28 was the 28th United Nations Climate Change Conference, held from November 30 to December 12, 2023, at Expo City, Dubai, United Arab Emirates. It is also known as the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

27 See seminal article: KRUGER, Justin; DUNNING, David. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. Journal of Personality and Social Psychology, v. 77, n. 6, p. 1121, 1999.

28 Source: Carta de Itacuruba – Antinuclear Constitutional Amendment Proposal. Available at: https://www.ecodebate.com.br/2011/11/04/carta-de-itacuruba-proposta-de-emenda-constitucional-antinuclear/. Accessed on: November 3, 2023.

to the general public. On the other hand, the planet is recognizing the effects of climate change – which is considered a supercomplex problem. Carr (2018) aligns with those who see nuclear energy as the only technological path to effectively reduce global warming within the time frame necessary and safe for humanity.

New post-Fukushima technologies for GEN III/III+ and GEN IV reactors[29] (third and fourth generation) are being applied, tested, and developed to make nuclear energy safer and more accessible, as well as resistant to proliferation and economically viable. Once again, CT&I proves fundamental so that natural disasters do not become man-made disasters (BRINKMANN, 2020). Solutions developed from learning from disasters serve as foundations to prevent new traumatic experiences. One of the major challenges of the SNCA lies in nuclear safety provided by a small reactor confined in a restricted space, operating continuously while the submarine may remain submerged for months at a time. But also on land, during fuel load exchanges, i.e., throughout the entire process. Higgins (2001) summarizes the largest nuclear accidents involving submarines up to the Kursk in 2000. However, the most absurd and emblematic case was the fire on the USS Miami (SSN-755) in 2012. The submarine was undergoing maintenance, and a painter started the fire due to technical negligence (USNI News, 2014).

The SNCA is a defense solution for deterrence and is a FOAK (first of a kind), i.e., the first of a class of Brazilian submarines. At least this should be the minimum expectation. Another possibility is that it will serve as a model for a more advanced class, with a different design and improvements. Therefore, the responsibility for the technological success of the SNCA is linked to the continuity of the PNM-PROSUB, which is strategic for the Brazilian Navy and, consequently, for the protection of national sovereignty. Defense, Nuclear, and CT&I are intertwined in a complex problem that requires at least coherent and coordinated public policies. Ideally, integrated public policies. As an example, the Committee for the Development of the Brazilian Nuclear Program (CDPNB), directly linked to the Institutional Security Office of the Presidency of the Republic (GSI/PR), integrates Technical Groups (GTs) created to discuss various specific aspects related to the Brazilian Nuclear Program (PNB). Each group coordinates initiatives proposing

29 Source: Gen IV International Forum (https://www.gen-4.org/).

actions and public policies. Some actors participate in more than one GT, which provides a more complete view, enabling coherence in decision-making (GUIMARÃES & ALMEIDA, 2021).

Rittel & Webber (1973) were the pioneers of the idea of wicked problems vs. tame problems. The typology mentioned in Table 3 was formalized and updated by Alford & Head in 2017. However, many earlier publications classify and mention "untamable" problems, i.e., complex ones, and those that are highly or supercomplex. King (1993) stated that "the nuclear sector is a mess" and that "the nuclear sector is a complex problem."[30] For Brünnengräber & Schreurs (2015, p. 48), "nuclear energy can be considered a complex problem." In Brünnengräber et al (2015; 2018; 2019), radioactive waste with high radioactivity is highlighted as a complex problem. Lee (2022) addresses the management of radioactive waste in Malaysia as a complex and technoscientific problem. Gruendel (2022) presents the technopolitics of complex problems, for which solutions (and public policies) should not be idealized by common sense or people's life experiences – which includes politicians and civil society.

The discussion of a complex problem requires scientific and technological expertise. This implies the unquestionable proximity of the nuclear sector with CT&I. Addressing the challenge of clarification and confronting divergences represents one of the many action areas in the legitimation of public policies for complex problems. The nuclear propulsion of the SNCA places it within the nuclear sector. The fact that the submarine is a military equipment links it to the defense area. Thus, the SNCA Program presents itself as a "doubly" complex public problem due to the simultaneous and permanent contributions from the nuclear and defense areas. Complex public problems require treatment through Complex Public Policies. Due to the issue of national sovereignty, the SNCA is a public good necessary for the country.

Final Considerations

National sovereignty is an inherent concern for the Armed Forces and the Ministry of Defense, but it remains outside the Brazilian

30 Given these wildly different views, who is right? Perhaps nobody is right in the sense that we may be trying to solve the wrong problems. Instead of being a "tame problem," nuclear power is decidedly a "mess" if not also a "wicked problem. "

political agenda. In this sense, this paper sought to discuss public policies, public goods, complex public problems, and the policy cycle to connect them with the SNCA Project/Program, thereby demonstrating the importance of Brazil building and operating its first Conventionally Armed Nuclear Submarine.

Nuclear technology is a complex, little-known subject that benefits the population in areas that are not widely known or publicized. Defense is a public good that is undervalued in Brazil. Clean energy is a contemporary global demand that scarcely resonates with the population of the country. The SNCA will be a strategic public good. The SNCA Project/Program, resulting from the intersection of PROSUB with the PNM, has the potential to generate significant positive externalities in the fields of Defense, Energy, and CT&I, which are fundamental to Brazil's sovereignty, prosperity, and future.

Furthermore, this article provides the following contributions: a new literature review on public policies; the presentation of the SNCA Project/Program beyond the construction of a defense asset for the Brazilian Navy or a high-tech item that merely consumes public funds for a specific purpose; and, finally, it aims to redirect the reader's perspective regarding the SNCA, clarifying why the equipment is a complex public good necessary for the country, requiring complex public policies for its realization.

In short, the text presents a paradigm shift by treating the Conventionally Armed Nuclear Submarine as the subject of complex public policies that aim to address complex public problems (wicked problems) simultaneously affecting the Defense, Energy, and CT&I sectors of the country.

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