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Enabling the Nuclear Renaissance: A Holistic Perspective on Adapting Licensing Frameworks for Conventional and Advanced Nuclear Power Plants

(*PhD Thesis*)

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1. Introduction

1.1. Energy in the spotlight

Energy as a commodity in recent years has garnered heightened attention in public discourse. While energy has been a significant geopolitical consideration affecting policy decisions and influencing productivity,[1] competitiveness,[2] and economic growth[3] – including our Central and Eastern European region[4] – it has in many cases been taken for granted. In fact, the structure of the European Union (EU) electricity market was built on the concept of liberalization, based on the belief in an abundant supply of energy, disregarding the importance of energy security.[5] This policy belief translated into the general public sphere as well, and when energy prices began rising in 2021 – and, after the outbreak of the Russian-Ukrainian war in 2022,[6] when these already elevated prices skyrocketed and reached record highs in August 2022 – this previously, we might even call it somewhat naive, attitude was forced to change permanently. As the importance of energy was felt directly through soaring energy bills and indirectly through inflation, a general realization emerged regarding our vulnerability, and that we have to fundamentally reconsider our relationship with energy. At this point, stepping outside the European bubble and recognizing the complexity of the energy sector, it must be emphasized that although the crisis hit Europe hard – leaving many businesses and households struggling to pay energy bills – the perception that Europe was the hardest-hit region due to its proximity to the conflict, its dependence on Russian energy, and perhaps the policy choices that had steered the EU in this direction, would be far from reality. The crisis extended far beyond Europe's borders, and its global consequences were equally severe, as shown by the International Energy Agency's (IEA) World Energy Outlook report, which found that the proportion of people lacking access to modern energy has been rising for the first time in a decade.[7] The fact that there are regions in the word,[8] where access to energy – let alone stable or clean energy – is not guaranteed is not surprising, but the fact that energy, a commodity fundamental to socio-economic development[9] (and even more so clean energy, plays an increasingly crucial role in this process),[10] has been declining in availability following the crisis reveals the true scale of its devastating impacts. However, these truly devastating effects were not predominantly experienced in Europe, and the reason lies in the fact that Europe, even if it was dependent on Russia, had the possibility to diversify its sources of supply. As experience in recent years has shown, there has been a significant shift from piped natural gas to liquefied natural gas (LNG) imports in Europe, new terminals were built, and previously unseen volumes of LNG were imported. Even if it was more expensive than the former Russian imports, Europe was prepared to pay the premium to compensate for the missing volumes. This premium price, which Europe was willing to pay to meet its energy needs, meant that the now highly valued

[1] André et al., 2023, pp. 18–21.
[2] Heussaff, 2024.
[3] Zhao et al., 2023.
[4] Gradzewicz et al., 2024.
[5] Cardinale, Cardinale and Zupic, 2024.
[6] *Electricity and gas hit record prices in 2022*, 2023.
[7] IEA, 2022b, p. 29.
[8] Agoundedemba, Kim and Kim, 2023.
[9] Zhang et al., 2019, pp. 223–231.
[10] Abbas et al., 2023.

LNG shipments – previously sold at lower prices in other parts of the world – were redirected towards Europe. The fact that Europe managed to resolve its energy needs was a positive development, even if it carried financial burdens. However, from the perspective of the original destination countries – especially developing nations – which used to receive these LNG shipments, this meant that they were deprived of their anticipated imports, as competing with the heightened prices offered by Europe was not an option. This disruption of usual supplies – although these countries were not directly affected by the conflict – evidently had devastating consequences, far more severe in the short term than in Europe. As a result of the shortages in energy supplies, which these countries were unable to fully mitigate immediately, massive power and fuel shortages occurred in countries such as Pakistan and Bangladesh.[11]

The events of the energy crisis related to the Russian Ukrainian war and more recently to the conflict surrounding Iran have shown how fragile the globalized energy sector is, and how the external dependence of one region can have global impacts due to its delicate interconnectivity. This realization, concerning the need to overcome such hurdles and to build more resilient energy sectors, was a catalyst for legal scholarship to engage more deeply with these issues and to direct greater attention towards energy law beyond the attention that has been targeted to it regarding the decarbonisation efforts. The reason why the author embarked on researching within the realm of energy law stems from this very realization and thus this work naturally aims to address a matter which can may also contribute to a more resilient energy sector.

1.2. What is energy law?

Before discussing the nuclear law subject of this thesis, it is imperative, given the specificity of the broader branch of energy law to address how this field differs from other areas of law, as this distinction has a significant impact on this work and is crucial for its proper understanding. Energy law, although its foundations go back to the 19th century with legislation governing the coal and oil sectors – by the end of the century legislation on secondary energy sources had already appeared, with Hungarian regulation being among the pioneers[12] – has been falsely understood by many as an area that emerged recently.[13] This field, despite its existence for quite a long time, did not for many years evolve into being considered a separate branch of law, however scholars – exemplarily of them Professor Adrian Bradbrook – have argued for why energy law should be regarded as a distinct legal discipline based on social and jurisprudential considerations.[14] In the last decade, the question of whether energy law is a separate branch of law has begun to be debated less, but in reality its distinction as a separate branch of law besides acknowledging its particular traits is primarily a consideration for developing legal curricula.

"Energy law concerns the management of energy resources" is the definition offered by one of the most prominent scholars in the field, Professor Raphael J. Heffron, but he immediately contextualizes it by stating that this simple definition conceals one of the most complex areas of law.[15] In understanding this definition we need to address its terms first energy sources. This is a broad concept which includes primary energy resources such as coal, oil, gas, but also

[11] Varadhan, Bukhari and Paul, 2023. Sullivan, 2022.
[12] Szuchy, 2021b, pp. 1–7.
[13] Heffron and Talus, 2016b, pp. 2–3.
[14] Bradbrook, 1996, pp. 193–217.
[15] Heffron, 2021, p. 1.

secondary ones such as electricity. The concept of management is equally broad and should be understood to encompass the entire lifecycle of energy resources – from extraction to end use – covering the upstream, midstream, and downstream stages. Furthermore, it should be interpreted even more expansively to include activities such as energy efficiency, which represents a specific form of management. The body of laws governing the wide-ranging aspects of energy resource management cannot be regarded as a single overarching legal regime applying uniformly to all energy sources; rather, energy laws typically address specific resources, and the concept of energy law denotes the collection of these distinct legal regimes which, taken together, regulate the various sources and their management.[16]

Although the scope of energy law and its general definition can be understood from this concept, Professor Heffron also cautiously notes that it is one of the most complex areas of law. But why is this so? The understand the unique complexity of this field its specific and common denominators have to be addressed which also provide further justification for recognizing it as a distinct legal discipline. Scholars have concisely summarized these characteristics, and to contextualise some of the themes of the thesis the author will provide a brief elaboration on these.[17]

The first specific common denominator of the field is its problem-based approach. This approach stems from the fact that energy law is a highly practical branch of law, designed to address real-world problems arising from the management of energy resources. It is a field in which values and theoretical considerations may be less fundamental than in other areas of law, although there is a growing tendency toward developing these aspects.[18] Professor Huhta also characterizes energy law as inherently dynamic and responsive to developments in the sector, a quality that stems from its close connection to rapidly evolving technologies. The author fully agrees with the first observation, although some scholars argue that the reactive nature of the field should ideally be reconsidered. However, the generally dynamic – although this may also depend on the definition of dynamic – character of energy law is not always evident in the management of all energy sources, as is best illustrated by the historical development of the nuclear sector. Even though technology often evolves rapidly, the law – due to conflicting interests that may override taking benefits of potential technological advancements – is sometimes unable to keep pace with what is technologically feasible, despite arguments that one of the primary objectives of energy law is to adapt to these developments.[19] In this sense energy law which can be understood as an enabling condition for capitalizing on technological developments is dynamic to the point the conflicting interests associated with that particular technological solution allow it to be. As such the highly politicised nature of the sector cannot be disregarded.

Very closely connected to the aforementioned problem-based approach, another distinctive feature of energy law and its subdisciplines is their inherently interdisciplinary nature. Energy law is not developed in a legal vacuum. The subject matter of this field does not allow for such an isolated approach, as the management of energy resources involves highly complex issues spanning technological, economic, political, environmental, and societal considerations. The

[16] Heffron and Talus, 2016b, pp. 2–3.
[17] Huhta, 2021, pp. 204–209.
[18] Heffron, McCauley and Sovacool, 2015, pp. 168–176.
[19] Fleming, 2019, p. 164.

differing interests of these disciplines often give rise to conflicts, and resolving these conflicts is ultimately translated into legal provisions. Energy law scholars who confine themselves solely to legal analysis risk overlooking the broader context within which the legislation operates. As Professor Huhta has also observed, energy law scholars frequently draw upon research from other fields, where non-legal experts make crucial contributions touching upon issues also affecting legal considerations. Ultimately these interdisciplinary factors and the resolution of their conflicts take shape in legislative frameworks as such one when delving into analysing the ways for future developments also must look at these interdisciplinary influencing factors. What this means for this thesis is that there is a certain level of interdisciplinarity to this work and many of the sources consulted come from outside the legal field, which phenomenon is especially present in the very technical nuclear sector where non-lawyers also engage with legal issues and where legal scholarship besides the limited number of works is lacking. While the thesis will remain focused on law, interdisciplinary perspectives will be incorporated for the sake of clarity and contextualisation.

A third defining feature of energy law is its distinctive balancing function, which extends beyond merely reconciling legal interests. As noted in connection with the interdisciplinary nature of energy law, the various fields it intersects often present conflicting interests, and sectoral legislation typically reflects how these competing interests have been managed. Although not exhaustive, these interests are often framed within the so-called energy policy trilemma, which guides energy policy-making and is subsequently translated into legislation. The trilemma encompasses three core considerations: environmental (e.g. sustainability), economic (e.g. competitiveness), and security of supply. In practice, the weight of these considerations differs across regions and over time, and they are not always equally prioritized. This was clearly demonstrated during the European energy crisis, where prior to the crisis environmental and economic considerations tended to outweigh security of supply concerns, whereas the crisis radically shifted this balance, placing security of supply above economic and environmental priorities. Staying true to the problem-solving nature of energy law, this thesis will also repeatedly seek to address such potential conflicting interests not only with regards the general concept of the nuclear renaissance, but also in relation to how licensing frameworks can incorporate efficiency considerations and also technological advancements while not compromising safety.

As argued by Professor Bradbrook in his work,[20] energy law is an applied branch of law that draws upon other, more traditional legal disciplines – such as contract, environmental, or administrative law – to resolve issues, and therefore requires a solid understanding of these fields to navigate its depths.[21] As previously noted, due to its problem-based and reactive nature, energy law is not defined by the scope of its legislation but rather by the problems it seeks to address concerning the management of energy resources.[22] Energy law is difficult to categorise: many legal disciplines influence it, and it cannot be placed solely within either public or private law; instead, it represents a hybrid of legal disciplines.[23] However, this hybridity does not mean that there is no tendency within energy law to develop its own principles independently from

[20] Braadbrook, 1996, pp. 193–217.
[21] Heffron et al., 2016, p. 350.
[22] Huhta, 2021, pp. 206–207.
[23] Ibid.

other fields.[24][25] This influence of other legal disciplines of energy law is very much true in the case of nuclear law, as will be presented in this thesis, where many other branches of law – such as environmental law and administrative law – will be touched upon in relation to the problems that this work raises and seeks to answer.[26]

The specialty of energy law as the broad subject matter of this work may now be sufficiently outlined for the reader's understanding, and as mentioned, these considerations are likewise applicable to its subbranch, nuclear law to which we can now turn our attention.

1.3. What is nuclear law?

As mentioned, energy law is composed of laws that govern the management of specific energy resources. Accordingly, we can distinguish subbranches of energy law along the lines of these particular resources.[27] As with energy law, we must begin the elaboration on nuclear law with a definition. Using the energy law analogy, we might say that nuclear law concerns the management of nuclear energy, however, if we wish to use a more sophisticated definition, we can refer to the one provided in the Handbook of Nuclear Law, which defines nuclear law as: "the body of special legal norms created to regulate the conduct of legal or natural persons engaged in activities related to fissionable materials, ionizing radiation and exposure to natural sources of radiation."[28] The definition is, in principle, a wordier version of the energy law definition, with a focus on nuclear energy, but it also includes specific considerations regarding the subject matter of this field, which is well reasoned, but also instantly presents us the interdisciplinarity of this branch with its terms. The subject matter includes fissionable materials, which are nuclides whose atoms can be split by either fast or slow neutrons.[29] Secondly the definition also covers ionising radiation, which, unlike non-ionising radiation, is more energetic and can cause changes in living cells, which, besides its benefits, can also cause harm.[30] The final element of the subject matter relates to exposure to natural sources of radiation, which can be cosmic or terrestrial in origin and generally exceeds the public's

[24] Heffron et al., 2018, pp. 34–48. Some even prescribe this as a task of energy lawyers "All energy law scholars need to move the discipline forward and consider the theoretical development of energy law, rather than to bring theory from other areas of law to focus on specific problems." See Heffron and Talus, 2016a, p. 14.

[25] In this regard, an interesting question arises as to whether the principles of its sub-branches could contribute to establishing the theoretical foundations of energy law, or whether such principles vary too greatly from one energy source to another. Yet, as energy law cannot be detached from the specific attributes of the energy sources it governs, accepting the existence of sub-variations of principles does not necessarily contradict the individualisation of energy law as a separate discipline.

[26] Besides these four principles, Professor Huhta also identifies a fifth one: multilevel governance and institutional fragmentation, which is generally characteristic of energy law. However, regarding international governance, significant reluctance still exists due to sovereignty implications – particularly in certain areas of nuclear law, such as installation safety. Nevertheless, these attributes are also applicable to other fields of law and are well understood, thus not warranting further elaboration here.

[27] However, it must be noted that not all legislation fit into these divisions and may affect the management of multiple resources. Thus, when discussing nuclear legislation, we will frequently come across legal sources that are not specifically intended for the nuclear sector yet still govern aspects of nuclear energy management. Consequently, even though this work will focus specifically on nuclear law and its particular segment, it will also regularly refer to sources that are not nuclear-specific.

[28] Stoiber et al., 2003, p. 5.

[29] *Fissionable material*, 2021.

[30] *Ionizing radiation*, 2021.

exposure to artificial sources, although its extent depends on many factors.[31] In relation to natural exposure there is more limited scope for legislative action, nonetheless regulatory measures can address long-term exposure, controlling radiation in drinking water,[32] such as under the Euratom Drinking Water Directive,[33] as well as managing radionuclides present in buildings.[34] One aspect of this definition that must be highlighted is its use of the term regulation. In this sector, regulation aims to manage and balance the risks associated with the use of nuclear energy, which originally arose from military applications,[35] but later expanded to include the protection of individuals and the public, as well as the environment from accidents, alongside the considerable benefits it can provide.[36] This dilemma in the sector – where significant benefits coexist with substantial risks, whether in relation to weapons,[37] or installations – fundamentally affects the sector being also the original motivation to embark on the adopting international instruments,[38] as a common intention to balance these interests was desired by all states. Furthermore, through the famous Atoms for Peace[39] speech of Dwight D. Eisenhower it also contributed to the establishment of international organizations that continue to follow this mandate today.[40] Nuclear law seeks to manage the challenging prospect of both benefits and risks and sets as its objective to establish frameworks which allow for harnessing benefits while protecting from potential harms.[41] While in this management of risks and benefits other disciplines such as engineering play a crucial role this doesn't diminish the role of lawyers as the frameworks which ultimately govern these activity are shaped by them.

The development of nuclear law, as noted by Professor Lamm Vanda,[42] has been shaped by a number of factors, one of the most significant being the nuclear accidents in which cases, the balance between benefits and harms was disrupted. These events have influenced not only the evolution of nuclear law but also the general public perception of the field. Consequently, the role of lawyers – who ultimately contribute to and formalize this management by establishing frameworks for conducting activities while providing adequate (it is impossible to eliminate all risk)[43] protection – is particularly impactful in the nuclear sector. In light of the above-mentioned objective, a substantial number of principles have evolved in nuclear law over the years, which the author does not intend to list here, as they have been very well summarized and elaborated on previously, instead, when these principles become relevant to the matter at hand, they will be discussed.

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[31] Jha et al., 2024, pp. 27–72.
[32] See more: Gómez et al., 2022, pp. 198–215.
[33] Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption.
[34] *Radiation protection exposure to natural sources*, 2025.
[35] Burns, 2022, p. 57.
[36] Boustany, 1993, pp. 8–9.
[37] Nuclear dilemma as a term developed during the Cold War also refers to the fact that the immens danger that nuclear weapons pose also detered nuclar weapons states from the use of it: Niebuhr, 1963.
[38] Pelzer, 1981, pp. 34–36.
[39] *Atoms for Peace Speech. Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly*, no date.
[40] Grossi, 2022, pp. 1–27.
[41] Stoiber et al., 2003, p. 5.
[42] Lamm, 2017, pp. 31–44.
[43] Stoiber et al., 2003, pp. 5–11.

In the case of many other areas of law, such an introduction might not have been necessary; however, the observations of Professor Bradbrook regarding the position of energy law – and, as part of it, nuclear law – in law curricula that it is not part of legal studies still hold to a large extent today. For this reason, the author deemed it necessary to provide a general introduction before delving into the discussion of the topic of this work.[44]

1.4. Key definitions and concepts

- **Increasing efficiency while not compromising safety:** This delimitation is necessary because increasing efficiency is a process that can be carried out in several ways. One way is by removing requirements or establishing less demanding ones, so that the same license can be obtained by meeting easier requirements. In most cases, however – unless certain requirements are unnecessarily strict – this will not be the desired approach in the nuclear sector, since the interests guarded by these frameworks must remain protected regardless of the public interest in having more nuclear capacities installed, the same level of protection must therefore be maintained. Efficiency-increasing measures are therefore limited, and can predominantly be implemented in two ways: on one hand, they may be implemented to remove redundancies and procedural hindrances, on the other, they may be implemented to better reflect the safety concerns associated with a given plant, which, due to less significant potential negative consequences, may justify less demanding requirements and evaluations. The underlying principle is that the renaissance cannot be achieved by lowering overall nuclear safety in order to increase efficiency, this is a trade-off that cannot be supported, as it would itself ultimately lead to the demise of the renaissance concept.
- **Small Modular Reactors (SMRs)**: The International Atomic Energy Agency (IAEA) uses the following definition to categorize SMRs: SMRs are advanced reactors that produce electricity of up to 300 MW(e) per module.[45] The categorization of these advanced technologies however should not solely be based on their size as it could lead to false conclusions such as excluding the Rolls Royce SMR since it has 470 MW(e) output,[46] or including Indian reactors with an output of 220 MW(e) in the scope of SMRs.[47] Nevertheless, their generally smaller size is an important feature that can help countries with weaker transmission systems to address transmission constraints by decentralising electricity generation.[48] In addition to defining ‘small’, the terms ‘modular’ and ‘reactor’ also need to be addressed. The modularity of SMRs refers to multiple attributes. Firstly, compared to conventional plants, these reactors are predominantly fabricated in a factory environment – which promises better oversight, quality and, consequently, overall safety, while also increasing efficiency – and then assembled on site reducing construction time,[49] which in case of conventional plant

[44] Braadbrook, 1996, pp. 193–217.
[45] Liou, 2023.
[46] *Rolls Royce SMR*, no date.
[47] Srinivasan et al., 2005, p. 5185.
[48] Jamwal, 2024, pp. 4–6.
[49] Pedraza, 2017, pp. 14–15. IAEA, 2021b, p. 82.

takes a staggering 85 months.[50] Secondly, modularity also refers to the ability to connect individual modules together to achieve higher capacities if needed, allowing them to better fit their intended purposes. Regarding the term 'reactor', their unique design features differ from those of conventional plants. According to the IAEA there are around 127 designs currently in development[51] which is a huge increase compared to what was experienced in case of conventional technologies. Ultimately, the number of designs is less important than the scale of the different technologies used by SMR designs compared to conventional technologies.[52] The number of companies developing SMRs is incomparable to the situation with conventional plants, as is the range of countries involved.[53] What is more the proposed novel applications proposals, such as locating these plants in populated areas for heat generation purposes,[54] deploying them on floating platforms, making them transportable or placing sealed reactor designs that do not require refuelling underground – resulting in increased security and greater resistance to non-proliferation[55] – further distinguish them from conventional technologies. While this surplus of designs and solutions presented by SMRs is beneficial for finding the best solution for a given application – such as desalination, hydrogen production, or heat generation – it also creates deployment challenges.

- **Prescriptive regulatory approach:** In the case of the prescriptive philosophy, the rules that have to be met by the licensee are established in detailed guides or standards which also contain the path how these provisions have to be met. The requirements in front of the licensee, and how these can be met are well determined, providing the regulatory bodies with task to determine whether these have been respected or not.[56]
- **Goal-setting/performance-based approach**: Such a system defines general safety objectives that must be met and entrusts the licensee with determining how to achieve them, omitting specific technical methods,[57] and thus offering greater flexibility licensee when presenting the safety case of the installation.
- **Graded-approach:** A graded approach entails conducting regulatory oversight, including licensing, in a manner where the level of regulatory requirements, documentation, analysis, and measures for ensuring safety and verification are commensurate with the likelihood of hazards and their possible consequences.[58] The graded approach aims to align the regulatory burden proportionally with the hazards.[59]
- **Emergency planning zones (EPZs):** These zones are established for the protection of the people and the environment in the cases of radiological emergencies.[60] These EPZs

[50] IAEA, 2021b, p. 82.
[51] NEA, 2025b.
[52] Vujić et al., 2012, p. 289.
[53] Pedraza, 2017, p. 31.
[54] This could be the result of increased safety features and thus reduced EPZ and exclusion zones. See: Hummel et al., 2020, p. 2.
[55] Zohuri, 2019, p. 101.
[56] IAEA (2005), p. 6.
[57] Söderholm, 2013, p. 75.
[58] Stevanka and Chvala, 2024, p. 13.
[59] IAEA, 2021c, p. 32.
[60] Rosa Blul, 2021, p. 1.

are areas established around nuclear power plants where certain actions have to be performed in cases of radiological emergencies.[61]

- **Generations of nuclear power plants:** Nuclear power plants have gone through several generations since their initial deployment, and their classification is tied to their safety features. Generation I. reactors were the first commercial reactors, deployed in the 1950s and 1960s, based largely on those developed for military use, and generally lacked safety features. Generation II. reactors began to be deployed from the 1960s onwards, these were designed specifically for civilian use and also incorporated safety features. These plants make up most of the currently operational nuclear power plant fleet. Generation III. reactors, incorporating lessons learned from nuclear accidents, began to be deployed in the second half of the 1980s, featuring more sophisticated safety systems, higher efficiency, and, in some cases, passive safety features that do not require active human or technical intervention to function. Generation III+ reactors, currently on offer, do not constitute an entirely new generation, as their designation suggests rather, they seek to make nuclear power plant construction more competitive by simplifying designs and reducing construction costs without compromising safety.[62] The next generation of reactors, currently under development, are Generation IV. reactors, these in cases employ significantly different designs from what is currently available and promise better economics, greater safety, higher efficiency, and less waste.[63]

1.5. Nuclear renaissance

Following this general introduction to the subject area of the thesis, we can now turn to the specific focus of this work. The underlying hypothesis is the concept of the nuclear renaissance.[64] Briefly described the term nuclear renaissance refers to the prospect of deploying increased nuclear capacities for electricity generation and for other potential applications. This proposition of expanding capacity and its proposed forms of implementation is very exciting for anyone interested in the energy sector, but why is that? After the Second World War, nuclear energy was widely perceived as the energy source of the future. Extensive scientific research was devoted to it, and several international organizations were established to promote its peaceful use such as the IAEA in 1957, the OEEC's Nuclear Energy Agency (predecessor of today's OECD NEA) in 1958,[65] and, as the founding fathers of the European Community saw great potential in its use, the European Atomic Energy Community (Euratom) was created with Treaty Establishing the European Atomic energy Community.[66] However, despite this early interest and optimism, the momentum of nuclear energy expansion was halted after a few decades, with its share in global electricity generation peaking around 1996.[67] While electricity production from nuclear in TWh for certain reasons continued to increase until the early 2000s,

[61] Kubanyi et al., 2008, p. 12.
[62] Reinberger, Ajanovic and Haas, 2019, pp. 243–251.
[63] Ibid. pp. 252–253.
[64] Explained in detail in a later chapter.
[65] *History of the NEA*, no date.
[66] Wolf, 2011, pp. 1637–1638.
[67] *Mapped: The words nuclear power plants*, 2016.

it has generally stagnated since then.[68] Financial aspects, such as the exceptionally high upfront investment costs,[69] safety concerns stemming from nuclear accidents,[70] and environmental issues – most notably the still-unresolved question of permanent nuclear waste management even in the most nuclearized states,[71] – have all contributed to declining interest and, in some cases, strong opposition toward nuclear energy.[72] All these factors, despite the occasional optimism of some scholars and members of the industry, led to a broad consensus that nuclear energy had no real future. Research in the sector increasingly shifted to analysing phasing out plants and waste management.[73] Consequently, the mere idea that this general consensus might no longer hold is intriguing and opens the door for valuable research analysing what obstacles may exist before this expansion and what enabling conditions – among them legal ones – are needed.

The challenges of the nuclear renaissance are complex and interdisciplinary, ranging from economic questions of how to secure funding for these projects to educational concerns about ensuring an adequate workforce, as well as technological and, of course, legal issues. The legal challenges are themselves also wide-ranging, appearing at both the international and national levels. Even though this is an interdisciplinary field, certain delimitations must be made, and as a law thesis, the focus has to be on legal matters. Among these legal challenges, a selection also has to be made based on the following question: what are the major legal obstacles to a nuclear renaissance? On this basis, the scope has been narrowed, leaving out matters such as contractual solutions or financing, which are negotiable and more flexible thus they do not inherently constitute institutional obstacles, – nevertheless, certain implications of such matters relevant to the topic will still be discussed. Based on this question from the legal enabling conditions which are needed to succeed with the nuclear expansion licensing implications emerged to be in this focus of this work.

1.6. The concept of licensing

A licence is a formal authority to carry out something that would otherwise be unlawful.[74] These procedures are not merely bureaucratic hurdles but serve a dual purpose: on the one hand, they grant authorisation to carry out a given activity; on the other, they protect the various interests that may be affected by such projects. If an activity had no benefits, no licensing, but a prohibition would be needed, while if it posed no risks or hazards, a licence would be equally unnecessary. Licences can go by several names, such as permits or authorisations, and this work will not approach the concept of licensing in a strict manner, tying it only to those instances that are formally labelled as such. Instead, the work will approach licensing from a functional perspective, discussing issues that, in effect, constitute an evaluation protecting certain

[68] *Trend in Electricity Supplied. Sum of electricity supplied from reactors connected to the grid*, no date.
[69] Robock, 2016, pp. 515–519.
[70] Ramana, 2011, pp. 43–51.
[71] Bell, 2022.
[72] Weish, 1988.
[73] During the International School of Nuclear Law (ISNL) the general consensus a few years ago was that nuclear energy does not have a future, students were principally interested in the legal considerations of decommissioning and nuclear waste management, however during the 2023 (ISNL)l it changed students were rather interested in other matters such as the deployments of new plants.
[74] Burns et al., 2022, p. 174.

interests, and that result in decisions without which a specified activity cannot be conducted.[75] Licensing unarguably bears particular importance in the nuclear sector. In the nuclear field, there is a so-called permission principle, which – considering the risks associated with the use of nuclear energy – generally requires some form of authorization before any activity can be conducted,[76] meaning licensing is an institution that all projects face. Licensing falls within the remit of national authorities there are no international licensing authorities, nor is there an international legal framework governing licensing,[77] meaning that these procedures and their requirements differ from one country to another. Licensing processes are complex and lengthy and follow the various different lifecycle stages – such as siting, design, construction, commissioning, operation, decommissioning – of nuclear power plants in a cradle to a grave manner. Despite the same lifecycle stages the architecture of nuclear safety licensing systems varies across jurisdictions. Some states adopt a single-step licensing model whereby a unified licence encompasses the siting, construction and initial operation of the plant. Others opt for a segmented or staggered regulatory approach, issuing distinct licences at each significant stage of the project's progression. Although no universally applicable model can be prescribed, the IAEA generally supports the staggered approach to licensing, recognising that it affords enhanced regulatory oversight and enables the competent authority to engage in a continuous evaluative process.[78] Nevertheless, proponents of the single-step model argue that the holistic assessment of all relevant factors within a consolidated procedure permits a more integrated and potentially better-informed regulatory determination.

As the IAEA puts it, the licensing process is an ongoing dialogue between the applicant or licensee and the regulator, whereby authorisations have to be obtained before progressing to the next stage, thereby providing the opportunity to flag concerns in time.[79] At their core lies the objective of ensuring nuclear safety, and regulators may at any point request additional information or demonstrations, which can ultimately lead to halting construction, redesigns, or even rebuilding.[80] Besides these comprehensive facility-level licences, separate licences may be required, within the nuclear sphere, for the manufacturing, construction, or operation of certain safety-important components or systems, which can be very numerous in these projects.[81] In addition to nuclear-safety-specific licensing procedures, several other licensing procedures may be associated with such massive projects, required by laws governing areas other than the nuclear field specifically – such as urban planning, general environmental permitting, which may incorporate environmental impact assessment procedures, water usage permits, or general energy-related licences. Given the multitude of licences involved, it would be impossible to cover every licensing-related aspect of these projects within a single thesis, therefore since the thesis is situated in nuclear law, nuclear-specific licensing procedures will remain its primary focus. Nonetheless, to illustrate one of the reasons why a comprehensive perspective is needed towards licensing at the time of the renaissance, certain other licensing

[75] IAEA, 2023, p. 5.
[76] Stoiber et al., 2003, pp. 7–8.
[77] However, requirements of having licensing procedures in place exists in the Convention on Nuclear Safety the Joint Convention or the Nuclear Safety Directive.
[78] IAEA, 2023, pp. 27–28.
[79] IAEA, 2023, p. 6–7.
[80] Mignacca, 2020.
[81] Engedélyezés, no date.

procedures will also be discussed, highlighting the complexity of the deployment frameworks and showing how these other licences interact with nuclear-specific procedures, and what decisive effect they may have on their course. One specific aspect to be discussed, with regard to the current legal frameworks governing conventional nuclear power plant deployments, is how EIA procedures are integrated with, and interact with, the nuclear safety licensing procedures.

Since this work is situated within the context of the renaissance, licensing considerations are examined through the lens of how these procedures may contribute to its materialisation. As the renaissance will – if it takes place – have several pathways materialising the thesis will also aim take a holistic view of licensing procedures during the nuclear renaissance, covering the licensing implications across these different pathways. In this respect, the thesis will cover three areas, with particular attention directed to the first two, as these can truly contribute to the nuclear renaissance in the sense of expanding nuclear capacities.

1.6.1. Licensing conventional nuclear power plants in a nuclear renaissance

The first topic that the thesis covers concerns the deployment of conventional nuclear power plants. While the most frequently discussed drivers of the nuclear renaissance are advanced nuclear power plants – particularly SMRs – the potential expansion is by no means limited to them. Generation III+ and IV conventional large-scale nuclear power plants may play an equally important role by multiplying their current scale of deployment. In relation to conventional plants, the existing international legal framework – having been developed with these types of plants in mind – does not set an outright barrier in front of their deployment. Moreover, while greater harmonisation or enhanced regulatory cooperation could facilitate their deployment, these are not as crucial for conventional technologies as they are for advanced ones. Rather, in their case, the primary focus of this thesis will be on current national licensing frameworks, with the goal of uncovering how the different national pathways operate, and whether redundancies can be identified and best practices drawn from their comparative analysis, with a view to identifying how these procedures may be further streamlined while maintaining nuclear safety. Despite these frameworks having been developed to host large-scale plants, over the past decades they have predominantly evolved with a view to increasing safety rather than achieving greater efficiency in these procedures, as such it is a topical issue to be discussed in order to provide a suitable climate for increased deployments. The subjects of this will be the Hungarian the Finnish and French, licensing systems. The reason why this selection of countries was made will be discussed in the section pertaining to this topic.

1.6.2. Licensing advanced nuclear technologies in a nuclear renaissance

The second major topic of this work focuses on advanced nuclear technologies, particularly Small Modular Reactors, – their detailed definition is provided in the definitions section – which are currently the most prominent in public and policy discourse as manifestations of the future of nuclear energy. These reactors bring a number of notable innovations over conventional technologies that have drawn increasing attention in recent years. While large nuclear power plants remain valuable assets in national energy mixes by providing significant baseload power, the challenges associated with them – such as high initial costs, siting

difficulties, and the need for robust electricity grids to absorb their output – have pushed developments toward SMRs. Advanced technologies and among them SMRs face several challenges some overlapping with conventional technologies and some peculiar to them. Among the legally relevant deployment challenges, licensing stands out as a paramount issue in their case, which relates to the novel attributes.[82] One of the key questions this thesis intends to address is which features of SMRs make their licensing difficult, and why current national licensing frameworks are, in some cases, ill-equipped to adequately license these reactors which ultimately threatens their economics. In addition to examining the challenges SMRs pose to national frameworks, this thesis will also explore regulatory approaches that could help mitigate these obstacles also not compromising nuclear safety. While the regulatory solutions proposed in this work could be implemented on a nation-by-nation basis, many authors and industry experts have argued that certain features of SMRs – such as the unprecedented variety of designs compared to conventional technologies,[83] and their standardised deployment potential – call for greater harmonisation of regulatory frameworks to fully harness the benefits of these innovative reactors. Consequently, this work will also consider how increased international cooperation could support the efficient and safe deployment of SMRs. However, before turning to the licensing considerations of SMRs, one other crucial legal question must be addressed first: the applicability of the international nuclear law framework to SMRs. Although this topic may seem to fall outside the licensing-focused scope of this thesis, a more holistic perspective on licensing would also need to account for these international instruments as they are the foundations of licensing procedures, and they represent some of the basic considerations appearing in these procedures. In addition, if the instruments of the international nuclear law framework – which were established as minimum standards for the sector – do not clearly cover SMRs, or if open questions remain about how they apply to them – with significant practical implications, such as liability amounts – public confidence in these reactors could easily be undermined hindering the whole prospect of their deployment. Very few studies have examined this issue comprehensively,[84] and if they did, they have generally not offered proposals for resolving interpretative challenges beyond making conclusions based merely on textual treaty analysis. The thesis will first examine the main international legal instruments governing the nuclear sector, the application of which could have serious implications for the deployment of advanced nuclear technologies, highlighting those provisions which – having been drafted without foreseeing the emergence of such reactors – could potentially raise interpretative questions regarding their applicability to advanced reactors. The analysis will go beyond merely identifying and categorising these challenging provisions – the author will also explore how these questions of scope could be resolved, considering solutions already proposed in the literature,[85] as well as other possible interpretative avenues that might exist to keep these treaties alive despite the changing circumstances.[86]

[82] Ramana, Berzak Hopkins and Glaser, 2013, pp. 555–564.
[83] Vujić et al., 2012, pp. 289–295.
[84] Van Kalleveen, 2022.
[85] Nriezedi-Anejionu, 2024.
[86] Moloo, 2012, p. 261.

1.6.3. Authorising long-term operation in a nuclear renaissance

The final aspect of the nuclear renaissance that this thesis seeks to address under the holistic perspective to licensing is long-term operation. While the deployment of new nuclear power plants – whether conventional or advanced – appears to be a promising prospect within the nuclear renaissance, it will still take considerable time before these plants become operational, even if licensing procedures and construction practices are made more efficient and streamlined. Consequently, one option that nuclearized states will need to consider, should their interest in nuclear energy be renewed, is the long-term operation of their existing nuclear power plants. Long-term operation refers to the comprehensive safety assessment of nuclear power plants that allows them to continue operating beyond their originally intended design lifetime.[87] Long-term operation is also a complex matter in the context of a nuclear renaissance involving economic, social and long-term energy policy planning considerations.[88] Such decisions also entail legal aspects in the form of licensing procedures or periodic safety assessments, but are further shaped by other processes, such as environmental assessments, which significantly influence their course.[89] In this part, due to the fact that long-term operation serves a different purpose in the nuclear renaissance compared to the two other topics of the thesis – as it is unable to contribute to the expansion – the analysis will be limited to addressing some of the most pressing legal considerations of long-term operation that may appear in its authorisation.

1.7. The main research questions

Viewing the licensing implications of the nuclear renaissance in a holistic manner, the thesis raises research questions that apply equally to each of the topics discussed, helping to clarify both the current state of affairs and the ways forward. In this spirit, the first research question is: in what aspects do licensing frameworks hinder the materialisation of the nuclear renaissance, and where might they pose an obstacle to it? The second question, which builds on the outcomes of the first, is: how can licensing frameworks be transformed to become more enabling of the nuclear renaissance, without compromising the safety of these installations? As noted, whether in relation to the licensing of conventional plants, the licensing of small modular reactors, or the authorisation of long-term operation, the same research questions apply throughout, as the notion of the renaissance – materialising in each case differently – demands an evaluation of current practices and a reconsideration of them to enable its manifestation. The analysis of these three complex matters through the lens of these two research questions aims to provide a comprehensive perspective on the key licensing related obstacles that will be faced in the nuclear renaissance, while also offering valuable *de lege ferenda* suggestions, insights into exemplary regulatory solutions, and international initiatives that aim to overcome these hindrances and obstacles. However, before discussing these questions in the context of the pathways of the nuclear renaissance, the thesis first seeks to answer what the nuclear renaissance is, and whether it is realistic today to discuss its enabling conditions. In addition, a particular research question appears in relation to the section on how international legal frameworks may cover advanced nuclear technologies. While the logic of this particular

[87] NEA, 2021a, p. 13.
[88] NEA, 2019.
[89] Sexton Nick, 2022, pp. 7–26.

research question may be similar to what is asked in the case of licensing procedures, the same questions cannot be asked here, since these instruments are not licensing frameworks themselves, but rather establish the need for such procedures, define certain elements to be incorporated into them, and generally stand as requirements for developing nuclear programmes.[90] As such in their case the particular research question is how these fundamental instruments of international law governing the nuclear sector may conflict with the advanced nuclear technologies or give rise to open questions and how the rules of interpretation may contribute to resolving these issues in due course? The thesis by carrying out the challenging task of seeking to answer these timely questions will – as seen from the preceding elaborations – remain true to the nature of energy law as a broad discipline, placing a problem-based approach at its centre to resolve practical issues, embracing its inherently interdisciplinary character, and constantly balancing the interests of successful deployment against competing considerations such as safety, security, and environmental protection.

1.8. Methodology

The thesis employs various methodologies, some of which correspond to specific sections, while others were applied throughout the work more generally.

The first among the general methods is the interdisciplinary approach, which extends beyond a technological background into several other fields. One of the key interdisciplinary aspect of this research is that a significant portion of the scientific literature drawn upon is not strictly legal in focus, but rather concerns various other fields that ultimately shape the relevant legal frameworks. In many cases, this interdisciplinary character involves technological and engineering questions. The subject matter is such that the current legal framework and potential future solutions cannot be properly understood without at least a basic grasp of the technology involved. For example, to understand why nuclear energy may be viewed favourably in the context of energy security and the green transition, one must understand the attributes of this source with regard to its emissions profile and supply chains – and this holds true throughout the following sections of the thesis that discuss different issues. This interdisciplinary approach is particularly relevant in the case of SMRs, whose licensing challenges, as well as their fit within the current international legal instruments governing the nuclear sector, cannot be properly assessed without first comprehending the technology behind SMRs and how it fundamentally differs from that of conventional plants. Besides the technology related questions interdisciplinarity further extends to economics and energy policy, both of which exercise a fundamental influence on the trajectory of the nuclear renaissance. From an economic perspective, such interdisciplinary analysis is not only essential for assessing whether nuclear energy represents a financially viable option in respect of other energy sources in the green transition, but it is even more so relevant from a licensing perspective given that licensing reforms partly aim to enhance the financial attractiveness of the technology. Energy policy considerations, particularly when examining the underlying rationale for the revival of nuclear energy, are likewise deeply interdisciplinary in nature.

[90] Although well-known exceptions exist of nuclear programmes that were not subject to these regimes, but especially in a European that is not the case now.

