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Nuclear Energy and Energy Security in the European Union: Strategic Imperatives and Policy Gaps

by

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Munteanu Rebeca Andreea

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Abstract

This dissertation examines how nuclear energy can contribute to strengthening the energy security of the European Union as a strategic alternative to fossil-fuel energy, and its development as a policy, regulatory and institutional constraint that limits its successful integration at the EU-level. Based on a qualitative, interpretivist research design, the present study integrates a literature review and policy analysis and conducted comparative case studies of France, Germany, and Poland to represent divergent national nuclear paths. The results show that nuclear power can be used as a source of energy security in terms of stability of supply, decarbonization, and the minimization of the reliance on the imports of fossil fuels. Nevertheless, its strategic value is very contingent and moderated by societal acceptability, institutional capability and political legitimacy. The review also shows that EU nuclear governance has remained fragmented due to the national sovereignty regarding energy decisions and the imbalance in regulatory and financial frameworks. The paper draws a conclusion that nuclear energy can contribute to energy security in some countries, but its integration into a coherent EU-wide strategy is limited by fragmented governance.

Keywords:

Nuclear energy; Energy security; European Union; Energy governance; Decarbonization

Chapter 1: Introduction

Energy security has been the core of the European Union (EU) political, economic, and environmental agenda. The difficulty has been compounded in the last 10 years as the EU tries to strike a balance between three competing requirements, namely, securing consistent and affordable energy supply, addressing high-target decarbonization targets in the Paris Agreement, and lessening the dependence on external suppliers, especially Russia. Nuclear energy, which is a low-carbon and geopolitical strategic asset, takes an ambiguous stance on this debate. It is credible and free of the fluctuating fossil fuel prices yet is stagnant in its anxieties regarding cost, safety, and social acceptability. The dissertation places nuclear energy in the context of the changing EU energy security, questioning whether it is a viable component of the overall collective resilience and sustainability in a discontinuous political space.

The necessity of reviewing the role of nuclear power in Europe was accentuated by the 2022 invasion of Ukraine by Russia, which revealed the profound weakness of Europe in its reliance on Russian gas imports. German Chancellor Olaf Scholz announced a Zeitenwende, or turning point, and the need to be energy independent and collectively resilient as a community (Blecking, 2024). This crisis was accompanied by soaring energy costs and the destabilization of long-established supply chains, highlighting how unstable the EU energy security structure is. Meanwhile, some of the member states including France doubled their efforts on nuclear energy whereas others including Germany and Austria stuck with phase-out paths. This internal rift makes it complex to govern energy at the EU level.

Conceptually, energy security is multidimensional, as it includes sovereignty, robustness and resilience (Cherp & Jewell, 2011). The sovereignty approach focuses on the national ownership of the energy resources and lack of reliance on external forces; the robustness approach is concerned with the technical stability and capacity of energy systems; the resilience approach is pertinent to the energy systems flexibility to shocks and transitions. These views tend to conflict in the EU where common markets and supranational policies come into conflict with the national prerogatives. These tensions are the core of nuclear energy: its promise to cut down on carbon emissions and reliance on foreign suppliers is in line with the aim of resilience and sovereignty, but its politically polarizing character does not augur well for the aim of strong EU-wide integration.

The EU in the past has been unable to formulate an energy policy. Energy is still under the national jurisdiction in part and nuclear energy controversy is the prime example of supranational governance limits. Nuttall (2009) notes that nuclear policy has been uneven among the member states since the inception of the Euratom Treaty due to the assessment of risks, historical legacies, and the domestic culture of politics. The expansion of 27 members further expanded these views, and Central and Eastern European countries tended to have more positive views of nuclear adoption as an option to decrease reliance on Russian hydrocarbons. This patchwork of strategies is such that nuclear energy, unlike renewables, is difficult to represent as a cohesive EU project.

There is yet another complexity in the economic aspect of nuclear energy. Its proponents note its low operation cost and close to zero emissions, whilst opponents note increasing construction costs, excessive lead times and subsidies. Thomas (2010) notes that the past years have been marred with cost overruns and delays in new nuclear build projects, including Olkiluoto in Finland and Flaman Ville in France, which has damaged the image of nuclear energy generation as being cost-effective. Nuclear energy projects cannot be undertaken by private utilities if they lack state assistance and assurance. This casts doubt over the economic viability of nuclear energy in competitive energy markets, especially when renewables have increasingly become cheap and scalable.

Nuclear energy is, however, still strong in terms of its geopolitical rationale. As noted by Khattak et al. (2018), the reliance of the EU on external suppliers, especially Russia, has turned the issue of energy security into a constant weakness. Diversification has become a strategic necessity with Russia in the past contributing close to 30 percent of the natural gas imports in the EU. Nuclear energy is a low-carbon, domestically controlled alternative which may act as a buffer to geopolitical risks. The same argument is made by Leal-Arcas et al. (2015), who state that the disjointed energy governance of the EU and the excessive dependence on imports demand the diversification of energy sources, such as nuclear, as a component of a larger policy of security. However, the quest to find nuclear remedies is checked by a high level of public distrust in some of the member states whereby dangers of accidents and waste management loom big in the collective memory.

Public perception is therefore a very decisive factor in forming nuclear policy. Research indicates that the perception of nuclear power does not solely consist of technical evaluation of risk and benefit but is deeply rooted in the political ideology, past, and cultural aspects

(Stoutenborough et al., 2013). The accident in Fukushima in 2011 strengthened the anti-nuclear feelings of most European nations, especially Germany, where the absence of opposition encouraged the phase-out scheme. In contrast, France, which has a long-running nuclear tradition, understands nuclear energy as the demonstration of sovereignty and technological might (Blecking, 2024). This rift explains why it is hard to establish an EU-wide consensus because the people have to accept these large-scale energy investments.

In addition to the opinion of the population, the nuclear energy paths are also defined by participatory governance. Charnley-Parry et al. (2024) emphasize the fact that the decision-making process of nuclear energy implies complicated trade-offs between energy self-sufficiency, ecological responsibility, and social acceptability. Their UK context review indicates that the participation of the people has in most cases been done through consultations and not through meaningful participation, something that has compromised trust and legitimacy. This gap poses critical issues in the EU context of whether it is possible to seek nuclear strategies in a democratically and inclusive manner, especially when the issue of radioactive waste disposal is transgenerational

Nuclear energy is a potential asset and a liability as shown in the interplay of energy security, climate policy and governance. Advocates say that nuclear power is complementary to renewables because it is a reliable baseload source of power, which in turn contributes to decarbonization goals (Blecking, 2024; Charnley-Parry et al., 2024). Critics, however, warn that the use of nuclear power could lead to diversion of resources to more sustainable and socially accepted technologies which cause long term lock-ins (Thomas, 2010). The discussion is more about questions of the ability of the EU to balance the national diversity with the unity of the ambitions in energy and climate governance.

The key objective of this dissertation is to investigate the strategic importance of nuclear energy in enhancing the long-term energy security of the European Union (EU), and critically establish policy, regulatory and institutional gaps that prevent its harmonious implementation across all member states. The paper aims at elucidating the fact that nuclear power can effectively be used as a unifying factor in the sustainable energy transition of the EU or it is some sort of divisive factor that signifies more fundamental political, economic and cultural differences in the Union. In answering these questions, the study uses a comparative policy analysis approach that assumes a qualitative, interpretivist approach. Three case studies are picked to illustrate the opposing nuclear paths, including France as a long-term nuclear

leader, Germany as a dedicated phase-out country and Poland as a new nuclear adopter. This paper analyzes the role of national decisions, institutional abilities and historical origins on the wider EU energy security framework through document and policy analysis.

This dissertation is methodologically based on a qualitative research design, which is interpretivist and has its basis on comparative policy analysis. The paper analyzes three EU countries (France, Germany, and Poland) as contrasting examples of nuclear energy development that have taken different courses, long-term growth, total phase-out and new introduction. The data are based on policy papers, EU laws, scholarly materials, reports and institutions of energy governance and its analysis is carried out on thematic and interpretative levels in order to determine the strategic imperatives, institutional dynamics and divergence trends in the cases.

The research questions, which the analysis will discuss, will include the following:

- What is the current role of nuclear energy in the energy security strategy of the EU?
- What are the strategic considerations that are causing its reconsideration within the EU context?
- What are the policy and regulatory loopholes which frustrate nuclear energy coordination across the EU?
- Are there differences or similarities in the approaches of member states? And what is the role of nuclear energy in the larger decarbonization and resilience schemes of the EU?

By doing so, the research makes contributions in three areas of scholarship. First, it revisits the multidimensional approach of energy security (Cherp & Jewell, 2011), extending it to the nuclear debate in the EU. Second, it is active in critical policy analysis, which anticipates the political, social and cultural forces behind energy decisions (Stoutenborough et al., 2013; Charnley-Parry et al., 2024). Third, it places nuclear policy in the context of the continuing debate in the EU to create a unified energy union through the disjointed national interest (Leal-Arcas et al., 2015; Nuttall, 2009). Through a combination of these viewpoints, the study will set out to offer a subtle insight into the strategic requirements and policy loopholes of nuclear energy in the European Union.

The thesis is divided into eight chapters. After the introduction, Chapter 2 will survey the theoretical and empirical literature on the topic of energy security and nuclear governance, identifying the major conceptual tensions and gaps in the research. Chapter 3 gives details of the design of the methodology and data collection. Chapters 4 and 5 explore respectively the strategic imperatives that inform nuclear policy and the differences in policy that disintegrate the unity of the EU. Chapter 6 gives a comparative view of the chosen case studies, whereas Chapter 7 summarizes the results and places them in a larger theoretical discussion. Lastly, Chapter 8 ends with some learning points, implications, and conclusions to the EU policymakers.

This research has a three-fold contribution. Theoretically, it enhances the scholarly literature of energy security, as it uses the multidimensional constructs of sovereignty, robustness, and resilience to the controversial topic of nuclear energy, a connection that has not been explored adequately in the current literature. Empirically, it identifies three critical EU member states with a comparative analysis that is systematic, showing how political culture and regulation and attitudes of society intersect to contribute to common energy goals. Methodologically, it illustrates the concept of the multidimensional nature of the cross-national energy governance which can be captured through interpretivist qualitative analysis and provides a model that can be replicated using the same approach in future comparative policy research. The dissertation is practically and politically relevant in that it presents a contribution to the existing debates on the integration of energy in the EU by pointing to viable options on how national independence could be balanced with the coordination of supranational nature. It provides policy insights that are relevant to the development of adaptive, inclusive, and resilient governance mechanisms to ensure that nuclear energy usage can meet the EU decarbonization and energy independence objectives.

Chapter 2: Literature Review & Theoretical Context

2.1 Introduction

This chapter gives a conceptual and academic background of the dissertation as it analyses the various sources of literature that contribute to the contemporary discussions on nuclear energy and energy security in the European Union. Since the two concepts are multidimensional and controversial politically, a systematic review is required to help in

identifying how the scholars, policymakers and international institutions have defined, framed and problematized them across time. The chapter starts with a discussion of how energy security evolved as an analytical concept, emphasizing the conflicting theories of sovereignty, robustness and resilience through which it can be understood today. It then places nuclear energy in the context of wider energy transition discussions, which follow academic disputes about its economic viability, environmental consequences, and strategic usefulness in decarbonizing Europe. Subsequent chapters discuss how the perception of the general populace, political opinion, and institutional intricacy impact the results of nuclear policy in EU member countries. Lastly, the chapter also gives the theoretical viewpoint that informs this research, uniting the energy security theory and comparative policy analysis in constructing a coherence analytical perspective. Combined, this review establishes the conceptual mismatches, evidence gaps, and debates that cannot be solved and thus provides the rationale why the current research is needed, as well as it forms the ground on which further chapters build their analysis.

2.2 Defining Energy Security: Frameworks and Dimensions

The concept of energy security has long been considered as a multidimensional concept and a changeable concept that is stipulated by political, economic, technological as well as environmental changes of global energy systems. Despite the fact that it was initially linked to the continuous availability of fuels to serve the industrial and military requirements, modern definitions have been broadened to include sustainability, cost-effectiveness and resiliency in the ever more interconnected markets (Cherp & Jewell, 2011). Specifically, the European Union (EU) is considering the notion of energy security as a means of defense against external shocks, but also as one of the core pillars of its economic stability and climate policy. What is confusing about the term is its multiplicity in its applicability to actors, scales, and time-horizons-what is considered secure energy to consumers, industries, and states, and is also affected by domestic policies and dependencies at the international level.

Cherp and Jewell (2011) set out an analytical model that enjoys a large following of three complementary visions of energy security: sovereignty, robustness, and resilience. The political science-based sovereignty view focuses on the power of states in control of the energy resources, diversification of supply channels, and defense against geopolitical coercion. The

dimension is especially crucial to the EU, which relies on imported fossil fuels, in particular, the Russian gas, and has had its weakness against external pressure revealed multiple times (Khattak et al., 2018). The robustness viewpoint that is based on engineering and natural sciences concentrates on having stable, reliable and efficient energy systems that can guarantee that the systems withstand technical or operational failures. Lastly, the resilience school of thought, which is a product of economics and complex systems theory highlights the adaptability and flexibility of the energy systems to shocks, market variability, and environmental changes. Combined these dimensions show that energy security cannot be perceived merely as continuity of supply but a wider ability to predict, absorb and recover in case of an emergency.

These views overlap in a unique institutional and policy context to the European Union. These ambitions of the Union to have one energy market and to become climate-neutral create a conflict between national sovereignty and common interdependence. Leal-Arcas et al. (2015) claim that such fragmentation, where energy is partially a national competence in the Treaty on the Functioning of the European Union, results in inconsistencies in strategic planning and enforcement of the regulations. The energy security issue of the EU is therefore not just external involving imports and geopolitical risks but also internal due to the differences in preferences and models of governance of the member-state.

2.3 Nuclear Energy in the Energy Transition Debate

Nuclear energy's place in modern energy transitions is a topic of intense academic and policy controversy, which demonstrates underlying conflicts between decarbonization needs, economic feasibility, value, and geopolitical imperatives. Although nuclear power can be discussed as a low-carbon technology that can be used to meet the climate mitigation goals, its strategic importance is disputed in academic, environmental, and political arenas. This discussion has become heated in the European Union (EU), where the countries which are the members have divergent positions on the nuclear development as they can be traced to the historical backgrounds and socio-technical systems and political culture (Wagner et al., 2016). Since the EU tries to move towards a climate-neutral energy system, it does not only concern the question of whether nuclear energy is technically feasible, but whether it is in line with the overall concepts of sustainability, energy democracy, and policy coherence.

One of the first axes of contention is the environmental and climatic performance of nuclear energy. Nuclear energy is often identified as a low greenhouse-gas (GHG) option, and the IPCC lists nuclear energy as one of the least emitting sources of electricity in the life-cycle (Bruckner et al., 2014). Other researches like the one conducted by Pehl et al. (2017) indicate that nuclear power can be as emitting as renewables in some situations. But there are new criticisms that question this optimistic opinion. Warner and Heath (2012) meta-analysis also revealed that previous life-cycle assessments failed to calculate the emissions because they had not included the upstream or downstream operations, including decommissioning, fuel cycle infrastructure, and long-term waste management. Recent studies indicate even greater emissions as compared to the canonical IPCC ones. According to Pomponi and Hart (2021), emissions of future nuclear plants can be two to ten times higher than the usual reports, particularly by adopting comprehensive hybrid LCA methods. These results make the story of nuclear energy an undoubtedly clean technology complex.

The sustainability aspect of nuclear energy is highly debatable. Nuclear energy does not comply with a variety of sustainability principles, such as decentralization, civic engagement, and precaution, as Pienkowski (2024) stresses in a critical analysis of the EU taxonomy debates, although its operational emissions are low. The move by the EU to include nuclear energy as sustainable under the Green Deal taxonomy has faced criticism on being a form of greenwashing, in particular, considering that high-level waste, risk of accidents, and reliance on imported uranium are still open issues (Anlar, 2022; Clifford, 2022). The Generation IV technologies, though they have closed fuel cycles and the reduction of wastes, are speculative and not available commercially (IEA, 2019; Westlen, 2016). Nuclear energy is run on an open fuel cycle, which produces long-lived radioactive waste, which casts the issues of intergenerational equity and environmental safety over the long term.

There are additional uncertainties which are economical in nature in nuclear energy. Nuclear power plants are expensive to start up, take a long period to be built, and need strong government subsidies, unlike renewable sources which can increase quickly. Empirical data indicate the increase in construction costs, numerous delays, and the fact that some of the projects have been abandoned on a large scale (Portugal-Pereira et al., 2018; Schneider and Froggatt, 2021). The levelized cost of energy (LCOE) of nuclear power is typically high compared to most renewable technologies, particularly solar and onshore wind, which has reduced its cost significantly (Ray, 2021; European Commission, 2020). These economic

dynamics limit the competitiveness of nuclear energy in the liberalized market and question its position as a cost-effective way of decarbonization.

A third key line of contention is with regard to the social-political and socio-political viability, legitimacy and perception. Nuclear energy, as depicted in Wagner et al. (2016), is frequently incorporated into technocratic frameworks of decision-making and does not involve mass discourse, particularly in Central and Eastern Europe. The historical accidents that caused Chernobyl and Fukushima are not the only sources of public acceptance as well as their perceived transparency, institutional trust, and inclusion of the energy policy processes. Countries such as Germany are also referring to nuclear phase-out as being in line with the values and energy democracy, but France considers nuclear energy as national identity and sovereignty. Meanwhile, the emerging adopters such as Poland suffer under intense polarization of the public (Wagner et al., 2016) and are at the same time affected by geopolitical threats and EU climate requirements.

In general, the nuclear energy discussion cannot be simplified to the dichotomies of clean and dangerous, cheap and expensive. Rather, it is a multifaceted interaction between environmental science, economical balance, social acceptability, and political expediency. In the case of energy transition in the EU, nuclear energy is both a possible source of decarbonization and a source of disintegration, given that the member states have different perceptions of risks, institutional capabilities, and long-term energy perspectives.

2.4 Public Perception, Ideology, and Risk in Nuclear Policy

The nuclear policy is determined by public perception, which most of the time has been more influential than technical arguments or financial issues. This is in contrast to other sources of energy since nuclear power is imbued in cultural memory due to past accidents, political mistrust and controversial accounts of technological advancement and environmental stewardship. Consequently, the nuclear energy acceptance among the population in the countries is different, by orders of magnitude, and this factor affects the development of nuclear technologies to continue, stay, or die off. These differences are not only of a risk computation but are the outcome of more ideological, historical and institutional conditions.

The available research has always indicated that the social perception of nuclear energy is organized on the basis of the view on risk and dependence and not on the objective safety or cost evaluation. Stoutenborough et al. (2013) also show that the issue of whether people support

nuclear power or not is not only obsolete to how they can acknowledge the victories of knowledge about such technology; it is largely determined by the perception of institutional competence, openness, and honesty among bureaucratic organizations. Nuclear emergencies with high popularity like Chernobyl and Fukushima help to fix nuclear risk in the minds of people and have long-standing psychological and political impacts that define national energy policies at decades of age following the incidence of accidents.

Europe's ideologically oriented views of nuclear energy are well conditioned in Europe. Anti-nuclear movements were traditionally identified with environmentalist, pacificist and left politics, in Germany and Austria in particular, nuclear energy became a symbol of state authoritarianism and ecological danger. Pro-nuclear discourses in France on the other hand are associated with national identity, technological prestige, and energy sovereignty; it is a consequence of the long-standing political tradition, which perceives nuclear power as a social good and not a social risk. These differences of ideologies can be used to understand why convergence in nuclear governance is also not created even when there are common policy frameworks at the EU level, meaning that the member states have diverse symbolic interpretations of the technology, which affects their approaches to the assessment of risks and benefits.

Scholarship in this field is focused on the recent view of the necessity of public engagement and democratic legitimacy in nuclear policy, which is usually unavailable. Wagner, Grobelski, and Harembski (2016) demonstrate that the public deliberation in Poland, which is an emerging nuclear adopter, has been constrained, expert-definite, and technocratic. This leads to the nuclear policy being framed in terms of national modernization, but ethnocentric of the concerns of the people and further polarization. On the same note, Charnley-Parry et al. (2024) claim that indeed, nuclear decision-making is often prioritized based on its technical efficiency rather than social legitimacy, which results in consultation procedures that fail to translate into any meaningful influence. These trends promote skepticism in the communities and also decrease confidence in bodies that are in charge of guaranteeing nuclear safety.

Perception of risks is also influenced by uncertainty and precautionary principle particularly in the discourse of sustainability in the EU. The fact that nuclear power is recognized as part of the sustainability taxonomy in the EU has received a lot of criticism, Pienkowski (2024) notes: the inclusion fails to acknowledge the unanswered questions of long-

term risks associated with radioactive waste, severity of accidents, and fuel cycle security. The geopolitical instability increases these fears like the situation observed in the conflict in Ukraine where the safety of nuclear facilities underscored the potential risks in security that are not well captured in the traditional risk assessment frameworks. Therefore, the risk perception taken by the population is not just emotional and irrational, but is also reflective of structural uncertainties of the nuclear systems.

Altogether, social attitudes, ideological flavoring, and risk discourses have a significant impact on the trends in nuclear energy in the EU. Such social-political forces lead to the disintegration of nuclear policies in the member countries and add to the difficulties in making nuclear energy a mutual remedy to climate change and energy security. These dynamics are therefore critical in terms of assessing the future of nuclear energy in the process of the EU transition into a low-carbon future.

2.5 EU Governance and Energy Policy Complexity

The institutional fragmentation, overlapping competencies, and conflicts between national sovereignty and supranational coordination define energy governance in the European Union (EU). In contrast to other policy areas where the EU wields a robust power on matters, e.g. the trade or competition policy, energy is a mixed area where the Union only provides a set of strategic directions, leaving member states with a veto in the choice of their national energy mixes. This ambiguity of structure makes collective action more difficult, particularly in the case of technologies, such as nuclear energy, which have such high levels of political, security, and economic consequences. Nuclear governance, therefore, demonstrates the overall issues of coherence in EU energy policy as the wider energy transition is being pursued.

The prevailing governance structure is defined by the past and restricted treaty requirements. Nuclear governance was established under a separate legal regime (Euratom Treaty 1957) to the general competences of the EU as it included early aspirations of coordinated nuclear development and anxieties about sovereignty in the nuclear affairs. Nevertheless, according to Nuttall (2009), Euratom did not develop in tandem with the political integration process of the EU, which created regulation mechanisms that were obsolete and generated little legitimacy in the recent discussions. This heritage implies that although the EU has a massive say on the nuclear safety standards and waste policies, it can have little say on the decision made by the member states to either seek or forgo nuclear energy. As a result,

other nations like France, Germany and Poland are taking different policy courses with little influence by the EU institutions.