As a second general methodology, the thesis adopts a strong doctrinal approach, within the framework of which it interprets international, community and national legislations, legislative proposals governing the licensing of nuclear power plants. As part of this doctrinal approach, the thesis employs analytical methods to examine the motivations underlying certain regulatory approaches and to evaluate the extent to which they may impede or support the materialization of a nuclear renaissance. The thesis seeks to refrain from being merely descriptive, however, the sections dealing with the different national licensing regimes currently in force inevitably contain some descriptive elements. These sections nonetheless serve as the basis for later comparisons and analyses, and while some parts are primarily concerned with presenting the current state of affairs in nuclear licensing procedures, they still retain scientific relevance, as they interpret the legal labyrinth surrounding the licensing of nuclear power plants.

Among the methods that appear in given sections of the thesis the comparative methodology can be highlighted. This methodology is primarily reflected in the sections discussing how the licensing of nuclear power plants is regulated in the three analysed countries, from the initial political decision to embark on such projects to the commencement of initial operation. Through this comparative approach, the thesis demonstrates the different licensing stages and regulatory methods that exist across jurisdictions, presents the various efforts undertaken to streamline these procedures, and evaluates the benefits and shortcomings of both the existing licensing frameworks and the streamlining efforts from the perspective of a potential nuclear renaissance, highlighting which solutions may be regarded as effective tools for facilitating and streamlining licensing procedures.

Furthermore, certain sections employ additional methods of legal analysis, such as interpretative and historical approaches. The methods of interpretation appear with particular relevance in case of addressing how the international legal instruments governing the nuclear sector may cover SMRs. Moreover, in various segments, the thesis utilizes historical methodology to present the broader development of the nuclear sector in order to contextualize the current state of affairs and the developments associated with the nuclear renaissance. Similarly, historical analysis is employed in the presentation of the selected national profiles to demonstrate why these states may be regarded as mature nuclear nations and how their regulatory frameworks have evolved over time. Beyond these approaches, the thesis employs an additional method closely tied to the doctrinal approach, the formulation of *de lege ferenda* proposals. For each of its major parts, the thesis seeks to offer suggestions on how the existing legal framework could be improved to better facilitate the implementation of nuclear expansion.

One methodological limitation of the research that has to be mentioned here is that it does not incorporate empirical data. As part of further research on this topic, empirical methodologies could be applied in several ways. One particularly valuable approach would be to conduct interviews with representatives of regulatory authorities or with licensees regarding what they have experienced or perceive to be the most important licensing-related hinderances and obstacles. While the absence of such formalized interviews may appear to constitute a limitation of the thesis, this does not mean that expert opinions have not been taken into account in a less structured manner. During the course of the research, the author had several opportunities to engage in discussions concerning the main research questions of the thesis. The author attended numerous international conferences related to the subject matter, where experts shared their insights and professional opinions, but in addition, he engaged in informal exchanges with

professionals in the nuclear sector both of which have significantly contributed to shaping the direction of this research. Nevertheless, the author acknowledges that a more systematic empirical approach, particularly through structured interviews, would constitute a valuable complement to the predominantly doctrinal research conducted at this stage.

2. The nuclear renaissance and its reasons

2.1. Why is it relevant to discuss the nuclear renaissance?

The term *Renaissance*, originating from French and translated as 'rebirth,' broadly refers to the historical period following the Middle Ages, during which renewed interest in classical scholarship emerged after a prolonged era of cultural decline. In the context of nuclear energy, the term has in recent years been applied to the anticipated and prospective increase in the deployment of nuclear power plants – a development that has garnered considerable scholarly and public attention.[91] The term *Renaissance* is frequently employed to describe this phenomenon owing to its conceptual plasticity. In its classical sense, *Renaissance* denotes, to a significant degree, a rebirth following a period characterized by diminished interest in innovation and learning, general intellectual stagnation, and a subsequent re-consideration of accepted truths and established knowledge moreover the emergence of new ideas. This process is often characterised as internally driven, in that the reconsideration in question arises from within rather than being imposed by external forces – reflecting a self-directed recognition that approaches previously accepted as absolute truth may warrant re-examination. In light of this understanding of the concept of *Renaissance*, some caution is advisable in how the term is applied within a nuclear context.

From the perspective of nuclear energy's role in national energy mixes, the notions of rebirth and reimagining are, to some extent, applicable to those countries that had either abandoned nuclear energy, moved away from incorporating it further into their energy mix, or scaled back its share – marking, in effect, a period of decline – and are now showing renewed interest in expanding it. However, this is by no means a universal experience, with China serving as a prominent counterexample which has been steadily increasing its nuclear capacities. Nuclear energy did not disappear, nor was it abandoned – 2018 recorded the highest electricity generation from nuclear power, and 2023 stood as the second highest, while grid connections have not disappeared either.[92] "What has occurred, however, is that since the early 1990s, the pace of reactor construction has slowed down considerably, and the subsequent growth in installed capacity has not continued at the pace observed in preceding decades. Since then, nuclear energy has been more or less stagnating, and even the maintenance of this stagnation-level capacity can be attributed to two contributing factors. First, despite the reduced number of units deployed, economies of scale have resulted in significantly larger output per unit design, and second, the sharp increase in Chinese installed capacity since the latter half of the 2010s.[93] What the stagnation of the industry has meant, however, is that against the background of continuously growing electricity demand – due to electrification – and the corresponding expansion of electricity generating capacity, the share of nuclear energy in global electricity generation has been declining since the 1990s.[94]

[91] Engagements among stakeholders focus on new plants, well represented by events such as the 2024 Nuclear Inter Iura Conference titled: "Nuclear New Build Renaissance – In Search for New Approaches to Legal Challenges and Regulatory Effectiveness."
[92] IAEA, 2024, pp. 19–21.
[93] *Nuclear Power in China*, 2026.
[94] Ritchie and Rosado, 2024.

So while there is partial truth to the narrative of decline and renewed interest, this shift has nevertheless not been driven by a genuine internal reconsideration – here understood as a self-directed realisation that earlier decisions to phase out or limit nuclear energy warrant revisiting – but predominantly by external factors that have pushed countries towards nuclear energy as a viable option, rather than by any genuine internal re-examination of previously held positions. Consequently, 'renaissance' may not, in fact, be the best-fitting term for what is happening to nuclear power's current perception in energy mixes.

When it comes to nuclear power plants as the industrial product, the narrative of the demise and revival does not hold up particularly well either. Large-scale nuclear power plants have continued to evolve, with successive generations featuring progressively enhanced safety features.[95] While one might argue that the accidents themselves represent a demise of the product, several considerations challenge this opinion. First, accidents, despite all preventative efforts, may occur in any industry, nuclear included. Furthermore, these accidents were not the result of systematic – meaning the whole sector – negligence towards safety, nor were they inherent to nuclear energy as such. Second, in practice, these accidents did not trigger a global phase-out of nuclear energy, and in those individual cases where they did, multiple other factors were equally at play that led countries to these decisions. Third, and perhaps most importantly, accidents drove innovation within the sector, advancing the development of the product itself. "It is therefore rather unjust to characterise nuclear accidents as the demise of the product – there has been no general 'dark age' for the product on offer, whether in terms of technological innovation or safety. Beyond the continuous innovation of large-scale plants, the sector has also invested significantly in research and development into markedly different reactor designs, such as SMRs. In reality, however, SMRs are not as new as one might think and what is currently presented as groundbreaking innovation had already been proposed decades earlier. Their origins go back to the very early days of nuclear power, when the US Air Force, Army, and Navy developed small reactors to power long-range bombers. Later, the US military deployed plants more closely resembling today's concept at several locations, with small civilian reactors following suit.[96] Beyond the technological concept itself, the economic advantages of smaller, standardised, factory-fabricated reactors are likewise not new.[97] Yet SMRs never quite caught on, and it is only recently – as part of the broader transformation of the energy sector, in which economic and climate obligations have narrowed the range of viable solutions to certain problems – that interest in, and investment into, technologies capable of addressing these challenges has grown considerably, driving significant research and development efforts – generally into nuclear energy, and particularly into SMRs.

Consequently, nor the interest in nuclear energy nor the nuclear industry has had a demise followed by a resurrection from its ashes, such a characterization would do injustice to nuclear energy's crucial and continuous role, and to the considerable body of knowledge and work that has been sustained alongside it – work that encompasses not only what the industry itself has produced, but also the technical and engineering research carried out at the academic level. What is rather happening is a marked increase in interest and an acceleration of development, two issues that are inherently interconnected.

[95] Reinberger, Ajanovic and Haas, 2019, pp. 243–258.
[96] Ramana, 2015, pp. 44–58.
[97] Egan, 1984, pp. 865–874.

All thing considered the renaissance in its traditional meaning of revival following a demise might not be the best fitting label to the currently ongoing processes, if however we speak about the renaissance in the sense of a boost or a push given to a stagnating field, then the term can be retained as illustrative.

2.2. The origins of the nuclear renaissance concept

Having uncovered the concept of the nuclear renaissance, it is now crucial to discuss why it is happening and what its drivers are. Before that, however, one factor of fundamental importance must be addressed: the concept of a nuclear renaissance is not itself new. According to some, it first appeared in 1990 in a news article published in *US News & World Report* under the title "Nuclear Renaissance," though it attracted little interest at the time.[98] Delving deeper into the origins of the term, one can find scientific articles that predate even this – among them one titled "The Second Nuclear Era: A Nuclear Renaissance," which argues that despite the halt in the expansion of nuclear energy in the United States, it ought not to be abandoned, given its inherent benefits and the continuous technological development capable of addressing issues such as safety and public acceptance.[99] Yet even this may not represent the true conceptual origin of the idea of a nuclear revival. Naturally, one might locate such an origin at the first major traumatic event in the life of an already globally functioning industry, and that is the Three Mile Island (TMI) accident of 1979. An important early contribution laying the foundations for the concept of a nuclear comeback came in reaction to these events from David E. Lilienthal – the first chairman of the US Atomic Energy Commission – who, in his book *Atomic Energy: A New Start*,[100] published a year after the accident, argued that nuclear energy shall not be forgotten and parted with, and public perception of it should be restored as nuclear energy can play an important role in the future. While it could be argued that a decline following an accident is natural – driven in no small part by the decline of public acceptance[101] – and that advocating for the continuation and expansion of nuclear energy in such circumstances carries little relevance to the situation currently unfolding, the contribution of David E. Lilienthal was not published in a landscape shaped solely by the events of TMI. Rather by the mid-1970s, orders for nuclear power plants had declined sharply, owing to a multitude of reasons: electricity demand grew more modestly than anticipated, partly as a result of the oil crisis,[102] and regulatory requirements increased, adopted in response to the growing number of operating reactors – which naturally raised the risk of accidents capable of dealing a blow to public perception – as well as to accumulating operating experience, which revealed shortcomings in existing designs. These more demanding regulatory requirements, while aimed at ensuring safer plants, inevitably translated into higher construction costs, rendering nuclear energy a progressively less competitive option.[103] In light of these circumstances, the projected return of

[98] Nuttall, 2005, p. 2.
[99] Weinberg et al., 1985, pp. 661–680.
[100] Lilienthal, 1980.
[101] Before Three Miles Island, in absence of a nuclear accident public acceptance was still not unanimous, concerns of safety or waste management already played a role, but naturally after the accident the share of those in favour and the percentage of those against have changed significantly although it still not shifted the scale for those opposing. See Melber, 1981, pp. 387–398.
[102] Hultman and Koomey, 2013, pp. 63–70.
[103] Komanoff, 1981, pp. 25–37.

nuclear energy as foreseen by Lilienthal and several other authors bears resemblance to what we are experiencing now, although they did not envisage it happening right away, but rather as a change that might occur at some point further down the line. Already then, observations were made that are highly relevant from our perspective: that the probability of accidents per reactor must be diminished in order to maintain public confidence, since accident probability naturally increases as more reactors are built – a realisation that predated TMI but was further brought into focus by the accident itself. Other factors were also noted, such as how the role of nuclear energy depends on the feasibility of its alternatives – how much longer CO2 emitting coal plants can remain in operation without irreversibly compromising the environment, or what potential role renewables, in particular solar, could fulfil.[104] While some of the projections, such as those dismissing solar as permanently too expensive, have since been proven wrong, the underlying drivers of a potential nuclear comeback were identified correctly – to which additional geopolitical factors have since joined, following the crises in Ukraine and the Middle East.

One further observation is worth making here regarding the original concept of the nuclear renaissance having originated in the US, drawing on the classical notion of returning to a state that preceded a period of decline. It is important to note that what were considered the prime years of nuclear energy – the second half of the 1960s through to the mid-1970s, as indicated by construction starts,[105] but even more so by new reactor orders reflect a pace of expansion that, in the US, was simply too ambitious in light of actual electricity demand,[106] while also neglecting considerations that would inevitably prove crucial to the sector's growth, such as the growing importance of safety. Thus, when we conceptualise today's so-called nuclear renaissance in the context of the US, where the term originates, we must ask whether a return to the period preceding the decline means a return to the late 1960s and early 1970s, a prospect that may be characterised as an illusion sustained by proponents of nuclear energy who in those decades failed to account for the crucial factors accompanying the expansion. Another central element of this illusion was the perceived economics of nuclear energy, which in the original deployment period rested on unrealistic assumptions and which have since deteriorated further due to emerging safety considerations and delays in licensing and construction.[107] One should be very cautious about wishing for an expansion like that of those days, even if it may appear desirable from an industry perspective in the short term. Those years ought to serve as an important reminder when revisiting this concept, and a return to that illusion should be avoided, what is needed instead is a more pragmatic conceptualisation – one that frames the inclusion and expansion of nuclear energy as a targeted response to problems for which it is a genuinely adequate tool, rather than a generic push for sector-wide acceleration. Repeating the same somewhat naive enthusiasm may well lead to similar outcomes and ultimately hinder the long-term prospects of nuclear energy.

2.3. The evolution of the nuclear renaissance concept

[104] Weinberg, 1979, p. 96.
[105] IAEA, 2024, pp.19–20.
[106] Craig, Gadgil and Koomey, 2002, pp. 83–118.
[107] Van de Graaff, 2016, pp. 62–64.

Following these initial mentions of a possible nuclear renaissance, the idea continued to echo in several other instances from 1990 onward, and with greater force in the second half of the decade. What had not changed in the meantime, however, was the state of public acceptance. The wound inflicted by the TMI accident[108] had barely begun to heal when the Chernobyl disaster of 1986 reopened it, undoing much of the effort that had been set in motion after TMI to rebuild trust in nuclear power generation. Even many years after Chernobyl – and despite opinion polls suggesting that public confidence was gradually recovering[109] – public perception of safety remained widely regarded as one of the greatest obstacles to expanding nuclear power plant deployment.[110] This was so despite the fact that, by then the international legal framework governing the nuclear sector had grown considerably more developed, with instruments such as the Convention on Nuclear Safety, the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, alongside strengthened liability regimes, all directed at restoring the public trust that had been lost.[111] However, from the 1990s onward, one of the externalities that may shape the future role of nuclear energy – that being its environmental aspects, namely its capacity to produce electricity in a largely CO2-neutral manner,[112] – was already being raised by scientists as a potential catalyst for its future expansion. In 1987 the Brundtland Report[113] highlighted the role of the energy sector in sustainable development, while the First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) of 1990[114] – which had a fundamental impact on the United Nations Framework Convention on Climate Change (UNFCCC) – emphasized the sector's role in CO2 emissions, and developed policy option intended to mitigate them. The UNFCCC, adopted in 1992 at the Earth Summit[115] did not contain any reference to specific measures or enshrined obligations in relation to the energy sector, but rather, under the broad clause of Art. 4(1)(c), promoted the development, application and diffusion of practices and processes which control, reduce or prevent greenhouse gas (GHG) emissions in the energy sector.[116] This lack of inclusion – when non-binding instruments had already drawn the connection between energy generation and GHG emissions – was not enshrined in the UNFCCC owing to the fact that uncertainty still existed regarding climate change and what actions could be taken without collapsing economies,[117] and also due to political interests such as those of countries belonging to the Organization of the Petroleum Exporting Countries (OPEC), which sought to avoid any binding obligations on energy.[118] The UNFCCC did, however, provide for the future adoption of targets and provisions, for which it also laid down the institutional foundations in the form of the Conference of the Parties (COP).

[108] Blix,1986, pp. 9–12.
[109] Renn, 1990, pp. 154–155.
[110] Mole, 1996, p. 82.
[111] Rautenbach, Tonhauser and Wetherall, 2006, pp. 7–36.
[112] Bodansky, 1992, pp. 7–15.
[113] World commission on Environment and Development, 1987.
[114] "It has stated in the context of pollution that the largest anthropogenic source of radiative forcing is energy production and use." Id., p. 57.
[115] Also at the Rio Conference the published non-binding Agenda 21 went further than the FCCC and in relation to Atmosphere in point 9.9 declared that the current energy production is unsustainable and there has to be more reliance on environmentally sound energy systems.
[116] Vinuales, 2022, p. 164.
[117] Hodas, 2003, p. 25.
[118] Van Asselt and Kulovesi, 2017, p. 361.

At the first COP meeting in 1995 it became evident that the GHG reductions with the approach of the UNFCCC were unattainable and work thus began to address this, eventually leading to the adoption of the Kyoto Protocol in 1997 at COP-3.[119] The Protocol for the first time set binding GHG emission limitations on certain industrialized countries – the merits of which approach were debated[120] – and in order to meet these targets it promoted the implementation of policies targeting the research, promotion, development and use of new and renewable forms of energy.[121] The targets set by the Kyoto Protocol – which eventually entered into force only in 2005 – implicitly necessitated a gradual reduction in dependence on fossil fuels, and further prompted academic voices calling for a possible expansion of nuclear energy.[122] However, during COP-6 the role of nuclear energy in relation to the Clean Development Mechanism,[123] became rather limited as a result of political compromise. Parties agreed to refrain from using certified emission reductions generated by nuclear facilities to meet their commitments under Article 3.1, which meant that while domestic construction of such plants could help Annex I countries meet their targets, they could not benefit from the GHG reductions resulting from building such plants in non-Annex I countries.[124]

At a similar period originating from the UK and in line with the neoliberal economic ideas, the liberalisation, privatisation and deregulation of energy markets began,[125] replacing political judgement with economic evaluation.[126] This process spread to the US as well, and, while environmental considerations were becoming increasingly important, economics played the central role in this shift of perspective. External factors, such as the emissions of generating capacities considered when selecting new capacity to be deployed, were assigned lesser importance.[127] Neoliberalism also found its way into the EU through the liberalisation of the EU energy market, pursued from 1996 onwards with the adoption of the first energy package, which was followed by four more.[128] The neoliberal approach, had a negative influence on the economics of nuclear energy,[129] owing to the financial risks associated with it compared to other generating means. The financial risks offset the potential advantages nuclear energy might otherwise have drawn from growing environmental awareness. This awareness was positive in the sense that it favoured nuclear energy's clean electricity generation, but it was also accompanied by concerns over the potential consequences of accidents and nuclear waste management.

From the 2000s onwards, discussions on a possible nuclear renaissance emerged at the largest scale yet, with various stakeholders examining the potential reemergence of nuclear energy

[119] Hodas, 2003, p. 26.
[120] Tenaw and Hawitibo, 2025.
[121] UN, 1997.
[122] Wälde, 2003, p. 187.
[123] Kyoto Protocol Art 12: The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.
[124] NEA, 2002, pp. 30–33.
[125] Van de Graaff, 2016, pp. 62–64.
[126] Davies, 2014, p. 3.
[127] Nuttall, 2005, pp. 2–3.
[128] Mádl, 2025a, p. 657.
[129] NEA, 2000a, pp. 45–48.

from a multitude of perspectives.[130] Those voicing this prospect had various reasons for envisaging or promoting the future use of nuclear energy, including growing energy needs,[131] the abovementioned awareness of climate change and the necessity of transforming the energy sector, increased safety measures adopted in the wake of past accidents, and the slowly recovering public perception of nuclear energy.[132] Multiple countries expressed interest in nuclear power both newcomers and already nuclearised states, moratoriums and phase-outs were postponed, and the renaissance was looking more realistic than ever before.[133] While this increased interest did result in more construction starts overall, nearly doubling from the levels of the 1990s,[134] it still fell far short of what the idea of a renaissance had actually entailed. The factors put forward as underpinning the renaissance's success failed to deliver the desired outcomes, and while it is widely held that the ultimate blow to the revival was dealt by the Fukushima accident in 2011 – once again by undermining public acceptance of nuclear energy – other factors thought to be prerequisites of the renaissance had not been achieved even before the disaster, with economic viability being the most important in this regard.[135] In fact, the sector had failed to find solutions to those underlying realities – particularly the expectation that the simplification of reactor designs would result in more predictable and less costly deployments[136] – that lead to the initial halting of the nuclear expansion. While environmental considerations were a key driver of increased interest in nuclear energy, this did not prevent alternatives such as shale gas – produced in the US using the widely criticised technique of fracking, and by no means CO2-neutral, though nevertheless a lesser polluter than coal – from becoming more economical than nuclear.[137] Even had Fukushima not occurred to undermine public acceptance, the economics of nuclear power plants would have remained unresolved in that period regardless, rendering the idea of a nuclear renaissance fundamentally flawed from the outset.

This background information is imperative for addressing the current prospect of a nuclear renaissance. The previous failures of the sector's expansion and their underlying reasons should be the first point of evaluation when assessing whether a favourable change has occurred regarding them and, consequently, the reality and feasibility of this renaissance. Based on past experiences, in which heightened discussion did not translate into increased deployment rates, one should be cautious this time too about drawing far-reaching conclusions merely from the increased interest ongoing today. On the other hand, one should also avoid being too anchored in past failures and dismissing the possibility that many factors shaping the role of nuclear energy – among them legal frameworks – may change in a favourable direction, accepting these

[130] For scholarship related to the nuclear renaissance, see Osman, 2008, pp. 10–13. Legal and licensing considerations of the perceived renaissance were also highlighted, see Burns, 2008, pp. 7–30. Pelzer, 2009, pp. 5–21. Certain interested countries aspirations were also expressed, see Iaccarino, 2009, pp. 65–80. Iaccarino, pp. 65–78. Naturally, critical voices have also emerged at this time which questioned the promises and the drivers of the renaissance, see Harding, 2008, pp. 53–61. Sovacool and D'Agostino, 2010, pp. 29–35. This skepticism was not only voiced by academics but importantly the World Energy Outlook in multiple years, 2003 and 2004 respectively, has stressed that nuclear energy has a limited role due to the economical and public opinion challenges. IEA, 2003.
[131] Maurel, 2006, pp. 1447–1454.
[132] Van de Graaff, 2016, pp. 26–30.
[133] Id., pp. 30–31.
[134] IAEA, 2024, pp. 20–21.
[135] Kessides, 2012, p. 187.
[136] Thomas, 2012, pp. 52–53.
[137] Meng and Ashby, 2014, pp. 124–126.

detriments as eternal truths of the sector leads nowhere. Instead, we should accept that the energy sector and the role of nuclear energy within it constitute a highly complex and living system shaped by many factors beyond economics alone. This living context may shift in favour of nuclear energy, or it may shift to push it further to the periphery. Scholars, amid these heightened discussions, should contribute to understanding what course this may take for the nuclear industry – but as it is a living system, the understanding of today may not reflect what actually manifests, as influencing factors may alter the course in unpredictable ways, such as through a new nuclear accident. Moreover, as was noted regarding the concept of the nuclear renaissance itself, it is equally difficult to generalise across the global nuclear industry; different parts of the world, while subject to broadly similar influences shaping the role of nuclear energy, may feel these influences with different weight, potentially leading to different outcomes. Thus, while the reasons to be explained in the following section may be broadly similar across most countries, they will by no means inevitably lead to the same results. In the following section, the main motivations behind the nuclear renaissance will be examined.

2.4. Current driving forces of the nuclear renaissance

2.4.1. Environmental considerations, climate change goals and clean energies

As mentioned before, environmental considerations did not play a major role when nuclear energy was first expanding, but when the idea of reinvigorating the sector came along, these considerations – while to a degree also serving as a counterargument, underscoring that the fuel cycle is not entirely carbon neutral and pointing to the possible ecological consequences of a nuclear accident and nuclear waste management – became increasingly relevant.[138] That international instruments in the realm of sustainable development and climate change mitigation are interlinked with the transformation of the energy sector is hardly surprising, given that the sector is responsible for more than three-quarters of global greenhouse gas emissions,[139] and that electricity and heat production alone accounts for a third of global CO2 emissions.[140] In 2015, the 2030 Agenda for Sustainable Development was adopted listing 17 Sustainable Development Goals (SDGs) which are interlinked and collectively seek to attain a better and more sustainable future globally by 2030. One of these goals, SDG 7 – Affordable and Clean Energy – specifically focuses on the energy sector and is a crucial manifestation of the growing realisation that the economic considerations associated with certain energy sources, disregarding associated greenhouse gas emissions, cannot be the sole factor choosing among them. While the targets of Goal 7 do not specifically mention nuclear energy,[141] the possible contribution of nuclear technology to meeting this goal – owing to its low-carbon, affordable, and reliable nature – has been expressed by international organisations such as the IAEA, even though efforts have predominantly focused on renewable energy sources. Nuclear energy's benefits are, moreover, argued to extend across several SDGs beyond SDG 7, to whose goals nuclear energy naturally contributes by being a low-carbon source,[142] – equally, in this way, to

[138] Van de Graaff, 2016, pp. 111–117.
[139] IEA, 2025c.
[140] Friedman, 2025.
[141] *Sustainable Development Goals. Ensure access to affordable, reliable, sustainable and modern energy*, 2025.
[142] IAEA, 2016, p. 10.

climate action (SDG 13), to life on land (SDG 15), and to life below water (SDG 14). Beyond this, however, the IAEA argues that nuclear energy contributes, directly or indirectly, to all 17 SDGs – for instance, reliable energy is essential to industry (SDG 9), agriculture (SDG 2), health (SDG 3), and education (SDG 4); and, as an affordable energy source, it helps reduce poverty (SDG 1) and contributes to economic growth (SDG 8).[143]

Under the UNFCCC framework since the 1997 Kyoto Protocol,[144] further efforts were limited and faced considerable challenges along the way, such as the troubled COP 15 in Copenhagen.[145] However in 2015 at COP 21 the Paris Agreement was adopted, which – similarly to previous efforts – does not determine national efforts but rather allows parties to determine their own course of action and the level of ambition,[146] while setting a binding target of keeping the global average temperature increase well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C above pre-industrial levels.[147] A notable mention must be made regarding the contributing role of Pope Francis in building momentum under a moral compass for both the Agreement and the SDGs adopted that same year, the main pillar of which was the papal encyclical letter titled *Laudato Si*,[148] which not only identifies the problems associated with climate change but also offers solutions – among which law holds a distinguished position[149] – and does so while remaining scientifically sound. *Laudato Si* makes several references to the crucial role of the energy sector, such as the need to reduce GHG emissions and thus phase out fossil fuels in favour of renewables and calls on countries possessing these technologies to share them with developing nations.[150] The Paris Agreement, by contrast, makes no specific mention of energy. However, the global goal it sets cannot be implemented without transforming the energy sector, and consequently a positive relationship between the Paris Agreement and countries promoting renewable energy sources can be observed.[151] This crucial position of the energy sector as an area where change has to be achieved was expressed in the Sixth Assessment Report of the IPCC, published in 2023, which stated that global warming in the near term will continue to increase and that deep and rapid GHG emission reductions are needed,[152] in achieving which the report highlights the crucial importance of transitioning to low-GHG energy carriers.[153] In line with the commitment enshrined in the Paris Agreement to "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development,"[154] this redirection of investments has taken multiple pathways, with support schemes being one of them.[155] Evidence suggests that efforts to redirect investments towards cleaner technologies – particularly renewables – have been successful, although it must be noted that several other factors also

[143] IAEA, 2017.
[144] The substantive commitments of the Protocol have expired in 2020.
[145] Maslin, Lang and Harvey, 2023. The Paris Agreement in many aspects still builds on the ideas of Copenhagen. See Bodansky, 2016, pp. 288–319.
[146] Mayer, 2022, p. 106.
[147] Article 2 of the Paris Agreement.
[148] *First Anniversary of Pope Francis' Encyclical "Laudato Si"*, 2016.
[149] Silecchia, 2016, pp. 376–379.
[150] Pope Francis, 2015.
[151] Berrich, Mafakheri and Dabbou, 2024, p. 2.
[152] IPCC, 2023, p. 68.
[153] Id., p. 86.
[154] Article 2,(1)(c) of the Paris Agreement.
[155] For more on support schemes see Kozlova, Huhta and Lohrmann, 2023.

contributed to this trend.[156] This means that clean energies, and in this case particularly renewables, which were at one point uncompetitive compared to fossil sources, became competitive through public intervention by way of a multitude of policies – whether discouraging dependence on fossil sources by making them more expensive, or promoting renewable deployment through subsidisation.[157] The renewable sector thus presents an example where purely economic rationale was overcome and environmental considerations became equally important, ultimately rendering renewables competitive through public intervention. Other important actors in global energy governance have also shifted their focus more towards clean energies since the last period of the nuclear renaissance. A prime example is the OECD International Energy Agency, once established to foster energy security in the oil and gas sector, which has significantly widened its portfolio and evolved since the last nuclear renaissance to engage more actively with clean energies,[158] particularly through the modernization strategy adopted in 2015.[159]

While such global efforts were important in combating climate change, in some cases their practical implementation and success left much to be desired – take, for example, the troubled relationship of the United States with the Paris Agreement. In the European Union, on the other hand, a much more far-reaching toolset has been provided. The European Union was essentially founded on the pillars of energy, based on the realisation of the founding fathers, in the aftermath of the Second World War, that cheap and stable energy is essential for economic prosperity,[160] subsequently the European Coal and Steel Community (ECSC) was established and just a few years later in 1957 two treaties were signed, one of them establishing the European Atomic Energy Community.[161] The Euratom Treaty and the Community as it can be deducted from the Treaty's content and based on the scholarly consensus, was established with the purpose of fostering the development of the nuclear industry at the supranational level, recognising that taking advantage of the benefits of nuclear energy at the national level[162] was not possible for most European nations.[163] The Treaty advocated for supranational action in a domain, at that time, largely free from political controversies associated with other areas, such as defence.[164] Given the founding purposes, it is unsurprising that neither in the case of the ECSC nor in that of the Euratom Community did environmental considerations, clean energy, or climate change mitigation play any role. Further development in the energy sector more broadly was rather limited in the decades that followed; the 1970s saw steps towards energy security, while the 1980s brought the foundational ideas of the internal energy market.[165] Initially, the Community's founding treaties made no reference to the environment, yet instruments were nonetheless adopted on the basis of the internal market – on which basis the liberalisation of the energy sector would later also begin. This changed in 1986, however, with

[156] Ozkan, Olasehinde-Williams and Olabisi Olanipekun, 2025.
[157] Aguirre and Ibikunle, 2014, pp. 374–375. Marques, Fuinhas and Pires Manso, 2010, pp. 6877–6885.
[158] Heubaum and Biermann, 2015, pp. 229–239.
[159] *History of the IEA. From oil security to steering the world toward secure and sustainable energy transitions*, no date.
[160] Mádl, 2025a, p. 654.
[161] Moravcsik, 2005, p. 80.
[162] Nanes, 1957, pp. 12–13.
[163] Barnes, 2007, p. 8.
[164] Hahn, 1958.
[165] Lehotay, 2020, pp. 263–267.

the Single European Act, which introduced an environmental title and several other innovations critical to the development of the EU energy law framework,[166] reflecting the growing importance of environmental considerations.[167] In the following decade, the lengthy liberalisation of the gas and electricity sectors began – with a more environmentally friendly energy sector also among its drivers[168] – and, at the same time, environmental considerations began to play a more pronounced role in shaping the energy sector, with the first proposals for renewable energy targets[169] – preceding the Kyoto protocol and its GHG targets – appearing in the Commission's Green Paper on renewable energy sources.[170] This was followed in 2001 by the RES Directive,[171] which enshrined a target of 22% of the Community's total electricity consumption to be produced from renewables by 2010, promoted streamlined licensing, and granted preferential rules – such as priority third-party access for renewables – departing from the principles of electricity market liberalisation and, to a degree, undermining its underlying rationale. This tendency was further reinforced by the 2009 Renewable Energy Directive,[172] which set more ambitious renewable energy targets for Member States.[173] To meet these goals Member States had to use extensive policy support for renewables to foster their deployment.[174] In line with this tendency, the 2009 Third Energy Package continued to place increased emphasis on environmental considerations in developing the internal electricity market. The same year also saw the adoption of the Lisbon Treaty, which introduced Article 194 on energy, affirming that the protection of the environment had become a crucial consideration in the establishment of the internal energy market, and enshrining that EU energy policy shall support the development of new and renewable energy sources. The next major step came in 2019 with the Clean Energy for All Europeans Package, which set a 32% renewable energy target in the EU energy mix by 2030 and, focusing even more strongly on the integration of renewables, required adjustments to the market structure to reflect these more decentralised sources.[175] The same year also saw the introduction of the European Green Deal, under the umbrella of which the Climate Law was adopted.[176] The Climate Law enshrined in law the European Union's climate neutrality goal, requiring emissions reduction to net zero by 2050[177] and as an intermediate step, prescribed a 55% reduction in greenhouse gas emissions by 2030 compared

[166] Versolmann, 2025, pp. 88–108.
[167] Farmer, 2012.
[168] Penttinen, 2021, pp. 77–89.
[169] Penttinen and Talus, 2015, pp. 33–50.
[170] European Commission, 1996.
[171] Council Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market, 2001. In its preamble, it specifically referred to the Kyoto Protocol, emphasizing that the increased role of renewable energy represents an important contribution to attainment of the goals enshrined in the therein.
[172] Chen and Vandendriessche, 2023.
[173] Interestingly, the special legislative procedure of Article 192(2) TFEU, despite its major influence on Member States' choices regarding their energy mix, was not used with regard to this Directive, raising interesting questions about how the Member States' freedom to determine their energy mix is ensured in practice.
[174] Kitzing, Mitchell and Morthorst, 2012, pp. 192–201.
[175] Szuchy, 2021a, pp. 151–157.
[176] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No. 401/2009 and (EU) 2018/1999 ('European Climate Law'), 2021.
[177] Id. Art. 2.

to 1990 levels.[178] These goals were subsequently complemented through the amendment of the Climate Law in March 2026, which set a 90% intermediate reduction target by 2040.[179] The Climate Law functions rather as a binding procedural instrument: while it sets out the high-level target, it does not directly contribute to achieving these goals; rather, it formulates and puts in place the necessary institutions and instruments needed to plan, implement, and enforce them.[180] Subsequently, in order to meet the 55% reduction target, the necessary substantive instruments to reach this intermediate goal were proposed in 2021 in the form of the Fit for 55 package. Since then, the legislation making up the package has been fully adopted, comprising revisions to existing instruments as well as new ones – including a 42.5% renewables target by 2030, an energy efficiency target of reducing final energy consumption at the EU level by 11.7% by 2030, increased energy efficiency requirements for buildings and methane emission reduction targets for the energy sector.[181] A final notable development in Europe with relevance to the present discussion is the REPowerEU plan, which seeks to address energy security in the wake of the Russian-Ukrainian crisis by phasing out Russian energy imports and accelerating the transition to clean energy.

What is clear from this analysis is that these targets, and the dedication to combating climate change through the transformation of energy systems, reflect a far greater level of commitment than was seen during previous nuclear renaissances. In many cases, environmental motivations are now a more important consideration than economic ones, unlike in the past. The effects of these efforts are particularly visible in the EU with the share of renewables in gross final energy consumption increasing significantly, from 9.6% in 2004 to 25.2% in 2024.[182] Nuclear energy has not been at the centre of these efforts, and the Euratom Community, throughout this transition to cleaner energy, has equally failed to promote the peaceful use of nuclear energy in line with its mandate. In more recent developments, however, the potential role of nuclear energy is being overlooked less and less.

2.4.2. A clean future for the energy sector is not so straightforward

The above-mentioned efforts to mitigate climate change and adopt cleaner energy systems were undoubtedly focused on renewable energies, seeking to expand their position and reduce the role of energy sources in electricity generation that contribute to greenhouse gas emissions.[183] However such a renewable based future has its technological realities, which in many cases are challenging to overcome. Without going into any detailed explanation a few attributes of these

[178] Id. Art. 4.
[179] Regulation (EU) 2026/667 of the European Parliament and of the Council of 11 March 2026 amending Regulation (EU) 2021/1119 as regards the setting of a Union intermediate climate target for 2040
[180] Kulovesi, 2024, p. 25.
[181] The package further contains the Social Climate Fund, the Carbon Border Adjustment Mechanism, emission standards for cars and vans, sustainable aviation fuel requirements, the extension of the Emissions Trading System, and annual GHG emission reduction targets for Member States in sectors not covered by the Emissions Trading System.
[182] *Share of energy from renewable sources*, 2026.
[183] While these efforts are mainly focused on the electricity sector, due to the specific nature of these energy sources, which are associated with electricity generation – although they, through energy carriers such as hydrogen or the use of geothermal energy, can also contribute to decarbonizing applications where direct decarbonization is not possible – this process has also brought about increasing electrification trends, both in transport and in household applications.

sources must be explained. One of the well know attributes of renewable energy sources is their intermittency. These sources are – with some exceptions – are dependent on weather conditions, which results in them generating electricity under preferable circumstances in great quantities, while under certain conditions, they can only moderately generate electricity. There are territories with more favourable weather conditions, where this intermittency is a lesser problem, while other regions are less predictable, facing greater intermittency. However, certain general physical realities hold true in both cases: the sun does not shine at night, meaning no electricity can be produced via solar panels, and snowfall – which occurs across much of Europe – renders these panels unable to generate power precisely when demand for electricity rises. This is exactly what happened in Hungary in early January 2026, when a significant snowstorm hit the country: large installed PV capacities were covered in snow and were largely unable to provide electricity even during the day, while all-time highs were reached in system load, owing to the surge in consumption driven by the severe weather.[184] Large-scale storage options would provide solutions to the intermittency of these sources, but, owing to geographical, financial, and technological constraints,[185] these are not yet universally available.

Existing grid infrastructure also presents a bottleneck to the deployment of renewable energy sources, and in many countries undergoing increasing electrification, long queues of capacity awaiting connection to the grid persist owing to insufficient grid capacity.[186] In order to facilitate the greening of the electricity sector, massive investments in, and upgrades to, electricity grids will be necessary;[187] until that point, grid operators will act cautiously with regard to renewable integration so as to prevent potential negative impacts on the grids.[188] This is not an entirely new problem – prior to the Renewable Energy Directive II it had already been established that grid infrastructure poses a barrier to renewable integration[189] – yet investments in grids did not expand substantially enough to accommodate the growing renewable demand. Another interesting situation in this regard arose in Hungary, where following the 2022 energy crisis there was a surge of interest in the already popular small household power plants,[190] in order to relieve pressure on the grid until the necessary upgrades could be carried out, a halt was placed on the further expansion of these plants.[191]

While renewables do not emit greenhouse gases, they are not entirely without negative environmental impact, wind farms may cause noise pollution and can have adverse effects on ecosystems,[192] while the production of solar cells involves the use of several raw materials that must be mined, meaning their manufacturing cannot be considered carbon-neutral.[193] A further challenge associated with renewable energy expansion is their land usages. These resources require far more extensive areas of land than other generation sources, which may give rise to conflicts of interest between central and local governments,[194] and between different interests

[184] *Rendszertehelés Terv és Tény adatok*, 2026.
[185] Trainer, 2017, pp. 386–393.
[186] Groman et al., 2025.
[187] IEA, 2023a.
[188] Gonzales, 2025, pp. 1–6.
[189] Chen and Vandendriessche, 2023.
[190] These small household power plants are, in a vast majority of cases, solar plants.
[191] Mádl, 2024, p. 138.
[192] Bošnjaković et al., 2024.
[193] Tawalbeh et al., 2021.
[194] Koelman, Hartmann and Spit, 2022, pp. 1–22.

regarding the use of that land – such as agriculture conflicting with solar energy.[195] Resolving these conflicts is a difficult task and is becoming an increasingly prominent issue as electrification requires ever greater amounts of electricity, larger shares of which will have to be provided by renewables. Another consideration while decentralised renewable energy generation also creates jobs, the phasing out of more centralised fossil-fuelled plants and their supply chains – particularly those related to mining – disrupts communities whose main labour potential was tied to these facilities.[196] A further aspect of these plants, which may be of lesser relevance from the perspective of national or regional energy policy but is rather important for local communities, is their visual impact, as renewable plants take up more and more space, in search of favourable wind and solar conditions, these plants may extend closer and closer to populated areas, potentially extending on areas of perceived scenic value where local communities may grow increasingly resistant to their expansion.[197]

Renewables are already undeniably crucial to the energy mix and will become even more so as the green transition advances and electricity demand continues to grow – two processes that go hand in hand.[198] However currently no solutions exist to establish electricity systems that rely exclusively on volatile renewables; they must be supplemented by other generating sources. The key drivers behind the green transition – as highlighted above – must not be forgotten when selecting the balancing and baseload capacities to supplement renewables, particularly as their share will remain significant for the foreseeable future. It would therefore not be unreasonable to argue that technologies which are cleaner and emit fewer greenhouse gases would naturally enter the discussion.