To make the EU governance more complicated, the institutional multi-level structure of the Union multiplies the duty of the European Commission, the Council, the European Parliament, the national governments, and the agencies in charge of regulations. As pointed out by Leal-Arcas et al. (2015), such overlapping competencies tend to create inconsistent or conflicting signals of policy. Indicatively, although the European Commission advocates an integrated Energy Union and diversification other than Russian fossil fuels, member states have the veto authority over vital decisions concerning energy, which makes it hard to harmonize. This disjointed system of governance has created what scholars term as polycentric energy governance whereby several centers of power are set to run concurrently and in many cases they are not fully aligned (Goldthau and Sitter, 2015).

The controversial nature of nuclear energy adds to these governance issues. Nuclear power lacks a single regulatory domicile within the EU as a technology which has some overlap with security, environment, industrial strategy, and the perceptions of the people. This ambiguity is depicted in the argument about the EU sustainability taxonomy. In 2022, the European Commission adopted a decision to consider nuclear power as a transitional activity that is green to elicit intense political divisions, where Austria and Luxembourg threatened to take it to court, and France and various Central and Eastern European states justified the inclusion as a necessity in decarbonization. According to Pienkowski (2024), this controversy illustrates structural conflicts between sustainability goals at the EU level and domestic interests, especially when nuclear energy is tied to the issue of political identity or economic organization.

Also, the complexity of governance arises due to an imbalance of energy dependence in the Union. Germany and Italy, as well as other countries, are traditionally very dependent on imported fossil-based energy sources, which has influenced the energies-security discourse of the countries differently than the nuclear-dependent France or coal-dependent Poland. Such asymmetries cause different perceptions of energy security and between national preferences in the EU negotiations. As Wagner et al. (2016) demonstrate, the nuclear policy in Poland is shaped to the ideals of decreasing reliance on coal and preserving the sovereignty of the nation-state, which is an ideology that clashes with the socially entrenched anti-nuclear agreement in

Germany. The institutional structure of the EU is unable to harmonize such conflicting narratives, and it is unable to fit them in a single policy umbrella.

Lastly, the emerging policies of market liberalization and decarbonization only exacerbate the situation in the governance space by bringing rival logic to the EU energy systems. Capital-intensive technologies, such as nuclear power, are usually punished in the context of liberalized electricity markets, with the climate targets of the EU pushing towards the rapid expansion of renewable energy, storage options, and grid upgrades. This generates structural uncertainty on nuclear investment because policy settings shift between nuclear as a low-carbon technology and relegate it to the periphery in favor of decentralized renewable systems.

The system of the EU energy governance is neither completely central nor completely intergovernmental, which leads to a hybrid model that does not manage to create a coherent or unitary nuclear policy. The institutional fragmentation, differing national energy cultures and the disputable position of nuclear power in sustainability and security agendas make it complicated. These dynamics are necessary to understand the strategic importance of nuclear energy in the EU entering the transition to a resilient and decarbonized energy future.

2.6 Theoretical Framework Applied

The dissertation is based on a multidimensional theoretical approach, incorporating the theories of energy security and institutionalist views on the EU governance system and socio-technical views on the perception of risks and the populace. Combined they offer a holistic analytical perspective within which to discuss the role of nuclear power in the intricate energy transition environment of the European Union.

The central point of analysis is the three-perspective model of energy security that was elaborated by Cherp and Jewell (2011) and conceptualizes the meaning of energy security in terms of the three interconnected dimensions, i.e. sovereignty, robustness and resilience. The framework can be especially relevant to the EU situation, where national independence in energy mixes is incompatible with the supranational aims of market integration and decarbonization. The sovereignty dimension helps to evaluate the motivation of the member states to decrease the reliance on external supplies, in particular, the reliance on Russian gas, and the robustness dimension shows the technical and infrastructural needs to the stable energy system. The resilience viewpoint, which relates to getting adjusted to shocks and long-term

changes, is critical in examining the potential of nuclear energy as a part of a climate-neutral energy system.

To supplement this, the dissertation relies on institutionalist and multi-level governance theories to explain the structural limitation and fragmentation which is inherent in EU energy policymaking. The hybrid governance system of the EU, as emphasized by Leal-Arcas et al. (2015) and Nuttall (2009), creates overlapping competences and lack of coherence in the policy signaling, which develops national nuclear paths in different directions. Polycentric governance theoretical perspective (Goldthau and Sitter, 2015) is thus used to interpret how decision-making processes work in various centers of power, which are EU institutions, national governments, regulators, and transnational networks, all of which have a role in the development of nuclear policies.

The third element of the theoretical framework is based on the socio-technical and interpretivist viewpoints, which focus on the influence of the cultural meaning, societal perception, and risk discourses on the nuclear energy policy. Research like Stoutenborough et al. (2013) and Wagner et al. (2016) indicate that policy can frequently be influenced by public trust, historical experiences, and ideological framing more than technical or economic factors do. This interpretive aspect is critical in explaining why nuclear energy is still a politically agreeable issue in certain states in the EU yet a very contentious issue in others.

2.7 Conclusion

Combining these three strands, the theory of energy security, multi-level governance and the socio-technical perspectives, the dissertation has developed a comprehensive analytical framework that can be used to identify both structural and sociopolitical factors of nuclear energy policy. This offers the combined method of assessing the interaction of strategic imperatives, policy gap, and societal perceptions to influence the divergent nuclear paths that have been experienced among France, Germany, and Poland. It will also give the conceptual framework of assessing whether nuclear energy can play a role in creating a more comprehensive and solid EU energy architecture or whether it is strengthening the existing disjoint in the Union.

Chapter 3: Methodology

3.1 Research Philosophy

This dissertation concurs with the interpretivist research philosophy in that it is considered to be shaped by the material factors, including technology, economics, and security considerations, but also by the social meanings, political cultures, and institutional contexts (Bryman, 2016; Fischer and Gottweis, 2012). Interpretivism presupposes that the reality can be constructed socially and that the results of the policy relate to the interaction of the perceptions, values, and interpretations of complex energy problems by actors (Creswell and Poth, 2018). This inclination fits the analysis of nuclear energy in the European Union (EU) where national paths are divergent based on historical embedded attitudes, and conflicting risk discourse, and disparate construals of energy security and sustainability (Cherp and Jewell, 2011; Stoutenborough et al., 2013; Wagner et al., 2016). Respecting this philosophical point of view, the research is not interested in universal causation, but it attempts to offer a localized and bespoke knowledge of the manner in which nuclear energy is redefined, justified, and challenged in various member states. The qualitative character of the research allows a close work with policy documents and institutional discourses, as well as the discussion of the topic in the public, and the analysis can reflect interpretive aspects of governance that may be missed by rather positivist and quantitative approaches (Fischer and Gottweis, 2012; Yanow, 2014). The interpretivist approach will allow addressing the broader goal of understanding the reasons why the policy of nuclear power is still disjointed in the EU and how these disparities influence the context of energy security in the Union by foregrounding meaning-making, institutional complexity, and socio-political acquisition of understanding (Leal-Arcas et al., 2015; Pienkowski, 2024).

3.2 Research Design

The research design used in this work is a comparative case study research design, which is most appropriate to consider complex phenomena related to policy formation that takes different forms in different countries (Gerring, 2007; Yin, 2018). Comparative case studies will additionally allow the researcher to investigate the influences of different political cultures, governance structures, and historical experiences on shaping different policy decisions, and still provide an opportunity to find out the general patterns and differences among different cases. Such a design is specifically suitable to the context of the nuclear energy governance within the European Union (EU), whereby the sovereignty of the individual

member states regarding their respective energy mixes is maintained in a common regulatory and strategic context (Leal-Arcas et al., 2015; Nuttall, 2009).

Information will be produced via the qualitative method of analyzing policy papers, EC legislations, scholarly articles, national policies, regulatory publications, and other pertinent governmental messages. A comparative design enables the research to track how the strategic value of nuclear energy is defined by the countries, the estimation of the risks, as well as the interpretation of how it fits within the overall energy transition of the EU (Cherp and Jewell, 2011; Leal-Arcas et al., 2015).

3.3 Data Collection

The current dissertation is founded on qualitative document analysis as the data collection method because it relies on a broad spectrum of literature that captures the policy, institutional and socio-political context of nuclear energy in the European Union (EU). Policy research especially requires qualitative document analysis as this offers the use of systematic interpretation of texts to identify meanings, themes, and patterns present in official and expert discourses (Bowen, 2009; Hodder, 2000). This is in line with the interpretivist orientation of the research, which aims to comprehend how narratives and policy stances are developed in various situations.

The main sources are national policy documents, which are the energy strategies, governmental white papers, parliamentary reports, regulatory decisions, and official communications of France, Germany, and Poland. Such documents can give the understanding of the priorities in the country, the legislative frameworks, and the political logic behind the path of nuclear energy (Leal-Arcas et al., 2015; Nuttall, 2009). Directives, regulations, communication packages, and documents related to the Green Deal are examined on an EU level in order to reflect the supranational governance environment and its impact on national decisions (European Commission, 2020).

The study also relies on scholarly articles, peer-reviewed and analytical reports of reputable entities, including the International Energy Agency (IEA), the World Nuclear Industry Status Report (Schneider and Froggatt, 2021), and other European organizations. These sources are useful in putting the policy developments in the framework of wider theoretical and empirical discussions on energy security, decarbonization, and nuclear governance (Bruckner et al., 2014; Pienkowski, 2024).

3.4 Case Selection Justification (France, Germany, Poland)

France, Germany, and Poland are chosen according to a purposive, theoretically informed sampling approach that aims at identifying the entire range of nuclear policy orientations in the European Union (EU) (Seawright and Gerring, 2008). The three countries are the mirror images of the nuclear paths, and a comparative analysis of these countries provides a vivid insight into the political, institutional, and societal forces that influence the different way of taking nuclear energy. The typical model of a pro-nuclear state was selected as France, which had one of the largest nuclear complexes and has long been characterized by centralization and technological development led by the state (Nuttall, 2009; Blecking, 2024).It has a highly centralized and technologically nationalist energy model, which would be a valuable case study to understand how nuclear energy can be positioned as a pillar of sovereignty and decarbonization.

By comparison, Germany is the best example of a phase-out case in the EU. The Fukushima accident prompted a move in the speed of the Energiewende strategy in Germany, introducing the anti-nuclear feel in the major political culture and law (Markard, 2018). This fact makes the study to investigate how the perception of the public, the environmental ideology, and the federal governance structures deter nuclear development even when the energy security pressure is acute (Stoutenborough et al., 2013). Poland is an interesting example of an emergent adopter, trying to use nuclear energy in the first place in the context of coal addiction, EU climate obligations, and the geopolitical susceptibility of the region (Pienkowski, 2024; Wagner et al., 2016).

Poland is a newcomer, and its changing strategy indicates the importance of the institutional capacity, the public discussion, and external influences on the nuclear policy creation. The combination of these three cases provides the maximum variation of pro-nuclear, phase-out, and emergent trajectories, which contribute to the solid empirical background of the EU-level fragmentation and possible ways of its restoration to a state of policy coherence (Gerring, 2007).

3.5 Data Analysis Method

The analysis presented in this dissertation is based on a qualitative, interpretive study of written material, and it, in turn, is based on the organized yet quite simple method of

research, which is aimed at establishing the key themes, arguments, and policy positions throughout the chosen material. Instead of applying formal coding programs or very technical coding processes, the analysis is conducted by manual thematic coding which is quite appropriate to policy research with meaning, narrative framing and contextual interpretation as its focus (Braun and Clarke, 2006; Nowell et al., 2017).

The process began with extensive reading and re-reading of all gathered papers, national energy strategies, EU legislation and communications, regulatory reports, and other appropriate academic literature. Recurring ideas, policy justifications, points of convergence and divergence across the national and supranational sources were taken note in this stage (Bowen, 2009). Based on these observations they were clustered into a set of analytical themes that demonstrate the objectives of the research: (1) strategic imperatives of nuclear energy, (2) forms of governance and institutional constraint, (3) general perceptions and socio-political legitimacy, and (4) regulatory and policy gaps.