2.4.3. Energy security a renewed consideration

Energy security – simplifying the otherwise complex definition – means in this context, the uninterrupted supply of energy sources. Energy security has long been an important driving factor in energy policy, as also reflected in the energy policy trilemma. European integration in relation to energy had strong foundations in energy security, and the establishment of international organisations such as the IEA equally carried significant energy security implications. In an increasingly globalised world, however, these considerations were, for a time, approached with insufficient caution in certain parts of the globe, and external dependence in the energy sector came to be treated as an acceptable risk. This paradigm changed drastically with the energy crisis that began in 2021 and was significantly amplified in 2022 following the outbreak of the Russia-Ukraine war. Russia, as one of the world's most important crude oil producers and its second-largest natural gas producer, held clear prominence in the energy sector,[199] and as an exporter, fulfilled a particularly important role in Europe.[200] External dependency naturally becomes one of the critical threats to energy security when the import

[195] Moore et al., 2022.
[196] Das and Patil, 2025.
[197] Although studies have already been conducted on this matter, the issue is becoming increasingly important. See Beer, Rybár and Gabhániová, 2023.
[198] IEA, 2026b, p. 13.
[199] IEA, 2026a.
[200] This position of Russia in the European energy market was, of course, not a *status quo* that served the geopolitical interests of other exporters, such as the United States, see: Zhang et al, 2024.

capabilities of dependent states are compromised. The sabotage of Nord Stream illustrated just how vulnerable such infrastructure can be from a security perspective.

Following the outbreak of the war, economic measures were taken against the Russian Federation in the form of sanctions, which also concerned the energy sector, and the reduction of Russian imports of fossil fuels began to take place. In the wake of the war, the European energy sector underwent a tremendous change; imports of LNG grew significantly to replace the previous pipeline imports from Russia, though such efforts also carried considerable associated costs and infrastructural limitations. At the EU level, this hardship also gave rise to the idea of limiting external dependency and strengthening energy security by increasing the share of renewable energy, alongside efforts on energy efficiency and savings,[201] measures that also serve the broader goal of climate change mitigation.[202] At the same time, such a shift – particularly as it seeks to replace gas, which serves as a crucial balancing capacity in the energy mix, with intermittent renewables – raises further challenges.[203] The IEA has argued that a key lesson from the energy crisis is that these vulnerabilities should not be addressed by ramping up the use of domestic energy resources – predominantly referring to coal in this context, as this would undermine climate targets – simply in order to limit dependence on gas imports.[204] However, from an energy policy perspective, it becomes an extremely difficult question when these vulnerabilities begin to override trust in global supply chains altogether, which, in light of recent developments such as the conflict concerning Iran are arguably becoming less reliable, leaving diversification efforts increasingly constrained. Similarly, the situation is not straightforward if countries instead remain externally dependent and fail to promote the use of domestic resources; as the IEA has likewise highlighted, it is extremely difficult, during a period of energy crisis, to advance the clean energy transition, since the short-term measures needed to shield consumers from such crises require significant government financing, thereby hindering that very transition.[205]

Energy security will continue to grow in importance if turbulent geopolitical times persist, and while renewables can help address these concerns, they will only further underline the importance of stable generating capacity, within which, if the continuation of the current paradigm is accepted, coal must not be considered an option. If gas remains unpredictable, alternative sources that are cleaner than coal yet capable of stable generation will inevitably come into consideration. If gas remains unpredictable, alternative sources that are cleaner than coal yet capable of stable generation will inevitably come into consideration.

2.4.4. Energy sector caught between a rock and a hard place

While the shift towards renewables is essential to meeting climate targets, intermittent sources alone cannot fully decarbonise the energy sector, and their integration into electricity systems beyond a certain threshold raises considerable challenges. Meanwhile traditional, easily dispatchable fossil sources such as coal-fired plants are, becoming an increasingly untenable option in light of decarbonisation objectives. However, solutions to these problems must be

[201] Mišík and Nosko, 2023.
[202] Pinar, 2025.
[203] Nguyen, Nguyen and Ngo, 2024.
[204] IEA, 2023b, p. 71.
[205] Id., p. 69.

found; climate objectives cannot result in energy systems which are unpredictable and unstable, dependent on weather conditions and adversely affected by climate change.[206] If one considers the options for how we can still contribute to reaching climate objectives while maintaining the stability of electricity systems, not many options present themselves that are capable of fulfilling both of these objectives. A further, even greater challenge lies in determining how to decarbonise those areas of the energy sector aimed at heat generation rather than electricity generation, where the available options become even more limited. Certain sources, such as gas with carbon capture and storage technology, may play a crucial role and prove cheaper than other options; however, energy security and external dependence may further complicate matters for countries that lack abundant domestic resources of such energy sources, given that trust in global supply chains is increasingly questionable in light of the Russia-Ukraine crisis and the more recent conflict involving Iran. Should such disruptions continue in the future, resulting in price fluctuations, the financial benefits of such projects may become far less evident.

2.5. How nuclear energy may contribute to mitigating the challenges of the energy sector

Global energy demand is continuously increasing, with electricity experiencing the highest growth rate,[207] but at the same time climate change mitigation under the Paris Agreement remains a crucial consideration – although the rather incentive legal nature of the regime based on the nationally determined contributions indicate that current efforts come short to reach the targets.[208] The acceleration of renewables to meet growing electricity demand and to replace fossil fuels is a crucial element in meeting these targets, but as presented above, they pose their own challenges. An equally important consideration, as explained above, is the change in how energy security is viewed and its elevated importance in the sector. Nuclear power generation, in the context of its revival, is argued to offer solutions to these issues, which role is increasingly being realised. This realisation, and the consequent notion of a nuclear renaissance, is in large part driven by the 'new' products offered by the industry – namely, SMRs – which seek to offer answers to the foundations of the traditional reluctance towards nuclear energy, while at the same time proposing applications not previously envisaged for the nuclear industry, thereby contributing significantly to the ongoing interest.

2.5.1. Nuclear energy in climate change mitigation

Nuclear energy shares many of the benefits of renewables and also offers solutions to some of the problems associated with them, while carrying its own set of challenges. Most importantly, the generation of electricity from nuclear is largely free of GHG emissions, comparable in this regard to renewable sources,[209] and as a result a future energy mix encompassing nuclear energy and renewables would have significantly lower GHG emissions compared to fossil sources even

[206] Such as the droughts in Brazil concerning hydropower. On this issue, see: Moura Porto et al., 2024, pp. 102–103.
[207] IEA, 2025b.
[208] IPCC, 2023, pp. 57–58.
[209] Abd El-Azeem, 2025, p. 19880.

with carbon capture and storage.[210] This beneficial attribute stems from the fact that fission – the process of splitting uranium atoms to generate energy – is itself free of GHG emissions, this, however, cannot be said of the entire fuel cycle, though the same is equally true of renewables. While nuclear energy is highly beneficial from a climate change mitigation perspective, its sustainability attracts more debate compared to renewables.[211] Many arguments centre on the additional difficulty of managing waste originating from such plants and the prospect of potential accidents. Concerns regarding these issues are rather a reflection of the risks of inadequate operation or mismanagement, and not an inevitable consequence of the use of nuclear power – if that were the case, a prohibition on its use would be the adequate measure.[212] While arguments against nuclear energy can be raised on these grounds, as human error may lead to such mismanagement, they rest on the presumption of inadequate operation or a failure to meet safety standards; the establishment and enforcement of such standards is precisely what an adequate legal framework is meant to ensure. A legal framework – encompassing not only licensing but all regulatory functions of oversight and enforcement – whose depth, detail, stringency and adequacy are made widely known to the general public may also play a role in shaping the perception of these risks. This is particularly important as science and technology-based claims from the industry may not always be sufficiently convincing, and thus the transparent communication of the requirements imposed on such installations and the impartial regulatory body presiding over them could be a valuable addition. It is also worth noting that these concerns have primarily developed in relation to conventional technologies, and that advanced technologies such as SMRs offer solutions to both of these reservations as regards accidents, while these cannot be entirely excluded in the case of SMRs either, their likelihood and potential consequences are, owing to their inherently safer designs, less pronounced; as regards waste, certain SMR designs promise significantly reduced waste profiles by comparison with conventional plants.

Beyond the low-carbon benefits it shares with renewables, nuclear also offers advantages of its own. Its key benefit over renewables is that it can constantly provide stable baseload power, relieving the burden on the grid in meeting the challenges of balancing demand and generation. In reaching net zero emissions by 2050, nuclear is perceived to play a crucial role; projections by the IEA suggest that a net zero future looks significantly more expensive without expanding nuclear generation capacities,[213] and country specific studies have also indicated similar outcomes.[214] However, as mentioned before, the finances of such projects depend on many factors and actual costs are as a result difficult to estimate, though adequate licensing procedures[215] may contribute significantly to realising these potentially advantageous cost projections. Additionally, while renewables may directly facilitate only the decarbonisation of electricity generation – though green hydrogen production may bring a change in this regard, in which nuclear may also play a role[216] – advanced nuclear reactors could also facilitate the decarbonisation of industries where heat is needed, thus filling the needs of sectors where

[210] Pehl et al., 2017, pp. 939–945.
[211] Pieńkowski, 2024.
[212] Stoiber et al., 2003, p. 3.
[213] IEA, 2022a, p. 37.
[214] NEA, 2026.
[215] IEA, 2022a, p. 22.
[216] IEA, 2021, p. 76.

renewables could not provide a solution. Other highly electricity-intensive industries are quickly emerging, such as data centres, which also require a constant and stable supply of electricity – in some cases delivered off-grid – SMRs and potentially even smaller microreactors are therefore considered a promising option for them.[217]

A further crucial contribution of nuclear energy to establishing clean energy mixes may lie in the fact that it has the highest energy density of any current generation source, requiring the smallest areas of land to produce equivalent amounts of electricity,[218] unlike renewables which require abundant land and preferable conditions at the same time.

2.5.2. Energy security and nuclear energy

It has been highlighted by others that nuclear energy, similarly to renewables, can significantly contribute to reaching climate goals while also strengthening energy security.[219] While one may argue that the nuclear sector is dependent on technology originating from one of a few vendor countries – a paradigm that is somewhat changing in the case of SMRs, where there are considerably more potential vendor countries – the critical minerals used in renewable supply chains are equally dominated by a limited number of countries, with China playing a crucial role.[220] While renewable capacities are free from fuel supply disruptions like fossils sources, the same cannot be said about nuclear with very few countries holding the large reserves of materials used in nuclear fuels. Uranium is a finite element and consequently exists in limited quantities; while it has been highlighted that uranium reserves are sufficient to meet the demand for nuclear fuels even in the case of a high level of expansion of nuclear energy up until 2050, beyond that point significant investments in the sector will be needed to recover potential further uranium reserves.[221] In combatting the limited uranium resources reprocessing may become an even more important consideration. However, beyond the use of uranium other options exist such as using thorium of which considerably more significant reserves exist than of uranium.[222]

Furthermore, nuclear power plants operate very differently from fossil fuel plants: while fuel imports remain critical, the energy density of nuclear fuel allows large quantities of electricity to be supplied from fuel stockpiled in confined spaces, and reactor configurations allow for longer periods of operation on a single fuel load. As a result, nuclear plants are far less vulnerable to sudden supply disruptions, which are far more devastating in the case of fossil fuels – these being less energy-dense and therefore difficult to stockpile in equivalent quantities, requiring instead a constant flow of supply. In this regard, SMRs offer further improvements through designs that operate on a single fuel load for much longer periods of time, making their operation independent of additional fuel supplies.

The revaluation of energy security in the wake of the energy crisis not only directly influenced energy mix choices – and in doing so highlighted the potential benefits of nuclear energy – but

[217] IEA, 2025a.
[218] Cheng and Hammond, 2014, p. 579.
[219] Moura Porto et al., 2024, p. 100. Davidson, 2022.
[220] IEA, 2023b, p. 70.
[221] NEA, 2025c.
[222] Vlasov, 2023.

also brought along systemic changes in the form of a move away from neoliberal policies,[223] which may also improve the position of nuclear energy. In essence, this means that the notion of the economic disadvantage of nuclear energy in a neoliberal setting may no longer persist to the same degree as it did before the crisis.

2.6. How is the nuclear renaissance indicated today?

2.6.1. Nuclear renaissance in the international sphere

Owing to the advantages offered by nuclear energy in contributing to climate change mitigation and to energy security – with SMRs, given their particular benefits, fuelling much of this renewed interest – the future, more pronounced role of nuclear energy on the global stage is being acknowledged in several ways. Some of the optimistic projections regarding the future role of nuclear power come from international organisations, some generally engaged with the energy sector and others focusing specifically on nuclear power.

The IAEA, for instance, predicts that nuclear energy's operational capacity will, in the low case, double, with 23% of the added capacity coming from SMRs, while in the high case, operational capacity will triple by 2060, with 28% of the added capacity coming from SMRs.[224] The OECD NEA, meanwhile, distinguishes between four scenarios for the future of nuclear energy: a low scenario – calculating only LTO and the materialisation of projects currently under way – which will see a decrease in installed capacity by 2050; a current trends scenario – reflecting today's commitments with incremental growth – which projects capacity to be somewhat below double by 2050; an ambitious scenario – projecting installed capacity to be well over double by 2050; and a transformative scenario – projecting installed capacity to more than triple by the same date.[225] While these organisations are among the most important actors in the nuclear energy sector, their projections regarding the future role of nuclear power – while relevant – may not be the best indicators of whether a more general, positive shift towards nuclear energy is occurring internationally, given that their mandate is precisely to promote nuclear energy. Thus, in this section, the author wishes instead to discuss the projections and efforts of institutions not particularly engaged in the nuclear field.

The first of these is the IEA, which in recent years has quite consistently addressed the role of nuclear power across its publications. The IEA in the Electricity 2026 report projects a 2,8% year on year growth for nuclear energy from 2026 until 2030.[226] While this is a modest increase, it is important to emphasise that nuclear projects – even SMRs, very few of which may begin operation before 2030 – are time-consuming, large-scale undertakings; projections covering only the period up to 2030 can therefore build only on already announced and ongoing constructions. The report foresees that, unlike the current expansion which almost exclusively concerns the developing world, the expansion expected to take place after 2030 will also involve the developed world, particularly in relation to SMRs.[227] Such projections are in line with the Agency's previous reports which state that energy supply from nuclear power will

[223] Fearn, 2026, pp. 429–446. Fearn, 2023, pp. 212–233.
[224] IAEA, 2026d.
[225] NEA, 2026c.
[226] IEA, 2026b, p. 38.
[227] Id., pp. 38–39.

double between 2020 and 2050,[228] although projections regarding the role of SMRs in advanced economises were more moderate.[229] The 2025 World Energy Outlook in its executive summary states that nuclear power is making a comeback and highlights that investment is rising in the sector and more than 40 countries now include nuclear power in their energy strategies.[230]

Under the framework of the United Nations, we first have to highlight the IPCC's work. In their fifth assessment report published in 2015 – which was a period characterised by more moderate willingness to take action for climate change and energy security considerations were not as urgent as today – it was highlighted that the emergence of climate change mitigation policies – which looking back we can conclude has indeed happened – increases the competitiveness of nuclear energy.[231] The expansion of nuclear was not envisaged in isolation, but rather as part of a broader shift towards low-carbon electricity supply – encompassing also renewables and CCS – which the report projected would reach an 80% share of total electricity supply by 2050.[232] The report raises two decarbonisation scenarios for energy supply: one centred on strong biomass and fossil CCS, and another on renewables and nuclear, without yet taking a position on which is more likely.[233] The IPCC addressed nuclear energy's role more concretely in its 2018 report on global warming, projecting that nuclear power will expand, particularly under the high overshoot scenario.[234]

Advocacy for recognising nuclear energy positive contribution for climate change mitigation was also taking place before the Conference of the Parties, notably through the IAEA, which argued at COP26 in Glasgow that the need for investment in nuclear should be recognised.[235] While the Glasgow Climate Pact,[236] did not specifically refer to nuclear – as its potential position was still significantly debated[237] – it urged transition to low emission energy systems – arguably a wide enough category also to include nuclear – and urged the phase-out of coal. The following COP27 in Sharm el-Sheikh marked a further step for nuclear power as for the first time the IAEA had its own pavilion called "Atoms4Cilmate."[238] The Implementation Plan,[239] adopted at the conference further strengthened the move away from coal, but still no mention of nuclear was made. The first Global Stocktake – which assessed efforts taken under the Paris Agreement to combat climate change and outlined areas where further action is needed – was concluded in 2023 at COP28. Importantly for the energy sector, it recognised the need to triple renewable energy capacity by 2030, and, as a novelty, also highlighted the importance of transitioning away from fossil fuels in energy systems. Most importantly for present purposes, it made direct reference to nuclear energy, recognising the need to accelerate zero- and low-emission technologies, among them nuclear specifically.[240]

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[228] IEA, 2021, p. 8.
[229] Id., p. 115.
[230] IEA, 2025e, p. 21.
[231] IPCC, 2014, p. 533.
[232] Id., p. 516.
[233] Id., p. 560.
[234] IPCC, 2018, pp. 132–134.
[235] IAEA, 2021a.
[236] UNFCCC, 2021.
[237] Depledge, Saldivia and Peñasco, 2022, p. 150.
[238] *IAEA Opens COP27 Pavilion, Highlights Role of Nuclear Science and Technology in Tackling Climate Change*, 2022.
[239] UNFCCC, 2022.
[240] UNFCCC, 2023b.

COP28 along with the recognition also saw more concrete steps towards strengthening the role of nuclear in climate change mitigation, as the Ministerial Declaration to Triple Nuclear Energy was signed by 22 countries.[241] The Declaration first builds on the assessments of various international organisations, such as the IAEA and the OECD NEA, in recognising that a tripling of nuclear energy is needed to achieve climate goals. In addition, it makes a further crucial recognition regarding the need for financing this expansion, inviting the World Bank, international financial institutions, and regional development banks to consider providing financial support for nuclear projects. While such a document naturally has no binding force on the parties, the Declaration states, among other things, that participants commit to working together to triple nuclear capacity by 2050, to support the development and construction of nuclear reactors including SMRs, and to mobilise investment in the sector. Concurrently at COP28, the Global Renewables and Energy Efficiency Pledge was signed by 133 countries, in which further reference was made to nuclear energy in the context of diverse technologies becoming available for decarbonisation after 2030, including nuclear energy for countries choosing to use it. While there is global consensus on the need for renewables, as articulated by the Pledge, this was clearly not the case for nuclear energy; nevertheless, the Pledge suggests a consensus that nuclear energy may contribute to decarbonising the energy sector in countries that decide to deploy it. Thus, while the Pledge clearly does not echo a global call for the expansion of nuclear energy to accelerate decarbonisation, it signals a general acceptance that nuclear can contribute to this goal.[242]

The main contribution of COP28 lies in the explicit, positive linking of nuclear energy to climate change mitigation under the most important international instrument in the climate change sphere, breaking through the glass ceiling that had previously prevented its inclusion as a means of combating climate change. Such inclusion of nuclear energy is a crucial argument for proponents seeking to frame it as a clean energy source – an argument that merits further support in shaping public perception.[243]

At the next COP29 in Baku significant steps were made for climate finance,[244] but its outcomes contained no direct reference to nuclear energy. According to some media sources, there were plans to reference the previous year's Global Stocktake document, including its treatment of nuclear energy, but in the end no such reference was made.[245] Thus, besides additional countries joining the Net Zero Initiative and some bilateral cooperation agreements announced – both between industry and countries, and among countries themselves – no significant steps were taken to expand the role of nuclear energy.[246]

The most recent COP30, held in Belém in 2025, was expected to bring further steps towards the decarbonisation of the energy sector, including a roadmap for the phase-out of fossil fuels; ultimately, however, no such roadmap was adopted. From a nuclear energy perspective, not much has been achieved beyond more countries joining the pledge to triple nuclear capacity by

[241] UNFCCC, 2023a.
[242] Cop28 also saw the adoption of the Net Zero Nuclear Industry Pledge, signed by 120 companies, which emphasized the need for nuclear energy and offered cooperation to accelerate its expansion.
[243] Research has shown that public perception is more positively associated with nuclear energy in terms of assuring energy security rather than with its contribution to climate change mitigation. Durdovic et al., 2024.
[244] UNFCCC, 2024.
[245] *Podcast: What happened with nuclear energy at COP29?*, 2024.
[246] NEA, 2024.

2050 – the number of which has since grown, as of today, to 39, making it a fairly diverse group, comprising countries with existing nuclear generating capacity, countries with none, and even countries that had previously imposed moratoriums on nuclear energy, such as Italy.[247] The COPs – in line with the aims of the Paris Agreement – have clearly indicated that cleaner energy sources are crucial for climate change mitigation, and that nuclear energy can play a role among them. Naturally, however, it is challenging to find compromises at the UN level, and what could have served as a catalyst for the expansion of clean energy sources, nuclear energy among them, has instead been impeded by countries whose interests do not lie in phasing out fossil fuels. Thus, while nuclear energy is positioned at the UN level to assume an important role, its expansion will be truly realised only once an agreement to phase out polluting fossil fuels is reached.

While under the auspices of the previously discussed international organisations there have been clear indications pointing towards the further expansion of nuclear energy, financing remains a crucial consideration yet to be resolved. In this regard, the author would like to specifically highlight the attitude of the World Bank towards nuclear energy. The World Bank is the most important multilateral development bank, which has assumed an important position in supporting developing countries in combating climate change through investments in the renewable energy sector.[248] However when it comes to the nuclear sector the World Bank besides the loan to the Garigliano nuclear power plant in 1959 has remained inactive.[249] Not only did it not finance any further nuclear projects, but in 2013, following the Fukushima accident, a formal ban on nuclear investments was introduced,[250] furthermore under the realm of the International Finance Corporation (IFC) – one of the branches of the World Bank lending to private entities – an exclusion list was maintained which listed projects the IFC would not finance, among them the production or trade in radioactive materials, which also applied to nuclear power plant projects.[251] However, in 2025, following political pressure from the pro-nuclear US administration, the World Bank's stance changed, and it lifted its ban on nuclear energy, making room for investment in SMR projects, lifetime extensions, and the grid upgrades necessary for nuclear energy. Subsequent to this announcement the World Bank also concluded a memorandum of understanding with the IAEA to support the use of nuclear energy in developing countries, which is critical in reacquainting them with nuclear energy projects. This decision is critical for the envisaged expansion, as the World Bank's move also encouraged other development banks to consider nuclear power in their portfolios. While for the moment this support remains rather theoretical, it fits well within the broader argument that the attitude towards nuclear power is changing; for its materialisation, however, many enabling factors still have to be established – such as a robust and adequate legal framework for SMRs – and in this sense the decisions of such financial institutions should also serve to accelerate progress in this regard.

2.6.2. Indicating factors in the context of the European Union

[247] Arrigoni et al., 2026.
[248] Won Kim and Lee, 2021.
[249] World Bank Group, 2016.
[250] World Bank Group, 2013, p. 14.
[251] IFC, 2007.

In the context of the EU, there are several initiatives and efforts that indicate nuclear energy is re-emerging in importance as an energy source. In the following section, the author will provide a glimpse into the most noteworthy efforts that have been carried out, or are currently under way.

One such step – which, on the one hand, can be interpreted as a necessary opening of sustainable investment towards nuclear energy in the clean energy transition, but, on the other, may also signal a limited future role for fission – is the EU Taxonomy Complementary Delegated Act, adopted in 2022, which classifies nuclear energy, alongside gas, as a transitional activity under certain circumstances.[252] Although being classified as transitional was not a *carte blanche* for nuclear power, it did mean that nuclear is, for the moment, an activity that cannot be replaced by a more technologically and economically feasible low-carbon alternative; nevertheless, investment in it must not lead to the crowding out of investment in renewables.[253] The term transitional, together with the wording referring to low-carbon renewables as the preferred means – which, of course, is by no means technology-neutral – clearly indicates that the intended role of nuclear is finite, and that it is only a matter of time until a more suitable renewable source becomes available. While a purely science-based approach might have reached different conclusions regarding the appropriate role for nuclear,[254] politics – as always driven, in part, by geopolitical factors – played a crucial role here. Nevertheless, it remains a positive tool in directing investment towards nuclear power.

The Russian-Ukrainian war was a further factor favouring nuclear energy's position in the clean energy transition. The aforementioned REPowerEU plan,[255] while also advocating for decreased dependence on Russian nuclear fuel, notably observes in its introduction that, as dependence on Russian fossil fuels is reduced, the role of gas as a transitional fuel becomes more limited, bringing nuclear power further into the picture,[256] – alongside highlighting the potential role of nuclear energy in fossil-free hydrogen generation. The Taxonomy Complementary Delegated Act as stated, clearly indicated that, in order to move towards a clean energy future, both nuclear and gas – one producing almost no GHG emissions, the other being a less polluting fossil source – remain essential, since a fully renewable energy system is hardly imaginable at present. The REPowerEU plan builds on this same premise but, in light of events occurring after the Delegated Act, shifts the balance between the two: it acknowledges that conditions have changed in the wake of the war, and implies that, while a fully renewable system is still not realistic, gas may no longer play as important a role as was previously imagined. While it does not explicitly state that nuclear will substitute for gas, keeping nuclear in the picture – alongside the extended operation of coal plants – logically suggests a more pronounced role for nuclear in the transition, given that no other substitute remains.

Besides the legal instruments and strategies that one way or another can contribute to the materialization of a nuclear expansion it is also important to mention how member states advocate for development in this regard.

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[252] This classification was challenged by Austria.
[253] Egres and Sarlós, 2024, p. 2.
[254] Abousahl et al, 2021.
[255] European Comission, 2022.
[256] However, one must observe that nuclear energy is mentioned in the same sentence as coal, the continued use of which is anticipated. Such reliance on coal clearly illustrates how policies are shaped by the different dimensions of the energy trilemma.

The initiative that has to be mentioned is the European Nuclear Alliance. The Alliance is based on the efforts of pro-nuclear states that advocated within the EU to recognize the contribution of nuclear energy to climate change mitigation. In 2021 these pro-nuclear Member States – prior to the above-mentioned inclusion of nuclear energy in the Taxonomy – released a Declaration arguing that nuclear energy is indispensable in climate change mitigation, given that based on science it is no less climate-friendly than other energy sources included in the Taxonomy, and especially in light of rising gas prices which underscored the importance of self-sufficiency. The ten countries which endorsed the Declaration also recalled in more general terms Article 194 TFEU and its provision on the free choice of Member States regarding their energy mix, arguing that all low-carbon technologies for electricity generation should be considered on an equal footing.[257] In connection with this, the parties to the Declaration expressed that no scientific evidence supports a more negative assessment of the climate-friendliness of nuclear power; so while the Declaration did not state it explicitly, it seems to suggest that if the Taxonomy were, without sound scientific reasoning, to fail to consider low-carbon technologies on an equal footing, the Member States' free choice of energy mix would be violated. While this may sound like a valid challenge on the part of the Member States when it comes to contesting it before the Court of Justice of the European Union it would not succeed, as the Court's previous case law[258] showed that Article 194(2) TFEU may only be invoked if the measure in question was adopted on the legal basis of that Article, which is not the case for the Taxonomy. Moreover, it seems that this particular limitation of Article 194(2), even if an EU measure were adopted on the energy legal basis, would have to be interpreted narrowly, limiting only those measures that directly aim to influence Member States' energy choices and are capable of giving effect to that aim,[259] this would further not apply to the taxonomy the primary aim of which is to direct investment towards economic activities needed for the green transition, thus its primary objective is not to decide on energy sources. In fact, this provision of the TFEU has not been used to contest EU measures adopted in the energy sector – even though, in more recent legislative packages, it has served as a legal basis and has affected Member States' energy mixes – but has rather, interestingly, served to support nuclear energy in the political battles initiated by Austria against nuclear power plant projects.[260] So while in principle the Member States' free energy mix choice sounds convincing in this narrow interpretation of the limitation its practical relevance is questionable. Even for obvious limitations on energy choices, certain external justifications – be it climate change mitigation or others – would not prove particularly difficult to find. While it is understandable that a very broad interpretation of this principle could set an enormous impediment to climate change mitigation efforts,[261] the question remains whether this narrow interpretation would be capable of protecting energy choices if fossil fuels are no longer the target and the classification of accepted and non-accepted sources begins to emerge among low-carbon technologies themselves.

[257] European Nuclear Alliance Declaration 'Why European Need Nuclear Power'
[258] *Poland v Commission* (T-370/11) ECLI:EU: T:2013:113, judgment of 7 March 2013, para 13.
[259] On this issue, see Huhta, 2021, pp. 991–1010.
[260] Id., pp. 1003–1005.
[261] Id., pp. 1009–1010.

While the outcome of the work of these pro-nuclear member states is known in relation to the Taxonomy, they continued their efforts to secure further support for nuclear energy, formally establishing the European Nuclear Alliance with an increasing number of countries joining over time. As part of promoting nuclear energy, they exchanged with the Commission to include nuclear power more extensively into EU energy strategy especially with regards to its role in decarbonising the energy sector.[262] In 2023 the Alliance adopted a further Declaration[263] arguing for the Commission to create a clear strategy for nuclear energy in the Community – grounded in its advantages with regards to climate change mitigation and energy security – and put forward that nuclear energy could provide 150 GW of capacity by 2050, representing a 50 GW increase delivered by approximately 40 reactors. The pro-nuclear states argued that the strategy should treat nuclear and renewables equally, so that implementing measures would reflect this as well. The proponents argued that the goal is to achieve net zero, not to establish a fully renewable energy sector; thus, the net zero goal should remain the focus, with greater freedom in choosing the technologies by which to reach it, and with EU measures reflecting the technological neutrality enshrined in the Treaties.[264]

In essence, proponents of nuclear energy argue that the Community should adopt a technology-neutral approach among the energy sources capable of contributing positively to net zero, so that strategies aimed at reaching this goal are established in a manner that does not, in effect, single out one solution, but rather supports a variety of pathways on an equal footing. This argument can be understood in light of the earlier conclusions drawn regarding the rather narrow limitation set out in Article 194(2) TFEU, and the consequent risk that climate change mitigation measures may significantly influence the free choice of energy mix. The Declaration, rather than relying on the free choice of energy mix as enshrined in the Treaty, argues for a technology-neutral approach – which entails regulations focusing on the effects of technologies, rather than on regulating the choice of technology itself.[265] The advantage of such an approach is that it is more flexible, and the resulting regulations are more future-proof – a particularly important consideration in the context of energy law – while technological diversity may also result in more resilient energy systems. In this respect it is crucial to mention that the Draghi Report,[266] adopted a year later, likewise recalls this principle in relation to accelerating decarbonisation by leveraging all technologies, including nuclear, and, in this context, notes that massive financing is needed, accompanied - crucially, from this work's perspective – by streamlined permitting procedures.

Besides this overarching principle, the Declaration includes more concrete proposals and actions, such as urging the Commission to foster an environment in which sufficient financing for nuclear energy can be secured. As the nuclear industry is extremely capital-intensive, and is characterised by strong state involvement – a paradigm that may somewhat change with SMRs – the Declaration makes special mention of state aid guidelines, which should be defined so as to allow for the development of nuclear supply chains and nuclear power plants.[267]

[262] European Nuclear Alliance, 2023b.
[263] European Nuclear Alliance, 2023a.
[264] Ibid.
[265] Ojanen, 2025, pp. 1440–1455.
[266] European Commission: European Political Strategy Centre, 2025, p. 50.
[267] European Nuclear Alliance, 2023a.

The Alliance continued its work through regular meetings and declarations; one of the acclaimed outcomes of this work, enshrined in the 2024 Declaration[268] concerned the Net-Zero Industry Act (NZIA). The NZIA seeks to ramp up the European manufacturing of clean technologies to lower the potential risk of supply disruptions due to external dependencies and it does so by establishing manufacturing benchmarks and streamlining the permitting procedures for such projects.[269] The Regulation,[270] lists the net-zero technologies covered under it and alongside renewables it includes nuclear fission energy technologies, and also fuel cycle technologies.[271] The Regulation incorporated nuclear energy more broadly than the initial proposal,[272] which concerned only SMRs – signalling an increasingly favourable attitude towards nuclear energy. This means that the development or scaling up of nuclear manufacturing capacities can be supported through the Act.

In 2025, the Alliance argued for the inclusion of nuclear power[273] in the Affordable Energy Action Plan, and its rationale was reflected in the Action Plan, which included nuclear energy and supported technology-neutral, cross-border power purchase agreements. It also foreshadowed the adoption of an updated Nuclear Illustrative Programme (PINC),[274] which is an overview of development trends in nuclear energy, published by the Commission as provided for under Article 40 of the Euratom Treaty. The PINC acknowledges that, compared to previous projections, nuclear operating capacity is higher owing to long-term operation, while also discussing multiple future scenarios for nuclear energy by 2050, with even the base case scenario showing a further increase in electricity generated from nuclear. The PINC also notes that, if lifetime extensions continue and all planned new projects are delivered on time, the 150 GWe goal envisaged by the Alliance is achievable, with SMRs potentially playing a crucial role in this regard. The Programme crucially mentions the massive investment needed, and highlights that five-year delays in projects – which are not considered extraordinary in the sector – not only threaten the achievement of the nuclear capacity target, but also increase the associated investment costs by 20%. Cross-border cooperation on licensing-related matters is also mentioned in the document, which could potentially contribute to the accelerated deployment of new installations. While the Programme acknowledges that nuclear energy may undergo a substantial expansion, it confines its investment projections to the base case scenario alone, leaving open the question of how it can fulfil its role – prescribed by the Euratom Treaty – of stimulating action by persons and undertakings, and facilitating the coordinated development of their investments in nuclear energy, if, in an area as complex as this one, which has already been somewhat neglected from an expansion perspective, its recommendations remain blatantly obvious to the sector and lack any substantive guidance, as is the case with licensing. Nevertheless, viewed from the perspective of supporting nuclear energy's expansion,

[268] European Nuclear Alliance, 2024.
[269] Boute, 2025.
[270] Consolidated text: Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem and amending Regulation (EU) 2018/1724, 2025.
[271] It also covers "other nuclear technologies" which may include fusion, as mentioned in the Regulation.
[272] European Commission, 2023b.
[273] European Nuclear Alliance, 2025.
[274] European Commission, 2025.

the Programme can itself serve as evidence that attitudes towards nuclear are shifting in a more favourable direction compared to previous editions of the PINCs.

The latest Declaration[275] by the Alliance was issued in spring of 2026 arguing for further investment possibilities in the sector and for the Commission to contribute to improving the legal certainty, predictability[276] and efficiency of state aid notification procedures which – in light of projects such as Paks II, where these procedures have caused severe complications over which the Hungarian party had no influence – is a justified demand.[277] What is more the Declaration recommends the Commission to develop a tailor-made approach for such capital-intensive projects. While the content of this recommendation is not explained in detail, it may refer to the fact that in the Hinkley Point C case[278] it was ruled that, as *lex generalis* to the *lex specialis* Euratom Treaty, the TFEU and thus its state aid provisions – which are not present in the Euratom Treaty – are applicable.[279] While these arguments predate the Court's decision, some contend that state aid rules were deliberately excluded from the Euratom Treaty, on the basis that such projects would not be realistic in the absence of state aid, and that applying state aid rules may violate the Treaty's "shall not derogate" clause,[280] – though strong counterarguments to this position also exist. The recommendation in the Declaration acknowledges that the question of the applicability of state aid rules to nuclear projects has already been settled; however, it seeks to recall that this issue has been seriously questioned by some. The Declaration does not advocate for the non-application of state aid rules – such a position would require the Court to overturn its previous decision – but rather suggests that a different, more tailored approach may be warranted, one that better reflects the specific nature of nuclear projects.

In summary, the Alliance has been, and continues to be, actively advocating for giving nuclear energy a more prominent role in the EU energy sector, and for providing an adequate legal framework to support this expansion. Its work can be considered successful, with tangible results, but the most important factor in these efforts may be that an increasing number of countries now back the initiative.

Besides the aforementioned efforts, advancements were also made withing the European Union which particularly concerned SMRs. In 2023 the Declaration on EU SMR 2030[281] was adopted stressing that the EU must be in the forefront of SMR development. While the political value of the document lies in recognising the role of SMRs in decarbonisation and in guaranteeing stable grids – alongside launching an SMR safety demonstration programme, and acknowledging that being at the forefront of SMR development also requires support for best licensing practices and human resources – the Declaration did not set out any revolutionary change.

A further notable mention in this regard is the EU SMR Alliance. The Alliance originated from the European SMR Partnership,[282] which was a collaborative initiative to support the creation

[275] European Nuclear Alliance, 2026.
[276] Kaminski, 2024.
[277] Court of Justice of the European Union, 2025.
[278] *Austria v Commission* (C-594/18 P) ECLI:EU:C:2020:742, judgment of 22 September 2020.
[279] Sikora, 2020, pp. 515–520.
[280] Södersten, 2018, pp. 130–133.
[281] European Commission, 2023a.
[282] Vaglio-Gaudard, 2026.

of enabling conditions for the deployment of SMRs in the EU by the 2030s.[283] The Partnership contributed to this goal via five working groups, addressing issues of market integration, financing, supply chains, research and development, and – most interestingly from this work's perspective – licensing. The report of this working group remained rather modest, however, offering only commendable observations regarding pre-licensing.[284] It did, nevertheless, propose that the initiative evolve into the SMR Industrial Alliance with a wider stakeholder representation. Like its founding organisation, the SMR Industrial Alliance carries out its work to accelerate the development and deployment of SMRs, doing so by identifying – from an interdisciplinary perspective – the most promising SMR designs.[285] The Alliance also continues to pursue its objectives through eight technical working groups focusing on nine selected promising SMR projects. In 2025 the Alliance published its Strategic Action Plan,[286] outlining ten actions supporting the industry on which its work will focus in order to achieve its objective. Additionally, complementing the work of the Alliance, the Nuclear Energy Summit was held in Paris in March 2026, where the President of the European Commission delivered a speech and foreshadowed the establishment of the European Strategy for Small Modular Reactors,[287] which is expected to ramp up investment in the sector, by de-risking these investments. To this end, the Strategy lays out multiple pathways, such as EU budgetary guarantees to mitigate potential failures, or the establishment, under the Net-Zero Industry Act, of 'SMR valleys', where SMR manufacturing could take place with improved access to financing.[288] While the tangible effects of these Strategies and efforts from given perspectives such as licensing, for the moment remains limited, their value in strengthening the confidence in the future of nuclear energy is important. It should be noted, however, that while these strategies are important indications of intent, if the envisaged nuclear expansion is to take place within its planned timeframe, tangible achievements will need to follow soon.

Finally, it is also adequate to address how the expansion of nuclear energy is envisaged at the national level in the EU. In the EU, the National Energy and Climate Plans (NECPs) of member states, which must be submitted to the Commission, can serve as a good starting point for assessing the future role of nuclear energy. The latest plans address the period between 2021 and 2030, and on the basis of their updated versions,[289] the Commission conducted an assessment highlighting efforts and trends visible in them. While it acknowledges that the plans suggest nuclear generating capacities in the EU will reach around 110 GWe by 2050, even this figure – rather conservative compared to the 150 GWe target articulated by the European Nuclear Alliance – is dependent on many uncertainties.[290] However one shall be careful to draw to far fetching conclusions from the modest nuclear expansion echoed in the plans as these were primarily dedicated to showcase how Member States plan to achieve the 2030 climate and energy targets. As such, these plans are rather limited in their temporal scope, and while nuclear energy projects envisaged prior to 2021 may be completed by 2030 and thus feature in the plans,

[283] European Nuclear Safety Regulators Group, 2024a, p. 4.
[284] European Nuclear Safety Regulators Group, 2024a, pp. 20–22.
[285] Souguero et al., 2025, p. 9.
[286] European Industrial Alliance on SMRs, 2025.
[287] European Commission, 2026.
[288] Ibid.
[289] These plans had to be updated in 2024.
[290] European Commission, 2025a.

project ideas that emerged after the 2022 energy crisis – particularly those concerning more advanced technologies such as SMRs – are not necessarily articulated in the NECPs, as their materialisation extends beyond the plans' temporal scope. Rather than focusing on these plans, one could instead observe the communications of states regarding nuclear energy, however, these communications most of the time lack any concrete commitments and are thus liable to change swiftly, and the author would therefore prefer not to delve into discussing them, as what holds true today may not hold true the next.

2.6.3. Observations on the ongoing efforts to support the nuclear renaissance

A crucial observation must be made with regard to the efforts signalling the expansion of nuclear energy: each of these current efforts is the product of political compromise. Politics itself – fundamentally shaped by a changing public perception that is becoming increasingly favourable towards nuclear energy, particularly in light of the energy crisis and the continued disruptions of recent years[291] – is also shifting course, as the range of energy source options available for a clean future narrows; countries once opposed to nuclear may now be stepping back from their previous policies and beginning to consider it a viable option. Essentially, the scale and depth of these measures – at least in an EU context – depend on the political consequences of either supporting or contesting these efforts; if nuclear becomes a more broadly accepted political option, then the efforts to support its deployment may be elevated to an unprecedented level, as was demonstrated in the case of renewables. In such a scenario, even if neoliberal ideas may not remain on its side – the prevalence of which is increasingly challenged by decarbonisation efforts and energy security imperatives – nuclear could still become a crucial option due to its value in contributing to decarbonisation and providing energy security. Nevertheless, a different path, one not favouring nuclear energy, is equally possible; the question is deeply rooted in the political acceptance of each path and the efforts of lobbyists on either side.

If the sector can attain this crucial political support, then an array of legal measures will be needed. Accommodating frameworks for investment in nuclear energy are needed to make the prospect of such plants a more economically viable proposition. Furthermore, if investments can be secured, the previous paradigm of slow, delayed and troubled deployments must be broken. In this, the industry itself – with its proposed product – and national legal frameworks providing adequate and efficient licensing procedures will play a crucial role in speeding up the deployment of these plants and challenging the previous paradigm.

While significant barriers still stand in the way of the nuclear renaissance, the preceding sections have shown that, owing to changed circumstances in the energy sector and ongoing improvements to the product on offer, increasing and tangible commitments and enabling steps are being made – by international organisations and actors among them ones that had previously ruled out the nuclear option, by governments and by the industry – complemented by growing public acceptance. As a result, the nuclear renaissance is more realistic than it has ever been before, and those seeking to contribute to resolving the challenges associated with it are not investing their resources into something doomed to failure from the outset.

[291] Durdovic and Čermák, 2026.

2.7. Projected execution of the renaissance

When addressing this renaissance, we should apply a very pragmatic approach, beginning with establishing what we actually consider an expansion – whether it is the increase in the number of units deployed, the increase in annual capacity additions, the share of nuclear energy in electricity generation, or the amount of installed nuclear generating capacities. Looking at either the number of new unit deployments or the newly added capacity may be a good indication that there has been an increase in the deployment of nuclear power plants, but both of these approaches lack context[292] and cannot reflect whether these expansions exceed the decommissioning rate or not.

The share of nuclear energy in electricity generation, while potentially a good indicator of the importance of nuclear energy, is likely to decrease overall even if major expansions of new capacities take place, due to the expanding scale of electrification and the proliferation of renewables – leading to false conclusions regarding the success of the renaissance. Moreover, as some of the advanced designs are not intended for electricity generation, certain plants would not be captured by this approach, further distorting any conclusions drawn.

While not perfect – given that accounting for non-electric applications also presents its own challenges – the approach of comparing future installed capacity to previous installed capacity seems most suitable for assessing the success of the renaissance. It is a relative measure, comparing nuclear capacity against nuclear capacity, and also accounting for the retirement of plants, benefiting from the fact that it considers installed capacity as a whole – reflecting the holistic perspective needed when assessing the nuclear renaissance.

What is meant by this holistic approach? It signals that the nuclear renaissance has several distinct pathways. While bringing new capacity online is crucial to the expansion, maintaining already-installed capacity – so as not to create a deficit that new additions would then have to compensate for – is equally important; in the timeline of the renaissance, this will be the first contributor, being the least time-consuming measure. Somewhere in between stands the recommissioning of shut-down plants, a prospect sometimes discussed as a means of restoring capacity more swiftly than entirely new construction would allow, though this may be limited to a very few cases. Following LTO and possible recommissioning, the means for genuine expansion will, in the short term, primarily follow through the addition of already-marketed conventional plants[293] followed by advanced reactors – most of which are, at this point, neither mature enough to be marketable, nor supported by adequate deployment frameworks. This should not come as a surprise, given that, as explained, the acknowledgement of nuclear energy's position in the future energy mix has only developed in recent years. Which approaches countries pursue will depend on their national context: LTO is only relevant for countries with operational plants, while in the case of new capacity additions, countries will differ as to whether they pursue both pathways within their national context, or only one of them.[294] The thesis from these pathways will devote particular attention to new capacity additions, since this alone can genuinely contribute to the renaissance's expansion.

[292] Focusing solely on the number of deployed units may be misleading in the future due to SMRs or microreactors having lower outputs. Thus, while the number of deployed units may increase, this does not necessarily translate into an increase in newly added MW capacity.
[293] IEA, 2025d, pp. 46–47.
[294] SFEN, 2023, p. 18.

Regardless of which pathway is being discussed, a multitude of legal considerations arise, and licensing issues in particular emerge as a crucial question across all scenarios. Licensing, permitting or authorisation – whatever we choose to call it – is a crucial part of establishing such infrastructural projects, with crucial implications for their financing and thus also for their competitiveness relative to other alternatives, the interest protected in case of large energy projects make licensing an integral part of deploying new plants. Licensing procedures, when functioning well, are effective regulatory tools, as the applicant for a licence bears the burden of proving that they comply with the predetermined requirements,[295] that permit the activity to be conducted; on the other hand, a licensing process must not serve as a praetorian opportunity to prevent applicants from conducting an activity if they do in fact comply with the set requirements.

Licensing procedures in relation to different energy sources – particularly renewables – have attracted considerable attention in to better enable their expansion, as also reflected beyond the national level in the EU acquis.[296] While some of the potential negative impacts of nuclear on human health and the environment, as well as its safeguards implications, are not comparable to those of renewables, the same principle applies in equal measure: that permitting procedures can constitute an hinderance or an obstacle to the deployment of these plants, thereby hindering the goals of reducing carbon emissions and increasing energy security. The task is in principle straightforward – if nuclear power plants are to be considered as contributors to climate change mitigation and energy security, then licensing procedures must be adopted to enable the reasonable implementation of this goal. In the case of nuclear power plants, however, this task is far more complex than in the case of renewable plants, owing to the risks associated with this generating source. Far greater consideration must therefore be given to balancing the interest in deploying more plants against the imperative of not creating an environment in which the risks associated with the industry are managed less stringently.

[295] Giles, 1957, pp. 301–302.

[296] In this regard the Clean Energy Package has to be mentioned which introduced provision in the Renewable Energy Directive which argued for licensing procedures that are objective transparent and proportionate. The more substantial efforts however were introduced with the EU/2023/2413 Directive as part of the RepowerEU plan which modified the Renewable energy Directive. The revised Directive acknowledged that the permitting procedures pose an obstacle to the swift rollout of renewable energy project, subsequently in the Renewable Energy Directive new provisions were included that addressed the acceleration and streamlining of permitting procedures. The Directive supports the streamlining by promoting the designation of supporting contact points digitalization of permit granting procedures, setting specific time limits for permitting in renewable acceleration areas and outside those, introduced the principle of overriding public interest.

3. Deployment of conventional nuclear power plants during the nuclear renaissance

As articulated above the nuclear expansion in the short term may primarily concern the construction of large-scale nuclear power plants, which have been dominant in the sector for a long time. Their benefits include the fact that the technology is well tested and widely available from renowned vendors; that safety improvements have been continuously implemented, with verifiable results that can serve as a positive argument in shaping public perception; that qualified staff can be trained to operate the plant by experienced professionals; and that the traditional economic reasoning behind nuclear power plants – namely, economies of scale – applies to them.[297]

Beyond the benefits of the product itself, its crucial position in energy mixes should also be underlined. Large-scale nuclear power plants may facilitate the transition away from large-scale fossil fuel plants in countries such as Poland. Such plants could be equally important in supplying adequate amounts of energy in emerging economies, though in many cases this will have to be preceded by grid upgrades; and finally, such plants may also be crucial in replacing decommissioned nuclear power plants.[298]

Large-scale nuclear power plants also carry benefits from a legal perspective. Their advantage is that the legal frameworks currently in place cover them. First of all, there is a robust international legal framework addressing multiple aspects of such installations, be it regarding safety, liability or security. Such an international framework raises no substantial unanswered questions that would affect the efficient deployment of these plants. The existence of such a framework, however, by no means entails that nuclear energy is sufficiently addressed or included in international or Community-level instruments that may support its deployment; quite the contrary, significant steps are still needed to ramp up the necessary investments.

From a national perspective, the existing legal framework – at least in countries that have had or currently have nuclear power plants – is well established, enabling the deployment of conventional plants, as these frameworks were developed with them in mind. However, since in most countries there have been no nuclear power plant constructions for a considerable time, not only the human resources utilised in such projects and the associated supply chains have to be rebuilt,[299] but the existing licensing frameworks have also become increasingly challenging to navigate. Not only the stringent safety requirements and the emergence of additional considerations – such as the environmental aspects of such installations – but also the fact that these procedures, unlike the industrial product itself, have not been subject to constant development, have together meant that licensing such a plant has become considerably more complex and time-consuming, resulting in higher deployment costs. It is a sobering reality of the nuclear sector that nuclear power plant projects frequently face significant cost overruns and delays,[300] due in part to the continual evolution of stringent regulatory requirements,[301] which in turn discourage viewing nuclear energy as a viable option in a country's energy mix.[302] It was articulated as early as the end of the 1970s that licensing procedures also need to evolve

[297] NEA, 2000b, p. 32.
[298] Sexton Nick, 2022, p. 9.
[299] Liou, 2024.
[300] Locatelli and Mancini, 2012, pp. 623–637.
[301] MacKerron, 1992, pp. 641–652.
[302] Berthélemy and Escobar Rangel, 2015, p. 119.

with efficiency in mind.[303] This observation throughout the history of the not successful nuclear renaissances – especially at the time preceding the Fukushima accident[304] – has been brought up on multiple occasion as crucial contributor to the manifestation of the expansion. The failure of the perceived renaissances while at that time certain improvements were made in given countries,[305] also meant that since the Fukushima incident not only the expansion stagnated, but the licensing frameworks also did not evolve into being more accommodating to the increased deployment of nuclear power plants. In fact, as organisations – Euratom being a prime example – shifted their focus from promoting nuclear energy to maintaining an ever-greater level of safety, licensing procedures followed a similar path in terms of their purpose, at the expense of several other expectations that may legitimately be held towards licensing.

While the undeniable purpose of licensing is not to promote the use of nuclear energy but rather on the one hand to maintain safety, it should equally not lose sight of the fact that it is also important – if the activity is not to be prohibited – to provide a framework which in itself does not render the activity uncompetitive relative to its alternatives. While naturally major differences may exist in licensing different generation capacities due to their specific challenges and features there is at least one realm of common expectation is that these procedures should be proportionate, not redundant, and predictable. These expectations apply equally whether the licensing of a nuclear power plant or an onshore wind farm is in question. However, due to public outrage associated with nuclear accidents and the fact that such frameworks are rarely used in practice – at least in the context of the western world – simply because of the low volume of nuclear power plant deployments, these frameworks have not reflected on themselves in terms of how the highest level of nuclear safety can be achieved while also being accommodating to an increased number of deployments.

While several challenges stand in front of the increased deployment of conventional large-scale nuclear power plants in the coming period one further crucial question will be licensing,[306] and particularly how these procedures can be transformed, while maintaining the necessary level of nuclear safety, to provide a basis for the efficient deployment of new nuclear generating capacities. The problems with currently existing licensing procedures can be wide-ranging; among others, these can relate to any stage in the deployment of such installations – from the decision-in-principle,[307] to siting, construction, environmental considerations, and beyond – as well as to the staging of licensing efforts, regulatory approaches to meeting safety requirements, and the involvement of third-party experts. What is essentially argued in this thesis is a call for self-reflection on the part of these national frameworks – an evaluation and analysis of where redundancies and uncertainties may exist in current processes which, in real-life applications, could potentially give rise to delays and subsequent cost overruns. International harmonisation of licensing frameworks is not going to be a decisive factor in the case of conventional plants, as well-established frameworks already exist in numerous countries. This does not mean that

[303] Rowden, 1978, pp. 40–56. Some particularly expressed these efficiency increasing measures regarding the emergence of environmental considerations as part of the licensing necessary for the deployment for new plants where procedures could be made more rationalised to increase efficiency. See Ramey, 1973, pp. 211–220. Manning Muntzing, 1976, pp. 35–45.

[304] Bredimas and Nuttall, 2008. Modarres, 2005, p. 221.

[305] Such as the United States, see Repka and Sutton, 2005, pp. 39–44.

[306] Kiser and Otero, 2024, pp. 1–2.

[307] For example, in the United Kingdom, see Van Balen, Read and Shwageraus, 2026.

harmonisation could not bring any benefits, but it is rather unlikely that any major steps in this regard will be taken in the foreseeable future; the reason being that regulators are familiar with current procedures, these administrative solutions are shaped by various national interests, and the prospect of relinquishing them – considering that these divergent national approaches, albeit with differing levels of challenge, are fundamentally capable of fulfilling their role of approving such installations – is not commensurate with the potential benefits of harmonisation. Nevertheless, as this work seeks to demonstrate, certain international approaches may prove useful in reforming current procedures.

States that are considering deploying nuclear power plants should not wait for actual deployments to expose the inefficiencies or uncertainties of their national licensing regimes; rather, they should seek to continuously update them in preparation for future deployments. While national efforts to reflect on and update these frameworks with more streamlined licensing solutions are crucial, the point at which international efforts come into the picture is in looking beyond national borders for promising solutions and analysing how different jurisdictions approach the task of making these procedures more efficient – an exercise that can prove highly beneficial. Comparative works addressing how licensing operates in different countries, and what measures they adopt to increase efficiency without compromising safety, can contribute greatly to the successful materialisation of the expansion of nuclear power.

In relation to conventional, large-scale nuclear power plants, this work seeks to present how different national licensing procedures function, and what their similarities and differences are, while also seeking to identify national solutions that may be considered either more or less accommodating of a nuclear renaissance, and what efforts these national frameworks are adopting to prepare for the forthcoming increase in nuclear power plant deployments. In the wake of the perceived expansion of nuclear power, considerably more effort should be dedicated to examining these divergent approaches, summarising their benefits and shortcomings and giving countries the opportunity to implement given institutions' approaches within their respective national systems.

The self-reflection of countries coupled with the adoption of international best practices can significantly contribute to making nuclear power plant projects more predictable and thus financially viable. Ultimately, licensing procedures that maintain safety while not negatively influencing the competitiveness of nuclear energy facilitate its contribution to the fight against climate change and to energy security; these efforts are therefore crucial from the perspective of the public interest.

3.1. A comparative analysis of national licensing frameworks for conventional nuclear power plants

The following part aims to unpack how the licensing process for new nuclear power plants functions – a topic with which, besides the very few lawyers working in the field, not many legal professionals are familiar.

As part of this procedure, the author will systematically analyse the countries, beginning with an overview of their historical relationship with nuclear energy and nuclear energy's current and possible future role in the given country. This will be followed by an overview of the legal

framework covering the licensing procedures and the institutions engaged in the licensing and deployment procedure of nuclear power plants.
The main focus of the analysis will cover the deployment stages of a nuclear power plant from the initial political decision through to the operation of the plant predominantly focusing on the installation level nuclear safety licenses.
However, beyond the analytical approach of addressing the whys and hows, the author will also aim to illustrate with this section why it is important for lawyers to revisit nuclear licensing frameworks at the time of a nuclear renaissance and how such frameworks may serve as a crucial tool in implementing these goals.
The Hungarian licensing framework, its recent experience and its innovations will form the basis of this section, a process that showed that innovation in these procedures is indeed needed if new capacities are to be deployed in the current climate. What was experienced in Hungary is not a unique case. Many countries that have had recent experiences of deployment, are currently in the process of deploying plants, or are planning to deploy nuclear power plants in the future are equally going through an innovation of their legal frameworks – particularly their licensing procedures – to create more conducive environments for the forthcoming deployments. To illustrate the different national approaches to licensing that may contribute to a more efficient and streamlined licensing procedure in a nuclear renaissance, both procedures that have been in force for a longer period of time – the fact that some approaches are not new does not mean that they cannot contribute to efficiency – and reforms that have recently been implemented or are currently under discussion will be presented.
The observations on these approaches can be formulated into *de lege ferenda* proposals for countries that are considering such reforms, but also for countries that have already implemented such changes, offering them ideas for further possible adaptations.

3.2. The selection method of comparator jurisdictions

Hungary's inclusion as a country for comparison in this section warrants little explanation, given the author's national connection and the topical relevance of the Paks II licensing process. Nonetheless, the selection criteria applied to the further comparator countries would equally justify Hungary's inclusion.
The hypothesis of the section is that, in the time of the nuclear renaissance, developing more streamlined, less redundant, more predictable licensing frameworks that do not compromise nuclear safety can be contributed to by looking at foreign licensing frameworks their potential best practices and their reform endeavours towards these ends, this naturally warrants looking at as many licensing frameworks as possible. However, due to the constraints of a work of this kind, and given that the present elaboration rather intends to highlight the importance of taking note of foreign approaches and reform efforts – describing some ideas and proposing their consideration for implementation in a national context – than a comprehensive listing of all different national solutions – which would be more akin to a policy document – such a listing would not only be impractical but, due to the underlying differences between legal systems, may not constitute a straightforward or adequate solution for every other country, and as such would not carry that significant an impact. Consequently, a selection among the countries and also among those engaged in such reforms had to be made.

The first criterion on which the selection is based is the Western European Nuclear Regulators Association (WENRA) and EU/Euratom membership. Since the thesis primarily adopts a European perspective, it is crucial to assess countries whose national solutions would be more easily adopted among European states. As the first criterion, this entails being members of WENRA, which seeks to develop common approaches to safety through its standards. While these approaches are non-binding, states nevertheless adopt them, resulting in a greater degree of convergence in the substantive content of their licensing evaluations, which in turn makes the adoption of best practices among member states more feasible. The United Arab Emirates is frequently cited as a country that successfully managed the deployment of a nuclear power plant within a demanding timeframe, and its licensing experience is notable. However, the safety standards applied there differ from those in Europe, resulting not only in a different plant design but in a fundamentally different licensing experience – one that is not fully transferable to European projects. Furthermore, a limitation has to be made to discuss only countries that are members of the EU/Euratom, not only given their shared commitments to nuclear safety and the general organisation of the sector under the Euratom Treaty, but also due to their more general commitments under the EU acquis that shape the course of these projects, such as those relating to Environmental Impact Assessment procedures or state aid. In this regard, countries such as the United States[308] or the United Kingdom[309] despite their relevance in the sector and their ongoing efforts to reform their licensing frameworks are excluded from the scope of this analysis. With regard to the efforts of these countries, particularly the United Kingdom, which is a member of WENRA and whose nuclear power plant deployment framework was, until Brexit, also shaped by EU/Euratom requirements, the author would still not consider their omission from the comparison to be critical. This is because the available literature showcasing these procedures has predominantly focused on the United States, Canada, and the United Kingdom[310] already providing a solid basis for comparison, whereas the mature frameworks of some other major nuclear-power-using states remain critically under-documented.

The second criterion on which the selection is based relates to nuclear power plant construction experience. The fact that licensing frameworks are being reconsidered at a time of renewed interest in nuclear is not surprising. The efforts intended to reshape licensing frameworks seek to address the reality that these have not been in active use for a long period of time in many countries, during which the stringency of the sector has only increased while no attention was paid to streamlining these procedures. Recent experiences with licensing such installations thus highlight the inefficiencies and redundancies of existing practices and generate ideas for change. Countries belonging to this group further narrow the options that may be discussed in this analysis, as in the European Union only very few nuclear power plant constructions have taken place in the last decade and even fewer are currently underway. As a result of these criteria, countries such as Sweden,[311] – which is otherwise undergoing a very instructive reform of its licensing framework – are not considered. This naturally also results in the exclusion of

[308] For more about the already implemented reforms and further proposals in the context of the US licensing framework, see Burdick et al., 2025.
[309] *Comprehensive changes made to nuclear licensing regime guidance*, 2026.
[310] A prime example being the recently published book Burges Salamon Guide to Nuclear Law 3rd Edition, discussing the United Kingdom's licensing architecture in detail.
[311] Morgunova and Linné, 2026.

countries that are still in the relatively early stages of deploying their nuclear power plants and have not yet reached the construction stage, such as units 5 and 6 of the Dukovany plant in the Czech Republic, or the Lubiatowo-Kopalino nuclear power plant in Poland, which, while having passed certain licensing stages, is by no means through all those necessary for its deployment.

Based on these criteria, besides Hungary not many countries can be considered for comparison, namely Slovakia, Finland and France. Each of them is a member of WENRA and the European Union and each of them has had recent experience with new-build projects – Finland with Olkiluoto, France with Flamanville and Slovakia with Mochovce. Of these three potential countries, to have a more concise comparison the scope was narrowed down to Finland and France. This was due to the fact that while Mochovce Units 3-4 recently finished construction, these were not new projects – rather, construction began in the 80's and was halted, only restarting in 2008, making it somewhat different from the projects in the other countries.

France and Finland are both mature nuclear legislative frameworks, Finland not only due to its long experience with nuclear energy but also owing to the variety of technologies it has deployed,[312] while France, despite having more uniform technologies, is equally instructive given the experience associated with its numerous deployments and the fact that its nuclear industry is considerably more comprehensive than that of other countries. In the professional domain, both countries enjoy a considerable positive reputation and are widely regarded as benchmarks when it comes to ensuring a safe nuclear industry.

In the following section, the national approaches of France and Finland countries, will be discussed in detail alongside Hungary.

3.3. The historical development of nuclear power and its role in each country's energy mix

3.3.1. Hungary[313]

Hungarians have played a significant and distinguished role in the global history of nuclear science. Although a detailed exposition on their contributions lies beyond the scope of this work it would be remiss not to mention two eminent figures: Ede Teller[314], who emigrated to the United States and took part in the Manhattan Project – thereafter becoming known as the 'father of the hydrogen bomb' – and Leó Szilárd,[315] likewise an émigré to the United States, whose discovery of the nuclear chain reaction stands as a foundational breakthrough in the field.

Hungary's relationship with nuclear installations dates back to the 1950s, when the Central Physics Research Institute[316] of the Hungarian Academy of Sciences proposed the construction of a research reactor in cooperation with the Soviet Union.[317] This proposal led to the conclusion of an interstate agreement between Hungary and the USSR, delineating the respective

[312] By comparison, the two Slovakian nuclear plants all employ VVER-440 reactors, the same reactor type used at Paks I in Hungary.
[313] The sections on Hungary are based on the author's previous publication. See Mádl, 2025, pp. 47–90.
[314] Teller and Brown, 1962.
[315] Lanouette and Szilárd, 2024.
[316] Central Research Institute for Physics *[Központi Fizikai Kutatóintézet]*.
[317] 4081/1955. Előterjesztés a kísérleti atomreaktor építéséről *[Government Proposal No. 4081/1955 concerning the construction of an experimental nuclear reactor]*, p. 3.

obligations of each party.[318] The research reactor was envisaged to be a crucial source of information to preparing for electricity-generating reactors, which were expected to become viable within a 15- to 20-year horizon.[319] The first Hungarian nuclear reactor was built in the Buda Hills in 1959 with an initial capacity 2 MW, subsequently increased in 1967 to 5 MW as part of its overhaul.[320] In 2023, the operating licence of the research reactor was extended for further 10 years with specific conditions.[321]

The success of the research reactor soon catalysed a broader vision: that of constructing a nuclear power plant for electricity generation. In pursuit of this goal, educational programmes were established at Hungarian universities to train future professionals in the sector, leading to the idea of building a university reactor. Ultimately Budapest University of Technology was selected as the best place to construct it.[322] A licence was granted in 1966 for the construction of a domestically designed training reactor, which reached first criticality in 1971.[323] True to its intended purpose, professionals educated in the reactor proved pivotal to the Paks I project.

The subsequent milestone in Hungary's nuclear development was establishing a power-generating nuclear plant. In 1966, pursuant to a resolution of the Council of Ministers,[324] an interstate agreement was signed between Hungary and the Soviet Union,[325] regarding the construction of two blocks, each with an output of 800 MW. The first unit was scheduled for commissioning in 1975.[326] Under the terms of the Convention, the Soviet party undertook responsibility for the design, fuel supply, and provision of major components, while the Hungarian side assumed responsibility for selecting the site and for construction and assembly works. The agreement further addressed financing, with the Soviet Union extending a loan of 50 million roubles at a 2% interest rate, repayable over ten years via importing Hungarian goods to the Soviet Union. This arrangement was considered quite beneficial from a Hungarian perspective, as it enabled repayment through the export of products that would have faced

[318] Jéki, 2000, p. 16.
[319] 4081/1955. Előterjesztés a kísérleti atomreaktor építéséről *[Government Proposal No. 4081/1955 concerning the construction of an experimental nuclear reactor]*, p. 1.
[320] HAEA, 2023, p. 6.
[321] Az OAH BKR-HA0074. határozata az Energiatudományi Kutatóközpont Budapesti Kutatóreaktor üzemeltetési engedélye tárgyában *[Decision No. BKR-HA0074 of the HAEA on the operating licence of the Budapest Research Reactor of the Centre for Energy Research]*.
[322] Institute of Nuclear Techniques of the Budapest University of Technology and Economics *[BME Nukleáris Technikai Intézet]*.
[323] Institute of Nuclear Techniques of the Budapest University of Technology and Economics *[BME Nukleáris Technikai Intézet]*.
[324] A Magyar Forradalmi Munkás-Paraszt Kormány 3397/1966. határozata a magyarországi atomerőmű megépítése tárgyában a Szovjetunió kormányával kötendő együttműködési megállapodásról *[Decision No. 3397/1966 of the Hungarian Revolutionary Workers' and Peasants' Government on the cooperation agreement to be concluded with the government of the Soviet Union concerning the construction of a nuclear power plant in Hungary]*.
[325] Magyar Népköztársaság területén létesítendő atomerőmű építése során folytatandó együttműködésről szóló, 1966. december 28-án kelt Egyezmény *[Agreement between the Government of the Hungarian People's Republic and the Government of the Union of Soviet Socialist Republics on cooperation in the construction of a nuclear power plant in the territory of the Hungarian People's Republic (1966) signed 28 December 1966]*.
[326] Id., section 1–2.

difficulty competing on the open market.[327] In the following year a resolution[328] was issued, which stated that the plant would provide around 15-16% of Hungary's electricity needs and it would be sited somewhere in Tolna County, close to the Danube. Ultimately, the decision was made[329] to select Paks as the location, and despite underlying political motivations, nuclear safety considerations prevailed as the decisive factor in the location decision.[330] Notwithstanding initial progress, a policy debate emerged regarding the economic viability of the nuclear project suggesting supplementing it with other types of power plants based on their perceived better economics.[331] In the course of this debate of energy generation, nuclear power lost favour and project was formally postponed.[332] Owing to Hungary's obligations under its treaty with the Soviet Union, the Hungarian Government sought clarification as to whether the postponement would be acceptable. In its communication to the Soviet side, Hungary reaffirmed its commitment to the project and argued that a deferral could be mutually beneficial, as it could result in installing a more modern plant.[333] Soon the answer came back from the Soviet side that they had nothing against the modification of the Convention.[334] In 1970, the formal decision was made to postpone the project to the period of 1980-1985.[335] The Ministry of Heavy Industry later issued a decision confirming the new timeline for the project's implementation.[336] Based on this mutual agreement the Interstate Convention had to be modified. The Hungarian delegation was entrusted[337] not only to set a later implementation date, but also to modify the project's scale to four 500 MW units.[338] In July of 1970, the Convention was amended by an additional protocol envisaging the construction of a nuclear power plant with an aggregated capacity of 1900-2000 MW. The first two 440 MW units were scheduled for commissioning by 1980, with the remaining units to follow with the entire 2000 MW plant until 1985.[339]

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[327] Bosák, 2016.

[328] A Magyar Forradalmi Munkás-Paraszt Kormány 3004/1967. határozata a szovjet segítséggel történő első magyar atomerőmű létesítésére kötött Egyezményről *[Decision No. 3004/1967 of the Hungarian Revolutionary Workers' and Peasants' Government concerning the agreement on the construction of the first Hungarian nuclear power plant with Soviet assistance]*.

[329] ETV-ERŐTERV, 2024, p. 14.

[330] Power Plant and Network Design Enterprise, 1967.

[331] Szabó, 2004, pp. 103–162.

[332] Id., pp. 140–162.

[333] Correspondence between Antal Apró and soviet deputy prime minister M. A. Leszecsko concerning the postponement of the construction of the nuclear power plant, Hungarian National Archives, MOL XIX-A-2-gg-21-338-1969 (Box No. 349).

[334] Ibid.

[335] A Magyar Forradalmi Munkás-Paraszt Kormány 3009/1970. határozata a szovjet segítséggel történő első magyar atomerőmű létesítésére kötött egyezmény határidejének módosításáról *[Decision No. 3009/1970 of the Hungarian Revolutionary Workers' and Peasants' Government concerning the amendment of the time limit set in the agreement on the construction of the first Hungarian nuclear power plant with Soviet assistance]*.

[336] 3068/1970 NIM decree. See Szabó, 2004, pp. 220–225.

[337] Id., pp. 194–209.

[338] During the negotiations, the Soviet party clarified that there was no 500 MW reactor model available. Instead, they could offer either the 440 MW or the 1000 MW reactor. Interestingly, this increase in capacity was not intentional on the Hungarian side, which is also reflected in the limited technical knowledge demonstrated regarding the reactor types. See Szabó, 2004, pp. 200–209.

[339] Jegyzőkönyv a Magyar Népköztársaság Forradalmi Munkás-Paraszt Kormánya és a Szovjet Szocialista Köztársaságok Szövetségének Kormánya között 1966. december 28-án, atomerőműnek a Magyar Népköztársaságban történő létesítésében való együttműködésről kötött Egyezményhez, 1970 *[Protocol to the*

With a slight delay, the plant became operational over the period from 1982 to 1987 and, for more than 40 years, the Paks I Nuclear Power Plant has been a cornerstone of Hungary's electricity mix, consistently accounting for more than 40% of national electricity generation. Following the expiration of their initial 30-year operational lifespans – beginning with the first unit in 2012,[340] shortly in the wake of the Fukushima accident – their operating licences were extended for another 20 years, thereby reinforcing Hungary's energy security. Given the delays associated with the construction of the Paks II and the renewed emphasis on national energy autonomy in the wake of the Russian-Ukrainian crisis,[341] the prospect of further extending the operational lifespan of Paks I appears not only rational but also prudent. Although the Hungarian Parliament passed a resolution in 2022 in support of such a course,[342] the ultimate decision lies with the competent regulatory authority.

In 2007, against the backdrop of ongoing discussions concerning the construction of an additional plant in Hungary, the so-called Teller Project was initiated[343] to assess more thoroughly the feasibility of establishing a new nuclear power plant. The project following the consent of the National Assembly advanced to its next stage. In 2012, MVM Hungarian Electricity Works Private Company Limited by Shares – a state-owned company also owner of the Paks I plant – established the MVM Paks II Nuclear Power Plant Development Private Company Limited by Shares. Later that same year, the project was deemed a priority investment for national economy and crucial to our energy security.[344] As a next step in 2014 an intergovernmental Convention was promulgated between the governments of Hungary and the Russian Federation on the cooperation in the peaceful uses of nuclear energy, enacted into Hungarian law as Act II of 2014. This convention set forth that the parties would cooperate in deploying two new reactor units at the Paks site, each with minimum electrical output of 1,000 MW; however, the precise reactor type to be deployed was not defined within the instrument.[345] Additionally, the convention provided that the Russian Federation would supply nuclear fuel to the new units for a period of 20 years, with a provision allowing for an extension of this arrangement. This 20-year fuel supply was ultimately modified to ten years due to diversification reasons following the procedure of the Euratom Supply Agency. Furthermore, the Convention stipulated as an option that spent nuclear fuel could be transported back to the

Agreement concluded between the Government of the Hungarian People's Republic and the Government of the Union of Soviet Socialist Republics concerning cooperation in the construction of a nuclear power plant in the Hungarian People's Republic (1970) signed 3 July 1970].

[340] Az OAH HA5601 határozata a Paksi Atomerőmű 1. blokkjának a tervezett üzemidő lejártát követő további működése tárgyában *[Decision No. HA5601 of the HAEA on the continued operation of Unit 1 of the Paks Nuclear Power Plant beyond its planned service life]*.

[341] For more, see Hartvig et al., 2024.

[342] 56/2022. (XII.8.) OGY határozat a Paksi Atomerőmű meglévő blokkjai üzemidejének további meghosszabbításáról *[Resolution No. 56/2022 (XII.8.) of the National Assembly on the further lifetime extension of the existing units of the Paks Nuclear Power Plant]*.

[343] After the decision-in-principle in 2009 the Project was renamed Lévai-project.

[344] 1194/2012. (VI. 18.) Korm. határozat a Paksi Atomerőmű telephelyén létesülő új atomerőművi blokkal (blokkokkal) kapcsolatos további feladatok meghatározásáról *[Government Decision No. 1194/2012 (VI.18.) on the definition of further tasks related to the new nuclear power plant unit(s) to be constructed at the site of the Paks Nuclear Power Plant]*.

[345] 2014. évi II. törvény a Magyarország Kormánya és az Oroszországi Föderáció Kormánya közötti nukleáris energia békés célú felhasználása terén folytatandó együttműködésről szóló Egyezmény kihirdetéséről *[Act No. II of 2014 on the promulgation of the Agreement between the Government of Hungary and the Government of the Russian Federation on cooperation in the peaceful use of nuclear energy]*, art. 5–6.

territory of the Russian Federation for reprocessing. The Convention prompted significant public and legal controversy. In 2014, the political party 'Együtt' initiated a referendum initiative posing the question: 'Do you agree that no new nuclear power plant units should be built in Hungary with the help of a public deficit-increasing loan?'[346] This initiative was rejected by the National Election Office, which based its decision on the Fundamental Law of Hungary, which precludes national referenda on obligations arising from international treaties.[347] In the Office's view, Article 1 of the Convention established such an international obligation.[348] The proponents of the referendum challenged this decision by lodging an application for review to the Curia (Supreme Court of Hungary), arguing that Article 1 did not impose a specific obligation on a project. The Curia, however, dismissed this contention, affirming the National Election Office's interpretation.[349] Dissatisfied with the ruling the proponents of the initiative filed a constitutional complaint with the Constitutional Court, which complaint was ultimately dismissed on the grounds that it did not raise any constitutional law issue of fundamental importance.[350] The decision to bar the referendum provoked criticism. Detractors argued that the Curia interpreted the commitment to cooperate in Article 1 – and the Convention in its entirety – with undue breadth. The Court, they contended, improperly inferred the existence of a public deficit-increasing loan arrangement from the Convention, despite the absence of any explicit reference thereto in the text. At the time the Curia rendered its decision, no loan agreement enshrining such a financial arrangement had yet been concluded. On this view, the Convention should have been construed more narrowly, with careful scrutiny of whether it actually contained a commitment directly corresponding to the subject of the proposed referendum.[351] Nevertheless, the Curia adopted a more substantive approach.[352] Although the Convention did not explicitly reference a public deficit-increasing loan, given the scale of the project, it is difficult to conceive of any other feasible arrangement. While the critique of the Curia's decision – namely, that it drew overly broad conclusions from the text of the Convention – is well reasoned, the countervailing view that, in a project of such profound and long-term significance to Hungary's energy portfolio and economic development, the final decision ought to lie with the electorate,[353] warrants closer scrutiny. The domain of nuclear energy is inherently technical, marked by a high degree of complexity and unpredictability, rendering it exceedingly difficult for the general public to form a fully informed judgment. Moreover, the ease with which emotionally charged, anti-nuclear arguments – often devoid of scientific rigour – may be disseminated and absorbed by public opinion results in an uneven playing field, where balanced discourse between opposing views is seldom achievable. Experiences from other countries, notably Germany, demonstrate that where nuclear-related decisions are driven purely by political rhetoric, untethered from scientific expertise, the outcomes may lead to grave disadvantages.

[346] For more, see Csink, 2014, pp. 37–42.
[347] Fundamental Law of Hungary, art. 8(d).
[348] A Nemzeti Választási Bizottság (NVB) 91/2014. határozata *[Judgment No. 91/2014 of the National Election Office of Hungary]*.
[349] A Kúria Knk.IV.37.178/2014/3. határozata, *[Judgment No. Knk.IV.37.178/2014/3 of the Curia of Hungary]*.
[350] 3195/2014. (VII. 15.) AB végzés *[Judgment No. 3195/2014 (VII.15.) of the Constitutional Court of Hungary]*.
[351] Csink, 2014, pp. 37–42.
[352] Ibid.
[353] Ibid.

Subsequently, a loan agreement was concluded between the contracting parties and thereafter promulgated by the Hungarian Parliament in 2014.[354] The agreement set forth that the Russian Federation undertook to extend a loan facility of up to EUR 10 billion for the purpose of financing the design, construction and commissioning of the two nuclear units, covering 80% of the project total costs, with the remaining 20%, as well as any cost overruns, to be borne by Hungary.[355] The repayment of the loan is structured over a period of 21 years, to be discharged through biannual instalments. Repayment is scheduled to commence upon the commissioning of the units, but in any event no later than 15 March 2026.[356] The repayment terms are delineated into three successive periods: during the first 7 years, Hungary is to repay 25% of the used loan amount at an interest rate of 4.50%; in the second 7-year period, 35% of the used loan is to be repaid at an interest rate of 4.80%; and during the final 7 years, the remaining 40% of the used loan is to be repaid at an interest rate of 4.95%.[357] In the event of late payment, a default interest rate equal to 150% of the applicable contractual interest for the respective period shall be imposed. Furthermore, should any payment remain outstanding for a period exceeding 180 days, the Russian Federation has the right to demand immediate repayment of the entire principal loan amount with all accrued interest.