This methodology is similar to thematic analysis as a versatile way of determining patterned meanings across qualitative data sets (Braun & Clarke, 2006). It is a comparative and interpretative approach. At the level of a theme, it was assessed using national documents of France, Germany, and Poland and EU-level sources to identify areas in which national discourses correspond to and atypical to the goals of a wider Europe (Leal-Arcas et al., 2015; Goldthau and Sitter, 2015). Especially the role of nuclear energy in energy security, decarbonization, economic development, and risk management was considered in terms of each country (Cherp & Jewell, 2011; Pienkowski, 2024). The theoretical framework of the dissertation, namely, multidimensional energy security theory and multi-level governance views, is also used to apply some conceptual parameters in the process of the findings interpretation (Cherp & Jewell, 2011; Goldthau and Sitter, 2015).

3.6 Ethical Considerations and Limitations

Since this dissertation is based on the publicly available resources only (policy papers, government strategies, academic literature, and EU legislation), the ethical risks related to data collection are minimal (Wiles, 2013). There are no interviews, personal data, or confidential materials utilized, and, thus, there is no problem with informed consent, anonymity, and privacy. Instead, ethics are upheld by proper citation of source material, openness in its

interpretation and compliance with academic standards of citation, referencing and avoiding plagiarism (BERA, 2018; Wiles, 2013).

Another aspect of the study is that it should also be sensitive to the political and social environment, especially in examining the national standpoints on nuclear energy to the extent that policy choices and attitudes are not misrepresented. The research design has a number of limitations despite its strength in conceptual aspects. To begin with, document-based analysis relies on the accessibility and completeness of policy documents which might not be an accurate reflection of the discussion within the government and in-text decision-making (Bowen, 2009; Hodder, 2000). Second, the use of qualitative interpretation also creates some subjectivity because the results are influenced by a researcher and the theoretical framework used to interpret them (Bryman, 2016). Third, the comparative case study is a method that allows depth and contextual understanding, but does not allow generalizing the results to the countries not included in the sample (Gerring, 2007; Yin, 2018).

Chapter 4: Strategic Imperatives of Nuclear Energy in the EU

4.1 Introduction

In this chapter, we look at the strategic demands that are determining the place of nuclear energy in the changing energy situation in the European Union. Based on the theoretical framework and the methodological approach to the analysis identified in the first two chapters, the analysis examines the critical elements of political, economic, environmental, and societal changes that affect the continued relevance of nuclear energy in the EU energy policy. Although nuclear energy is often a controversial technology, it is often put in terms of the possibility of providing energy security, decarbonization and stability of long-term systems. Through examining these strategic aspects, this chapter seeks to explain why nuclear energy remains a significant and divisive issue in the energy discussions in Europe. These imperatives are fundamental to understanding the bigger policy issues and gaps in governance that influence the integration of nuclear energy into the EU energy policy.

4.2 Political Rationale

The European Union (EU) political justification of nuclear energy lies in the geopolitical, energy self-sufficiency, and systematic endurance reasons. The EU has long been

at risk with foreign supply, as it relied on imported fossil fuels, especially Russian natural gas, to a great degree (Khattak et al., 2018). These vulnerabilities were summed up by the Russian invasion of Ukraine in 2022: the sharp rise in prices, supply chain breakdown, and politicization of energy flows demonstrated the weakness of the current arrangements and put energy security in the focus of the EU agenda again (Blecking, 2024). Nuclear energy is being shaped in this respect as a strategic resource by some member states that can minimize vulnerability to foreign coercion and support a more independent European energy supply chain.

In the sovereignty regard nuclear energy seems to enhance the national and EU level of control of certain critical infrastructure and fuel provision. Uranium is also an internationally traded commodity, but the long fuel cycles, the diversity of suppliers and the availability of homegrown fuel cycles are seen to be less susceptible to the leveraging of geopolitics compared to the pipeline gas or oil imports (Cherp & Jewell, 2011). The reasons why France and some Central and Eastern European member states believe that the nuclear capacity should be maintained or even increased are the necessity to secure strategic autonomy and decrease vulnerability to unpredictable markets based on fossil fuels (Leal-Arcas et al., 2015; Nuttall, 2009). This perception makes nuclear energy a geopolitical insurance which can be used to supplement the fast development of renewables instead of being used to rival it.

Simultaneously, the idea of nuclear energy being a contributor to systemic resilience is encouraged. By the definition of Cherp and Jewell (2011), resilience can be seen as the capacity of energy systems to absorb shock, as well as to adjust to long-term change. The high-capacity, low-carbon, dispatchable generation in large nuclear plants will be able to stabilize grids with increasing proportions of shifting renewables, potentially reducing risks caused by weather-dependent generation and unstable fuel costs (Bruckner et al., 2014). The proponents argue that a diversified portfolio of nuclear and renewables is better resilient to both geopolitical and climatic uncertainties compared to a regime based on imported gas or one technology direction (Blecking, 2024).

This, however, is not a universally accepted political justification in the EU. To some countries, like Germany and Austria, nuclear power is not considered as a guarantee of sovereignty or even resilience but a basis of long-term security and even long-term legitimacy risks in terms of accidents, waste management, and intergenerational accountability (Wagner et al., 2016). These conflicting interpretations reveal that the political value of a nuclear energy

is intermediated by historical experiences of the nation and social conventions. Subsequently, nuclear energy, at once, serves as a geopolitical reassurance instrument to certain member states and a beacon of unacceptable risk to others, which only adds to internal dissonance by making it more difficult to achieve a consistent EU-wide approach on the matter of energy security and resilience (Leal-Arcas et al., 2015; Pienkowski, 2024).

4.3 Economic and Technological Imperatives

Nuclear energy is linked with the economic and technological imperatives that have been identified as the driving force of many European Union (EU) member states whose perception of nuclear energy as a tool of long-term competitiveness, industrial growth, and stability of an energy system. According to its proponents, nuclear energy is a sure source of low-carbon electricity whose operation costs are predictable over the lifetime of plants, which can last up to 60 years (Bruckner et al., 2014). Though initial capital outlay is large relative to most renewable energy technologies, nuclear energy can provide consistent baseload and predictable prices over the long term, and is desirable to countries wishing to diversify energy supply and eliminate the risk of fluctuation in the price of fossil fuels (Blecking, 2024). In this regard, nuclear energy is placed on the strategic industrial investment as opposed to being an energy supply option.

A second economic need is that of the survival and development of nuclear industrial infrastructure of Europe. In France, an example, it has created a great deal of technological and manufacturing capacity in reactor design, fuel-cycle services, and nuclear engineering which is providing high-skilled jobs and can be exported (Nuttall, 2009). The renewal and development of nuclear infrastructure is also discussed by political forces as a way of remaining technologically superior to competitors in a sector that is becoming largely dominated by state-supported players like Russia and China (IEA, 2019). In the case of new nuclear adopters, such as Poland, the nuclear capacity building is also associated with modernization of the industry and creation of new supply chains, which are regarded as drivers to economic resilience and technological modernization (Pienkowski, 2024).

Nuclear energy is also strategic due to the imperatives of innovation. Innovation in generation III+ reactors, small modular reactors (SMRs), and newer fuel cycles seems to be touted as possible solutions to classic economic and safety problems. In particular, small modular reactors are advertised because they are less expensive in the initial investments, have

a modular design, and can fit smaller grids or industrial needs (Davis, 2022). Even though most of these technologies are in different levels of development, their potentiality is one of the reasons why even the politics and industry believe in keeping nuclear skills within the EU. According to critics, these innovations, however, are just a speculation in the short term because of uncertainties around costs, timelines, and regulatory adaptation (Schneider and Froggatt, 2021).

In spite of these plans, nuclear power has also become a great economic challenge. The new nuclear construction in the liberalized markets has been challenged as financially unstable with major cost overruns and delays being experienced in large-scale projects in Finland (Olkiluoto-3) and France (Flamanville-3) (Thomas, 2010). Besides, as nuclear energy may provide a predictable and stable cost of operation in the long term, it has lost its competitiveness compared to fast-lowering renewable energy prices (European Commission, 2020). Because of this, most nuclear projects are strongly dependent on state guarantees, price regulation, or publicly-funded models of finance to be viable.

4.4 Environmental and Climate Imperatives

One of the major pillars of the strategic justification of nuclear power in the European Union (EU) is the factor of environment and climate. With the EU working towards ambitious decarbonization goals as part of the European Green Deal, and having long-range goals of becoming climate neutral by 2050, it is considered that low-carbon energy sources that can provide large-scale, sustained electricity output will continue to be significant. Scientific evaluations, such as the Intergovernmental Panel on Climate Change (IPCC), have continuously found nuclear energy, with its extremely low lifecycle greenhouse gas emissions, to be as low-carbon as wind and solar when considering the entire lifecycle (Bruckner et al., 2014). Nuclear energy is the key to rapid emissions cuts and thus positioned as a necessity to the member states with limited renewable potential or coal dependency (Pienkowski, 2024).

One of the environmental arguments that have been put forward by nuclear power as its contribution to the renewable energy systems is a supplement to that energy system. Although wind and solar energy have grown fast in Europe, their variability poses problems with stabilizing the grid, particularly when the generation is low or demand is high (European Commission, 2020). Nuclear plants, conversely, offer provision of mass dispatchable baseload power, which is not dependent on weather and therefore helps increase system reliability as the

renewable penetration increases. It is suggested by some analysts that nuclear power might result in the lessening of the necessity of fossil-fuel back-up capacity, as it will allow more significant integration of the renewable and lead to the energy system resiliency in the long-term perspective (Blecking, 2024; IEA, 2019). In addition to the generation of electricity, nuclear energy is regarded within the framework of the wider decarbonization routes. There are advanced reactor technologies and high-temperature reactors that might help to produce low-carbon hydrogen, district heating, or industrial heating, although much of this use is still in its early phases of development (Davis, 2022). Advocates believe that these innovations extend the role of nuclear energy in achieving the EU climate goals in several areas.

Although these are the possible advantages, the environmental claims of nuclear energy have been disputed. Opponents point to open questions about radioactive waste disposal, long-term storage, and the risks of an accident to the environment, which remain open to this day and are still shaping the views and policies of a number of member states (Wagner et al., 2016). Moreover, some recent life-cycle analysis indicates that the nuclear emissions can grow in the future as the high-grade uranium reserves are exhausted, bringing the suitability of long-term sustainability into doubt (Pomponi & Hart, 2021). Besides this, megaprojects in nuclear activities demand a lot of land, water, as well as materials, which makes it harder to evaluate their total environmental effect compared to renewable technologies advancing fast. Nuclear energy holds a complicated role in the EU environmental and climate strategy. Although it is evidently beneficial as an energy source with low carbon emission that could be used as a complement to renewable energy systems, it has also posed multi-dimensional sustainability issues that lead to the difference in national policies. The resultant tension is the overall debate of whether nuclear energy could help, or even impede, the process of the EU going climate-neutral.

4.5 Societal and Security Concerns

Societal acceptance and security issues are among the greatest forms of limitations when it comes to developing nuclear energy in the European Union (EU). The memory of the major accidents that happened in 1986 (Chernobyl) and 2011 (Fukushima) further predetermined the connection of nuclear energy with the catastrophic risk in the minds of people of most of the member states (Stoutenborough et al., 2013). In contrast to other energy sources, nuclear power is commonly considered in terms of the low-probability, high-impact

events, and the trustworthiness of regulatory agencies and the professionalism of power operators is a critical factor of political viability (Wagner et al., 2016). Such dynamics in society affect policy making in nations despite high standards of safety in technical evaluations, which shows the social and cultural aspects of embeddedness of nuclear risk perception.

The issue of safety governance is a constant one. In spite of the advanced safety infrastructure of modern reactors, and even Generation III plus designs, the EU member states do not trust nuclear regulation and oversight to the same level. Opponents believe that nuclear accidents are trans-boundary and accordingly, the national borders cannot delimit the risk, which has led to doubts as to the effectiveness of EU-wide emergency response and safety coordination mechanisms (Leal-Arcas et al., 2015). Nuclear installations may be exposed to cyber-attacks, natural disasters, or warfare as the recent events in Ukraine have demonstrated this once again, which further boosted security discussions and supported the idea of increased transnational control (IEA, 2019).

The other urgent issue in society is processing of radioactive wastes that is not solved despite decades of scientific research. High-level waste would need tens of thousands of years of isolation and despite deep geological repositories being seen as technically viable, they have not been applied widely to date due to political resistance, location issues, and governance challenges over the long term (Schneider and Froggatt, 2021). The opposition of waste plants to the population represents the overall suspicion of those in the state institutions and industry players of warranting the safety in the intergenerational perspective (Pienkowski, 2024). These questions make it difficult to frame nuclear energy as a sustainable choice in the EU climate strategies.

The aspect of trust in the population is a cross-cutting factor that influences the acceptance of both the current and the potential nuclear technologies. The absence of meaningful public involvement, as well as historical secrecy in relation to nuclear programs, have also led to distrust by other countries, including Germany and Austria, where anti-nuclear movements are still thriving (Wagner et al., 2016). In contrast, France has had a long-established nuclear culture and well-organized institutions of the state which have led to a relatively high level of trust and has encouraged continuity in the policy (Nuttall, 2009). These contradictory dynamics of trust indicate that social legitimacy rather than technical performance usually defines the political direction of nuclear energy in Europe.

4.6 Conclusion

As has been evidenced in the analysis in this chapter, nuclear energy is still strategically important to most member states of the European Union, especially concerning energy security, the goal of decarbonization, and the stability of the electricity systems in the long term. The issues of geopolitical resilience and energy independence, as well as the economic and technological ones, still foster the need to preserve or even increase nuclear capacity in some national settings. Meanwhile, social issues relating to safety and waste disposal, as well as to public confidence, complicate the further implementation of nuclear energy in the EU. These conflicting imperatives emphasize the complicated and even contradictory nature of the significance of nuclear power in the energy transition of the Union. Consequently, even though nuclear energy may play a role in various strategic objectives, it is not easy to integrate it in a coordinated EU policy agenda. The next chapter thus looks at the policy voids, institutional discrepancies which form this disjointed governance terrain.

Chapter 5: Policy Gaps and Divergences

5.1 Introduction

Chapter 5 discusses structural and regulatory issues that cause persistent fragmentation in the governance of nuclear energy in the European Union. Although the EU has built up an array of supranational instruments on nuclear safety, radioactive waste management, and integration of energy markets, the power to decide the national energy mixes is very firmly in member states hands. This institutional division has created a policy area where nuclear energy can be indirectly regulated through safety and environmental, while strategic choices on expansion or phase-out vary substantially in each country (Council of the European Union, 2011; Leal-Arcas et al., 2015).

The recent energy crisis prompted by geopolitical instability further underscored these divergences as member states reacted to it with different national strategies encouraged by their domestic energy structure and political priorities instead of a coordinated EU action (Konopelko et al., 2023). At the same time, important critiques against the nuclear industry point to a lack of alignment and regulatory vigilance in investment systems and long-term waste disposal that creates lacunae in policy consistency at the EU level (Molin et al., 2024). This chapter therefore maps the policy landscape at the EU level and points out key policy, financial and institutional gaps that prevent the integration of nuclear energy into a unified EU

energy security strategy. By doing so, it offers a basis for understanding how policy fragmentation leads in turn to divergent national trajectories which are discussed specifically with the comparative case studies in the following chapter.

5.2 EU-Level Policy Landscape

The institutional landscape on nuclear energy in the European Union (EU) can be characterized by institutional fragmentation and regulatory ambiguity, reflecting the lack of harmonious and coherent policies and respective competences in the energy area held by the EU. While a large body of legislation has been established by the EU on electricity markets, climate policy, and energy efficiency, decisions about the energy mix at the national level, including the one on nuclear energy use, are still determined by member states, as asserted by Article 194 of the treaty on the working of the European Union (Leal-Arcas et al., 2015). This separation of competence has manifested itself in a policy environment in which nuclear energy is indirectly influenced by climate, safety and market regulations instead of by a coherent and dedicated strategy.

Historically, nuclear governance has been grounded at EU level in the Euratom Treaty whose main features are nuclear safety, radiation protection and safeguards. While Euratom forms a legal basis for cooperation and oversight, its overly dated structure, lack of democratic accountability has been widely criticized, as Euratom has evolved independently from the EU's much broader energy and climate governance structure (Nuttall, 2009). As such Euratom has failed as a mechanism to bring nuclear electricity in tune with modern EU policy (e.g. decarbonization, energy transition etc.).

More recently, however, nuclear energy has been indirectly included in EU climate policy, via the European Green Deal and the sustainable finance framework that came with it. The most controversial feature has been the incorporation of nuclear energy into the EU's sustainable finance taxonomy as a "transitional" activity, with certain stringent conditions attached to it with regard to safety and waste management. This decision revealed profound political divisions among the member states with nations such as France and Poland arguing in favor of inclusion on grounds of climate and energy security while others, most notably Germany and Austria, arguing against on the basis of being incompatible with the principles of sustainability (Pienowski, 2024; Blecking, 2024).

These debates represent the EU's dilemma in competing between climate ambitions and different national energy preferences. Rather than solving the incoherence of EU policy, the current EU-level framework translates a pragmatic compromise, enabling the cohabitation of nuclear energy within the framework of climate policy in an uneasy ambivalence that does not give it a clear strategic direction. This ambiguity opens the way for inconsistencies in the regulation and differences between nations, as discussed later on in the following sections.

5.3 Regulatory Inconsistencies

Despite the fact that EU-level solutions are available to control the energy markets and nuclear safety, there still remain major regulatory discrepancies in assorted countries that result in obstacles for the coherent development of nuclear energy in the European Union. While the EU has defined common principles via instruments such as the Nuclear Safety Directive and standards for radiation protection under Euratom, the implementation of rules is highly decentralized with allied variations in licensing procedures, safety interpretation and the timeframe for implementing these (Nuttall, 2009; Leal-Arcas et al., 2015). These inconsistencies complicate international cooperation, raise the level of uncertainty for projects, and reduce the ability for nuclear investment to scale throughout the Union.

An example of such fragmentation lies in the licensing processes of nuclear facility. Given the difference in the implementation of various approvals procedures, environmental impact assessment, and the need to consult the public between states, several member states exercise differing criteria, which in many cases are based on the national political and legal culture as opposed to aligned EU standards. Thus, nuclear projects can be characterized by the levels of regulation that are highly variable, leading to delays, excessive cost increases as in the case of the latest projects in France and Finland (Thomas, 2010). The absence of a coherent licensing environment also makes the investment of the investors less predictable as well as discourages more investors to invest in small modular reactors (SMR) in the private firms due to the absence of a well-established regulatory pathway at the EU level (IEA, 2019).

Another equally large threat is safety standards. Even though the EU directives are promoting high standards of nuclear safety, the national regulatory bodies still have the mandate on how to interpret and enforce the two aforementioned standards. It results in fragmented safety cultures, and introduces difficulties to transnational risk management cross-recognition among member states, which consequently causes a lack of trust in the systems

(Wagner et al., 2016). More so, regulatory methods have been unable to adjust to new security challenges, including on cyber security and safety of nuclear facilities in times of conflict as they indicate deficiencies in EU wide preparedness.

One more level of inconsistency is rules of investment. Nuclear deterministic projects model is based on the support mechanisms of the state (e.g., the contracts of difference or the state aids), in contact with the unease of EU competition and state aid rules. Projects have also been newly granted in exceptional situations, but, due to the absence of a distinctly clear and stable investment structure, there is some uncertainty regarding long-term planning (European Commission, 2020). These regulatory differences, in combination with each other, justify national departure and have hindered the ability of the EU to consider nuclear energy as one of the integral concepts of energy security of decarbonization.

5.4 National Divergences

National divergences are one of the biggest hurdles to a coherent strategy in terms of nuclear energy in the European Union. While matrixes such as the EU set out efforts to facilitate market integration and decarbonization policies on EU level, they kept the sovereignty over their energy mix up to their own states, thus making their domestic approach to nuclear energy widespread right up to divergent. These divergences are best illustrated by the differences between countries that have adopted nuclear phase-out policies and others that are following a strategy of nuclear expansion or new build (Leal-Arcas et al., 2015).

Germany is a good example of the phase-out curve, having voted for the complete closure of its nuclear fleet, as part of the overall Energiewende. This decision is based on a lack of acceptance of nuclear energy by large parts of the population based on historical experience, environmental ideology, and risk perception rather than straight economics or security considerations (Stoutenborough et al., 2013; Wagner et al., 2016). Despite the disruption of energy supplies brought on by the war in Ukraine, Germany has kept to its anti-nuclear nut, continuing to focus on the expansion of renewable and energy efficiency rather than to reevaluate its use of nuclear energy (Markard, 2018).

Nuclear energy on the other hand is very well seen by certain countries like France or some Central and Eastern European member states as a strategic aspect of energy security and decarbonization. France continues to invest in a seventeen-year extension of the lifetime of current reactors and plans to build more, implying that nuclear energy is vital for nationhood

and industrial supremacy (Nuttall, 2009; Blecking, 2024). Similarly, Poland has turned to nuclear power as a way to switch away from coal and to increase energy independence and comply with EU climate targets (Pienkowski,2024).

5.5 Financial and Institutional Challenges

Financial and institutional challenges are a major hurdle in the integration of nuclear energy in the European Union's liberalized energy markets. Nuclear power is characterized by its high upfront capital costs, long construction times, and long payback times, which contrast with investment profiles preferred by competitive electricity markets (Thomas, 2010). In the absence of long-term price guarantees or state-backed financing mechanisms, nuclear projects are often unwilling to include private investors, especially in the face of threats of regulatory change and public opposition (Schneider & Froggatt, 2021). As a result, nuclear development in the EU is still highly reliant on government intervention and this raises concerns about market distortion and conforming to EU rules on competition and state aid (European Commission, 2020).

Market integration makes nuclear financing even more difficult. Liberalized electricity markets place emphasis on short-term price signals; these tend to have a negative effect on capital-intensive technologies that have high fixed costs and low marginal costs, such as nuclear energy. While the decreasing price of capital costs and flexibility of deployment are to the advantage of renewables, nuclear plants need stable and long-term revenue frameworks for economic viability (IEA, 2019). Mechanisms like contracts for difference or regulated asset base models are proposed or implemented in some member states, however their compatibility with EU level market rules is disputable and inconsistently followed (Leal-Arcas et al., 2015).

Another thing that complicates the governance scene is institutional fragmentation. Energy policy, nuclear safety, competition policy, and climate governance are shared across various other EU institutions and national authority with the result that they often overlap in their competencies. This dissemination prevents decision making, delays project approval, and encourages uncertainties in the policy making process (Nuttall, 2009). In case of nascent nuclear states like Poland, there is less administrative capacity and regulation experience, which further increases risk associated with a project, which requires the use of artificial intelligence and external sources (Pienkowski, 2024).