Concerning the loan agreement, it is worth apposite to briefly address the state aid considerations arising from the case. In 2015, Hungary formally notified the European Commission of the Paks II project, expressing that in its view, the arrangement did not constitute a state aid measure. However, their reasoning was rejected by the Commission, which subsequently initiated a state aid investigation. In the final analysis, the Commission found that the aid was compatible with the internal market and approved the measure.[358] This decision of the Commission, was later challenged by Austria before the General Court, which dismissed the action.[359] However, Austria appealed this decision before the Court of Justice and in 2025, the Advocate General, Laila Medina, has opined that the appeal ought to be upheld. In line with the Opinion of the Advocate General, the Court of Justice of the European Union set aside the judgment of the General Court and annulled the Commission's decision approving the state aid, on the ground that, within the state aid procedure, the Commission should itself have ascertained whether the awarding of the contract to the Russian party under the Agreement – which was concluded without a public procurement procedure – complied with EU public procurement rules.[360] Opinions are divided as to what this decision means for the fate of the project. On the one hand, the Commission, in a separate procedure, approved that no public procurement procedure was initiated in relation to the plant. Consequently, some argue that, although the Commission's decision was annulled on this basis, this does not mean that the Commission had failed to consider these aspects of the project at all, rather, it means that they should also have been addressed as part of the state aid approval procedure – a step that would

[354] 2014. évi II. törvény a Magyarország Kormánya és az Oroszországi Föderáció Kormánya közötti nukleáris energia békés célú felhasználása terén folytatandó együttműködésről szóló Egyezmény kihirdetéséről *[Act No. II of 2014 on the promulgation of the Agreement between the Government of Hungary and the Government of the Russian Federation on cooperation in the peaceful use of nuclear energy]*.
[355] Id., section 1.
[356] Id., section 3.
[357] Id., section 3–4.
[358] European Commission, 2017.
[359] *Austria v Commission* (T-101/18) ECLI:EU:T:2022:728, judgment of 30 November 2022.
[360] Angyal 2025, pp. 35–53.

not necessarily have led to a different outcome than the separate approval. On the other hand, relations between the European Union and the Russian Federation have significantly deteriorated since the initial approval, and aspects of the project, such as its cost compared to what was originally agreed, will now have to be taken into account, potentially resulting in a different decision.[361] One aspect unaffected by the Court's decision is the progress of the project itself, which officially began construction in early 2026 despite this uncertainty.

Owing to considerable delays in the implementation of the project – delays which now render the commencement of operations more probable to begin in the 2030s – the original loan repayment commencement date of 2026 proved untenable. Consequently, the parties proceeded to amend the loan agreement in 2021,[362] specifically revising the provisions governing the repayment schedule. Pursuant to this amendment, Hungary shall repay the loan over a period of sixteen years, commencing from the date of commissioning of the units, but no later than 2031. Essentially, this amendment postponed the first repayment date by five years, from 2026 to 2031, while simultaneously shortening the overall repayment period from 21 to 16 years. On the face of it, this adjustment does not seem to improve Hungary's position much. However, the underlying rationale is that it is more favourable to start the repayment when the plant is operational and generating revenue. That said, as of 2026, the presumption that the plant will indeed be operational by 2031 is itself increasingly uncertain. The instalments were also changed accordingly: under the amended terms, 10% of the utilised loan is to be repaid in the first two years at an interest rate of 3.95%; 40% is to be repaid over the subsequent seven years at 4.50% interest; and the final 50% is to be repaid in the last seven years, at an interest rate of 4.80%.

Another additional pivotal development in the trajectory of the Paks II project was the 2015 resolution of the National Assembly, whereby legislation was enacted: an Act granting the Paks II project special status in view of its exceptional significance for the national economy.[363] Among its various provisions, the Act prescribed that documentation and contractual materials related to the project would be exempt from disclosure as data of public interest for a period of 30 years.[364] In effect, this legislative measure essentially rendered the whole documentation of the project inaccessible to the public. In 2016,[365] this stringent confidentiality regime was partially relaxed. The exemption was no longer applied wholesale to all documents, but rather limited to specific trade and technical information, the disclosure of which could either compromise national security interests or infringe intellectual property rights. Notwithstanding

[361] Id. p. 52.

[362] 2021. évi LXXI. törvény a Magyarország Kormánya és az Oroszországi Föderáció Kormánya között a Magyarország Kormányának a magyarországi atomerőmű építésének finanszírozásához nyújtandó állami hitel folyósításáról szóló, 2014. március 28-án kelt megállapodás módosításáról szóló jegyzőkönyv kihirdetéséről *[Act No. LXXI of 2021 on the promulgation of the Protocol amending the Agreement of 28 March 2014 between the Government of Hungary and the Government of the Russian Federation on the disbursement of a state loan to be provided to the Government of Hungary for financing the construction of a nuclear power plant in Hungary]*.

[363] 2015. évi VII. törvény a Paksi Atomerőmű kapacitásának fenntartásával kapcsolatos beruházásról, valamint az ezzel kapcsolatos egyes törvények módosításáról *[Act No. VII of 2015 on the investment related to maintaining the capacity of the Paks Nuclear Power Plant and on the amendment of certain related acts]*.

[364] Id., section 5.

[365] 2016. évi XIX. törvény a Paksi Atomerőmű kapacitásának fenntartásával kapcsolatos beruházásról, valamint az ezzel kapcsolatos egyes törvények módosításáról szóló 2015. évi VII. törvény módosításáról *[Act No. XIX of 2016 amending Act VII of 2015 on the investment related to maintaining the capacity of the Paks Nuclear Power Plant and on the amendment of certain related acts]*.

this legislative change, the contracts related to the project remained undisclosed. This impasse was ultimately broken in 2019, when the Budapest Regional Court of Appeal[366] rendered a landmark judgment obliging Paks to release the relevant information, including the Engineering, Procurement and Construction (EPC) contract – albeit with the caveat certain sections may lawfully remain redacted.

Regarding the contractual framework underpinning the project, a 'turnkey' Engineering, Procurement and Construction (EPC)[367] contract, drafted in English, was executed between the parties in 2014,[368] along with an equally important Operation and Maintenance Agreement and Fuel Supply Agreement. While a comprehensive analysis of these instruments lies beyond the scope of this discussion, certain pivotal elements warrant emphasis. Under the EPC contract, the Russian party, in its capacity as contractor, is obliged to deliver a turnkey nuclear power plant in compliance with the owner's requirements and applicable regulatory provisions. Conversely, Paks, as the owner, is responsible for making the site available to the contractor free of charge, ensuring its protection at its expense throughout the project, and supplying all pertinent information concerning the site. Of particular legal and practical import is the provision allocating responsibility for the licensing process: under the terms of the agreement, the contractor is designated as the party primarily responsible for securing the requisite licences, with the owner under a duty to render reasonable assistance. However, in practice, the differences in the applied standards necessitated a more active role by the owner than mere assistance, who has effectively assumed a leading position in the licensing procedure. Since its original execution, the EPC contract has undergone six amendments, the majority of which pertain to adjustments in project deadlines.

Finally, the role of nuclear power within the Hungarian electricity mix must be addressed in this section. In line with Hungary's commitment to achieving climate neutrality by 2050, its energy mix – and particularly its electricity mix – has undergone significant transformation in recent years, with efforts made to increase the share of renewables so as to contribute to the goals set out in instruments such as the National Energy and Climate Plan.[369] Hungary's electricity generation mix now consists predominantly of low-carbon sources, with coal's role diminishing considerably. This decline is most visible at the predominantly lignite-fired Mátra Power Plant, Hungary's second-largest power plant, where only one of five units remains in permanent operation, two are retained for balancing capacity, and the plant is being converted to gas firing by the end of the decade. Offsetting this decline in carbon-emitting sources, the most significant change in the electricity mix has occurred in solar power, which now accounts for over 26% of electricity generation, with installed capacity of around 9,000 MW, up from 1,500 MW in 2019. This expansion was driven in part by support for small household power plants – domestic rooftop solar panels – which, through various support schemes, have grown so significantly. Wind power, by contrast, has remained largely undeveloped in Hungary, owing to regulatory restrictions that, until recently, prohibited the installation of wind turbines within

[366] A Fővárosi Ítélőtábla Pf. 20775/2019/7. határozata *[Judgment No. Pf.20.775/2019/7 of the Budapest Regional Court of Appeal]*.

[367] For more, see Frank and Fork, 2022, p. 501.

[368] MVM Paks II Nuclear Power Plant Development Private Company Limited by Shares and Joint-Stock Company Nizhny Novgorod Engineering Company Atomenergoproekt, *Engineering, procurement and construction (EPC) contract* (signed 9 December 2014).

[369] Directorate-General for Communication, 2024b.

12 kilometres of built-up urban areas, rendering expansion practically impossible. Although this distance restriction was reduced to 700 metres amid the energy crisis, the updated National Energy and Climate Plan still envisages only a modest 1,000 MW of wind capacity by 2030. Amid this broader transformation of the electricity mix, nuclear power has remained constant, with Paks I – discussed above – continuing to supply around 40% of national electricity generation.

Regarding the future role of nuclear power in the electricity mix, the National Energy and Climate Plan mentions nuclear power on several occasions, most notably in its support for the long-term operation of the Paks I plant and the construction of Paks II, without which energy security and sovereignty, as well as the decarbonisation targets set for the energy sector, would be impossible to achieve. As now appears overly optimistic in light of the progress of the Paks II project, the National Energy and Climate Plan projected a 118% increase in the use of nuclear energy between 2019 and 2030, which would account for around 30% of final energy consumption by that year. Since construction of Paks II only began in early 2026, however, this projection is no longer realistic – particularly following the 2026 parliamentary elections, after which the newly elected government has been closely reviewing the project and its contractual framework in deciding how to proceed with it. This decision is further complicated by the drought that occurred in the summer of 2026, which affected the operation of the Paks I plant, given that it relies on water from the Danube for cooling; although the project has not been physically halted, this has made the question of how to proceed even more difficult, since the same cooling method that Paks II intends to employ has, on this occasion, been called into question by many. In addition to these large-scale capacities, the National Energy and Climate Plan also discusses SMRs, the feasibility of which Hungary is currently evaluating.

3.3.2. Finland

Finland, like the other two countries analysed in this section, has had a relatively long history with nuclear power. The idea of including nuclear energy in the Finnish energy mix emerged in the 1960s, and by the end of the decade the first nuclear power plant order was placed; subsequently, the first nuclear power plant to come into operation was the Loviisa 1 reactor in 1977, situated on the southern coast of Finland not far from Helsinki. Interestingly, the Loviisa plant – while Finland was clearly not behind the Iron Curtain – housed two units of Soviet VVER-440 reactors. In terms of major components, the power plant was therefore the same as that of Paks I, complemented by many ancillary western systems, as the plant generally had to meet western safety standards.[370] The underlying reason why a country belonging to the Western world would, at that time, choose Soviet technology lies in Finland's close bilateral trade cooperation with its neighbour, the Soviet Union,[371] as well as in the Soviet Union's own political interests, which made its offer comparatively more advantageous than those from Western competitors.[372] The two units of the Loviisa nuclear power plant were granted a long-term operation licence for the first time in 2007, allowing them to operate for a further 20

[370] *Loviisa Nuclear Power Plant. History*, no date. Setting western safety standards in front of a design that was intended to meet different safety requirements had its fair share of challenges. See Hyvärinen et al., 2024.
[371] Kara and Mattila, 1996, pp. 49–56.
[372] Lounasmeri, 2022.

years,[373] a second long-term operation licence was granted in 2023, permitting them to continue operating until 2050.[374]

The second nuclear power plant in Finland – under different ownership – was the Olkiluoto plant. The Olkiluoto plant was built around a Swedish boiling water reactor design with two reactors, the first of which became operational in 1978.[375] These two units initially received their operating licences for 40 years, meaning they could operate until 2018; subsequently, the operating licences of the reactors were extended to 2038, though Teollisuuden Voima Oyj (TVO), the operator of the plant, is already exploring the further extension of the licences until 2048 or 2058.[376]

Finland is a good example – at least in conceptual terms – that nuclear energy did not previously disappear in the western world and that the comeback we are witnessing today is not as radical as the term renaissance tends to suggest. In the period predating the Fukushima accident – a period which some also referred to as a renaissance –Finland remained committed to the expansion of its nuclear generating capacity, and two projects received parliamentary approval to proceed: first, the third unit of the Olkiluoto nuclear power plant, housing an EPR pressurised water reactor, and later its fourth unit; and second, the Hanhikivi nuclear power plant, which was planned to employ the same Russian technology being deployed at Paks II.[377] Of these projects, ultimately only Olkiluoto unit three materialised, and even this was not without considerable challenges, as the project faced severe delays due to, among other reasons, subcontractors failing to meet nuclear industry standards, a lack of substantial experience in the deployment of the EPR design, and difficulties in the coordination of the numerous actors involved.[378] As a result, instead of the initially planned start-up date of 2009, the plant only became operational in 2023 – fourteen years behind schedule. Of the other initiated projects, the first to be cancelled was unit four of Olkiluoto, where, following the substantial delays associated with unit three, no application for a construction licence was ultimately submitted.[379] The Hanhikivi nuclear power plant also experienced significant delays and ultimately did not materialise either, specifically due to the Russian-Ukrainian war.[380] However this is not unusual in Finland as there were several other plants that also failed at different stages.[381] In this regard, the conclusion drawn previously – that the seriousness of the nuclear renaissance should not be assessed on the basis of mere discussions but rather on tangible steps – acquires particular relevance in the Finnish context, demonstrating that even tangible steps such as issued decision-in-principles do not necessarily mean that a plant will ultimately be built.

Electricity generation in Finland is dominated by carbon-neutral sources. While coal used to play an important role, since the 2010s it has shown a gradual decrease and its contribution to electricity generation has diminished considerably. Among renewables, wind power has shown a sharp increase, currently accounting for approximately a quarter of electricity generation and

[373] Becker and Mraz, 2022, p. 3.
[374] *Lifetime extension of the Loviisa Nuclear Power Plant*, no date.
[375] Ministry of Employment and the Economy, no date, p. 9.
[376] TVO, 2024, p. 6.
[377] Lounasmeri, 2023, p. 3.
[378] Ruuska et al., 2011, pp. 654–655.
[379] For more about the project, see TVO, 2008.
[380] In practice the argument for terminating the contract with the Russian party was beacuse of the significant delays and their inability to deliver the plant. For more, see Husu, Talala and Kojo, 2025.
[381] Lampinen, 2009, p. 42.Vehkalahti, 2017.

expected to continue growing.[382] Other important energy sources in the Finnish electricity generation include biofuels – which are interlinked with the strong forest industry in Finland[383] – and hydropower. However, the most prominent role in electricity generation is played by nuclear energy, with its five reactors accounting for around 40% of electricity generation[384] a share that has increased significantly following the coming online of Olkiluoto unit 3.

While the EU is aiming to be climate neutral by 2050, Finland has more ambitious goals, as its national target enshrined in law sets climate neutrality by 2035 as the goal, with emissions to continue decreasing thereafter.[385] Finland is adopting wide-ranging measures to meet this ambitious target, and these naturally also concern the further transformation of the energy sector; one of the core areas is district heating, in which fossil fuels still hold a large share. One of the potential areas where nuclear power may make a further positive contribution to reaching net zero is the district heating sector, via the supply of excess electricity to heat pumps.[386] The future role of nuclear energy is primarily articulated in the National Energy and Climate Plan of Finland. One sphere of action in the sector that the plan recalls is the long-term operation of Olkiluoto units 1 and 2, including the uprating of the units to achieve a higher output.[387] The other context in which nuclear energy is mentioned is the construction of new units. While the plan makes mention of large-scale nuclear power plants also being considered, particular interest is directed towards SMRs, with 10 to 20 units being investigated for deployment not only for electricity generation but also for heat, which could directly contribute to the decarbonisation of the heating sector.[388] In this regard, the plan also makes special mention of the forthcoming reform of the nuclear law framework in Finland, noting that a separate decree on SMRs may be adopted to enable their deployment.[389]

Currently there are no concrete plans for new nuclear power plant constructions in Finland, but this does not mean that given actors are not looking into the option of deploying new nuclear capacities – particularly as public perception of nuclear energy is at an all-time high.[390] These efforts – also taking into account that licence extensions appear likely and that, after a long struggle, Olkiluoto unit 3 has only recently come into operation – are predominantly focused on SMRs.[391] With respect to SMRs several companies have expressed interest, such as the Finnish energy company Fortum in the BWRX-300 design.[392] An interesting case in Finland concerns the Finnis developed LDR-50 reactor argued to be suitable for decarbonising the district heating sector.[393] Helen, a Finnish energy company, has signed a letter of intent to cooperate on establishing the necessary conditions – including lobbying for the reform of the

[382] Proskurina, 2024, p. 1068.
[383] Ranta, 2023, pp. 46–47.
[384] IEA, 2024.
[385] Act No. 423/2022 (Climate Act), section 2(1).
[386] Khosravi et al., 2020.
[387] Ministry of Economic Affairs and Employment of Finland, 2024, p. 146.
[388] Id., p. 166.
[389] Id., p. 39.
[390] Penttinen, 2025, p. 97.
[391] Some stakeholders such as Fortum not only assessed SMRs but also looked into large scale nuclar power plants See: *Selvitys ydinenergian tuotannon edistämisen vaihtoehdoista, kustannuksista ja sähkömarkkinavaikutuksista [AFRY's study examines the options and impacts of promoting nuclear energy production in Finland],* 2026, pp. 21–23.
[392] *Early works agreement for BWRX-300 SMRs in Finland and Sweden*, 2025.
[393] Sokka, Kirppu and Leppänen, 2024.

legislative framework – to invest in the technology.[394] Since the plant is intended for heat generation, which entails siting it closer to populated areas, Helen is looking into potential sites in the Helsinki area,[395] for which the change in provisions governing Emergency Planning Zones was welcome news as Finland has removed the previous 20-kilometre radius requirement[396] and now allows a flexible approach to determining the size of the EPZ.[397] The draft design concept was also evaluated by STUK – the Finnish regulatory authority – in the process also testing the concept assessment procedure proposed to be implemented in the reformed Nuclear Energy Act, with the conclusion that the solutions of the LDR-50 plant can be designed to meet the regulatory requirements.[398] It should be noted, however, that this opinion has no tangible legal effects and does not necessarily mean that the design would be licensed. The project is moving forward, and in 2026 it was announced that a pilot plant of the SMR design, without the nuclear fuel components, will be constructed to test the plant.[399] This project is particularly interesting from the perspective of how a domestic vendor could respond to a domestic challenge – the decarbonisation of district heating – in a relatively small country such as Finland, and how in this domestic context the early engagement of several stakeholders may facilitate the deployment of such SMRs.

One particular aspect of the Finnish nuclear sector that cannot be left unaddressed is their unique investor financing model, the so-called Mankala approach. In this model, investors – typically power companies – join forces to provide sufficient capital and diversify risks[400] establishing a limited liability company – the Mankala company – which is not profit-oriented and does not pay dividends. The costs of this company, which in the case of nuclear power plants primarily concern the construction and operation of the plant, are covered by the investors. The investors in turn receive the power produced by the Mankala company at cost price, in proportion to their shares.[401] In Finland this financing model has a long-standing history; units 1 and 2 of the Olkiluoto nuclear power plant also stemmed from a private sector initiative – primarily from the paper and pulp industry – to retain control over their energy source.[402] However, it was not only popular in the case of nuclear power plants but also for hydropower plants – the name Mankala originates from the first hydropower plant built under such a financing structure[403] – and currently more than half of the electricity production takes place within this model.[404]

In summary, there are currently five operating nuclear power reactors in Finland, featuring varying technological solutions and divergent vendor philosophies – both western and eastern – which makes Finland a unique country globally and especially within the western world. This also entails that its national regulatory framework and the expertise of the regulator must reflect

[394] *Helen and Steady Energy aim to introduce nuclear hear production in Finland*, 2023.
[395] *Potential sites identified for Helsinki SMR plant*, 2025.
[396] Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant. STUK Y/2/2024, section 3a.
[397] *According to STUK's new regulation, nuclear power plant's precautionary action zone and emergency planning zone are defined on a case-by-case basis*, 2024.
[398] Regulator completes preliminary assessment of Steady Energy's SMR concept, 2025.
[399] *Minister Multala: Piloting small modular reactor in Helsinki signals Finland's leading role in nuclear energy solutions*, no date.
[400] Terlikowski, 2019, p. 33.
[401] Ialenti, 2021, p. 1380.
[402] IAEA, 2014, pp. 61–62.
[403] Id., p. 62.
[404] NEA, 2024, p. 22.

these differing installations. Besides its legacy installations, Finland has also had recent experience with constructing and licensing a large-scale modern nuclear power plant, that is a rather unique body of knowledge in the EU. Moreover, despite the challenges of the recent project, Finland has remained open towards nuclear energy, which is viewed as a cornerstone of its commitment to climate neutrality; in this regard, the installation of new nuclear generating capacities is also being discussed, particularly with respect to SMRs. While some countries have jumped on the promises of SMRs by issuing decisions-in-principle to signal political commitment, Finland is more restrained and focuses on SMRs primarily in the context of harder-to-decarbonise sectors.

3.3.3. France

In the case of France, the critical role of nuclear power requires less explanation than in the case of the other countries under consideration. France's electricity generation mix is characterised by a remarkably high share of low-carbon sources, within which hydropower is the largest renewable contributor, accounting for slightly over 10% of generation, while onshore and offshore wind together supply around 9% followed by solar power. However, among the low-carbon sources nuclear power remains dominant, accounting for 67% of electricity generation which is the highest share among all countries operating nuclear power plants – a position France is set to hand over to Slovakia once unit 4 of the Mochovce plant comes online – and globally, France ranks as the third-largest producer of nuclear electricity, behind only the considerably larger United States and China.

The origins of nuclear energy in France differ from those of the other two countries analysed, as they are rooted equally in its civilian and military applications. Under the authority of General de Gaulle, France launched its broad nuclear programme in 1945 by establishing the French Atomic Energy Commission (Commissariat à l'Énergie Atomique, CEA), which proved to be a crucial step for both military and civilian applications.[405] One of the first major milestones in the history of the French nuclear programme was the ZOE heavy water experimental reactor,[406] commissioned in 1948,[407] which was crucial in developing France's independent program. At the same time as a further enabling factor for the extension substantial uranium reserves were discovered in France.[408] The next important step came in 1952 when the first five-year plan was adopted, which initially sought two – later three – plutonium-producing plants at the Marcoule site, also generating electricity in cooperation with EDF, in which the military had substantial interests.[409] Reflecting the full fuel cycle approach of the French programme, the same site also saw the construction of France's first large reprocessing plant, the UP1.[410] In the wake of the shock of the Suez Canal Crises of 1957, a second five year plan was adopted with a much more substantive budget reflecting the military interests,[411] as in 1955

[405] Coutrot, 1981, pp. 343–371.
[406] The following period saw the construction of several other research reactors such as the EL2 or the EL3 and the emergence of the CEA Paris-Saclay site, which still today plays a crucial role in research.
[407] Foasso, 2003, pp. 32–34.
[408] Boyle and Robinson, 1981, p. 302.
[409] Mendl, 1965, pp. 22–36.
[410] Schneider and Marignac, 2008, p. 16.
[411] Kojima, 2019, pp. 34–35.

a memorandum of understanding was signed – which financed the third plutonium producing reactor and equally the reprocessing plant – between the Defence Minister and the Atomic Energy Commission to develop nuclear weapons.[412] The weapons were developed by 1960 and subsequently the first test took place in the Tanezrouft desert of Algeria, however in 1962 due to the independence of Algeria,[413] these had to be moved elsewhere and French Polynesia was selected as site for the continuous tests.[414] De Gaulle saw the merits of nuclear weapons in ensuring the sovereignty of France as self-determination can only exist if the nation is not dependent on foreign forces such as the United States,[415] though as argued by some, the programme in reality lacked strategy and the claimed benefits of nuclear weapons proved considerably more modest in practice.[416] Naturally, since France had developed not only a civilian but also a military programme, the criticism and opposition it faced were correspondingly more varied in nature, extending beyond purely civilian safety concerns to arguments against nuclear proliferation, as advanced by some influential figures in French and European politics – such as François Mitterrand – who argued that the development of nuclear weapons only contributed to proliferation.[417] Although figures such as Mitterrand were aslo less strongly supportive of the civilian programme than other politicians, its development was not significantly hampered during their time in office. Alongside the weapons programme, civilian developments also continued from 1957 onwards, initially in the spirit of independence pursuing the deployment of developed versions of the already used dual-purpose reactors at the Chinon, Saint-Laurent and Bugey sites.[418] This same period and technology also marked the beginning of France's international vendor position, with the Vandellós plant in Spain being the pioneer.[419] However due to some technological debates,[420] and limitations of the existing design philosophy in the 60's France together with Belgium began to diversify its technological expertise with pressurised water reactors, the benefits of which were soon realized consequently future deployment strategies focused on these technologies.[421] While the initial plans for this expansion were rather conservative, they were revised just before the 1973 oil crisis – a decision quickly reinforced by the events of the crisis itself – thus propelling an ambitious nuclear expansion in France unmatched anywhere else in the world.[422] The all nuclear so-called Messmer Plan – named after the then Prime Minister Pierre Messmer – was adopted in the wake of the crisis, with the ambitious goal of deploying 170 reactors by 2000,[423] which while was not fulfilled the expansion was nevertheless remarkable. During this fruitful period of the French nuclear industry, the focus was exclusively on PWR reactors. Framatome emerged as the only French company with prior experience in this technology through its prior cooperation with

[412] Billaud and Journé, 2008, pp. 353–372.
[413] While Algeria gained independence under Chapter III. of the France-Algeria independence agreements (so called Evian agreements) France could still retain certain sites and military airfields in Algeria, and the nuclear test continued until 1996.
[414] Norris, 1996, pp. 39–54.
[415] Tertrais, 2020, p. 8.
[416] Pelopidas and Philippe, 2021, pp. 243–260.
[417] Lieber, 1966, pp. 421–431.
[418] Morlat, 1978, p. 962.
[419] Id., p. 962.
[420] Le Renard, 2017, pp. 59–60.
[421] Morlat, 1978, p. 963.
[422] Stuart et al., 2017, pp. 31–32.
[423] Liu, 2025, pp. 32–33.

Westinghouse. This resulted in a highly advantageous position for Framatome, with numerous orders and no real domestic competition, allowing it to benefit from large-scale, standardised series production.[424] In the span of a decade and a half alone, France built 56 reactors, although the pace of expansion slowed somewhat in the early 1980s.[425] This period was not only marked with the domestic expansion of PWR plants, but France also appeared on the international vendor map with their first project being the Koeberg nuclear power plant in South Africa.[426] Projects abroad continued with Iran – whose nuclear ambitions were viewed with suspicion by the Carter administration – as Mohammad Reza Pahlavi turned to France to supply nuclear power plants. Discussions concerned a total of ten reactors, but ultimately, in 1977, the only contract signed covered two units of the Darkhovin nuclear power plant, work on which was halted following the outbreak of the Islamic Revolution.[427] South Korea, with the Uljin 1 and 2 units, was the last country to which France sold its technology during this period, although this project involved considerably more substantial local content.[428]

The Chernobyl accident did not constitute a major impediment to the development of nuclear energy in France: the public did not outright reject the continued use of nuclear power, but rather viewed government secrecy in the sector as the primary problem.[429] However, following the fall of the Berlin Wall, globalisation accelerated, and in the 1990s the liberalisation of energy sectors began, including within the European Union, promoting the idea of trading self-sufficiency for external dependence in the pursuit of cheap energy, and thereby undermining the economic rationale for nuclear power plants.[430] This indeed induced a change in the French nuclear sector from the 1990s onwards, with only one new construction start during that decade and a consequent decline in the share of nuclear power in domestic electricity generation.[431] Nevertheless, France remained continuously determined to market its reactors internationally. China was at the centre of these efforts, negotiations on the possible purchase of French reactors had been ongoing for a considerable period, and while these were largely unsuccessful, construction of the Daya Bay nuclear power plant – comprising two French-supplied reactors – began in the late 1980s, continuing in the 1990s with two further units at the Ling'ao nuclear power plant.[432]

In the wake of declining interest in deploying nuclear power plants both domestically and internationally, vendors such as Framatome and Siemens were reluctant to pursue the development of new designs on their own, support from future customers was indispensable. Consequently, in the early 1990s EDF, together with German electricity companies and several vendors, decided to begin the development of a new design that would later become the European Pressurised Water Reactor (EPR).[433] The efforts to deploy these plants encountered

[424] Collingridge, 1984, pp. 190–191.
[425] Some projects were abandoned in the beginning of the 80's such as the Plogoff site. See De Carmoy, 1982, pp. 182–184.
[426] For more about the details what were the reasons for selecting France as a vendor, see Konieczna, 2021, pp. 292–293.
[427] Therme, 2023, pp. 119–121.
[428] Park, 1992, p. 726.
[429] Fröhlig, 2023, p. 3971.
[430] Bouttes, 2023, pp. 31–40.
[431] Teles da Silva, 2025, pp. 160–161.
[432] Yue and Yunyi, 2024, pp. 97–124.
[433] Teichel, 1996, pp. 271–272.

numerous challenges both in France and Germany, and where constructions began they were plagued by delays and cost overruns. The first order for this reactor design came from Finland's Olkiluoto site, where, as mentioned above, construction started in 2005 but, after a myriad of challenges, the plant only became commissioned in 2023.[434] A more successful – though still delayed – deployment of the design concerned the Taishan 1 and 2 units in China, which began construction in 2009 and reached commercial operation in 2018, although it should be kept in mind that the Fukushima accident occurred in 2011. The last foreign deal to have materialised, and one still under construction, is the two-unit Hinkley Point C project, for which the final investment decision was made in 2013, though construction only began in 2018, and which has faced significant setbacks from the outset.[435] There were several other countries that were interested in the new design, but those projects never materialised.

The new EPR unit was also deployed domestically after a long hiatus of nuclear power plant constructions in France, with construction of the Flamanville plant starting in 2007. Despite some favourable conditions[436] this project equally experienced delays and significant cost increases only to be commissioned in 2024, almost taking four times as long as initially projected. After the turn of the millennium, there were efforts to revive the nuclear industry through new construction and lifetime extensions, primarily advocated by President Nicolas Sarkozy though his predecessor Jacques Chirac was also a supporter of nuclear power.[437] While the Fukushima disaster did not have a significant effect on these efforts, and even more extensive long-term operation was being discussed, the change in political leadership brought about by the election of François Hollande as President brought a shift in direction: further new-build projects were cancelled, a decree limiting the share of nuclear power to a maximum of 50% of the electricity mix was introduced,[438] and the oldest French nuclear reactor at the Fessenheim site was proposed for shutdown[439] – a decision that also had its peculiarities.[440] President Hollande was succeeded by Emmanuel Macron, under whom France once again returned to a pro-nuclear stance,[441] with the law limiting the share of nuclear energy first being posteponed and later abolished.[442] France once again became interested in deploying new nuclear generating capacities, setting out the deployment of six EPR2 plants with eight more under planning. This shift is also reflected in France's updated National Energy and Climate Plan, in which France pledged a revival of the nuclear sector encompassing the continued operation of the existing fleet, the planned construction of six EPR2 units, and the study of further extensive nuclear capacity deployment.[443] France is planning the deployment of six EPR2 reactors in pairs at three different sites, planned to be commissioned between 2038 and

[434] Skiba, Roguz and Kinasz, 2025, p. 10.
[435] Thomas, 2016, pp. 421–431.
[436] Josephson and Kasperski, 2024, p. 333.
[437] Baker and Stoker, 2015, p. 147.
[438] Loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte *[Act No. 2015-992 of 17 August 2015 on Energy Transition for Green Growth]*.
[439] Brouard and Guinaudeau, 2017, pp. 128–129.
[440] Fröhlig, 2023, pp. 3968–3978.
[441] Schweitzer and Mix, 2026.
[442] Décret n° 2023-1366 du 28 décembre 2023 pris pour l'application, sur le territoire métropolitain continental, de l'article L. 211-2-1 du code de l'énergie et de l'article 12 de la loi n° 2023-491 du 22 juin 2023 *[Decree No. 2023-1366 of 28 December 2023 implementing Article L. 211-2-1 of the French Energy Code and Article 12 of Law No. 2023-491 of 22 June 2023]*.
[443] Directorate-General for Communication, 2024a, p. 18.

2044. Since the French state intends to support the deployment of these units through subsidised loans and contracts for difference, the Commission, upon notification by France, initiated a state aid investigation but in its preliminary assessment found the project to be compliant with the state aid rules.[444] The National Energy and Climate Plan also envisages the deployment of Small Modular Reactors after 2035, with particular mention made of the Nuward SMR project, which the government intends to support.[445] The reason this design is specifically mentioned is that Nuward is a subsidiary of EDF and the Plan makes explicit that France intends to support the emergence of domestic designs.[446] The Nuward plant has been in development for quite some time now and there have been ongoing exchanges between the regulator and the developer regarding the design and its licensability,[447] – appropriate given that the deployment of the first prototype had been planned to begin by 2030, though delays in the design process have since occurred, making it likely that the first unit will take longer to be deployed. However, Nuward is not the only domestic pursuit, several other designs are being developed in France, such as Newcleo and Calogena, some of which have progressed even further in the formal deployment process than the Nuward SMRs. When it comes to licensing, the most advanced project is the Jimmy Energy design, intended for industrial heat generation, for which a construction licence application was already submitted in 2024.[448]

As of now France operates 57 nuclear power reactors, representing a large, accumulated body of experience – although with mostly uniform technologies – while also being in the process of deploying further units, with advanced reactors equally under discussion. Moreover, with regards to France's position in the nuclear industry, it must be stressed that it has not only developed knowledge regarding the operation of nuclear power plants, but also regarding their design and construction, and equally other elements of the fuel cycle, from uranium extraction, enrichment and fuel fabrication to reprocessing and waste management – knowledge which, at a time of energy security concerns, constitutes a major strategic asset.[449]

3.4. The history and development of the legislative framework governing the sector

3.4.1. Hungary

The first legislative instrument governing the sector in Hungary dates back to the 1960s. It contained rudimentary licensing provisions, on the basis of which the construction licence for the reactor at the Budapest University of Technology was issued.[450] In practice, however, these procedures were largely informed by the regulatory practices of other nations and by the guidelines of the IAEA, rather than being the product of domestic development. As the Paks I project evolved, legislative reforms accompanied its advancement. In 1976, a resolution was

[444] *Commission opens formal State aid assessment of French support to new nuclear programme*, 2026.
[445] Directorate-General for Communication, 2024, p. 73.
[446] Id., p. 113.
[447] Francis and Beils, 2024, p. 1035.
[448] *SMR projects and their fuel manufacturing and assembly plants*, no date.
[449] Teles da Silva, 2025, p. 160.
[450] 10/1964. (V.7.) Korm. rendelet a sugárzó (radioaktív) anyagokról és készítményekről *[Government Decree No. 10/1964 (V.7.) on radioactive substances and preparations]*.

made by the Council of Ministers,[451] expressing that the nuclear safety licensing has to be determined by the President of the National Atomic Energy Commission in coordination with the Minister of Heavy Industry, and based on Soviet regulatory standards.[452] From a modern perspective –particularly in relation to the principle of regulatory independence – it is noteworthy that the nuclear safety provisions were adopted by the Ministry, which was itself the key stakeholder in the building of the plant. However, one might contend that in the political and industrial context of the time, the Ministry's interest extended beyond mere economic considerations.[453] The substantive safety regulations adopted during this period took the form of what are known as Blue-Books – essentially Hungarian translations of Soviet standards originally issued by the State Mining Technical Inspectorate and the State Atomic Energy Committee of the USSR.[454] The first comprehensive legislative instrument governing the nuclear sector in Hungary was enacted in 1978.[455] This decree delineated the respective responsibilities of state authorities in relation to the nuclear power plant. It vested the Minister of Heavy Industry with the authority to establish the safety requirements applicable to the plant's implementation, commissioning, operation, and licensing. Meanwhile, the National Atomic Energy Commission was tasked solely with the coordination of inter-authority activities in relation to the plant.[456] Mirroring broader development in international nuclear law, the decree also codified fundamental nuclear law principles such as the responsibility of the operator.[457] Based on this decree, the Minister of Heavy Industry issued a decree in the following year covering the assigned areas.[458] Much like our contemporary legislation, this ministerial decree has set out detailed rules in the form of annexes covering the implementation, commissioning, operation and licensing of the plant.[459] While these provisions were already being applied in practice, the decree served to codify their use.[460] Under this framework, two distinct nuclear safety licences were introduced for new nuclear facilities: the implementation licence and the operating licence, the latter also covering the commissioning stage.[461] The State Energy and Energy Safety Inspectorate acted as the first-instance authority, while the Ministry of Heavy Industry's National Energy Authority served as the appellate body.[462]

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[451] Magyar Népköztársaság Minisztertanácsának 3296/1976. határozata a paksi atomerőmű 1760 MW teljesítményű első kiépítésének beruházási javaslatáról *[Decision No. 3296/1976 (VI.17.) of the Council of Ministers of the Hungarian People's Republic on the investment proposal for the first 1760 MW construction phase of the Paks Nuclear Power Plant]*.
[452] Ibid.
[453] Szabó, 2004, pp. 567–585.
[454] Tóth, 2024, p. 146.
455 A Minisztertanács 10/1978. (II.2.) rendelete az atomerőművel kapcsolatos egyes feladatokról *[Decree No. 10/1978 (II.2.) of the Council of Ministers of the Hungarian People's Republic concerning certain duties related to the nuclear power plant]*.
[456] Id., section 1(3).
[457] Id., section 1(3).
[458] 5/1979 (III.31.) NIM rendelet az atomerőmű biztonságtechnikai kérdéseiről *[Decree No. 5/1979 (III.31.) of the Ministry of Heavy Industry concerning the safety aspects of nuclear power plants]*.
[459] Id., section 2.
[460] Szabó, 2004, pp. 567–585.
[461] 5/1979 (III.31.) NIM rendelet az atomerőmű biztonságtechnikai kérdéseiről *[Decree No. 5/1979 (III.31.) of the Ministry of Heavy Industry concerning the safety aspects of nuclear power plants]*, section 4.
[462] Id., section 3.

A further milestone came with the adoption of the first Act on Atomic Energy in 1980,[463] which remained in force until it was superseded in 1996 by the current legislation. The Act, together with its implementing decree, introduced broader regulation of the sector, covering areas that had hitherto remained unaddressed – most notably, third-party nuclear liability.[464] This represented a significant innovation, as such liability had previously been treated under the general regime of strict liability for hazardous activities, as provided in the 1959 Civil Code. Although at the Act's adoption, Hungary was not yet party to the principal international conventions of the sector,[465] the legislator nonetheless sought to align the domestic framework with emerging global standards. In the domain of regulation and licensing, the implementing decree conferred upon the Minister of Heavy Industry the power to establish safety requirements and issue the relevant licences. These licences were to be supplemented[466] with the opinion of the State Commissioning and Handover Committee.[467] Despite its limited scope – confined to the safe use of nuclear energy and liability issues – it was considered, for its time, a forward-looking and progressive piece of legislation.[468] It was under these provisions that the plant's first reactor received its licence and commenced commercial operation in 1983.[469] Despite efforts after the regime change to update the legislation in line with international developments and address existing lacunae,[470] it became evident that a new Act was required – one that would comprehensively reflect Hungary's international obligations. Owing to a confluence of factors,[471] this legislative renewal did not materialise until 1996 when the Act No. CXVI of 1996 on Atomic Energy was adopted which has been amended numerous times since then.

3.4.2. Finland

Regarding the origins of nuclear legislation in Finland, the first comprehensive regulation of the sector dates back to 1957 with the enactment of the Atomic Energy Act.[472] The approach of this Act was ideologically very different from that of the Hungarian model under a Soviet-type dictatorship, where electricity generation was nationalised.[473] In Finland an economically liberal ideology was pursued, from which the nuclear sector, despite its specificities, was not excluded – only a particular licence under the Act was required to engage in the use of nuclear energy, and the conditions attached to it were rather permissive.[474] In essence, Finnish state intervention in the sector was limited to the authorisation of these installations; no political

[463] 1980. évi I. törvény az atomenergiáról *[Act No. I of 1980 on nuclear energy]*.
[464] Ibid.
[465] Hungary acceded to the 1963 Vienna Convention and the Joint Protocol in the year of the regime change 1989.
[466] 5/1979 (III.31.) NIM rendelet az atomerőmű biztonságtechnikai kérdéseiről *[Decree No. 5/1979 (III.31.) of the Ministry of Heavy Industry concerning the safety aspects of nuclear power plants]*, section 24.
[467] An intermediary role was fulfilled by the "Állami Indító és Ellenőrző Átvételi Bizottság" (State Commission for Commissioning and Acceptance Inspections, AIB), which was not a licensing authority but examined crucial safety aspects prior to the formal licensing procedures. See Szabó, 2004, pp. 567–585.
[468] Lamm, 1997, pp. 159–167.
[469] State Energy and Energy Safety Supervisory Authority (ÁEEF), 1983.
[470] Id., p. 162.
[471] Ibid., such as the negotiations on the revision of the Vienna Convention.
[472] Act No. 356/1957 on Atomic Energy.
[473] Mádl, 2024, pp. 127–129.
[474] Säynässalo, 2009, p. 141.

backing was required, the political weight of the matter was not approached by political debates on the use of nuclear energy but rather it was embodied by directing the administrative decision on these matter to a proper authorizing body withing the executive branch and thus framing it as an administrative matter rather than political.[475] By adopting such an approach – that the decision on these plants is a well-founded administrative matter – the political sphere remained rather distant from debates on nuclear issues, even in the case of events that shook confidence in this energy source.[476] This approach naturally makes the licensing framework particularly interesting in the Finnish context, as this process also bears the weight that would otherwise fall on the political decision.

The next important stage in the development of the nuclear law framework in Finland was the adoption of the still currently in force 1986 Nuclear Energy Act and the 1988 Nuclear Energy Decree.[477] What changed in relation to the previous Act was that the new Act introduced stricter licensing conditions, increased the number of actors involved in the licensing process by providing the opportunity for public participation, and entrusted Parliament with the ultimate responsibility to decide on the acceptability of the decision-in-principle.[478] What remained the same in the approach of the Act. The opportunity to deploy such plants remained in the realm of the applicant and that it is not the government that influences nuclear policy, but rather the applicant who decides on pursuing it and its contents, thereby influencing the nuclear policy of the government, which – along with Parliament – must treat the proposal for an installation in accordance with the procedures laid down in the legislation.[479] Although the Act has been amended several times it has been in force since then, providing the foundation also for the licensing of nuclear power plants; it should be noted, however, that it will most likely remain in effect only until 2027.

Despite the frequent amendments of the Nuclear Energy Act, one topic that was overlooked was the licensing of new technologies. As predicted by some,[480] this changed in 2021[481] when work began on a reformed Nuclear Energy Act and the pertaining legislations. The primary objective of the government with the new Act is to position Finland as an attractive country for establishing new nuclear power plant projects by providing a legislative framework that can help the timely and cost-efficient implementation of nuclear power plant projects, while not compromising nuclear safety.[482] While it was expressed that government policy sought to remain neutral towards the use of nuclear energy and leave it to the applicant to pursue such projects, the approach of the reform and its aims clearly indicate that the attitude towards nuclear energy has not changed negatively. If anything, the contrary may be true – the revised legislation seeks to provide opportunities for advanced technologies, indicating an overall technologically neutral approach, not just in the nuclear sense but in relation to resolving energy needs more broadly. STUK which is also responsible for issuing the pertaining regulations and

[475] Id., p. 143.
[476] Id., p. 143.
[477] Lampinen, 2009, p. 41.
[478] Säynässalo, 2009, p. 145.
[479] Id., p. 144.
[480] Skön and Alm-Lytz, 2017, p. 15.
[481] This was naturally proceeded by extensive work background work leading up to the initiation of the reform by various organizations such as the working group set up by the Ministry of Economic Affairs and Employment or the even before that the Finnish Nuclear Safety Advisory Board's opinions.
[482] Hallituksen esitys eduskunnalle ydinenergialaiksi ja siihen liittyviksi laeiksi, HE 24/2026 vp.

guides under the Act, is likewise actively engaged in the overhaul of this legislation.[483] As part of the streamlining efforts and the move away from more prescriptive approaches, the number of requirements set forth by STUK is proposed to be reduced from 7,800 currently to 1,200 – which is naturally a considerable challenge for STUK.[484] The proposal of the Nuclear Energy Act was submitted to the Parliament in March 2026.[485]

3.4.3. France

With regards to the legislative framework in France, interestingly its roots cannot be traced back to the earliest days of nuclear installations, as the first regulatory instrument on the construction and operation of nuclear installations was adopted considerably later, in 1963[486] and the first legislative instrument only in 1968.[487] In the meantime, one has to acknowledge the role the CEA assumed in this regard – that despite the absence of an applicable legal framework for particular nuclear issues, it devoted significant attention to both radiation protection and nuclear safety.[488] Two factors had a decisive impact on bringing an end to the situation in which the country lacked a legislative framework for the sector. Firstly, in 1957 the Rome Treaty establishing the European Atomic Energy Community was signed, establishing the Community framework for nuclear energy, which naturally also necessitated the adoption of a national legal framework in which, for example, the basic safety standards provided for in the Treaty could be implemented. Secondly, as mentioned before, besides the Commission a new actor emerged in the sector in the form of EDF, further necessitating the adoption of a legal framework governing the use of nuclear energy.[489] In the period between the start of the industrialisation of the sector with the appearance of EDF and the adoption of the first legal framework governing the authorisation of nuclear power plants, deployment was governed by the safety report adopted as a result of a dialogue between the Commission and EDF.[490] Subsequently in 1963,[491] a decree[492] was adopted which from a licensing perspective is rather remarkable in the French context but also quite forward looking in light of principles – such as the permission principle – of nuclear law that did not yet exist at the time but are now widely accepted. It introduced a licensing system requiring prior authorisation already for the construction of the nuclear installation, rather than only for its operation, which was the prevailing licensing approach for establishing similar installations. While the decree set out the administrative process and the parties involved in the granting of authorisation – marking a shift in that for

[483] Tyllilä, 2025, p. 75.
[484] Ministry of Economic Affairs and Employment, 2025.
[485] Hallituksen esitys eduskunnalle ydinenergialaiksi ja siihen liittyviksi laeiksi, HE 24/2026 vp *[Government Proposal No. HE 24/2026 to Parliament on the Nuclear Energy Act and related acts]*.
[486] Décret n°63-1228 du 11 décembre 1963 relatif aux installations nucléaires *[Decree No. 63-1228 of 11 December 1963 on nuclear installations]*.
[487] Loi n° 68-943 du 30 octobre 1968 relative à la responsabilité civile dans le domaine de l'énergie nucléaire *[Act No. 68-943 of 30 October 1968 on civil liability in the field of nuclear energy]*.
[488] Hebert, 1973, pp. 39–40.
[489] Id., p. 40.
[490] Mangeon, 2018, p. 2.
[491] The basis of this decree was Loi n°61-842 du 2 août 1961 relative à la lutte contre les pollutions atmosphériques et les odeurs et portant modification de la loi du 19 décembre 1917 *[Act No. 61-842 of 2 August 1961 on the control of atmospheric pollution and odours and amending the Act of 19 December 1917]*.
[492] Décret 63-1228 du 11 décembre 1963 reltif aux installations nucléaires *[Decree No. 63-1228 of 11 December 1963 on nuclear installations]*.

these installations it was no longer the prefect but the central government,[493] that held this role – it remained silent on the content of these safety reviews. These gaps in the legislative framework were filled by practice, and customary requirements emerged such as the submission of safety reviews.[494] The decree was amended several times, but in 2006 a new law[495] was adopted that set out to bring the fragmented and complex regulations of the field into a more consistent legal framework,[496] and thereby correcting the democratic deficit in a field of significant public interest as in the absence of an act, there had been no parliamentary debate on these considerations.[497]

Partly in response to this democratic deficit, the title of the act also invoked transparency.[498] In the realm of transparency it played a particularly important role regarding organisations providing public information, such as the strengthening of local information commissions – which will be discussed later in more detail due to their role in the licensing process – and the establishment of the High Committee for Nuclear Safety Transparency (Haut Comité pour la Transparence et l'Information sur la Sécurité Nucléaire, HCTISN), a body for information exchange and debate on the risks and impacts of nuclear power in general, not related to any particular site.[499] Besides these transparency measures[500] and those concerning the regulatory authority, from our perspective importantly, the Act also modified the licensing process of new nuclear installations,[501] the detailed provision of which were contained in the implementing decree.[502]

The legislations pertaining to the nuclear sector contained in the Act were ultimately codified in the legislative part of the Environmental Code in 2012,[503] as it was argued that these matters more logically belong to the Environmental Code than the Energy Code,[504] while the provision of the decree were integrated in the regulatory part in 2019.[505]

3.5. The structure of the current legislative framework governing the licensing of nuclear power plants

[493] OECD, 2003, p. 6.
[494] Hebert, 1973, pp. 41.
[495] Loi n° 2006-686 du 13 juin 2006 relative à la transparence et à la sécurité en matière nucléaire *[Act No. 2006-686 of 13 June 2006 on transparency and nuclear safety]*.
[496] NEA, 2006, p. 25.
[497] Léger and Grammatico, 2006, p. 8.
[498] Lucas-Alberni, 2007, pp. 707–729.
[499] Léger and Grammatico, 2006, p. 14.
[500] For more information on the transparency of the sector in France, see Delzangles, Fleury and Monnier, 2018, pp. 675–692.
[501] Léger and Grammatico, 2006, p. 17.
[502] Décret n°2007-1557 du 2 novembre 2007 relatif aux installations nucléaires de base et au contrôle, en matière de sûreté nucléaire, du transport de substances radioactives *[Decree No. 2007-1557 of 2 November 2007 concerning basic nuclear installations and the supervision, with regard to nuclear safety, of the transport of radioactive substances]*.
[503] Ordonnance n° 2012-6 du 5 janvier 2012 modifiant les livres Ier et V du code de l'environnement Ordonnance n° 2012-6 du 5 janvier 2012 modifiant les livres Ier et V du code de l'environnement *[Ordinance No. 2012-6 of 5 January 2012 amending Books I and V of the Environmental Code]*.
[504] Rapport au Président de la République relatif à l'ordonnance n° 2012-6 du 5 janvier 2012 modifiant les livres Ier et V du code de l'environnement. *[Report to the President of the Republic concerning Ordinance No. 2012-6 of 5 January 2012 amending Books I and V of the Environmental Code]*.
[505] Decree No. 2019-190 of 14 March 2019 codifying the provisions applicable to basic nuclear installations, the transport of radioactive substances, and transparency in nuclear matters.

3.5.1. Hungary

At the constitutional level, there exist no provisions that make explicit reference to nuclear energy. However, naturally certain provisions, particularly those related to fundamental rights, remain inherently relevant from a nuclear perspective. These rights have been invoked in past legal challenges[506] and may well re-emerge in future proceedings, particularly amid a prospective nuclear renaissance. Hungary follows a single nuclear law model, whereby a single Act governs several areas, including liability, safeguards, and security. This stands in contrast to the separate-law model, where these areas would be addressed individually.[507] As a result the Act is a comprehensive and wide-ranging piece of legislation, albeit one whose treatment of individual subject areas varies considerably in depth and detail.[508] Article 1 of the Act delineates its scope, stating that it governs the peaceful use of nuclear energy, the attendant rights and obligations, as well as the protection of both the public and the environment from the hazards posed by ionising radiation, whether of natural or artificial origin.

From a licensing perspective, the Act establishes only the overarching framework, enumerating the principal installation-level licences rather than setting out detailed provisions. Although the Act itself contains only limited provisions on licensing, it empowers the president of the authority to establish detailed rules governing the licensing procedure.[509]

Consequently, based on the mandate conferred by the Act, the Hungarian Atomic Energy Authority (HAEA) adopted a decree setting forth the nuclear safety requirements applicable to nuclear installations and the related regulatory activities.[510] This decree is structured in two principal parts, the first of which comprises a relatively concise general part. This portion lays down provisions of general applicability to nuclear installations, among them the basics of licensing.

More importantly, however, the decree also has ten annexes, collectively designated as the 'nuclear safety rules,' which contain the detailed mandatory provisions on licensing. Initially these rules, annexed to Decree No. 5/1979 NIM of the Ministry of Industry, were referred to as 'nuclear power plant safety regulations.' At that time, the rules applied exclusively to nuclear power plants and were predominantly grounded in Soviet regulatory models.[511] The term 'nuclear safety rules' was subsequently introduced[512] in the wake of the adoption of the new Act on Atomic Energy, reflecting a marked philosophical shift. No longer based on Soviet precedents, these rules began to align with the standards promulgated by the IAEA.[513] New

[506] For more on the fundamental right aspects of nuclear energy in Hungary, see Kocsis, 2016, pp. 137–156.
[507] Cook, 2022, p. 108.
[508] For more on the areas covered by the act, see Kocsis Fekácsné, 2020, pp. 202–229.
[509] Id., section 68(12).
[510] 1/2022. (IV.29.) OAH rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities]*.
[511] Tóth, 2024, p. 147.
[512] 87/1997. (V.28.) Korm. rendelet az Országos Atomenergia Bizottság feladatáról, hatásköréről, valamint az országos Atomenergia Hivatal feladat- és hatásköréről, bírságolási jogköréről *[Government Decree No. 87/1997 (V.28.) on the tasks and competences of the National Atomic Energy Commission and on the tasks, competences, and fining powers of the Hungarian Atomic Energy Authority, and on the activities of the Atomic Energy Coordination Council]*.
[513] Tóth, 2024, p. 148.

government decrees on which the 'nuclear safety rules' were based were adopted in 2005[514] and 2011,[515] in this latter iteration, the current ten-annex structure of nuclear safety rules was established. Following a structural reorganisation of the regulatory authority, – to be discussed in the next section – which provided it with legislative power in the sector, provisions had hitherto been issued as government decrees were reissued in the form of HAEA decrees such as Decree 1/2022. HAEA, which now contains the 'nuclear safety rules.' However, one notable shortcoming of this reissuance arises from its lower position in the hierarchy of legal norms. Unlike its predecessor in the hierarchy of legal norms, an HAEA decree cannot be contrary to government, prime ministerial, and ministerial decrees, or those of the president of the Hungarian National Bank either. Although the issuance of the decree by the sector's most technically competent authority enhances its regulatory credibility, this demotion in the legal hierarchy from the level of government decrees arguably undermines the overall effectiveness of this structural change.

The requirements contained in the nuclear safety rules are reviewed every five years, designed to ensure their alignment with the most recent national and international developments, including those emanating from relevant international organisations.[516] This revision process is rooted in international obligations and to some extent it mirrors the peer-reviews conducted under the Convention on Nuclear Safety (CNS), the Joint Convention (JC), and the Nuclear Safety Directive. Since other countries also follow similar procedures, incorporating the recommendations of international organisations, this practice contributes to a certain degree of regulatory harmonisation.

The system of nuclear safety rules constitutes a notably intricate regulatory framework. Certain annexes are drafted with broad applicability, extending to a range of nuclear facilities – including nuclear power plants, research reactors, and storage facilities – while others are specific to particular types of installations. From the perspective of licensing new nuclear power plants, the most pertinent annexes are the following: NSR-7, which covers the site inspection and assessment, NSR-3a, that regulates the design requirements of new power plant units, and NSR-9, which regulates the requirements applicable during the design and implementation phases.

The final set of instruments to be considered within the framework of nuclear licensing are the guidelines issued by the HAEA. These guidelines outline methods for complying with the requirements contained in the 'nuclear safety rules.' While these methods in the guidelines are not binding on the applicant, following them has significant practical implications. Where an applicant chooses to follow the methods in the guidelines, to demonstrate compliance with the 'nuclear safety rules' then the authority is naturally not going to evaluate the adequacy of the method,[517] as it was recommended by them. However, since the guidelines are not mandatory,

[514] 89/2005 (V.5.) Korm. rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Government Decree No. 89/2005 (V.5.) on the nuclear safety requirements for nuclear facilities and related regulatory activities]*.

[515] 118/2011. (VII.11.) Korm. rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Government Decree No. 118/2011 (VII.11.) on the nuclear safety requirements for nuclear facilities and related regulatory activities]*.

[516] Kádár and Majoros, 2024, p. 703.

[517] 1/2022. (IV.29.) OAH rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities]*.

applicants may opt for alternative methods, but in this case, the authority will extensively evaluate the correctness, appropriateness and completeness of the alternative method,[518] which evaluation has to be financed by the licensee.[519] In this regard, guidelines offer a useful degree of flexibility within the licensing system – particularly in respect of the assessment and integration of advanced technologies. However, this flexibility comes at a price: deviation from the established guidance may lead to protracted procedures and increased financial burden, rendering the guidelines a double-edged sword in regulatory practice. It is also noteworthy that the guidelines are subject to regular revision. In addition to periodic reviews, licensees may also initiate requests for updates.

3.5.2. Finland

In Finland, the general legal framework governing the nuclear sector bears resemblance to the Hungarian solution, with a dedicated Nuclear Energy Act.[520] The Hungarian approach is, however, more comprehensive, encompassing radiation protection within the Act on Atomic Energy itself; Finland, by contrast, regulates radiation protection and nuclear energy through two separate Acts, with its international obligations in the field of nuclear liability contained in a further, separate Act.[521] Like its Hungarian counterpart, the Act is also generally framework-like in character, with more detailed provisions contained in lower-level legislation. It also invokes general principles, such as defence in depth, which carry particular relevance for nuclear safety licensing. When it comes to the concrete provisions on the licensing of nuclear power plants, the Act's provisions are more detailed and instructive regarding the course of licensing than is the case in Hungary. Chapter 3 of the Act sets out some general provisions on licensing, firstly echoing principles of nuclear law such as the permission and responsibility principles. The following chapter deals with the decision-in-principle stage in the deployment procedure of a nuclear power plant, but unlike the Hungarian approach, where a single sentence is dedicated to the parliamentary consent stage mentioning in which cases it is required, the Finnish approach goes considerably further, also devoting provisions to the application for the decision, the public hearings, the government's role in the process, the conditions for the decision and ultimately Parliament's involvement. It further indicates the procedural aspects of this stage – which given its complexity and the multitude of actors involved is very much justified – but also its contents and the manner in which the decision is to be made. Chapter 5 of the Act deals with the licensing stages following the decision-in-principle, beginning with some common provisions followed by the individual licences, among them the construction and operation licences which are at the centre of our attention. Among the common provisions, the Act sets out that applications for construction and operation licences can only be made by a natural or legal person or an authority that falls under the jurisdiction of a Member State of the European Union.[522] Furthermore one particularly interesting feature of the Finnish licensing system is that it recognises the use of a nuclear facility in a vehicle – that is, the use of nuclear energy for propulsion – to which the general rules on the construction of a facility apply to the

[518] Id., section 3.
[519] Aradszki and Borsos, 2024, p. 344.
[520] Act No. 990/1987 on Nuclear Energy.
[521] Act No. 416/2002 on Nuclear Liability.
[522] Act No. 990/1987 on Nuclear Energy, section 17.

extent they are relevant.[523] From the perspective of maritime propulsion, where nuclear energy may also find a place in the future, this provision carries particular relevance, demonstrating that there is a legal basis for licensing such propulsion means, although the provisions currently in effect are neither very instructive nor tailor-made for these applications.

Decrees issued by the government or ministry occupy the second level of the legislative framework, of which the most important is the Nuclear Energy Decree, which complements the Act. The Decree elaborates on the provisions of the Act and in this regard also details the provisions on the licensing of these installations, further elaborating on the process and content of the decision-in-principle procedure, but also on the content of the construction and operation licence applications, along with other relevant steps such as the notification procedure under the Euratom Treaty.

In the hierarchy of legal norms governing the sector, the last effectively binding level comprises the regulations issued by STUK. Under the Nuclear Energy Act, STUK is entrusted with issuing general safety provisions, which also concern nuclear power plants.[524] Alongside regulations addressing emergency arrangements for nuclear power plants, the most important of these from a licensing perspective is the regulation addressing the safety of nuclear power plants, adopted to specify the provisions of the Act with regards to the design, construction and operation of the facility.[525] In line with the mandate contained in the Act regarding the areas in which STUK is required to adopt regulations, the Regulation contains provisions on matters such as the safety classification of nuclear facilities, site safety, defence in depth, and the safety of commissioning, among others. In essence, the function of the Regulation is very similar to that of the Nuclear Safety Rules and their Annexes in providing the detailed rules applicable to these installations and thus also shaping the content of the licensing procedure; in practice, however, the Nuclear Safety Rules in Hungary are considerably more extensive and detailed, covering nuclear safety provisions at a legally binding level in far greater depth.

The last level of the legislative framework to be discussed in relation to the deployment of new plants is that of guidelines. In Finland, the regulatory authority STUK also issues guidelines, though the approach it follows in this regard differs somewhat from its Hungarian counterpart. Guidelines issued by STUK are by default binding on the licensee, but the Act provides them with the opportunity to demonstrate that an alternative solution may meet the safety standards set out in the Act, in which case STUK may deem it acceptable.[526] In effect, while the framing of the mandatory nature of guidelines differs between the two countries, the practical approach is very similar, as it essentially provides the licensee with the opportunity to use alternative methods – though in such cases additional administrative burdens may naturally arise from evaluating the adequacy of the proposed method. There are several guidelines issued by the authority, addressing matters ranging from facility-level issues such as siting considerations, construction and commissioning, and ageing management, to more specific issues such as the ventilation systems of the facility.[527] Content-wise, the guidelines also differ somewhat from

[523] Id., section 22.
[524] Act No. 990/1987 on Nuclear Energy, section 7q.
[525] Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant, explanatory memorandum. STUK 1/0007/2017, p. 3.
[526] Act No. 990/1987 on Nuclear Energy, section 7r.
[527] STUK, no date.

the Hungarian solution as these instruments also fulfil a function similar to that of the Nuclear Safety Rules by setting safety requirements, but also cover methods for meeting them. The other legislative instruments in the field are generally more goal-oriented, providing the applicant with the opportunity to present their safety case in a more flexible manner, whereas the guidelines are in most cases rather prescriptive. What can be concluded from this is that safety requirements at the binding level typically go no further than setting very general goals, while it is the guidelines that impose rather detailed requirements on applicants and licensees.

3.5.3. France

In France the legislative framework governing the nuclear sector is grounded in the Environmental Code, and, unlike in Hungary or Finland, France has no separate act dedicated to nuclear energy. In the Environmental Code, Book V, Title IX regulates *"nuclear sécurité"*[528] – which in the French meaning encompasses both nuclear safety and security – and nuclear installations. The legislative part of the Code contains high-level provisions and general principles, along with general provisions on the regulatory authority, liability, transport, and financial matters related to decommissioning. In general, this is very similar to what the Acts contain in the case of the two other countries. However, an interesting aspect of its provisions is that in the section pertaining to nuclear installations the Code follows a very pragmatic approach: it first sets out some definitions and general provisions, followed by a stage-by-stage elaboration on the lifecycle phases of a nuclear installation from its establishment through to commissioning. What is particularly interesting is that these provisions are generally applicable to nuclear installations as a whole, rather than being specific to nuclear power plants – a term the Code does not in fact use, referring instead to nuclear reactors. Accordingly, in relation to these major milestones in the life of a facility, the Code identifies the corresponding licensing stages. In addition, unlike its Hungarian counterpart but more similarly to the Finnish solution, the Code's legislative part also addresses the basic content of the required licences and the procedures by which they may be obtained. In relation to the licensing of nuclear installations, the regulatory part of the Code contains more detailed provisions regarding the procedure itself and also the contents of the licence applications, with the differences among the different types of nuclear installations articulated at this level. The provisions contained in this regulatory part of the Code are comparable in their level of detail and nature to the more general provisions contained in the Nuclear Safety Rules in Hungary.

The next category of instruments applicable to the licensing of nuclear power plants in France consists of what are generally termed as general technical requirements, which may encompass a variety of instruments. Some of these have a binding nature, such as ministerial decrees or regulatory decisions subject to approval, while there are also non-binding ones in the form of guides.[529]

Among the binding instruments, the nuclear installation decree (INB Decree)[530] has to be highlighted first as it contains relevant provisions for the entire lifecycle of the plant and

[528] *Nuclear sécurité* has a different meaning also under the Defense Code. While the term seeks to encompass security and safety in practice separate bodies are handling these issues.
[529] *Regulations*, no date.
[530] Arrêté du 7 février 2012 fixant les règles générales relatives aux installations nucléaires de base *[Decree of 7 February 2012 laying down the general rules for basic nuclear installations]*.

principally establishes that the application of these provisions should rely on a graded approach, entailing that they are rather goal-setting in nature.[531] Since the Decree covers the whole lifecycle, it uses the term operator in general, which according to its own definition also includes the applicant who has submitted an application for a creation authorisation – so in practice both licence applicants and licensees are covered. Important principles that the operator must adhere to also appear here, such as defence in depth, the implementation of which – for a new facility – should rely, among other things, on a suitable site and a prudent design approach.[532] In some respects it is similar to the general part of the nuclear safety rules in Hungary, but it contains even more general requirements applying to all lifecycle stages. The Decree is also the instrument that incorporates the WENRA, the reference levels into the French framework in a binding fashion.[533]

A further category of binding instruments comprises the regulatory decisions of the French Nuclear Safety and Radiation Protection Authority (ASNR) – technical in nature and issued pursuant to the Code to implement decrees[534] – which become binding once approved by the responsible minister. In this sense the French regulator has more limited powers in these technical matters than its Hungarian or Finnish counterpart, as their decisions are subject to ministerial approval. There are several such decisions, concerning different lifecycle stages of a nuclear installation. From the perspective of licensing a new nuclear power plant, of particular interest are those relating to the safety report,[535] along with those concerning pressure equipment in the facility,[536] accredited organisations, and emergency planning.[537] The provisions enshrined here would in the Hungarian framework mostly be covered by the Nuclear Safety Rules, but in the French system they are more fragmented across these decisions and the previously mentioned instruments. This is very much the case, for example, for the nuclear safety report, which in the Hungarian system would be contained in the Nuclear Safety Rules, although in the Hungarian framework it is rather akin to a list supplemented by the relevant guideline, while in France, due to its goal-setting approach, it provides more general and broader topics to which elaborations are attached. Similarly to the other two countries analysed, the French legal framework also includes non-binding guidelines, which cover not only issues connected to the safety of nuclear installations but also radiological protection, transport and

[531] Id., art. 1.1.
[532] Id., art. 3.1.
[533] *Regulations*, no date.
[534] Code de l'environnement, art. L592-20.
[535] Arrêté du 11 janvier 2016 portant homologation de la décision n° 2015-DC-0532 de l'Autorité de sûreté nucléaire du 17 novembre 2015 relative au rapport de sûreté des installations nucléaires de base *[Order of 11 January 2016 approving the decision No. 2015-DC-0532 of the Nuclear Safety Authority of 17 November 2015 relating to the safety report of basic nuclear installations]*.
[536] Such as Arrêté du 6 janvier 2022 portant homologation de la décision n° 2021-DC-0714 de l'Autorité de sûreté nucléaire du 23 septembre 2021 relative à l'intégration au sein d'une installation nucléaire de base de certains équipements sous pression nucléaires en cours d'évaluation de la conformité *[Order of 6 January 2022 approving Decision No. 2021-DC-0714 of the Nuclear Safety Authority of 23 September 2021 relating to the integration within a basic nuclear installation of certain nuclear pressure equipment undergoing conformity assessment]*.
[537] Arrêté du 28 août 2017 portant homologation de la décision n° 2017-DC-0592 de l'Autorité de sûreté nucléaire du 13 juin 2017 relative aux obligations des exploitants d'installations nucléaires de base en matière de préparation et de gestion des situations d'urgence et au contenu du plan d'urgence interne *[Order of 28 August 2017 approving Decision No. 2017-DC-0592 of the Nuclear Safety Authority of 13 June 2017 concerning the obligations of operators of basic nuclear installations regarding the preparation and management of emergency situations and the content of the internal emergency plan]*.

other matters. These guidelines are of non-binding character, but the operator – in the broad French sense – has obligations concerning them. In the safety report, the operator must indicate the relevant applicable guidelines and identify among these those it decided to apply, illustrating their non-binding nature furthermore, the operator also describes the conditions and limits under which these guides were applied, since a guide that is more specific to a given technology may have limitations in its application to the licensed design.[538] Among the guidelines relevant to new nuclear power plants, some are technology-specific, reflecting the technology predominantly used in France – for example, guides concerning the design of pressurised water reactors.[539] However, compared to other national legal frameworks that include detailed information on all aspects of installations – from siting and design through to commissioning and operation – the French approach is more limited in the volume and depth of guides pertaining to new nuclear installations, with the exception of those related to pressurised vessel equipment.

3.6. The regulatory authority and other relevant bodies engaged in the licensing of nuclear power plants

3.6.1. Hungary

As evidenced by the historical analysis, regulatory functions in the sector in Hungary were initially distributed among various ministerial bodies. Nonetheless, authorities with sector-specific mandates – albeit with primarily advisory roles – have existed since the inception of nuclear energy in the country. Notably, the National Atomic Energy Commission was established in 1955[540] to oversee matters regarding the peaceful utilisation of nuclear energy. Over time, its remit steadily expanded. The implementing decree of the 1980 Atomic Act only prescribed that the safety requirements for the use of atomic energy have to be developed by the relevant minister in agreement with the Commission's president.[541] However, a significant shift occurred following the political transition, embodied in Government decree 104/1990.[542] In its philosophy, this instrument entailed a departure from this centralised approach by entrusting the authority with regulatory functions which was not directly involved in promoting the use of nuclear energy. The Commission itself was composed of a president appointed by the Prime Minister and other members appointed by respective ministers, thereby theoretically retaining a degree of political influence. In order to empower the Commission to exercise its

[538] Loi n° 2024-450 du 21 mai 2024 relative à l'organisation de la gouvernance de la sûreté nucléaire et de la radioprotection pour répondre au défi de la relance de la filière nucléaire *[Act No. 2024-450 of 21 May 2024 on the organisation of the governance of nuclear safety and radiation protection to meet the challenge of the revival of the nuclear sector]* art. 3.3.2.
[539] ASN, 2017.
[540] A Magyar Népköztársaság Minisztertanácsának 4621/XII.15/1955. határozata Országos Atomenergia Bizottság létrehozásáról *[Decision No. 4621/XII.15/1955 of the Council of Ministers of the Hungarian People's Republic concerning the establishment of the National Atomic Energy Commission]*.
[541] A Minisztertanács 12/1980. (IV.5.) rendelete az atomenergiáról szóló 1980. évi I. számú törvény végrehajtásáról *[Decree No. 12/1980 (IV.5.) of the Council of Ministers of the Hungarian People's Republic on the implementation of Act No. I of 1980 on atomic energy]*, section 5.
542 104/1990. (XII.15.) Korm. rendelet az Országos Atomenergia Bizottság, valamint az Országos Atomenergia Hivatal feladatáról és hatásköréről *[Government Decree No. 104/1990 (XII.15.) on the tasks and competences of the National Atomic Energy Commission and the Hungarian Atomic Energy Authority]*.

new public administrative mandate, the Hungarian Atomic Energy Authority was established under the management of the Commission's president.[543]

Subsequently, the 1996 Atomic Energy Act led to the reregulation of both the Commission and the Authority in 1997.[544] This reform enhanced the authority's independence – an evolution that was no mere coincidence, as Hungary had acceded to the Convention on Nuclear Safety earlier that year, thereby assuming the obligation to ensure an effective separation[545] between the regulatory body and entities engaged in the promotion or utilisation of nuclear energy.[546]

In anticipation of accession to the European Union, Hungary further strengthened the independence of its regulatory framework in 2003 by removing the Commission[547] from its supervisory position over the HAEA.[548] The competences and tasks of the authority were accordingly revised,[549] ensuring that it could neither be instructed in the exercise of its regulatory functions, nor have its decisions altered by any superior administrative power.[550] This then newly adopted independent decision-making power was a crucial step in ensuring effective regulatory autonomy.[551]

In 2004, Hungary acceded to both the European Union and the Euratom Community. Within the latter framework, significant strides were made in bolstering the independence of the regulatory authorities particularly following the adoption of the 2014 revised Nuclear Safety Directive,[552] which incorporated the lessons drawn from the stress tests[553] conducted after the Fukushima Daiichi accident.[554] Reflecting the Directive's commitments to strengthening the independence of regulators from undue governmental influence,[555] the final major structural reform took place regarding the HAEA in 2021.[556] Under this reform, the HAEA was restructured from a central governmental agency into an independent regulatory body. Since 2022, the HAEA has operated in this format, reporting directly to the National Assembly,[557] and

[543] Kádár and Majoros, 2024, p. 690.

[544] 87/1997. (V.28.) Korm. rendelet az Országos Atomenergia Bizottság feladatáról, hatásköréről, valamint az országos Atomenergia Hivatal feladat- és hatásköréről, bírságolási jogköréről *[Government Decree No. 87/1997 (V.28.) on the tasks and competences of the National Atomic Energy Commission and on the tasks, competences, and fining powers of the Hungarian Atomic Energy Authority, and on the activities of the Atomic Energy Coordination Council]*.

[545] For more, see MacKenzie, 2010, p. 50. Burns et al., 2022, pp. 190–191. Stoiber et al., 2003, pp. 27–28. Sexton, 2015, pp. 39–41. Michel, 2021, pp. 14–16.

[546] IAEA, 1994, section 7–8.

[547] 2003. évi XLII. törvény a földgázellárásról *[Act No. XLII of 2003 on the supply of natural gas]*.

[548] HAEA, 2006, p. 33.

[549] 114/2003. (VII.29.) Korm. rendelet az Országos Atomenergia Hivatal feladatáról, hatásköréről és bírságolási jogköréről, valamint az Atomenergia Koordinációs Tanács tevékenységéről *[Government Decree No. 114/2003 (VII.29.) on the tasks, competences, and fining powers of the Hungarian Atomic Energy Authority]*.

[550] HAEA, 2006, p. 33.

[551] NEA, 2014, pp. 14–15.

[552] Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, 2014.

[553] Aradszki and Borsos, 2024, p. 331. The stress test did not reveal significant shortcomings in the case of the Paks plant.

[554] For more, see Burns, 2012, pp. 739–779.

[555] Florea, 2022, p. 75.

[556] 2021. évi CXIV. törvény az atomenergia-felügyeleti szerv jogállásával összefüggésben egyes törvények módosításáról *[Act No. CXIV of 2021 on the amendment of certain laws in connection with the legal status of the nuclear energy supervisory authority]*.

[557] Fundamental Law of Hungary, art. 23.

its president has been vested with decree-making authority.[558] This structure of the regulatory organ compared to other national structures entails a level of autonomy which goes beyond the generally accepted measures of ensuring effective independence.[559] Regulatory independence, though often invoked to prevent interference from pro-nuclear interests, is equally vital – if not more so during a time of nuclear renaissance – in safeguarding against undue influence from unfounded anti-nuclear agendas. By reporting to the National Assembly and provided with the authority to effectively regulate in the sector, the regulator gained stability, ensuring its decisions are driven by expertise rather than shifting political oscillations on nuclear. This sense of stability and impartiality also strengthens the credibility of the authority's decisions. Financial autonomy constitutes a cornerstone of effective regulatory independence, for without adequate and independent financial provision, the Authority would be unable to discharge its statutory functions with efficacy. The HAEA's finances are managed as a separate chapter within the central finances of the National Assembly. This arrangement ensures that any changes to its budget may only be approved by the National Assembly itself,[560] thereby insulating the Authority from executive influence and securing its fiscal independence from the Government. In addition to this appropriated budgetary support, the HAEA is endowed with supplementary revenue streams derived directly from the exercise of its regulatory functions.[561] These include annual regulatory fees remitted by licensees,[562] charges levied for the conduct of licensing procedures,[563] and fines imposed by them.

The institutional architecture of nuclear regulatory bodies exhibits considerable variation across jurisdictions,[564] but in practice, there are two predominant models. The first is a commission-based structure, wherein regulatory authority is vested in a collegiate body. The second model vests regulatory powers in a singular executive authority – typically a director or president – who acts as the head of the regulatory institution. The HAEA adheres to this latter model, being headed by a president appointed by the Prime Minister for nine years.[565]

As is the case in other jurisdictions, the principal mandate of the authority is to ensure the safe and secure utilisation of nuclear energy and of nuclear and radioactive materials, while simultaneously safeguarding against the proliferation of nuclear weapons.[566] In pursuit of these overarching objectives, the functions of nuclear regulatory authorities customarily cover three core domains: licensing, inspection and enforcement.

When discussing the Authority, it is also worth briefly considering the procedural regime governing its activities. This regime is naturally grounded in the General Administrative Procedural Code,[567] which functions as *lex generalis*. Nevertheless, owing to the sector's technical and legal particularities, the Act on Atomic Energy introduces special provisions

[558] Id., art. T.
[559] Cook, 2022, p. 115.
[560] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section. 6(6).
[561] Kádár and Majoros, 2024, pp. 690–691.
[562] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 19.
[563] Id., section 8(1c).
[564] Burns et al., 2022, p. 169.
[565] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 6/A.
[566] Kádár and Majoros, 2024, p. 692.
[567] 2016. évi CL. törvény az általános közigazgatási rendtartásról *[Act No. CL of 2016 on the General Administrative Procedure]*.

serving as *lex specialis*. The four selected tailored procedural rules discussed below reflect the distinctive regulatory demands of the nuclear field.

The language employed in the documentation pertaining to the licensed design constitutes a matter of critical importance, especially for countries which do not have indigenous nuclear technology. Variations in technical terminology, coupled with the inherent difficulties of translation, may present significant hurdles during the licensing procedures. To address this, the Act on Nuclear Energy[568] – distinctly diverging from the General Administrative Procedural Code – permits the submission of technical documentation in the English language for procedures involving the nuclear safety of nuclear installations. While this approach could be quite beneficial in mitigating translation-related challenges, its practical utility remains questionable in instances where the technology originates from a non-English-speaking country.

A further point of divergence lies in the limited concept of the party to public administrative proceedings, more commonly known in the Hungarian legal terminology as client within the context of licensing procedures for new nuclear power plants. Under the prevailing domestic framework, this designation is limited to the licensee,[569] individuals whose property lies within the affected zone, and those whose rights are recorded in the land registry.[570] Such a formulation is markedly more restrictive than that found in the model provisions of the International Atomic Energy Agency, which adopt a broader interpretation encompassing 'other persons substantially impacted.'[571]

Another divergence relates to the temporal dimension of regulatory proceedings. This deviation is not without justification, as the procedures in question necessitate the submission of voluminous technical documentation, which must undergo comprehensive scrutiny prior to the issuance of any licensing decision. The precise duration of these procedures shall be considered in connection with the individual licences in the subsequent sections. Interestingly, despite the explicit procedural timeframes prescribed within the Act, there exist no tailored provisions addressing instances in which the HAEA fails to meet the procedural deadlines. Consequently, the general administrative procedural rules apply. Pursuant to these general provisions, where an authority exceeds the procedural deadline, it becomes liable to pay the client a due fee, in case there is no such fee, 10,000 forints (approximately 25 EUR) has to be paid.[572] The standard fee in administrative procedures is 3,000 forints (less than 8 EUR),[573] a sum wholly negligible when juxtaposed with the enormous cost of a nuclear project where delays can lead to extra costs in the millions of euros. While it is self-evident that the authority must not be unduly hastened at the expense of nuclear safety – which must at all times remain paramount – this framework offers minimal incentive for the authority to adhere rigorously to procedural deadlines.

The final procedural element warranting clarification regarding the procedures of the authority concerns the scope of legal remedies. In this regard, the Atomic Energy Act includes special

[568] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 11/A(3a).
[569] Defined as a 'user of nuclear energy who carries out an activity subject to a licence'.
[570] Kádár and Majoros, 2024, p. 703.
[571] Stoiber et al., 2010, p. 45.
[572] 2016. évi CL. törvény az általános közigazgatási rendtartásról *[Act No. CL of 2016 on the General Administrative Procedure]*, section 51.
[573] 1990. évi XCIII. törvény az illetékről *[Act No. XCIII of 1990 on Stamp Duties]*, section 29.

provisions: decisions rendered of the HAEA may be challenged only through administrative proceedings by those parties formally recognised as clients, there exists no right of administrative appeal against such decisions.