5.6 Conclusion

As it has been evidenced in this chapter, the EU nuclear energy situation is being typified by a number of salient policy gaps, regulatory discrepancies, and financial limitations. Despite the efforts of the EU-level structures to promote decarbonization and market integration, the activities, combined with the difference in the national priorities, contribute to a lack of coordination. These problems are complicated by regulatory fragmentation, varied safety and licensing regimes, and disputed investment rules. Taken together, these aspects hamper the ability of the EU to incorporate nuclear energy in a universal energy-security policy and promote national drift. In the next chapter, this analysis is continued by the discussion of the practical implications of these structural issues on the example of France, Germany, and Poland.

Chapter 6: Comparative Case Studies

6.1 Introduction

This chapter investigates the effects that the strategic imperatives and policy gaps established in the previous chapters have in practice with the help of a comparative analysis of three European Union member states: France, Germany and Poland. These cases represent very different nuclear energy pathways (long-standing reliance and expansion, complete phase-out, and incipient adoption) that are amenable to anoscopy of the impact of national contexts on nuclear policy outcomes.

Drawing on the results of recent academic work, policy analyses, and regulatory framework, the chapter examines how each country views nuclear energy's contribution to energy security, dicarbon knows and economic development. Particular attention is paid to the interplay between national policy choices and EU level constraints, including waste governance policies, rules on the market and responses to crises. In order to compare these divergent paths, the present chapter focuses on the structural and socio-political factors that enable the existence of fragmentation within EU nuclear governance and sets the basis for the cross-case analysis carried out on them.

Country	Nuclear electricity share (%)	Operating reactors	Reactors planned	Nuclear policy direction
France	~65	56	~14	Expansion and modernization
Germany	0	0 (17 prior to phase-out)	0	Phase-out completed (2023)
Poland	0	0	~6	First nuclear program planned

Table 1: *Nuclear energy indicators in selected EU countries (Data compiled from Molin et al. (2024), Konopelko et al. (2023), and national policy reports)*

Table 1 shows how sharply the energy directions of France, Germany and Poland diverge on the issue of nuclear energy. France is also very reliant on nuclear energy, as most of the electricity production is mainly attributed to nuclear energy with further plans of its expansion. On the contrary, Germany has totally abandoned nuclear energy indicating a strategic decision towards renewable energy. Another example of an emerging case is Poland, where no nuclear capacity can be found but there are great expectations of further development. The given example throws light on the lack of a homogenized nuclear policy in the European Union and supports the thesis that the policies of national preferences and political decisions are the main factor in formulating energy policy.

6.2 France: Pro-Nuclear Tradition and Strategic Expansion

France is the European Union's most established and institutionally embedded pro-nuclear model with nuclear forming the backbone of the electricity system for several decades. In contrast to other countries of the European Union where nuclear energy is in dispute, in France, nuclear energy dependence has traditionally been presented as a strategic tool for guaranteeing energy independence, stability of energy prices and low-carbon electricity production. This model is consistent with a strong tradition of planning from the center of the state and technological centralization, where nuclear power is closely tied to national sovereignty and industrial policy (Mbarek et al., 2017).

France operates one of the world’s largest civilian nuclear fleets. As of 2023, the country maintained 56 operating reactors across 18 nuclear power plants, generating

approximately 65–70% of national electricity production, making France the most nuclear-dependent electricity system in the European Union (Molin et al., 2024). This large-scale deployment has historically enabled France to maintain relatively low electricity-sector carbon emissions while ensuring stable baseload generation. France remains the most nuclear-dependent electricity system in the European Union, while Germany has completed its nuclear phase-out and Poland currently operates no nuclear power plants.

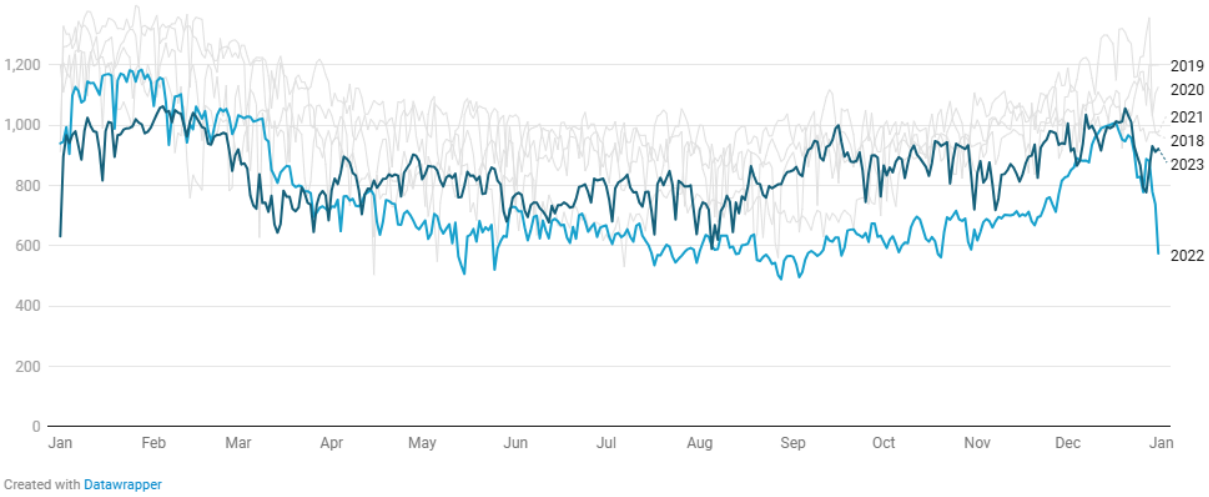

Figure 1: *France daily nuclear electricity production (Source: Open Data Réseaux Énergies (ODRÉ))*

Figure 1 shows data from France's daily nuclear electricity production that support the findings above. Specifically, the figure visually reinforces the central role of nuclear energy in the French electricity system by illustrating the scale and continuity of nuclear output over time. This pattern helps explain why France remains the most nuclear-dependent country in the European Union and why nuclear power continues to be treated as a strategic asset in terms of energy security, system stability, and decarbonization. At the same time, fluctuations in daily output also suggest that, although nuclear energy remains dominant, operational performance is still influenced by maintenance cycles, technical conditions, and broader pressures affecting the reactor fleet. Therefore, the figure complements the argument that France's nuclear model is defined by both structural strength and the need for modernization.

From an economic standpoint, nuclear power has been an important factor in France's long-term growth process. Empirical evidence suggests that nuclear power has been a positive contributor to economic growth both in the short and long run through aiding stable electricity

supply and reducing exposure to importing fossil fuels (Mbarek et al., 2017). This stability has allowed France to have relatively low electricity prices and a relatively low carbon energy mix which has strengthened political support for ongoing nuclear investment. In recent years this rationale has been reiterated via plans to prolong key aspects of the operational lives of existing reactors and build new-generation reactors as part of a larger plan to ensure long term energy security.

However, France's strategy for nuclear expansion is not without problems. World Nuclear Industry Status Report 2024 reports ongoing technical, financial and organizational challenges in the French nuclear power sector, which consist of delays, cost overruns and declining operational performance in some parts of the reactor fleet (Molin et al, 2024). These problems lead to doubts about the sustainability of high scale nuclear growth under existing institutional arrangements. Nevertheless, French policymakers still organize nuclear energy as key to meet climate targets while ensuring the reliability of the system, especially as electricity demand is projected to increase due to electrification (Molin et al., 2024).

In contrast to other EU member states, there have still been comparatively limited societal resistances against nuclear energy in France. Public acceptance is aided by institutional heritage of trust and a view of nuclear energy as an asset for the country, not as a window of transition and compromise. As such, France's nuclear policy is based on continuity and not rupture, thus making it an important actor to ensure the inclusion of nuclear energy in climate and energy frameworks at the EU level. This position leaves the French nation at the heart of nuclear debates in the EU; in many cases in direct opposition to phase-out states; and reinforces the overall trend of disconnection in energy governance in the EU.

6.3 Germany: Phase-Out, Renewables Priority, and Security Risks

Germany is the most forward-looking instance of nuclear phase-out in the European Union and has pledged to phase-out nuclear energy altogether as part of its wider Energiewende plan. This decision, which has been expedited following the 2011 disaster in Fukushima, reflects profound societal innovation against nuclear energy and a political consensus that values the expansion of renewable energy sources over those solutions based on nuclear energy (Glynos & Scharf, 2024). Unlike France, Germany defines energy security more in terms of decentralization, public legitimacy and renewable deployment rather than technological centralization.

Germany previously operated 17 nuclear reactors, which collectively supplied roughly 25-30% of national electricity generation in the early 2000s. After the Fukushima accident in 2011 the German government accelerated its phase-out policy and began to close reactors one by one until the last three plants were closed permanently in April 2023 (Glynos and Scharf, 2024; Molin et al., 2024). Nuclear capacity has also been eliminated, the impact has been the substitution of nuclear power with more renewable energy, and the short-term safeguarding of fossil fuels usage in the transition of this energy source.

Reactor Name	Model	Reactor Type	Permanent Shutdown
AVR Juelich	Pebble bed reactor prototype	HTGR	1988-12-31
Biblis A	PWR	PWR	2011-08-06
Biblis B	PWR	PWR	2011-08-06
Brokdorf	PWR	PWR	2021-12-31
Brunsbuettel	BWR-69	BWR	2011-08-06
Emsland	Konvoi	PWR	2023-04-15
Grafenrheinfeld	PWR	PWR	2015-06-27
Greifswald 1	VVER V-230	PWR	1990-12-18
Greifswald 2	VVER V-230	PWR	1990-02-14
Greifswald 3	VVER V-230	PWR	1990-02-28
Greifswald 4	VVER V-230	PWR	1990-06-02
Greifswald 5	VVER V-213	PWR	1989-11-24
Grohnde	PWR	PWR	2021-12-31
Gundremmingen A	BWR-1	BWR	1977-01-13
Gundremmingen B	BWR-72	BWR	2017-12-31
Gundremmingen C	BWR-72	BWR	2021-12-31
HDR Grosswelzheim	Superheated steam reactor	BWR	1971-07-20
Isar 1	BWR-69	BWR	2011-08-06
Isar 2	Konvoi	PWR	2023-04-15
KNK II	Prototype	FBR	1991-08-23
Kruemmel	BWR-69	BWR	2011-08-06
Lingen	BWR with fossil fuel-fired superheater	BWR	1977-01-05

Reactor Name	Model	Reactor Type	Permanent Shutdown
Muelheim Kaerlich	PWR	PWR	1988-09-09
Mzfr	-	PHWR	1984-05-03
Neckarwestheim 1	PWR	PWR	2011-08-06
Neckarwestheim 2	Konvoi	PWR	2023-04-15
Niederaichbach	pressure tube reactor	HWGCR	1974-07-31
Obrigheim	PWR	PWR	2005-05-11
Philippsburg 1	BWR-69	BWR	2011-08-06
Philippsburg 2	PWR	PWR	2019-12-31
Rheinsberg	VVER-70	PWR	1990-06-01
Stade	PWR	PWR	2003-11-14
THTR-300	Pebble bed reactor	HTGR	1988-09-29
Unterweser	PWR	PWR	2011-08-06
VAK Kahl	BWR	BWR	1985-11-25
Wuergassen	BWR	BWR	1994-08-26

Table 2: *Shutdown reactors in Germany (Source: World Nuclear Organization)*

Table 2 explains the nuclear plant shutdowns in Germany over the years. It shows that Germany's nuclear phase-out was not a single event, but a gradual and politically shaped process that unfolded across several decades, with a clear acceleration after the Fukushima accident in 2011. The table demonstrates the breadth of the German retreat from nuclear power by listing not only the most recent closures, but also earlier shutdowns of older and prototype reactors. This makes clear that the German nuclear exit reflects a long-term strategic and ideological shift rather than a temporary response to a short-term crisis. In this sense, the table supports the broader argument of the chapter that Germany's energy policy has been shaped

primarily by public legitimacy, environmental priorities, and anti-nuclear political consensus, even when this created energy security trade-offs.