3.6.2. Finland

In Finland the origins of the authorising body naturally date back to the adoption of the first Act, but as was also articulated in the case of Hungary, the principles of nuclear law that fundamentally govern the sector today were not prevalent at that time, and regulators were not independent in today's sense. It was the Ministry of Trade and Industry that fulfilled this role, although in the case of Finland the particularly limited promotional or obstructive role of the state in the sector – compared, for example, to France – has to be remembered.[574]

When it comes to the institutional framework engaged in the licensing of nuclear power plants, Finland applies a different approach from its Hungarian counterpart. The authority responsible for the supreme management and regulation of the sector is not the regulatory authority itself but rather the Ministry of Economic Affairs and Employment,[575] which in this respect fulfils a crucial co-ordinational role in the licensing process of new nuclear power plants.[576]

In accordance with the Convention on Nuclear Safety, signatories are obliged to establish national regulatory authorities, a role fulfilled by STUK, which was established in 1983. STUK is the organisation responsible for overseeing the safe use of nuclear energy, with its responsibilities extending also to nuclear security and non-proliferation.[577]

STUK's status as a regulatory authority was also affected by the general international trend, following the Fukushima disaster, of placing greater emphasis on the independence of regulatory authorities – a shift IRRS reports[578] had likewise indicated was necessary in Finland's case.[579] The Nuclear Energy Act was amended in 2015[580] and entrusted STUK with the role to issuing mandatory general safety provisions that were previously contained in government decrees.[581] While this provided the authority with a legislative role, it did not transform its legal status as was the case in Hungary. It is interesting to observe that these changes were driven by similar international expectations, yet there is a significant gap in time between the adoption of the two measures – although the Hungarian approach was arguably more substantial. Similarly to the HAEA, STUK is also headed by a single Director General, though unlike in the Hungarian approach, the Director General is not appointed by the Government.[582] While licences are issued by the Government as mentioned before, this can only occur if compliance with the regulatory requirements has been confirmed by STUK.

With regard to STUK, it is also crucial to highlight its independence. STUK is not responsible to the Ministry of Economic Affairs and Employment but rather to the Ministry of Social Affairs

[574] Säynässalo, 2009, pp. 141–142.
[575] Act No. 990/1987 on Nuclear Energy, section 54.
[576] NEA, 2026b, p. 18.
[577] Act No. 990/1987 on Nuclear Energy, section 55.
[578] *Integrated Regulatory Review Service of the IAEA (IRRS)*, no date.
[579] IAEA, 2015, pp. 7–8.
[580] Amendment No. 2015/676 of the Nuclear Energy Act.
[581] Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant. Explanatory memorandum. STUK Y/1/2018.
[582] Act No. 1164 on the Radiation and Nuclear Safety Authority, section 4.

and Health, which has no engagement with, or interest in the use of nuclear energy, being concerned instead with social protection and healthcare.[583] While being responsible to a ministry, STUK's independence is thus preserved by virtue of not being answerable to a ministry engaged in the promotion of nuclear energy. Regarding STUK's financial autonomy while a substantial portion their financial resources comes from the government budget – which also differs from the Hungarian approach – it also generates its own revenue by charging licensees in full for the costs of regulatory oversight.[584] Finally with regards to the work of STUK it is important to highlight that they are complimented by advisory committees set up by the government,[585] assisting their work in relation to nuclear safety and security.

In the Finnish institutional setting for the deployment of new nuclear power plants, the government and Parliament cannot go unmentioned. While Parliament's primary role concerns the approval or reversal of the decision-in-principle, the government not only decides on the decision-in-principle but also grants the licences for the subsequent construction and operation stages.[586] Naturally, in a Finnish system where the Ministry and the government hold such a strong position, independence from political or industry pressure becomes a particularly interesting question – one that some countries have sought to resolve through empowered independent regulators, as was the case in Hungary. In Finland, however, two considerations have to be kept in mind: first, that governments, as articulated before, make decisions on these matters in a rather politically neutral manner, and second, that public servants in the Ministry are legally mandated to remain independent from political influence in their work and to conduct it in accordance with statutory requirements – a requirement that is not merely theoretical, but one for which adequate instruments exist to ensure it also manifests in practice.[587]

3.6.3. France

The most important body warranting discussion here is the ASNR, the French Nuclear Safety and Radiation Protection Authority, which is the nuclear regulatory authority. Before discussing the role of ASNR, its history also deserves a brief elaboration given the recent changes to the Authority. The origins of controlling the nuclear safety of installations go back to the CEA, which created the Nuclear Installation Safety Commission in 1960 – though it did not have legal standing – which sought to respond to the less formalised nature of the French approach to nuclear safety compared to foreign counterparts.[588] Eventually a more formalised approach was adopted in the wake of the rapid nuclear expansion in 1973, at which point the relevant body was placed under the Ministry of Industry – no longer within the realm of the CEA, to the satisfaction of other industry actors, as this resolved the conflict of interest inherent in that arrangement.[589]

[583] NEA, 2026b, pp. 18–19.
[584] STUK, 2022, p. 51.
[585] Act No. 990/1987 on Nuclear Energy, section 56.
[586] Act No. 990/1987 on Nuclear Energy, section 54.
[587] Penttinen, 2025, p. 98.
[588] Mangeon and Bouchain, 2024, pp. 1–10.
[589] Foasso, 2007, p. 3.

The idea to have an independent administrative authority – as up until this point the organs despite their name did not have the status of administrative authority[590] – in France first surfaced in the wake of the Chernobyl accident,[591] but only gained momentum in the late 1990s when the reforms of the existing regulatory framework began. Before these legislative reforms materialised, the General Directorate for Nuclear Safety and Radiation Protection (DGSNR), which assumed the regulatory role, and the Institute for Radiation Protection and Nuclear Safety (IRSN) were established in 2002.[592] The DGSNR did not exist in this format for very long; in 2006 the TSN law was adopted, creating the Nuclear Safety Authority (ASN). The TSN law further strengthened the independence of the regulator by organising it as an independent regulatory authority not structured under a ministry,[593] thus signalling the depoliticization of its operation based on foreign examples.[594] ASN incorporated a commission-like organisation, the independence of which was granted by the appointment procedure of the commissioners, though as explained later this was subject to criticism.

In 2024 the final structural change occurred regarding the regulatory authority in France with the merger of ASN and the technical support organisation,[595] the Institute for Radiological Protection and Nuclear Safety (IRNS) into ASNR.[596] The reason behind this change has to be interpreted as part of France's broader efforts to facilitate the execution of the nuclear revival with a regulatory authority that has the resources and capabilities to conduct its regulatory role more efficiently, while not compromising nuclear safety as argued by the government. The proposal for this reform came rather surprisingly to the nuclear sector and faced substantial opposition from stakeholders, who argued that these two bodies had drastically different roles – IRSN was a purely expert technical and scientific organisation providing assessments, while ASN was a decision-making body taking further considerations into account – and that the merger would compromise the independent role of the experts.[597] While these roles are certainly different, nuclear regulatory authorities in many cases function with both capacities within a single organisation, the reason being that while other considerations may certainly be taken into account by authorities, these are strictly limited by the statutory requirements applicable to such installations. Moreover, while experts, due to the generally goal-setting nature of the French system, enjoyed greater freedom in making their assessments, this also meant that their work was not merely the completion of a checklist but rather the evaluation of safety – and thus it might be argued that it was itself quasi-decisional in nature, albeit without the effect of a formalised licence. On the decision-making side, further limits are set by the independent mandate of regulatory authorities, which under international instruments such as the Convention on Nuclear Safety – and as reinforced by the Nuclear Safety Directive in Europe

[590] Rolina, 2008, pp. 80–81.
[591] Rolina, 2012, pp. 55–67.
[592] ASN, 2007, p. 20.
[593] Lacoste, 2007, pp. 38–41.
[594] Delzangles, 2013, pp. 8–9.
[595] In the nuclear safety licensing procedure, but in reality, their scope of activities is more extensive such as the manufacturing of dosimeters.
[596] Loi n° 2024-450 du 21 mai 2024 relative à l'organisation de la gouvernance de la sûreté nucléaire et de la radioprotection pour répondre au défi de la relance de la filière nucléaire *[Act No. 2024-450 of 21 May 2024 on the organisation of the governance of nuclear safety and radiation protection to meet the challenge of the revival of the nuclear sector]*.
[597] Roger, 2024.

following Fukushima – should be independent of organisations concerned with the promotion and utilisation of nuclear energy. Despite arguments that the degree of functional difference would not necessarily necessitate institutional separation, acknowledging these concerns the legislation included a provision stating that where under ASNR an investigation involves an expert assessment, a distinction must be made between the expert and the decision-making person,[598] though this naturally does not provide the same level of separation as before.[599] Beyond arguments of a non-legal nature, what is argued in scholarly works is that such a centralisation of expertise and decision-making powers in one organisation is dangerous in light of the government's active role in promoting the use of nuclear energy and the pressure it exerts on the sector, the concern being that this pressure could extend to the authority itself – not an unimaginable scenario given the government's stated intention to streamline and accelerate deployment – and that the authority, in meeting these expectations, might compromise its evaluations.[600] In the author's opinion, what is disregarded in this argument is the independent mandate of these organisations, which by their mandate should resist such influences, as is prescribed at both the international and Community level. While one may argue that legal protection is one thing and practice another, and that such bodies could be influenced, the same question arises regarding IRSN – a public body previously under the direct supervision of ministries is equally susceptible to influence, whether from the government, the industry, or anti-nuclear agendas.[601] The author's general view is that trust in these authorities is necessary, but this should be combined with meaningful opportunities to challenge their decisions. These authorities are of course capable of error, but a general presumption of trust towards them is warranted – otherwise, how can we have confidence in the safe use of nuclear energy? Furthermore, it is precisely these independent organisations that institutionally guarantee the independence of experts through the independence safeguards established for nuclear regulatory authorities. Thirdly, this debate also highlights how crucial independence is – especially at the time of a renaissance – so that the public can be reassured that streamlined procedures equally maintain well-founded expert evaluations with safety firmly at their centre. The commission type structure of ASNR, like its predecessor, consists of five members, three of whom – including the president – are appointed by the President of the Republic, one by the President of the National Assembly and one by the President of the Senate.[602] In this regard, the criticism voiced in France regarding the appointment of ASNR commissioners remains pertinent; that such an organisation should not be dominantly influenced by the executive is not perfectly executed in France, as the executive appoints the majority of the commissioners. Despite the voicing of these concerns, this matter was not corrected – for example by increasing the number of members appointed by the other branches – at the time of the restructuring.[603]

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[598] Loi n° 2024-450 du 21 mai 2024 relative à l'organisation de la gouvernance de la sûreté nucléaire et de la radioprotection pour répondre au défi de la relance de la filière nucléaire *[Act No. 2024-450 of 21 May 2024 on the organisation of the governance of nuclear safety and radiation protection to meet the challenge of the revival of the nuclear sector]*.
[599] Lorino, 2024, pp. 9–13.
[600] Ibid.
[601] The view expressed in this regard by industry representatives to the author is that this structural reform has, in fact, resulted in a more independent authority, as technical expertise is now more effectively safeguarded from external influence.
[602] Code de l'environnement *[Environmental Code],* art. L592-2.
[603] Delzangles, 2013, p. 12.

Unlike in Hungary, in France the issuance of the licence in the creation authorisation stage – which corresponds to the implementation licensing stage in Hungary – is not carried out by the regulatory authority itself. This creation authorisation stage is more complex than in Hungary, it does not only address nuclear safety considerations but also issues such as the environmental impacts of the plant, and therefore the scope of the licence goes beyond the remit of the nuclear regulatory authority. Consequently, a crucial co-ordinational role in this process is vested in the minister responsible for nuclear safety – currently the Ministry of Ecological Transition, Biodiversity, Forests, Seas, and Fisheries – though the authorisation itself is issued by decree of the Prime Minister, countersigned by the responsible minister.

The last organisation the author would like to mention is the so-called Local Information Commission (CLI), an interesting novelty of the French system. These local information commissions began to be established around most nuclear installations pursuant to the instruction of Prime Minister Pierre Mauroy to local governments in 1981.[604] While many CLIs were established around nuclear installations, they were non-mandatory. This changed in 2006 with the abovementioned TSN law, which made the establishment of CLIs compulsory, with their position further strengthened in 2015.[605] Their role involves carrying out monitoring work, disseminating information, and holding consultations regarding nuclear safety, radiation protection, and the impact of the installation on the public and the environment at the given site,[606] – tasks they carry out on the basis of the information that must be provided to them by the operator and ASNR. In simple terms, CLIs are locally institutionalised bodies that inform and involve local communities in the effects of the operation of such installations. The commission is made up of various elected representatives, representatives of different groups related to environmental protection and economic interests, and qualified individuals. As these commissions must be established once an authorisation has been granted, but not before an application for a creation licence has been made, their participation in the licensing process is conditional on whether they have been established or not. If a CLI has been established by the time the public inquiry is conducted, the Prefect must consult it, secondly, if it has been established by the time the draft authorisation decree is prepared and ASNR is consulted for the second time, the operator and the CLI are heard before ASNR issues its final opinion.

3.7. The general outline of the licensing stages of new build nuclear power plants

3.7.1. Hungary and its staged approach

As mentioned before licensing a nuclear power plant constitutes a procedure of exceptional complexity. In Hungary this is no different, a new nuclear power plant requires several thousands of licences – just within the nuclear sphere – before the facility may lawfully commence operations.[607] Given the sheer number of licences, and as established previously,

[604] Sugawara and Shiroyama, 2010, pp. 368–383.
[605] Loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte *[Act No. 2015-992 of 17 August 2015 on Energy Transition for Green Growth]*.
[606] Code de l'environnement *[Environmental Code],* art. L125-17.
[607] In the case of Paks II. it will be around 7000-8000 licences until the operation of the plant can begin. A large number of these licences are manufacturing, construction and installation licences.

this comparative section is confined to the installation-level nuclear safety[608] licensing stages applicable to new nuclear power plants, supplemented, where relevant, by reference to other key licences which, though issued by authorities other than the HAEA, exert a material influence on the trajectory of the nuclear safety licensing procedure. The nuclear safety licensing in Hungary falls in the category a segmented or staggered regulatory approach requiring individual licences corresponding to each critical milestone in the development of the plant. Chapter III of the Act on Nuclear Energy enumerates the principal installation-level licences which must be secured prior to a new nuclear power plant commencing power generation. These are as follows:

- the site inspection and assessment licence,
- the site licence,
- the implementation licence,
- the commissioning licence and
- the operation licence.[609]

In addition to these nuclear-safety related licences issued by the HAEA, the Act also requires the preliminary consent of the National Assembly for preliminary works on a new plant[610] and it further references other requisite licences, such as those issued by the Hungarian Energy and Public Utility Regulatory Authority.[611] In the sections pertaining to Hungary, practical insights from the Paks II project will be interwoven where appropriate.

3.7.2. Finland

In Finland the licensing process for new nuclear power plants can be divided into two distinct stages: a preparatory phase and a statutory license-granting stage.[612] he first is manifested in the complex and demanding decision-in-principle, as part of which the EIA report must also be submitted, while the second statutory licence-granting stage encompasses the nuclear safety licences. These are as follows:

- the construction license (which also encompasses siting considerations) and
- the operation licence.

Both between and within these two stages it is a linear process, with each step following the previous one in a given sequence. As it can be observed Finland belongs to the countries that have a more consolidated nuclear safety licensing structure, as the statutory licence-granting stage comprises only two licences, unlike the staggered five stages of the Hungarian framework. The regulatory reforms currently before Parliament propose significant changes in these respects. Firstly, the necessary stages, but also the linearity of the process – while the sequence between the two distinct stages will formally remain – are proposed to change substantially, though the question is more complex in terms of its contents. Elements that were previously brought under the decision-in-principle procedure in the preparatory stage will become more

[608] Naturally, there are not only safety-related licences issued by the authority, but also physical protection of the plant, dose limits, etc.
[609] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 17.
[610] Id., section 7.
[611] Id., section 33.
[612] Penttinen, 2025, p. 101.

autonomous procedures; alongside the remaining decision-in-principle, a dedicated site evaluation approval and a separate safety concept evaluation procedure will be introduced.

3.7.3. France

Unlike Hungary, France does not follow a staggered licensing approach that individually licences different focal points in the deployment of a new nuclear power plant. Instead, the French approach – more similar to what was seen in the case of Finland – relies on two comprehensive licences which cover multiple stages of deployment. These are as follows:

- the creation authorisation (this similarly to the Finnish construction licence extends to siting considerations) and
- the commissioning authorisation.

This approach may be considered even more comprehensive than the Finnish one, given that its scope extends also to non-nuclear-specific considerations, with the creation authorisation also encompassing the EIA procedure. However, unlike the two other countries assessed, France does not employ such a dedicated decision-in-principle procedure, which in other systems serves as a distinct political green light for the plant.

3.8. The decision-in-principle stage

3.8.1. Hungary's dedicated yet non-exhaustive decision-in-principle stage

In some countries the prerequisite to any other licensing step in the deployment of a nuclear power plant is a decision-in-principle stage. While not, in the strict sense, a licensing phase, a decision-in-principle is more akin to a policy decision by the country embarking on the deployment of a nuclear power plant, as such, it is heavily influenced by the current political climate.[613] In this regard it has to be mentioned that within the legal order of the European Community, the justification of practices resulting in radiation exposure is prescribed by the Basic Safety Standards Directive (BSS Directive), requiring that nuclear practices shall be justified; that is, they may only proceed where it can be demonstrated that the benefits to individuals and society outweigh the potential health detriments arising from ionising radiation.[614] While the BSS directive does not require project specific justification but with regards the class or type[615] – albeit the meaning of which can be confusing – some countries introduces specific justification procedures – that serve radiological protection purposes – that get entangled with decision-in-principle elements, however this should not be confused and decision-in-principle stages are such are not mandated, nor at the international, nor at the EU level. Given that such a balancing exercise of the decision-in-principle stage involves socio-political, economic, and ethical considerations, it falls beyond the remit of the regulatory authority.[616] Regulatory bodies must maintain strict neutrality towards nuclear energy: they are neither to advocate for its deployment nor to oppose it.

[613] Cook, 2022, pp. 193–194.
[614] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, 2013. Article 5.
[615] Van Balen, Read and Shwageraus, 2026.
[616] Engstedt, 2020, p. 89.

In Hungary, the requirement for the decision-in-principle is codified under Section 7 of Act CXVI of 1996 on Atomic Energy which requires that the National Assembly provide preliminary consent before any further licensing may be undertaken. While this preliminary consent from the perspective of State-led projects is largely procedural, it carries more significance for private projects, which are imaginable in the case of SMRs such as those proposed for industrial applications. In such cases, the evaluation of the potential benefits and harms can lead to conflicts between the private entities involved and the state. Besides the abovementioned requirement, however, neither the Act nor the implementing legislation contains any information on what aspects of the project must be presented to the National Assembly, how detailed the documentation must be, to what extent the outline of the project is bound by the decision of the National Assembly, or how far it may deviate from it. Such a decision, assessing whether the social and economic benefits of the activity outweigh its potential risks, would presuppose a certain level of detail regarding the proposed project. While it may be argued that, since the Act already requires consent for the initiation of preparatory activities, this stage functions rather as an early political green light for the use of nuclear energy – in which case a less detailed proposal might be justifiable – the adequacy of the evaluation of the potential benefits and detriments of the activity remains only superficially addressed. Furthermore, having such a stage, whose scope and permissible deviations from it are so open to interpretation, as will be seen later in the thesis in connection with SMRs, can result in difficulties in interpreting the scope of these consents.

In case of the Paks II project, the preliminary consent for the project was given with an overwhelming majority of the Parliament pursuant to Parliamentary Resolution 25/2009 (IV. 2.) OGY, a concise and unelaborate decision endorsing the initiative, although at that time there were certain requirements regarding what the consent had to include.[617] The resolution was grounded in the findings of the 2007 Teller project,[618] but the documentation underpinning this project was not readily available to the public, although it concerned the spending of thousands of billions of forints in public funds. This lack of transparency prompted litigation under the Act on the Right of Access to Data of Public Interest, ultimately compelling the release of the underlying documents.[619] The foundations of this policy decision[620] also did not escape scrutiny. The Parliamentary Commissioner for Future Generations voiced criticism, asserting that the consent had not been supported by a sufficiently robust evaluation of the necessity of constructing an additional nuclear power plant in Hungary.[621]

3.8.2. Finland's demanding decision-in-principle stage

[617] Despite an existing parliamentary resolution on energy (40/2008 (IV. 17.), which set specific requirements for the level of project detail needed before consent could be granted, these requirements were not reflected in practice, as the government argued that the resolution was not binding on its motion. The parliamentary resolution on energy was later repealed by 77/2011 (X.14.) the Resolution of the National Assembly on the National Energy Strategy, which does not impose comparable requirements for granting consent.

[618] After the decision-in-principle in 2009 the Project was renamed Lévai-project.

[619] Tolna Megyei Bíróság 13.Gf.40.024/2011/4. számú ítélete *[Judgment No. 13.Gf.40.024/2011/4 of the Tolna County Court]*.

[620] For more, see Kocsis 2016, pp. 230–231.

[621] PCFG, 2010.

The decision-in-principle procedure in Finland is not merely a formal justification of the project, but bears particular relevance and is a considerably more complex institution than in the case of Hungary. This stage is mandated by the Nuclear Energy Act for nuclear power plants exceeding 50 MW thermal capacity,[622] which also entails that certain facilities with a smaller capacity may not be subject to a decision-in-principle – as we will see, however, this observation may not necessarily be applicable to every assessment conducted as part of this stage. The purpose of the decision-in-principle – what such stages should generally serve – is to eliminate the political interference in the regulatory process,[623] and in Finland this is currently a complex and demanding process serving to make a well-founded political commitment. While alleviating political risk at such an early stage is hypothetically possible, in practice several deployment cases have shown that this is not always achievable, and the proposed new licensing architecture significantly alters how demanding this stage is.

As part of the decision-in-principle stage, the applicant submits the application to the government. Unlike in Hungary, the Nuclear Energy Decree sets rather detailed requirements regarding what information must be disclosed and attached to the application; some of this is more general in nature, concerning the applicant itself, the planned financing, or the plant's necessity in light of Finland's energy supply, but this must be supplemented by rather specific information on the technical principles of the facility, the description of the suitability of the site, the plan for fuel and nuclear waste management, and most demandingly, the environmental impact assessment report.[624] The Finnish system places environmental considerations at the outset of the project; in fact, the preparation of the EIA constitutes the first stage of embarking on a project, as it must be completed by the time the application for the decision-in-principle is submitted.

Following the application, the Ministry of Trade and Industry coordinates the procedure; first it collects the preliminary safety assessment from the Radiation and Nuclear Safety Authority, which must also include the opinion of the advisory committee on the application,[625] as well as the views of the Ministry of the Environment, various other stakeholders,[626] and of the municipality and neighbouring municipalities where the facility is to be located, which municipalities play a particularly crucial role in the process.[627]

Within the decision-in-principle procedure – despite that the EIA procedure already encompassed one – there is another public hearing. The subject of this second public participation has a broader scope, its basis is the report the applicant draws up under the instruction and oversight of the Ministry, covering the project, its safety and its environmental impacts once more. The participation has two levels of addressees: opinions may be expressed in writing by the residents and municipalities in the immediate vicinity of the facility, but besides this a public event in the municipality of the site should also be held where these opinions may be expressed orally or in writing; what is equally true for both of these procedures is that the opinions have to be communicated to the government.[628] The Ministry does not make

[622] Act No. 990/1987 on Nuclear Energy, section 11.
[623] Kojo, 2009, p. 226.
[624] Decree No. 161/1988 of the Ministry of Economic Affairs and Employment on Nuclear Energy, section 24.
[625] Decree No. 161/1988 of the Ministry of Economic Affairs and Employment on Nuclear Energy, section 25.
[626] Ibid.
[627] Id., section 12.
[628] Id., section 13.

the decision-in-principle; rather, this task is reserved for the government. The government is provided with the information mentioned above, but besides that the Ministry also prepares two specific reviews that assist in this decision-making: one concerns the waste management of the facility while the other concerns the facility's importance for Finnish energy supply. Both of these cover topics on which the applicant also submitted information in their application, but this is complemented by the Ministry's own assessment of these considerations, underlining their particular relevance.[629]

Before making its own decision on the application, the government must satisfy itself that the municipality where the plant is proposed to be located has, in the above-mentioned stage, supported the construction. Municipalities in Finland hold a strong veto at a very early stage in such projects, as without their consent the government cannot even consider granting the decision-in-principle. The government must equally ensure that no facts indicate that the plant should not be built – in particular that it can be operated safely and should not in principle cause harm to people or damage to the environment or property. After these mandatory affirmative determinations comes the deliberation of the government, which constitutes the policy decision as is generally the case at these stages. Throughout their evaluation, particular attention is paid to the need for the facility, the suitability of the site, the environmental impacts, waste and fuel management, and generally the perspective of the overall good of society.[630] As mentioned before, as part of the decision-in-principle procedure the government does not make the ultimate decision – that is reserved for the Parliament. Consequently, after the government makes a supportive decision – which may include certain conditions – it is forwarded to Parliament, which, after scrutinising the government's decision, may either reverse or approve it.[631] Since this is not a formal licensing stage but rather a political approval, the Nuclear Energy Act explicitly declares, both on the part of the government and Parliament, that there is no appeal against either of their decisions.[632] While it is understandable why an appeal procedure is not provided against such a political decision, one has to keep in mind that applying for this decision requires the investment of significant resources in the planning of the installation, as well as in the EIA procedure, and yet political will may still override the fate of the project even if the opinions of the authorities were generally favourable – which presents a unique risk at this stage. The reformed Act's approach with a reconsidered decision-in-principle may bring some mitigation of these currently present risks. Importantly unlike in Hungary decision-in-principle procedures, owing to changing circumstances, usually include a validity period within which the construction licence application must be submitted, although this may be extended.

To illustrate the current length of this stage, we can look at the Olkiluoto 3 plant, where the EIA procedure preceding the decision-in-principle was initiated in 1998 and reached completion in 2000, at which point the application for the decision-in-principle could be submitted – which was ultimately endorsed by Parliament in 2002,[633] after lengthy and uncertain debates.[634] Thus, just to obtain the political green light, four years of effort had to be invested. The validity period

[629] Id., section 26.
[630] Id., section 14.
[631] Act No. 990/1987 on Nuclear Energy, section 15.
[632] Penttinen, 2025, p. 107.
[633] Javanainen, 2006, pp. 22–23.
[634] Nikula and Kätkä, 2004, p. 217.

for the decision-in-principle in this case was five years from the time of Parliament's decision.[635]

3.8.3. France and its less formalised decision-in-principle stage

In France, a very different approach has been adopted towards this initial stage in the licensing process compared to the Hungarian and especially the Finnish approach. France does not employ a dedicated decision-in-principle which would have to be obtained before the future licensee may proceed with their licence applications. This in turn means there is no dedicated process in which the individual societal benefits and advantages of a given project are evaluated. However, this does not mean that certain instruments do not partially fill this role. What may serve as an overall political green light for nuclear power is, firstly, the Multi-year Energy Programme (PPE), introduced into the Energy Code[636] by the Energy Transition Act,[637] the purpose of which is to set trajectories for the energy sector and, by extension, the energy mix. The latest 2026 programme[638] makes several mentions of nuclear power and in particular its future role, establishing that studies support the view that a significant reduction in the nuclear fleet would endanger energy security and that, alongside decommissioning, new deployments are therefore needed. More concretely, the programme sets out a number of specific actions, including confirming the launch of a programme led by EDF to build six EPR2 reactors, naming the specific sites, affirming government support, and, in a separate action, expressing support for SMR deployment.[639] What is expressed with regard to the more concrete projects at the mentioned sites is, in substance, similar to a decision-in-principle. It conveys high-level political support for the projects concerned, however, since no legal requirement exists to make such a decision, this support is expressed less explicitly than in other countries. The second instrument of importance in this regard is the acceleration Act,[640] which while not making specific reference to a given project – and thus being less concrete in nature than the PPE[641] – establishes that the construction of nuclear power plants, including SMRs, in the vicinity of existing nuclear installations[642] constitutes overriding reasons of major public interest as enshrined in the Environmental Code, if their thermal power exceeds 750 MW thermal, or 30 MW thermal in the case of an innovative reactor design.[643] While this is a general

[635] Government decision on the application of Teollisuuden Voima Oy for the construction of a new nuclear power plant unit and for the expansion or construction of the nuclear facilities required for the operation of the unit at the same plant site, 2002, p. 6.
[636] Code de l'énergie, L141-1.
[637] Loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte *[Act No. 2015-992 of 17 August 2015 on Energy Transition for Green Growth]*, art. 176.
[638] Programmation pluriannuelle de l'énergie (2026–2035) Stratégie française pour l'énergie et le climat *[Multi-year Energy Plan (2026–2035) French Energy and Climate Strategy]*.
[639] Id., pp. 108–109.
[640] Décret n° 2023-1366 du 28 décembre 2023 pris pour l'application, sur le territoire métropolitain continental, de l'article L. 211-2-1 du code de l'énergie et de l'article 12 de la loi n° 2023-491 du 22 juin 2023 2023 *[Decree No. 2023-1366 of 28 December 2023 implementing Article L. 211-2-1 of the French Energy Code and Article 12 of Law No. 2023-491 of 22 June 2023]*.
[641] Some argue that how democratic this process may be. See Stenberg and Topçu, 2019, p. 233.
[642] Id., art. 7. II.
[643] The outputs referred here can be the combined outputs of multiple reactors in one project. Décret n° 2023-1366 du 28 décembre 2023 pris pour l'application, sur le territoire métropolitain continental, de l'article L. 211-2-1 du

criterion, it indicates that projects falling within its scope bear particular importance justifying their special status, and as such it also entails a certain evaluation of their societal benefits.
In addition a further element that may also partially serve these purposes is the participation of the National Commission for Public Debate (CNDP), which provides for public participation at the development stage – thus prior to actual licensing – on the objectives and characteristics of the project, related socio-economic issues and potential alternatives. However, it does not apply to all installations, certain conditions must be met, and in the case of new sites for nuclear power plants, referral to the CNDP is required where the investment exceeds 460 million euros.[644] This threshold can have practical relevance, for example, the Jimmy Energy design was excluded from this scope due to its lower investment cost. In this respect it constitutes a project-specific evaluation, but one that is non-binding regarding the course of the project and therefore does not amount to a political green light.

3.9. Generic design licensing and pre-licensing possibilities for nuclear power plants

3.9.1. Hungary's preliminary safety information

The Hungarian legislation with respect to conventional nuclear power plants does not provide for a generic design licensing stage where a given reactor design may be granted generic approval in advance of project-specific licensing. Nevertheless, given the relatively modest scale of Hungary's nuclear energy programme – and the correspondingly limited number of reactors that might realistically be deployed – this omission has not, to date, presented a major regulatory obstacle. That said, in the wake of the nuclear renaissance driven by SMRs, the introduction of such a design certification stage may make more sense; this consideration was indeed reflected in the recent amendment to the Act on Atomic Energy. However, as this amendment is specific to SMRs, it will be discussed in a later part of this work.
Nevertheless, while it does not constitute a formal pre-licensing phase, there exists an important preliminary stage which may materially influence the course of the implementation licensing procedure. This step is the submission of the Preliminary Safety Information (PSI), a document which serves a dual function: first, to demonstrate that the proposed plant complies with the safety requirements; and second, to provide the regulatory authority with adequate information at an early stage of the process. Within the PSI, the licensee is expected to evidence compliance with nuclear safety rules by presenting data from reactors similar to or identical to the one proposed. Although the submission of the PSI is not mandatory, it holds considerable practical relevance. In particular, its submission enables a reduction in the statutory timeframe for the implementation licensing procedure from 18 months to 12, however, the implementation licence application itself may only be lodged twelve months after the PSI has been submitted.

3.9.2. Finland's consultative mechanisms

code de l'énergie et de l'article 12 de la loi n° 2023-491 du 22 juin 2023 2023 *[Decree No. 2023-1366 of 28 December 2023 implementing Article L. 211-2-1 of the French Energy Code and Article 12 of Law No. 2023-491 of 22 June 2023]*, art. 3.
[644] Code de l'environnement *[Environmental Code],* art. R121-2.

Finland's current regulatory framework does not employ a generic design licensing stage, although this may change with the forthcoming amendment which, unlike in the case of Hungary, would also cover conventional large-scale plants. However, as explained above regarding Hungary, its practical relevance is questionable, given the comparable size of Finland. However, a consultative pre-licensing stage exists in which anyone planning to use nuclear energy may discuss their plans with the authority, which may also issue preliminary instructions; unlike in Hungary, this does not have a determinative effect on the future licensing of the installation, but it still plays an important role in mitigating licensing risks.[645] The approach to shorten licensing timelines would conceptually be difficult in Finland as there are no predetermined licensing timelines during which the authorities are mandated to evaluate the license applications,[646] so in that respect there is no reference point from which such a pre-licensing could grant a deviation from. That said, this does not mean that certain issues cannot be treated as already evaluated, thereby resulting in more efficient evaluations.

3.9.3. France

Similarly to Finland and Hungary, France does not have a generic design licensing stage that would eliminate the need to reassess non-project-specific aspects within project-specific licensing procedures. However, unlike in the two other countries, such an approach would carry considerably more relevance in France for conventional plants, given the sheer size of the country.

Similarly to the other two countries, France also employs a pre-licensing stage, one that may likewise have more tangible effects on the later course of the licensing procedure than in Finland, albeit without the automatically declared effects seen in Hungary. In France, an entity planning the construction of a nuclear facility may, before initiating the licensing procedure, request ASNR to give an opinion on the adequacy of the solutions to be employed in the plant. ASNR will evaluate the submitted plans and issue an opinion on how these comply with the nuclear safety requirements, furthermore, it can also determine supplementary studies or documentation that would be required during the actual creation authorisation. In its opinion the authority will determine its validity period and will also forward it to the Minister responsible for nuclear safety – which already indicates that it is not merely a consultative stage.[647] The practical relevance of this stage relates to the Preliminary Safety Analysis Report (PSAR), in which the applicant must indicate which aspects have already been studied by the authority, and must equally present any additional studies and documentation conducted, as well as demonstrate how it has fulfilled the requirements set by the authority in its opinion.[648] While this procedure does not replace the evaluation of the application during the actual licensing stage, nor does it result in an automatically shorter procedure, its formalised nature – having already produced an opinion to which the applicant must specifically respond – provides tangible evidence of the authority's prior efforts, thereby possibly helping to streamline the

[645] Act No. 990/1987 on Nuclear Energy, section 55.
[646] Act 434/2003 on the Administrative Procedure, section 23.
[647] Code de l'environnement *[Environmental Code]*, art. R593-14.
[648] Id., art. R593-18.

licensing process. It should be noted, however, that deriving such benefits from this process requires the authority's initial evaluation to be similarly resource-intensive.[649]

3.10. Siting of a nuclear power plant

3.10.1. Hungary and its separate site license

According to the guidance of the IAEA, the siting of a nuclear power plant is an activity for which generally no specific licence is required consequently they do not refer to it as one particular licensing stage.[650] Instead, the IAEA foresees the licensing of the site as an integral component of the Preliminary Safety Analysis Report,[651] which is to be prepared prior to the authorisation of the construction and is assessed by the regulatory authority in tandem with the evaluation of the plant's design during the construction licensing phase. This position should not, however, be understood as a negation of the importance of site selection. On the contrary, the IAEA has developed detailed practices for selecting an adequate site for a nuclear plant, although it refrains from subsuming these procedures under the rubric of a specific 'site licence'. Accordingly, the IAEA advocates a two-stage approach to site selection. The first stage entails a broad site evaluation process to identify possible locations for nuclear power plants, a task it recommends should be carried out by a ministry or national authority. The second stage involves the detailed evaluation and assessment of a specific proposed site, a responsibility placed upon the prospective licensee.[652]

In Hungary, a markedly different approach has been adopted in contrast to the methodology endorsed by the IAEA. A dedicated site licensing stage has been established as the first installation level nuclear safety licence issued by the HAEA within the broader authorisation process for the construction of a new nuclear power plant. Proponents of the non-separate site licence approach claim that incorporating site evaluation into the construction licensing procedure – wherein it is considered alongside the key design parameters – yields a more informed and holistic regulatory decision. However, such an approach places greater pressure on the regulator. Conversely, the existence of a separate site licence approach distributes regulatory workload more evenly. While it is true that, at this preliminary juncture, the plant's design is not yet subject to a comprehensive evaluation, the licensee still has to assess the suitability of the proposed site in light of the envisaged design.

This site licensing process itself is further subdivided into two distinct stages. The first phase of site licensing in Hungary consists in the granting of the site inspection and assessment licence. As part of this licence, the license applicant presents the site inspection and assessment program, which sets forth the methods and theoretical consideration intended to be used in evaluating the site, together with a justification demonstrating the adequacy of such methods for the purposes of site assessment. The general rules of the site inspection and assessment licensing stage are contained in Annex I of the NSRs, while more detailed provisions specific to this process are contained in Annex VII, which is specifically dedicated to the site inspection

[649] In this regard it is interesting to note that for example in the case of the Jimmy Energy plant no such pre-licensing step was initiated.
[650] IAEA, 2015c, p. 8.
[651] IAEA, 2010, p. 52.
[652] Stoiber et al., 2003, pp. 62–63.

and assessment procedure. Further guidance is provided by Regulatory Guideline 1.1, concerning the siting licence of nuclear installations. At this stage, the primary task of the regulatory authority is to determine whether these presented evaluation methods are adequate for evaluating a site or not. The licence application must include methodologies for evaluating a range of factors, including but not limited to: geotechnical hazards, meteorological conditions, seismic activity, external man-made hazards, floods, fire hazards and biological hazards, etc.[653] The objective of this preliminary stage is to enable the prospective licensee to obtain a decision early on whether the proposed methods are methodologically sound, sufficiently comprehensive, and appropriately tailored to cover all relevant aspects of site suitability.[654] Once these methods are endorsed and subsequently applied to a specific site, their suitability will not be subject to further challenge, thereby ensuring that the site assessment proceeds in a manner that is both effective and procedurally secure.[655]

Paks II, submitted its application for the site inspection and assessment licence in April 2014. Under the applicable regulatory framework, the HAEA was afforded a period of 120 days within which to evaluate the licence application, a period which also encompassed the conduct of a public hearing – an obligatory component of every installation level nuclear safety licence. During the evaluation, the HAEA sought the expert opinion of the 'Hungarian Office of Mining and Geology, Pécs Mining Department' which acted in the capacity of a specialised authority with regard to the geological dimensions of the proposed development. In November 2014, albeit beyond the statutory time limit, the HAEA issued the site inspection and assessment licence to Paks II, subject to the fulfilment of certain conditions.[656] From a procedural standpoint, it is noteworthy that at this junction in the licensing process, Paks II held the status not of a licensee, but merely that of an applicant. The legal transition from applicant to licensee occurs only upon obtaining this licence, thus during the procedure the applicant also has to prove that they are qualified to become a licensee.[657] The temporal validity of the site inspection and assessment licence extends until the authority issues the site licence, but may not in any event exceed a period of five years.

The second stage of the site licensing procedure involves obtaining the actual site licence. Unlike the site inspection and assessment licence, this phase does not have a dedicated NSR annex, as it is principally concerned with the practical application of the previously approved evaluation methodologies to a specific site. The same regulatory guidelines as those applicable to the inspection and assessment stage remain in force at this juncture. During this stage, the licensee is required to establish two principal assertions: firstly, that no disqualifying conditions exist which would render the proposed site unsuitable for the siting of a nuclear power plant; and secondly, that the site-specific data, obtained through the application of the previous methods, substantiate the future construction of the plant. The findings of the assessments and

[653] 1/2022. (IV.29.) OAH rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities]*.

[654] HAEA, 2014, p. 9.

[655] HAEA, 2025b.

[656] Az OAH HA5919. határozata az MVM Paks II. Zártkörűen Működő Részvénytársaság kérelmére telephely vizsgálati és értékelési engedély tárgyában *[Decision No. HA5919 of the HAEA on the application of MVM Paks II Zártkörűen Működő Részvénytársaság for a site inspection and assessment]*.

[657] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy],* section 17(7).

inspections are included in the final report document, which forms the core of the licence application.[658] This final report demonstrates that the evaluation follows the preapproved methods, and must clearly state whether the findings support a positive or negative determination as to the suitability of the site.[659] Should the licensee elect to employ alternative methods, the report must also provide a substantiated justification for their adequacy.

Paks II submitted its application for the site licence in October 2016, which was issued with some conditions in March 2017,[660] thus exceeding once more the prescribed 120-day evaluation period. The conditions attached to the licence were predominantly technical in nature rather than legal. However, one noteworthy requirement imposed upon Paks II was the obligation to carry out an analysis examining the potential effects of site-related activities on the safety of the adjacent Paks I plant, and to submit this assessment prior to the commencement of any implementation works. This obligation aptly reflects a particularly distinctive and complicating feature of the project – namely, that it is situated in the immediate vicinity of an operational nuclear power station.