The retirement in Germany has never been explained as a democratic and precautionary measure against the nuclear threat. Germany resisted a wholesome reversal of its nuclear exit path even in the 2022-2023 energy crisis, when the gas shortages and volatility in valuing energy prices exposed the weaknesses in the energy system. According to Glynos and Scharf (2024) there was no strategic shift behind the temporary extension of the remaining reactors but it was crisis management that did it, noting how politically resilient the phase-out consensus has proved. Through this direction, the role of ideological commitment and public faith in ignoring the short-term impacts on security in national energy policy formulation is indicated.

Simultaneously, the case of Germany shows significant compromises in energy security. Counterfactual analysis gives the recommendation that an additional investment in nuclear energy would have allowed changing the reliance of Germany on fossil fuels and alleviating at least the emissions in the period of transition (Emblemsvag, 2024). Upscale in renewables has failed to compensate enough of the displaced nuclear generation particularly when the wind and solar react poorly necessitating increased reliance on coal burning and gas imports in the near and medium term (Molin et al., 2024). The dynamics leave a challenge of supporting the perspective of Germany that nuclear phase-out naturally improves energy security.

The wider implications of the nuclear exit of Germany are also in the co-ordination at an EU-level. Its arguments against nuclear energy have shaped debates on EU taxonomy, investment systems and crisis management, and frequently pitted Germany against EU member states in favor of nuclear energy (Konopelko et al., 2023). This drift reveals the restriction of energy policy as an element of EU integration wherein nationwide preferences remain to be the major determinant of strategic decisions.

6.4 Poland: Emerging Nuclear Adopter in Energy Transition

Poland is a new nuclear entry in the European Union and it is confronted with a distinctive combination of structure pressures, geopolitical pressures, and societal pressures. This is in contrast to France, where nuclear power is a well-established sector, or Germany, where it is a distinctly unsuccessful one, in Poland even the policy towards nuclear energy is a strategic one of nuclear power as a technique to overcome the system constraints most

prominently of which is its excessive dependence on coal, escalating costs of emissions and foreign energy shocks. Polish policy makers increasingly speak about nuclear energy as the required means to achieve energy security and comply with the decarbonization requirements of the EU (Konopelko et al., 2023).

Poland does not have an active nuclear power plant, like France and Germany do, and presently uses coal as an electricity producer. Poland is a country where approximately 70% of electricity was produced using coal, and uses one of the most carbon-intensive energy systems in Europe (Konopelko et al., 2023). To counter the increasing emissions costs and energy security issues, Poland has declared its intention to construct its first nuclear energy plants in the time frame of 2030s as part of its energy transition plan.

Location / site	Type	Gross capacity (MWe)
Pątnów	APR1400	2x1400
Dąbrowa Górnicza	BWRX-300	4x300
Nowa Huta	BWRX-300	4x300
Ostrołęka	BWRX-300	4x300
Stawy Monowskie	BWRX-300	4x300
Tarnobrzeg Special Economic Zone	BWRX-300	4x300

Table 3: *Reactors proposed in Poland (Source: World Nuclear Organization)*

Table 3 provides a comprehensive overview of the nuclear reactors proposed in Poland. It highlights the scale and ambition of Poland's planned nuclear program by showing that the country is not considering a single isolated project, but a broader expansion strategy involving multiple locations and reactor designs. This is significant because it illustrates that Poland views nuclear energy as a long-term structural component of its future energy mix rather than as a limited supplementary option. The table also reflects Poland's effort to reduce its heavy dependence on coal and to align energy diversification with decarbonization and energy security objectives. At the same time, the number and scale of the proposed projects underline the magnitude of the institutional, financial, and regulatory challenges that Poland will need to overcome in order to move from planning to implementation.

The geopolitical environment has made a choice to influence the nuclear ambitions in Poland. With the disasters of the post-2022 energy crisis in the rearview mirror, the risks associated with reliance on fossil fuel have become evident, and in that regard, the search to establish consistent, domestic-controllable energy sources becomes increasingly assured. Poland views nuclear power in contrast to Germany as a long-term means of generating baseload power that can help the country meet the demands of the coal-free industry and grid stability (Konopelko et al., 2023). This contextualization preconditions the prospective nuclear energy as one-fourths but as a supplement to renewables, not an energy-enhancing direction.

The crucial approach to the nuclear strategy in Poland is societal acceptance. Empirical data compiled by Smolinski et al. (2024) indicates that the plea of the population support of nuclear energy in Poland differs rather positively than in traditional phase-out states, though the acceptance varies in terms of regions and demographics. Notably, the perception of economic development, energy security and institutional competence have a strong connection to the extent to which people are supported. Opposition to nuclear energy in Poland has not yet focused around a strong ideological movement as is the case in Germany and as a result, policy makers have higher headroom to pursue nuclear investment.

Nonetheless, the nuclear way pursued in Poland is under threat. The nation has not had any prior experience of using nuclear power facilities and this has raised concerns on regulatory capability, disposal of wastes in the long run and sustainability. The report World nuclear industry status report 2024 highlighted the risks of price overruns, project delays and dependence on foreign technology manufacturers in the newer states (Molin et al., 2024). These limitations serve to highlight to which extent it is around external assistance and the stability of nuclear policies on the EU level that the nuclear strategy of Poland is still happening.

6.5 Cross-Case Comparison: Drivers, Barriers, and EU Integration Implications

The comparative analysis of the case in France, Germany and Poland serves to underscore the degree of national divergence in the origins of nuclear energy policy in the European Union, imposing strong limits on the sense in which a shared strategic conception predominates over the various strengths and weaknesses of national approaches to energy policy. Although all three countries operate within the same EU regulatory framework, they have clearly different nuclear trajectories that are based on their different understanding of energy security, risk and sustainability.

Country	Nuclear	Renewables	Fossil fuels
France	~65	~25	~10
Germany	0	~50	~50
Poland	0	~25	~75

Table 4: *Electricity generation structure in selected EU countries (% of total electricity production) (Sources: Molin et al. (2024) and Konopelko et al. (2023).)*

Table 4 demonstrates that the energy composition in the three countries is quite different, which indicates different views on energy insecurity and decarbonization. France is highly dependent on nuclear energy which allows them to depend less on fossil fuels, and they are also assured of availability of electricity. Germany, in its turn, will cover the nuclear phase-out by the mix of renewables and fossil fuels, which makes the energy security and emissions stability problematic. Poland is still very reliant on fossil fuels, which points to structural limitations to switching to a low-carbon energy system. These disparities show how national energy arrangements influence policy decision-making and make the attempt to build a coherent EU-wide energy policy difficult.

France's nuclear strategy is largely defined by institutional continuity and state capacity. Nuclear energy is presented as a mature and indispensable part of national energy security, economic stability and climate policies. Strong institutional experience and public legitimacy makes it possible for France to pursue strategic expansion despite technical and financial challenges identified in sector-wide assessments (Mbarek et al., 2017; Molin et al., 2024). Germany, on the other hand, is influenced by bureaucracy's resistance and moral commitment to withdrawal from nuclear technologies. Even with the increase in crisis conditions, political legitimacy and threat assessment trumped short-term security considerations in reinforcing a renewable center of gravity (Glynos & Scharf, 2024).

Poland is in an intermediate position, where the driving factor behind nuclear adoption is structural necessity and not ideology. Its strategy represents the result of a response to coal dependence, geopolitical vulnerability, and EU climate obligations, as a combination of relatively favorable public acceptance (Smolinski et al., 2024; Konopelko et al., 2023). However, there is limited institutional experience and reliance on outside actors that limit

Poland's ability to define its nuclear future independently. Table 6.5 summarizes the different nuclear policy trajectories of the three case study countries.

Country	Historical nuclear role	Current policy	Strategic rationale
France	Long-standing nuclear system	Expansion and reactor renewal	Energy security and low-carbon electricity
Germany	Significant nuclear capacity until 2011	Phase-out completed	Public opposition and renewable transition
Poland	No nuclear generation historically	First nuclear program planned	Energy diversification and decarbonisation

Table 5: *Comparative nuclear policy trajectories (Glynos and Scharf (2024))*

Table 5 summarizes the different nuclear policy paths of the three nations, and it is evident that historical experience and political interests played a central role in the shape of these paths. The nuclear tradition of France underlies expansion strategy, whereas phase-out of Germany is the outcome of high level of opposition to the idea of nuclear energy as well as environmental ideology in the society. The energy security issues and the necessity to decrease the coal reliance are the main factors that fuel the development of nuclear program in Poland. The comparison affirms that the EU nuclear policy cannot be said to be set in line with any kind of common framework but rather with strategic considerations at the national level, which further supports the general argument of the fragmentation of governance.

The comparative analysis of the three case studies and the three data sets indicates that nuclear energy is not a cohesive policy instrument in the European Union. Rather it represents more profound structural, political and societal divisions across member states. This disintegration constrains the capacity of EU to come up with a consistent energy security policy that can effectively accommodate nuclear energy.

6.6 Conclusion

A common theme to barriers emerges in all 3 cases. These include high capital costs, regulation complexity, long-term obligations involved in managing waste through Euratom legal frameworks with regards to waste management, and uncertainty associated with integration in EU markets (Council of the European Union, 2011; Molin et al., 2024). Yet the political salience of these barriers are quite different. In France, they are handled under an

established system of governance, in Germany, rejection is reinforced and, in Poland, they signify at least risks for the future, not immediate deal-breakers.

From the perspective of EU integration, the comparison is revealing a structural mismatch between a supranational ambition for climate and energy and a national rootedness of energy strategies. The simultaneous existence of expansion, phase-out and emergent adoption makes coherent EU-wide nuclear policy difficult to define. Instead, nuclear energy operates as a polarizing technology that reflects the dynamics of disintegration in a policy sphere where sovereignty, public trust and experience are decisive. This fragmentation has important implications though for the EU's ability to coordinate its long needing common strategies around energy security and decarbonization, which challenge is discussed in the following discussion chapter.

Chapter 7: Discussion

7.1 Introduction

This chapter gathers theoretical perspectives, empirical research findings, and insights gathered from the comparative exercises developed throughout the dissertation with a view to critically evaluating the role of nuclear energy in the framework of the European Union's energy security relations. Moving beyond descriptive analysis the chapter revisits the research questions in light of the evidence provided in the preceding chapters and evaluates the wider implications of national nuclear strategies for governing at EU-level.

By working across constituencies, by synthesizing strategic imperatives and policy gaps with the findings of the case studies, the discussion emphasizes the tension between the potential contributions that a nuclear energy could make to energy security and the underlying fragmentation of policy at a country-by-country level. The chapter also discusses the theoretical implications of these findings, providing the background for the summary and recommendations in the concluding chapter.

7.2 Revisiting Research Questions in Light of Findings

This dissertation aimed to look at the strategic role of nuclear power in strengthening the energy security of the European Union and, at the same time, identify the factors of the policies and governance of the nuclear power that limit its coherent integration. The

conclusions that can be drawn from Chapters 4 to 6 is that nuclear energy holds a place between incompatible positions within the EU energy mix - it is both a strategic asset and a source of political fragmentation.

The first research question was about whether nuclear energy can make a significant contribution to EU energy security. From the perspective of strategic possibilities, the analysis shows that nuclear power has a number of benefits that are in tune with multidimensional schemes of energy security. In some countries like France and Poland, nuclear energy comes with stability in the long-term supply of energy, independence from the energy of fossil fuels and support of the decarbonization goals (Mbarek et al, 2017; Konopelko et al, 2023). These results confirm that, in terms of energy security in terms of sovereignty and system robustness and under conditions of geopolitical uncertainty, nuclear energy can improve energy security.

However, the second point of the research question, which is whether nuclear energy can be inserted in a coherent EU-wide strategy, leads to a more critical answer. The comparative case studies show that national conceptions of the nuclear risk, legitimacy and strategic value differ fundamentally. Germany's phase-out strategy, which has been based on societal opposition and perception of risk, is quite different from the continuity in France and emergent adoption in Poland (Glynos & Scharf, 2024; Smolinski et al., 2024). These divergences are favored by institutional fragmentation and regulatory inconsistency at the EU level, detracting from coordination apart from minimum safety and waste governance requirements (Council of the European Union, 2011).

7.3 Nuclear Energy’s Role in EU Energy Security: Strategic Value vs. Policy Fragmentation

This dissertation analysis highlights a critical tension within the very system of EU energy governance: nuclear energy already has a significant strategic role in energy security and decarbonization, but its inclusion is still limited by the unresolved policy fragmentation. This conflict is similar to a wider struggle between the national rights in energy-related choices and the common EU developments.

Strategically, nuclear energy is congruent with important aspects of energy security. It also provides low-carbon capacity, high electricity storage and is also relatively immune to the short-term fuel-market volatility, thus providing greater system resiliency and long-term planning (Mbarek et al., 2017; Molin et al., 2024). Within a dynamic geopolitical situation,

accompanied by supply shocks, some member states take nuclear energy as a stabilizing power to supplement the unreliable renewable resources and decrease reliance on the imported fossil energy (Konopelko et al., 2023).

However, the empirical findings also prove that these strategic advantages are unevenly recognized and politically fought throughout the EU. Germany's nuclear phase-out shows that technological soundness or contradicting economics can lose out to value systems (trust, ideology, risk awareness, etc.) in times of crisis (Glynos & Scharf, 2024). On the contrary, maintaining France's reliance on nuclear energy is marked by high-quality institutional continuity and people's acceptance of the government's energy, whereas Poland's nuclear ambitions stem from necessity rather than ideological affinity (Smolinski et al., 2024). These opposite pathways highlight the fact that energy security is not interpreted in a similar way, but is influenced by national histories and political cultures, as well as by institutional arrangements.

At the EU level this diversity means fragmented governance. Although there are supranational frameworks in place regarding nuclear safety and radioactive waste management, decisions on whether to expand or phase out reactors are still left in the hands of the nations (Council of the European Union, 2011). Financial mechanisms, market rules and sustainability classifications are other instances of compromise rather than coherence, impairing the EU's ability to set out a coherent nuclear strategy (Molin et al., 2024).

As a result of this, nuclear energy plays less of a role as a unifying strut of EU energy security policy and more of a telling example of the limits of integration in a highly politicized policy area. While nuclear power under certain national conditions could strengthen energy security, a lack of political legitimacy at any level of sort and institutional convergence means that it cannot be systematically deployed at the European level. This tension between strategic value and policy fragmentation represents a major part of the insight in the dissertation, and sets the stage for the evaluation of the theoretical implications of the findings in the next section.

7.4 Prospects for EU-Level Coherence in Nuclear Strategy

The possibilities for attaining a coherence of nuclear energy strategy across the Union are challenged by the limits of structural, political and institutional factors despite an emerging awareness of shared energy security problems. While recent crises have served to heighten

debates about strategic autonomy, resilience and decarbonization, nuclear energy remains an area of such profound national sovereignty that it reveals the limits of supranational co-ordination.

At the level of international cooperation, the EU has regulatory power mostly in connection with nuclear safety, waste disposal and market rules but no authority to influence the composition of national energy mixes. This splitting of competencies limits the authority of the EU to formulate a cohesive nuclear strategy beyond minimum governance standards. Attempts to indirectly merge nuclear energy through climate and finance tools - the most prominent of which has been the sustainable finance taxonomy - have led to so-called compromise solutions that recognize the low carbon nature of nuclear energy while falling short of full strategic endorsement. These developments represent pragmatic accommodation, rather than actual policy convergence.

The lack of coherence is further exacerbated by political differences among members. The role of nuclear power energy differs significantly across national political systems, as illustrated in the comparative case studies. In some states, it is a sign of technological sovereignty and stability of the system, at least, in others, this is the indicator of the unacceptable risk and deficit of democracy. These institutionalized differences lower the level of efficiency of coordination mechanisms at the EU level particularly when issues of public trust and political legitimacy are intertwined to the energy policy.

However, only limited opportunities exist for movement toward greater functional coherence. Cross-divisional safety standards, emergency preparedness, waste governance and research on next generation of technologies on nuclear power would be an example of areas of convergence that does not oppose national autonomies. Equally, grid stability, system balancing and future planning investment frameworks, might place it through an advantage of accommodating nuclear energy indirectly under a wider investment approach. The measures would likely however help in a pluralistic and not a unifying approach.

7.5 Theoretical Implications

The application of multidimensional energy security frameworks to the findings of this study offers important theoretical insights into the nature of energy governance in the European Union. The analysis confirms the idea that energy security cannot be seen as a singular or

objective condition, but rather as a construct, which is context construing, depending on political priorities, institutional capacity and societal values.

Using the framework of sovereignty, robustness and resilience, the study shows that nuclear energy contributes differently in these dimensions. In terms of sovereignty, nuclear energy makes for greater long-term autonomy for states who have the institutional capacity and public legitimacy to sustain it. France is an example of this dynamic behavior, and Poland attempts to lean in this direction. However, in states where nuclear energy is not socially accepted such as Germany, sovereignty is redefined through decentralization and renewable self-sufficiency as opposed to technological centralization.

With regard to robustness, nuclear energy provides the stability and predictability of systems and power output, but this comes at the cost of effective governance, and investment sustainability. The findings reveal that it is not just technical robustness that is required to ensure policy durability; political and institutional robustness are equally important. Finally, resilience has been identified as the most contested dimension. While nuclear energy can provide long-term system resilience under some circumstances, it can at the same time undermine political resilience where trust by the public does not exist. Theoretically, the result of these findings illuminates the limits of the application of universal models of energy security without taking into consideration the variation that exists in interpretation and institutional setups. Energy security frameworks only gain explanatory power if placed in multi-level governance and socio-political contexts. This reaffirms the usefulness of interpretivist approaches to energy policy analysis, and furthermore suggests that theoretical models used in the future should incorporate legitimacy, trust and governance capacity as fundamental components and not as peripheral variables.

7.6 Conclusion

This chapter has synthesized the empirical findings and theoretical insights of the dissertation for the purpose of assessing the role played by nuclear energy in the European Union's energy security landscape. The analysis shows that the contribution of nuclear energy in terms of strategic relevance (stability and decarbonization and long-term planning) is fundamentally limited by political fragmentation, institutional limits and fragmented societal attitudes between member states. Rather than acting as a cohesive part of energy security within the Union, nuclear demonstrates the inherent cracks between the extraordinary balance of national sovereignty and supranational co-ordination. By using multidimensional energy

security frameworks, the chapter has stressed the conditional and context-dependency of the benefits of nuclear security. These insights emphasise the importance of realistic expectations about the level of coherence at EU level and provide the analytical basis for the conclusion chapter, which summarizes some key findings and discards some implications for policy and further research

Chapter 8: Conclusion

8.1 Summary of Key Findings

This dissertation focused on the strategic role played by nuclear energy in boosting the European Union's energy security, while identifying the policy, regulatory and institutional factors which hinder its coherent integration. The findings show that nuclear energy has an inherently ambivalent position in the EU energy landscape. From a strategic point of view, nuclear power can play its role as part of long-term supply security, fossil fuel import dependency, and decarbonization targets especially for those member states who have an established nuclear capacity or structural energy constraints. These benefits were clear in the cases of France and Poland where nuclear energy comes to be presented as a tool for sovereignty, resilience and transition management.

The analysis also revealed that national nuclear strategies are deeply and persistently fragmented. The experience in Germany with the phase-out of nuclear facilities shows that the sense of risk to social security, political legitimacy and ideological commitment could be prevailing over technical or economic security reasons. The governance of EU level, only with regards to safety and waste management and market regulation, does not involve strategic choices at all, without corrupting the national competence. This consequence is that, instead of being a collusive support structure of EU energy security, nuclear energy is becoming increasingly an identity of a technology that exposes the constraints of integration. On the whole, the results attest to the conditional and situational as well as to the national political and institutional impacts of nuclear energy to the energy security of the EU.

8.2 Contributions to Scholarship and Policy

The dissertation is a contribution to the literature of nuclear energy and applies a multidimensional, interpretivist notion of energy security. Instead of elucidating the nature of energy security as a technical or economical phenomenon, the research of the study establishes that political culture, institutional power and legitimacy of a society influence the consequences

of nuclear policies. The study has also exposed the drawbacks of universal security models by adopting security notions related to sovereignty, robustness, and resilience to nuclear governance out of the socio-political reality. The article thus builds on the existing literature by applying energy security theory to multi-level governance and the view of public legitimacy.

In terms of policy, the dissertation provides a comparative evidence-based evaluation on the ongoing antagonism of nuclear power in the energy policy consultations in Europe. The case studies show that the national differences are not merely a product of the current political conflicts but rather they are ingrained in the historically disintegrating culture of ruling and trust of people. This study provides policymakers with a better insight into the structural limitations that carry out EU-level coordination by connecting the strategic pressures and the regulatory and institutional constraints. As such, the work attempts to close the gap between theoretical policy rhetorics and actualities in decision-making on nuclear issues within the European Union.

8.3 Practical Recommendations for EU Policymakers

Based on the results of this study, a number of concrete recommendations can be made for EU policy makers. First of all, expectations of a fully harmonized EU nuclear strategy should be tempered. Given the deeply- ingrained national differences in nuclear policy, efforts must be made to increase the functionality of coordination, rather than impose strategic uniformity. Strengthening EU-level co-operation on nuclear safety standards, emergency preparedness, waste issues and regulatory best practices constitute a realistic and politically feasible way forward.

Second, EU institutions need to make regulatory clarity and predictability better for nuclear-related investments. Clearer guidance on the interplay with state aid rules and market design as well as long-term financing mechanisms would decrease the level of uncertainty for both established and emerging nuclear states. This becomes especially important for new countries such as Poland where institutional capacity is still being built.

Finally, more attention should be given to transparency and participation of the public, at EU and national level. Building public trust through inclusive communications, evidence-based risk assessment and democratic accountability is essential for long term legitimacy of the nuclear related policy of any kind. While different member states will not be suited to nuclear energy, a governance structure allowing creativity and diversity, while delivering

demanding safety and accountability, would help build the EU as a whole's energy security architecture.

8.4 Limitations and Future Research Directions

Despite its contributions, this dissertation is subject to some limitations. Also, the study is based solely on qualitative documents analysis, which although appropriate for interpretive policy research cannot describe informal decision-making processes and evolving political negotiations adequately. The lack of interviews with policymakers, regulators or industry stakeholders also limits information on the dynamics that occur behind the scenes which can impact nuclear policy outcomes. In addition, the comparative case study approach, although providing depth and contextual richness, limits the generalizability of findings to countries beyond the chosen ones.

Future research could address these limitations through mixed-method research, with either expert interviews or survey data, to supplement the document-based analysis. This may help increase the comparative focus to other EU member states or non-EU nuclear countries to provide an additional insight of the influence of various governance models in nuclear policy integration. Furthermore, as new technologies (e.g. small modular reactors and advanced nuclear systems) are developed, the specifics of how innovation will impact the acceptance of the population and rules, as well as energy security calculations should be researched further. Further investigation in this area is, however, still required because of the dynamic environment of the geopolitical and climatic environment, onto which EU energy policy is unfolding.

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