In 2021, the temporal scope of the site licence was extended, as the implementation licence had yet to be obtained, and the original five-year validity period was approaching its expiration. Under the Nuclear Safety Rules, an extension may be granted by the HAEA, provided the original licensing conditions remain satisfied. In accordance with this framework, the HAEA duly extended the site licence in 2022, prolonging its validity by a further five years.[661]

In the case of Paks II, this less conventional site licensing approach, presented notable challenges for the IAEA. The Agency had anticipated that the documentation of the site would be included in the PSAR, customarily submitted during the implementation (construction) licensing stage. However, in the case of Paks II project, such extensive site documentation was absent from the PSAR, as it had already been submitted during the earlier phases of the site inspection and assessment, and the subsequent site licensing stages.[662]

3.10.2. Finland's more conventional approach to siting

Finland unlike Hungary does not have a site-specific licence, site related considerations, in line with the IAEA's guidance are taken into account as part of the construction licensing stage. Regarding the siting of nuclear power plants, the Act, the Decree and the Regulations remain rather limited in their provisions. The Act provides that the general rules for land use planning are applicable to nuclear facility sites, but before a local plan of the site is drawn up and approved, STUK's statements must be obtained.[663] With regards to siting the Regulation only states that local conditions relating to safety, security and emergency arrangements should be taken into account when selecting a site, and that the impediments and threats the plant would

[658] HAEA, 2014, p. 18.
[659] Ibid.
[660] Az OAH P2-HA0008. határozata Az MVM Paks II. Atomerőmű Fejlesztő Zrt. kérelmére telephelyengedély tárgyában *[Decision No. P2-HA0008 of the HAEA on the application of MVM Paks II Zártkörűen Működő Részvénytársaság for a site licence]*.
[661] Az OAH P2-HA0264. határozata a P2-HA0008 számú határozattal kiadott telephelyengedély időbeli hatályának meghosszabbítása tárgyában *[Decision No. P2-HA0264 of the HAEA on the extension of the validity period of the site licence issued by Decision No. P2-HA0008].*
[662] Katona, 2024, pp. 408–409.
[663] Act No. 990/1987 on Nuclear Energy, section 58.

pose to its surroundings must remain extremely limited. In this regard, it particularly notes that reliable heat removal, one of the most challenging issues during operation, must be dependably achievable at the site.[664] Detailed, although not binding, requirements on siting are found in STUK's guidelines.[665] While it was noted earlier that guidelines generally tend to employ a prescriptive approach, this particular guideline instead adopts a generally goal-setting approach in defining siting criteria. For instance, it provides that the plant should not be located in a densely populated area, so that emergency plans can be more effectively implemented given the lower population density. Following the same methodology, it also establishes that no activities may be carried out in the vicinity that could endanger the plant. Prescriptive elements do appear, though they are not particularly demanding – for example, that two road connections must be available for the plant.[666] Further considerations regarding siting are rather self-explanatory relating to external hazards affecting the site.

The Preliminary Safety Assessment Report submitted as part of this stage and reviewed by STUK contains the site-relevant aspects, similar in content to the issues evaluated in the site licensing stage in Hungary, addressing factors such as the geography of the site, land and water usage in the area, site climate, meteorological conditions, hydrological factors, geology, seismology, and the cooling water intake and discharge. Since these siting aspects are only formally approved at the construction licence stage, yet the practical schedule of related works does not always align with this, excavation and earthmoving works may be carried out even before the construction licence has been issued, in order to accommodate this scheduling reality.[667]

One crucial aspect with regard to the siting of nuclear power plants relates to emergency planning zones, which, in the context of SMRs, bear particular importance and were thus also highlighted by industry representatives during the preparatory discussions on the reform of the legislative framework.[668] Interestingly, this shift had already taken place before the reform of the Act, as in 2024 a new STUK regulation,[669] on the emergency arrangements of nuclear power plants was adopted, the explanatory memorandum of which explicitly stated that the previous 20 km EPZ was unnecessarily large for SMRs, and that a more graded approach would therefore be adopted, under which the licensee suggests the appropriate zone and provides justification for it.[670] This naturally aims to allow for the siting of these novel installations closer to more densely populated areas, which in the case of district heating applications – currently the most often discussed deployment idea in Finland – is crucial.

3.10.3. France's also conventional approach

As in Finland, and in line with IAEA guidance, siting considerations in France are also addressed in the PSAR, which forms part of the application for the creation authorisation. The

[664] Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant. STUK Y/1/2018, section 8.
[665] STUK, 2019a.
[666] Id., p. 402.
[667] STUK, 2019b, p. 360.
[668] Kojo et al., 2023, p. 4.
[669] Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant. STUK Y/2/2024.
[670] Id., Explanatory memorandum.

preliminary safety report must contain a dedicated section describing the site of the installation. This description is not limited to the natural characteristics of the site but also covers its demographic, urban, commercial, agricultural and industrial environment. It further extends to planned developments that may affect the installation in the future, namely projects that have received a building permit, projects that have been subject environmental authorisation, and projects that required an environmental impact assessment, as the legislator evidently regards these projects as sufficiently concrete and relevant to require their inclusion. The information provided must be detailed enough to verify whether the measures adopted against the associated risks are adequate. The description of the environment is also required as part of the report which as in the other countries covers the geology, seismicity, hydrology and hydrogeology of the site and, where relevant, its oceanographic characteristics. Climatic and meteorological conditions must also be addressed together with their foreseeable evolution over the operating period of the installation. In light of the droughts of summer 2026 in Europe and their effect on the operation of certain nuclear power plants – such as in Hungary or Romania – this requirement is of particular relevance. Since the notion of environment is not confined to natural factors, the description must also include industrial activities that could affect nuclear safety, as well as various transport means and their foreseeable development over the lifetime of the installation. The provisions governing these considerations are largely goal-oriented, requiring that the information submitted be sufficient to assess the external hazards taken into account in the safety case.[671]

However, in this respect, recently adopted reforms have brought about changes: as explained in the section on recent reforms, in certain cases preparatory works at the site may now be carried out under a separate environmental authorisation, before the creation authorisation itself is issued.

Similarly to Hungary, France also employs a traditional, large-scale emergency planning zone, the size of which was extended from 10 km to 20 km in response to the Fukushima disaster.

3.11. Environmental impact assessment procedures in the context of nuclear power plant deployments

With regards to this section a short general elaboration is needed. Although environmental licensing falls outside the ambit of the nuclear safety licensing regime, it nonetheless constitutes an indispensable element in the authorisation process of a new nuclear power plant, given the paramount importance of environmental protection in relation to such installations – a principle underscored by international instruments such as the Convention on Nuclear Safety.[672] In some countries, environmental licences are issued also by the nuclear regulatory authority itself, while in others this task is entrusted to a separate authority, which may not, in all cases, oversee the entire environmental licensing process,[673] particularly since separate environmental licences

[671] Arrêté du 11 janvier 2016 portant homologation de la décision n° 2015-DC-0532 de l'Autorité de sûreté nucléaire du 17 novembre 2015 relative au rapport de sûreté des installations nucléaires de base *[Order of 11 January 2016 approving the decision No. 2015-DC-0532 of the Nuclear Safety Authority of 17 November 2015 relating to the safety report of basic nuclear installations]*, art. 4-4-1.
[672] IAEA, 1994.
[673] Raetzke, 2013, pp. 69–70.

may in cases, be required, each covering only a specific area, such as air pollution or water usage.

Given this variation in licensing arrangements, this section focuses instead on how EIA procedures – which are mandated under European Union Law[674] in case of nuclear power plants – are integrated into the licensing process for new-build nuclear power plants. As various legal scholars and practitioners have observed, environmental assessment procedures, though not themselves determinative of the fate of a nuclear project, are designed to ensure that authorisation decisions are made on the basis of the most complete and reliable information available.[675] These procedures are also of particular relevance because of the role they give the public: corresponding to the three pillars enshrined in the Aarhus Convention, Community secondary legislation[676] provided for public access to information, participation in decision-making and access to justice with regard to these procedures.

Furthermore, although they will not be discussed in detail in relation to the individual countries, it should be noted that such plants may also be addressed in the strategic environmental assessments required under EU law,[677] where they form part of plans and programmes covered by Directive which aims to integrate environmental considerations into the preparation and adoption of such plans and programmes.[678]

3.11.1. Hungary with a separate environmental license encompassing an EIA

Hungary falls into the category where a separate environmental license exists that encompasses an EIA procedure. In Hungary, nuclear power plants – irrespective of their generating capacity – are required an environmental licence, based on an environmental impact assessment procedure.[679] This licence, while employing an EIA procedure that extends, in an integrated manner, to all aspects of the environment, does not itself authorise the use of the environment; rather, on the basis of the envisaged environmental aspects of the plant, it constitutes a prerequisite for obtaining those environmental licences which allow for the actual use of the environment. The crucial nature of the environmental license based on an EIA in relation to the nuclear safety licensing procedure lies in the fact that the implementation licence may not be

[674] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, 2012.
[675] Sexton Nick, 2022, p. 23.
[676] Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC, 2003; Directive 2003/35/EC of the European Parliament and of the Council of 26 May 2003 providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC, 2003.
[677] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, 2001.
[678] In 2008, the European Community approved the Protocol on Strategic Environmental Assessment (the Kyiv Protocol) to the Espoo Convention, to which all three analysed states have since also become parties, and which in certain respects has a broader scope than the Directive. 2008/871/EC: Council Decision of 20 October 2008 on the approval, on behalf of the European Community, of the Protocol on Strategic Environmental Assessment to the 1991 UN/ECE Espoo Convention on Environmental Impact Assessment in a Transboundary Context, 2008.
[679] Korm. rendelet a környezeti hatásvizsgálati és az egységes környezethasználati engedélyezési eljárásról *[Government Decree No. 314/2005 (XII.25.) on environmental impact assessment and the integrated environmental permitting procedure]*.

issued in the absence of a valid the environmental licence. While the applicant is permitted to initiate the implementation licensing procedure prior to obtaining the environmental licence, the implementation licence itself cannot be granted until the latter has been secured.
The Paks II project initiated preliminary consultations regarding the environmental licence in 2012, and by 2014, the Environmental Impact Assessment had been completed. This assessment addressed a wide range of potential environmental effects, including noise pollution, dust emissions, cooling water (thermal) discharges into the Danube, and the management of radioactive waste.[680] Public hearings were held in the course of the national EIA procedure, though no material objections were raised therein. In addition to the domestic EIA, a transboundary environmental impact assessment was also required under Hungary's obligations pursuant to the Espoo Convention. Accordingly, in 2015, a transboundary EIA procedure was launched, resulting in seven public hearings being conducted in participating states. This procedure was brought to a conclusion in 2016.[681] Subsequently, later that same year, the Baranya County Government Office issued the first-instance environmental licence to the plant.[682] However, this decision was swiftly challenged by environmental and anti-nuclear organisations. In 2017, the Pest County Government Office upheld the first instance decision.[683] Dissatisfied with the outcome, the same organisations sought judicial review of the licensing decision, but their challenge was ultimately dismissed by the courts.[684]

3.11.2. Finland's EIA procedure, conducted ahead of the decision-in-principle stage

Rather differently from Hungary as mentioned before the EIA process constitutes the first stage of embarking on a nuclear power plant project in Finland, as it must be completed by the time the application for the decision-in-principle is submitted. The foundation of this front-loaded approach lies in the Act on Environmental Impact Assessment Procedure, which prescribes that EIA procedures must be conducted at the earliest possible stage of planning,[685] and further mandates that the EIA report and conclusions be attached to the permit application before any decisions are made.[686] One clarification has to be made regarding the EIA procedures and nuclear power plants. Since the decision-in-principle stage is prescribed for projects exceeding 50 MW thermal capacity, the ambiguity regarding how the environmental impacts of plants below this capacity are addressed arises as a question which from the perspective of microreactors could be relevant. The issue is resolved by the Act on Environmental Impact Assessment Procedure which in Annex 1, in line with the Directive, lists nuclear power stations regardless of their capacity as projects for which an EIA is required.[687] Consequently even if a decision-in-principle would not be required the EIA procedure nevertheless would have to be

[680] Kocsis, 2017, p. 84.
[681] A Baranya Megyei Kormányhivatal 78-140/2016. határozata a környezetvédelmi engedély megadásáról *[Decision No. 78-140/2016 of the Baranya County Government Office granting an environmental licence]*, p. 74.
[682] Ibid.
[683] A Pest Megyei Kormányhivatal PE-KTF/203-40/2017. határozata a II. fokú környezetvédelmi engedély megadásáról *[Decision No. PE-KTF/203-40/2017 of the Pest County Government Office granting a second-instance environmental licence]*.
[684] Kocsis, 2017, p. 67.
[685] Act No. 252/2017 on Environmental Impact Assessment Procedure, section 15.
[686] Id., section 25.
[687] Id., Annex 1, pt. 7.

carried out. The Act on Environmental Impact Assessment Procedure does not contain specific provisions on the content of the EIA for nuclear power stations; it requires standard information about the proposed project. However, certain elements, such as the project's radiation emissions and its use of natural resources, are of particular importance, and the Finnish system also emphasises the presentation of alternatives to the project – a requirement that, while also present in Hungary, carries particular relevance at this comparatively early stage.[688]

The EIA process has two distinct stages: the first is the preparation of the programme, and the second is the report itself. The assessment programme, which contains a proposal for organising the procedure and its content, is submitted to the Ministry of Economic Affairs and Employment.[689] The Ministry has a complex role, as part of which coordinates the participation of several other parties and gathers their feedback. Public involvement is already granted at this stage through a public notice, which provides information on the project and allows the public to submit opinions and statements,[690] in this respect the first official interaction of the public with the prospect of the nuclear power plants is carried out as part of this procedure. The Ministry collects the statements from the various stakeholders and also issues its own statement on the EIA programme, particularly regarding its scope and accuracy, which it then submits to the developer.[691] Subsequently, the developer prepares the EIA report based on the programme and the received statements. Thus, the concern that there is no specific information provided in regulations on the factors that have to be assessed with respect to nuclear power plants is resolved by this early discourse with the authority. On the submitted assessment report, the Ministry concludes a public notice procedure and again involves other authorities to submit their assessments, which it also collects as in the case of the programme.[692] The Ministry itself will also evaluate the proposed plant and submit its reasoned conclusion on the assessment within two months of the deadline for submitting statements. This conclusion is forwarded to the developer, to other relevant authorities, and to public notice.[693] If the report is deemed inadequate, the authority informs the developer of the necessary supplements, after which a revised assessment may be submitted. In such cases, the same public inquiry procedure must be conducted again, including the possibility for other authorities to express their views. For nuclear power plants, this procedure does not in itself constitute a license; rather, it results in a document that is then taken into account during the subsequent decision-in-principle stage.

3.11.3. France where the EIA is taken into account as part of the creation authorisation

As mentioned before, France follows a different path: rather than requiring a separate environmental licence incorporating an EIA, its findings are incorporated as one of the factors assessed by the competent authority when granting a creation authorisation for the plant.[694]

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[688] Government decree No. 277/2017 on the Environmental Impact Assessment Procedure, art. 4.
[689] The default organization is a different one their role in the process involving nuclear facilities is specifically prescribed by the Act on Environmental Impact Assessment procedure, see id., art. 11.
[690] Act No. 252/2017 on Environmental Impact Assessment Procedure, art. 17.
[691] Id., art. 19.
[692] Id., art. 20.
[693] Id., art. 23.
[694] In certain cases if there is no authorization required the project there is a specific authorization on environmental matters issued by the Prefect.

Similarly to the two other countries, France has also implemented the provisions of the Environmental Impact Assessment Directive into its national legal framework, and, as such, environmental impact assessments are required for nuclear power plants regardless of their size.[695] The content of the assessment combines both generic,[696] and nuclear-specific requirements, addressing issues such as water usage and discharges as well as the radiological state of the site,[697] however, these issues are generally very similar to what was discussed in the case of the other countries. Additionally, French law provides the possibility of a pre-submission consultation, whereby the project owner may request the competent authority's opinion on the scope and level of detail required for the impact assessment.[698] Thus as part of this application, the applicant must submit the EIA, which is then forwarded to the competent environmental authority for evaluation.[699] To avoid any conflict of interest, this task in case of nuclear projects is not entrusted to the ministry responsible for issuing the creation license, but rather to the General Inspectorate of the Environment and Sustainable Development.[700][701]

3.12. The construction of the facility

3.12.1. Hungary and its implementation license

Before turning to the discussion of the implementation licence, which functions as the construction licence, one ancillary authorisation must first be briefly addressed: an authorisation required by the Act on Atomic Energy, without which the implementation licensing procedure may not be initiated. This is the Authorisation in Principle for a Power Plant with a Significant Impact on the Electricity Grid, issued by the Hungarian Energy and Public Utility Regulatory Authority (MEKH). This licence, governed by the provisions of the Act on Electricity, is required in the case of plants exceeding 500 MW in capacity.[702] The purpose of this preliminary licence is to evaluate, at an early stage, the prospective integration of such a large-scale installation into the national electricity system, with particular regard to the availability of domestic reserves. This preliminary assessment is conducted prior to the commencement of other licensing procedures in which the authority would be limited to examining the formal adequacy of the application materials.[703] Additionally, this stage provides the possibility to the grid operator to identify what infrastructural upgrades might be needed to accommodate the projected output of the plant. By conducting this analysis at a preliminary stage, the legislation seeks to forestall a scenario in which grid infrastructure might prove inadequate at the time the plant enters into commercial operation. The Act on Electricity specifically mentions that for nuclear power plants, this licence may only be applied for after the decision-in-principle has been granted by the National Assembly. In the case of the Paks II project, this authorisation-in-principle is not the

[695] Code de l'environnement *[Environmental Code],* art. R122-2.
[696] Further content is provided in id., art. R122-5.
[697] Id., art. R593-17.
[698] Id., art. L122-1-2.
[699] Id., art. L 122-1.
[700] D'autorité environnementale de l'inspection générale de l'environnement et du développement durable.
[701] Code de l'environnement *[Environmental Code],* art. R122-6.
[702] 2007. évi LXXXVI. törvény a villamos energiáról *[Act No. LXXXVI of 2007 on Electricity]* section 80/A.
[703] Id., Explanatory Memorandum.

sole licence which has to be obtained under the Act on Electricity. The electrical implementation licensing procedure for power plants with a capacity exceeding 50 MW likewise applies to Paks II, and this licence was obtained in 2020.[704]

Following the site licence and the MEKH authorisation in principle, the next installation-level nuclear safety licence is the implementation licence. The implementation licence diverges from the approach applied to site licensing, in that, while the licensee may submit a unified application covering all proposed units, separate licences must be obtained for each reactor unit, rather than a single licence covering the whole plant, as in the case of the site licensing procedure. The implementation licence is by far the most comprehensive and extensive of all nuclear safety licences, as it includes the entire design of the plant. Notwithstanding its scope, the implementation licence does not in itself authorise the commencement of any physical construction works. Rather, it functions as an 'umbrella licence' which permits obtaining individual licences for building,[705] manufacturing procurement, and installation works, collectively referred to as system and system component nuclear safety licences. As such, the implementation licence, in its capacity as an umbrella licence constitutes a detailed and authoritative confirmation that the overall design concept of the plant is sound and that the plant, as envisaged, may be operated safely on the chosen site. The regulatory framework governing the implementation licensing process is set out across three annexes to the Nuclear Safety Rules: NSR 1, governing the nuclear safety procedures of installations; NSR 3a, which sets out design requirements for new nuclear power plant units; and NSR. 9, which details the provisions governing the design and construction phase of new nuclear installations. These are complemented by their corresponding guidelines, which offer further elaboration and practical interpretation.

The central document in the implementation licensing process is the Preliminary Safety Analysis Report which substantiates the plant's compliance with all applicable regulatory requirements necessary for the plant's implementation. The content and structure of the PSAR is detailed in a separate guideline, which itself extends to over 200 pages.[706] Besides the core contents of the PSAR, a wide array of supplementary technical and supporting documentation must be submitted. For instance, while the PSAR contains the summaries of the deterministic and probabilistic safety analyses, their comprehensive versions are provided as separate attachments.[707] The PSAR can specify building works – though the scope of these is strictly limited – and long-lead manufacturing components in respect of which the building and manufacturing licences can be obtained before the implementation licence is issued, provided these are expressly approved in advance by the regulatory authority. This procedural flexibility was introduced by the legislature in recognition of the complexity and duration of the implementation licensing process, with the aim of enhancing project efficiency by allowing preparatory works on time-critical components to proceed. However, any risk arising from this

[704] MEKH 2413/2020. határozata erőmű létesítésére vonatkozó engedély tárgyában *[Decision No. 2413/2020 of the Hungarian Energy and Public Utility Regulatory Authority on the preliminary licence for the implementation of a power plant]*.

[705] As of 2016 the HAEA also acts as a general building authority and building supervisory authority in the nuclear safety zone of the nuclear installations. For more, see Kádár and Majoros, 2024, p. 692.

[706] HAEA, 2020.

[707] HAEA, 2018, p. 22.

approach – namely, that the implementation licence might ultimately not be issued – rests entirely with the licensee.[708]

Another key document in the licensing process is the Nuclear Accident Response Action Plan, which has to be first submitted at this stage, and then continuously revised, to ensure preparedness for radiological emergencies. Since the new Paks II plant is being built adjacent to the operational Paks I facility, these action plans have to be aligned with those already in place for the existing units.[709]

In the case of the Paks II licensing process, the Preliminary Safety Information was submitted in 2015, projecting the reduction of the implementation licensing process from 18 to 12 months – which may be prolonged by three months without reasoning in that case amounting to 15 months –. The formal implementation licence application, accompanied by very extensive documentation, was submitted in 2020.06.30. The PSAR alone comprised in excess of 37,000 pages, supplemented by a further 40,000 pages of technical documentation, with the authority subsequently requesting more than 200,000 pages of further documentation.[710] In parallel, the licensee used the opportunity to licence long-lead manufacturing components prior to the implementation licence being issued. Consequently, the manufacturing licenses of the core catchers were granted before[711] the issuance of the implementation licence, one of them has already arrived on site.[712] The IAEA was also involved in evaluating the implementation license application. Their group of experts made some remarks; however, their overall opinion of the documentation was positive. The HAEA ultimately granted the implementation licences for both units in 25 August 2022. However, the procedure, which ought to have been completed within 12 months by virtue of the PSI, extended to a full 26 months with all the deficiency clearances. Moreover, the licences were not granted unconditionally: the HAEA imposed a hold-point requiring the submission of a revised PSAR.[713] A revised version of the PSAR was submitted later that same year, followed by an extended period of iterative consultation between the licensee and the authority, This process culminated in the submission of the final version in 2024.[714] Although not formally mandated by law, the HAEA initiated a procedure to evaluate the removal of the hold-points, which subsequently led to the granting of an unconditional implementation licence.[715] Currently, this marks the latest stage in the Paks II licensing process in relation to installation-level authorisations. Meanwhile, system- and system component-level licences are still being issued based on the implementation licence. As part of this ongoing

[708] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 12(7).
[709] HAEA, 2018, p. 17.
710 HAEA, 2025a.
[711] On 30 June 2022, which meant that in reality, the benefits of long-lead manufacturing licensing were not fully harnessed.
[712] *Megérkezett a zónaolvadék-csapda Paksra*, 2024.
[713] Az OAH P2-HA0375. határozata a Paks II. Atomerőmű Zrt. kérelmére létesítési engedély a paksi telephelyen létesítendő 5. és 6. atomerőművi blokkokra tárgyban *[Decision No. P2-HA0375 of the HAEA granting, upon the application of MVM Paks II Atomerőmű Fejlesztő Zrt., the implementation licence for Units 5 and 6 of the nuclear power plant to be built at the Paks site]*.
714 HAEA, 2024.
[715] Az OAH P2-HA0696. határozata a paksi telephelyen létesítendő 5. és 6. atomerőművi blokkok létesítésére vonatkozó engedélyben meghatározott visszatartási pont feloldásának vizsgálatára hivatalból indított közigazgatási hatósági eljárásban hozott döntés tárgyában *[Decision No. P2-HA0696 of the HAEA on the ex officio administrative procedure concerning the review of the release of a hold point specified in the implementation licence for Units 5 and 6 to be built at the Paks site]*.

process, the first concrete pouring took place on the 5th February 2026 which formally designated the Paks II project as an active nuclear power plant construction under the criteria of the IAEA.

3.12.2. Finland and its construction license

In Finland in the statutory licence-granting stage, the first licence to be obtained is the construction licence. Similarly to Hungary's long-lead manufacturing process, the Finnish legal system also recognises that the manufacturing of certain components takes considerably longer than that of others, and accordingly STUK allows to approve the plans of devices and inspect and oversee their manufacturing prior to the issuance of the construction licence. The limitation is that works affecting nuclear safety at the site cannot be performed at this stage,[716] and these components later may only be used if they comply with the construction licence, in this sense placing the risk on the applicant requesting the approval.[717]

The application for the licence naturally covers a wide array of issues – broader in scope than in Hungary since it covers more lifecycle stages, such as the site's suitability and partially commissioning. Some issues covered by the application concern recurring topics such as the fuel supply to the facility or waste management, though this is to a degree natural since at this stage the concept of the project is considerably less abstract and such crucial aspects can therefore be assessed much more concretely.[718]

Within the construction licence application, one of the most important tasks of the authority is to evaluate the design of the facility. The construction licence application as such remains rather theoretical in that the authority conceptually approves the plant; however, as can be easily deduced, at a facility of the scale of a nuclear power plant a mere conceptual approval – even with a subsequent operational licence stage during which nuclear tests are conducted and the option of subsequent inspections by the authority – is insufficient. Consequently, similarly to the Hungarian approach, the Finnish construction licence is also more akin to an umbrella licence, under which in the Finnish system approvals must be obtained from STUK to ensure that the practical implementation of the project also complies with the regulatory framework and with what was conceptually approved. These approvals may concern the manufacturing of structures or components,[719] the manufacturers themselves,[720] the construction and installation activities, but also commissioning.[721] Since the number of approvals would place an extremely demanding burden on the authority and would hinder the efficiency of deployments, the Finnish system employs a mechanism by which this burden on the regulator can be eased by delegating the approvals. To understand the delegation of these tasks, two principal considerations must be addressed: the already mentioned safety classifications and the authorised inspection bodies.[722] As mentioned before, a safety classification document is submitted at the licence

[716] Ibid.
[717] Stuk, 2019b, pp. 354–355.
[718] STUK, 2020, A03–A17.
[719] Act No. 990/1987 on Nuclear Energy, section 63(3).
[720] In case of pressure equipment. See id., 60a. STUK, 2020, p. 321.
[721] Testing programs of certain safety class systems and low-power and power tests are also submitted to STUK for approval as part of the commissioning of the plant, see STUK, 2019a, p. 420.
[722] Söderholm, 2013, p. 87.

application stage, in which the systems, structures and components are grouped into four categories according to their safety significance: classes 1, 2 and 3, and those of non-nuclear safety significance. With regard to items belonging to the highest safety class 1, STUK retains its approval rights from their planning and design through to their installation.[723] In safety classes 2 and 3, these approvals and inspections are carried out by an authorised inspection body, and in cases of lesser safety significance by the in-house inspection organisation of the licensee.[724] In Finland, an authorised inspection body refers to an independent organisation approved by STUK to carry out inspections of equipment, structures and components, exercising this task as if it were the regulator.[725] Accredited organisations[726] – accreditation decisions from bodies other than the Finnish Accreditation Service may be accepted on the basis of multilateral agreements on the mutual recognition of accreditations – can apply for STUK's approval. The requirements for this authorisation are that the organisation must be operationally and economically independent, hold liability insurance, and possess the competences to carry out the tasks conferred upon it – a natural requirement given that they are performing functions that would otherwise fall to the authority.[727] Their approval is issued for a fix term, maximum of five years,[728] but approval does not mean they are not subject to regulatory oversight as these organisations have reporting obligations, STUK may demand new accreditations and approvals may be cancelled by STUK. The in-house inspection organisation's STUK approval is requested by the applicant; the organisation must already been accredited,[729] their scope of competencies is determined by STUK,[730] but allows them to carry out inspections related to installation, commissioning and repair works.[731]

In essence this system utilised in Finland is very similar to the role of the authorised inspection organisations in Hungary, though in Finland such a role for these bodies predated the reforms in Hungary that introduced them. While there are similarities between the two approaches – as they both serve the same purpose of alleviating burdens from the authority and improving the efficiency of licensing procedures – there are some crucial differences, mainly concerning the mandate of the authorised inspection organisations. Authorised inspection organisations in Finland issue decisions or inspection protocols on the conformity of the inspection.[732] Unlike in Hungary, where the decision is ultimately issued by the regulator and the authorised inspection organisations provide their findings to facilitate the authority's decision-making, in Finland the inspection organisations themselves are mandated to make these decisions, and the regulatory authority's participation is not required in all of these individual decisions, which can further improve efficiency but also places greater responsibility on the inspection

[723] STUK, 2019d, A01.
[724] For components that are not of nuclear safety importancet Hungary equally utilises the in-house unspection organisations of the licensee to inspect these componens.
[725] The inspections can cover a wide range of areas such as construction plans manufacturing, installations commissioning and operation.
[726] ISO, 2026, type A requirement.
[727] STUK, 2019d, p. 106.
[728] Id., p. 320.
[729] ISO, 2026, type B requirement.
[730] Decree No. 161/1988 of the Ministry of Economic Affairs and Employment on Nuclear Energy, section 113a.
[731] STUK, 2019d, pp. 901–907.
[732] STUK, 2019d, C01.

organisations. Since in Finland these organisations make decisions within their areas of competence, their decisions are also subject to appeal.[733]
Consequently, during the construction phase, the licensee may apply for approvals either from STUK or from an authorised inspection body,[734] depending on the safety classification which division of inspection responsibilities is presented by the licensee to STUK for an approval.[735]
The Act provides that, for a nuclear power plant exceeding the 50 MW thermal threshold to grant a construction license, a valid decision-in-principle is required, along with – among other requirements – compliance with safety requirements, a suitable site where environmental protection considerations have been taken into account, appropriate waste disposal and decommissioning methodologies together with sufficient fuel arrangements, and a demonstration by the applicant that it is capable of implementing the project, both in terms of expertise and financing.[736]
To illustrate the practical implications of this stage, the Olkiluoto experience can again be mentioned. TVO signed a turnkey contract with the Framatome ANP Siemens consortium in 2003 for the deployment of Olkiluoto unit 3.[737] Shortly thereafter, TVO submitted its construction licence application in 2004 and approximately a year later, in 2005, the licence was issued.[738] The general impression of the process was that the statutory framework functioned well, though it was highlighted that while significant public participation in the deployment process of such installations is important for the expression of public opinions, repetitive and overlapping hearings can undermine participants' interest in engaging.[739] This was a first-of-a-kind experience, as since the Nuclear Energy Act had been in force this was the first time the construction licence procedure had been tested in practice. The construction licence in the case of the Olkiluoto plant set a validity period of two years within which construction had to commence.[740]

3.12.3. France and its creation authorisation

The first main licensing stage in France is the creation authorisation. The creation authorisation procedure is initiated by submitting a comprehensive dossier to the minister responsible for nuclear safety, this dossier must also be sent to ASNR.[741] This licensing stage is a comprehensive one for multiple reasons; for example, under the French provisions it is permitted to submit a single application for several nuclear installations to be operated at the same site by the same operator. Moreover, the scope of the aspects of the project covered by the application is equally broad, encompassing a multitude of issues such as risk management studies, the professional and financial capabilities of the operator, and naturally the preliminary

[733] STUK, 2019d, 1113.
[734] STUK, 2020, 320.
[735] STUK, 2019d, 1101a.
[736] Act No. 990/1987 on Nuclear Energy, section 19.
[737] Giese and Leverenz, 2005, p. 6.
[738] Javanainen, 2006, pp. 23–24.
[739] Aurela, 2005, p. 4.
[740] Government decision on the application by Teollisuuden Voima Oy to obtain a license, referred to in section 18 of the Nuclear Energy Act, for the construction of a new nuclear power plant unit on the Olkiluoto plant site in Eurajoki, 2005.
[741] Code de l'environnement *[Environmental Code],* art. R593-14–15.

safety report. Being comprehensive, it also covers site-related issues, the site owner's consent for the installation if it is not owned by the operator, as well as the previously mentioned environmental impact assessment study.
The preliminary safety report is the main document of this stage; besides the site considerations discussed above, its other crucial element is the presentation of the design itself. In line with the goal-setting approach of the French system in demonstrating the nuclear safety of the installation, the report sets out concrete safety objectives, together with the methods by which the licensee intends to meet them; these elaborations must, in turn, be carried out by applying the defence-in-depth principle.[742]
In addition, the safety report contains a section presenting the equipment and structures important to nuclear safety – addressing their lifecycle, the methods used for their classification, and the classification itself – as well as the activities important to nuclear safety.[743] This process is essentially the system and system component level classification, though the terminology used in France differs from that encountered in the case of the other two countries.
Finally, also true to the goal-setting approach the operator must submit the technical codes and standards it has selected to analyse the site characteristics and the design and construction of the installation, indicating, within that scope, any documents of international organisations relied upon for these analyses.[744]
Having addressed the broad content of the licence application, we shall now address the course of the procedure subsequent to the application. As mentioned, upon submitting the application the EIA, which forms part of the process, is forwarded to the relevant authority for assessment, which then sends back its opinion to be used in the public inquiry procedure. The process essentially runs on two parallel paths: one is technical, carried out by ASNR, and the other is the public inquiry initiated by the Prefect. Public participation is a cornerstone of the French licensing process. Local authorities and groups,[745] municipalities, their groupings, departments and territories where the facility lies,[746] which are determined by the prefect but must extend at least five kilometres from the facility's perimeter.[747] The minister responsible for nuclear safety transmits the application and its accompanying documentation to the relevant prefects, who are then responsible for organizing public participation together with the opinion of the environmental authority,[748] to which the future operator is also entitled to respond.[749] Interestingly, what does not form part of these inquiries is the preliminary version of the safety report, nevertheless, other means are provided for the public to consult this document, but since the technical assessment runs in parallel, the opinion of ASNR cannot be provided at this stage,[750] nevertheless, if the pre-licensing stage was conducted and ASNR issued an opinion,

[742] Arrêté du 11 janvier 2016 portant homologation de la décision n° 2015-DC-0532 de l'Autorité de sûreté nucléaire du 17 novembre 2015 relative au rapport de sûreté des installations nucléaires de base *[Order of 11 January 2016 approving the decision No. 2015-DC-0532 of the Nuclear Safety Authority of 17 November 2015 relating to the safety report of basic nuclear installations]*, art. 4-4-1.
[743] Id., arts. 4-5-1–4-5-8.
[744] Id., arts. 3-2-3.–3-2-4.
[745] Code de l'environnement *[Environmental Code],* art. L122-1 V.
[746] Id., art. R593-20.
[747] Id., art. R593-5.
[748] Id., art. R593-21 II.
[749] Id., art. R593-22.
[750] Id., arts. L593-9 and R593-21.

this will also form part of the documentation provided to the public.[751] Also throughout this process local information commissions are consulted subject to them being already established. At the conclusion of the consultations, the prefect forwards all opinions and conclusions to ASNR and to the minister responsible for nuclear safety.[752][753] ASNR, after conducting its review, proposes a preliminary draft decree on the creation authorisation to the minister, either refusing or granting it.[754] Following this opinion of ASNR, the minister forwards the draft decree to applicant which has two months to submit comments on it,[755] these opinions consolidated with the result of the inquiry are sent by the minister to ASNR again to issue its opinion on the authorization, during which period the applicant and the local information commissions may again be heard.[756] If the authority's opinion is not expressed within two months, it is deemed favourable.[757] As mentioned before, however, the authorisation is formally issued by a decree of the Prime Minister countersigned by the responsible minister. The entire creation authorization procedure lasts three years and may be extended by two years by the minister if justified by complexity; however, at the end of this period, the silence of the authority constitutes a rejection rather than an approval.[758] The content of the authorisation is rather straightforward, naturally addressing the operator, the installations covered and their capacity, but also setting the commissioning deadline. Substance to the implementation of the authorisation is provided by ASNR, which establishes design, operation and construction requirements, and certain uses of the environment and emissions from it may also be concretely defined at this stage.[759] In essence, this stage also reflects the goal-setting approach, affording the applicant greater freedom to present their safety case; since the regulations do not generally contain prescriptive requirements and authorise the creation of the installation, this stage may also allow for the enshrining of particular requirements in the given case on the part of the regulator.

Naturally, in France the creation authorisation is a comprehensive umbrella licence that does not alleviate the further oversight of the regulator during the construction stage. The regime for pressure equipment is of particular interest, as these are naturally one of the most crucial items of equipment in the facility, directly connected to the operation of the reactor and thus bearing particular relevance from an accident perspective. The regime for pressure equipment is based on their classification, which categorises equipment into three categories depending on the risk of radioactive emissions (N1, N2, N3) and into five categories depending on the temperature and pressure under which they operate (0, I, II, III, IV), the levels are defined by the responsible minister, though as mentioned before it is the applicant that categorises the equipment accordingly and communicates this in the licence application.[760] For the most critical equipment, the manufacturer may optionally request an approval from ASNR regarding the

[751] Id., art. R593-22.
[752] Id., art. R593-21 IV.
[753] Id., art. R593-24.
[754] Teles da Silva, 2025, p. 174.
[755] Code de l'environnement *[Environmental Code],* art. R593-25.
[756] Décision n° 2010-DC-0179 de l'ASN du 13 avril 2010 *[Decision No. 2010-DC-0179 of the French Nuclear Safety Authority (ASN) dated 13 April 2010]*.
[757] Code de l'environnement *[Environmental Code],* art. R593-25.
[758] Id., art. R593-28.
[759] Id., art. L593-10.
[760] Id., art. R557-12-3.

intended approach; they must then have a quality assurance system in place, which is checked by an authorised inspection organisation, and finally there is a unit verification process principally carried out by ASNR. For less critical pressure equipment, this work is carried out by the authorised inspection organisations.[761] These accredited organisations are authorized by ASNR[762] to carry out these functions and must naturally comply with similar criteria to those presented in the case of other countries, such as the requirement of independence.
In the case of the Flamanville plant, following the preparatory phase, the creation authorisation application, encompassing the abovementioned documents, was submitted in May 2006, and less than a year later, in April 2007, creation authorisation was granted. Despite this timely authorisation, however, the project later progressed rather slowly, owing to the underestimated complexity of the EPR technology.

3.13. The commissioning and the operation of a new nuclear power plant

3.13.1. Hungary and its separate commissioning and operation licenses

The next installation-level nuclear safety licence to be obtained following the plant's construction is the commissioning licence. Unlike the previous licensing stages, no dedicated annex or standalone guideline has been issued specifically for this phase. However, it is addressed within the framework of NSR 1, beginning from Section 1.2.4.0100, as well as in the guideline concerning the Safety Analysis Report of New Nuclear Power Plants.
This licensing stage confirms that the plant was built according to the design intent, and that the as-built facility conforms with both the expectations of the regulatory authority and the applicable regulatory requirements.[763] The central document of the commissioning stage is the Preliminary Final Version of the Safety Analysis Report – an updated and actualised version of the PSAR. This revised report must incorporate the details of the commissioning programme, including its various stages, the stakeholders involved, and updated technical data based on the completed construction of the facility.[764] The said commissioning program governs the initial start-up of the plant encompassing the systems checks, tests and the evaluation of these results.[765] The aim of this evaluation is to assess whether the plant is fit for commissioning in accordance with the relevant requirements. The subsequently performed commissioning is the confirmation of the correct functioning of the plant's systems. Once obtained, the commissioning licence allows the licensee to undertake the first fuel load into the reactor, execute the commissioning program in its entirety – including the active testing of systems – and, most significantly, proceed with the initial start-up and operation of the plant at nominal capacity.

[761] Arrêté du 30 décembre 2015 relatif aux équipements sous pression nucléaires et à certains accessoires de sécurité destinés à leur protection *[Order of 30 December 2015 concerning nuclear pressure equipment and certain safety accessories designed for their protection]*, art. 6.
[762] Code de l'environnement *[Environmental Code],* art. R557-4-2.
[763] 1/2022. (IV.29.) OAH rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities]*, section 12(1).
[764] HAEA, 2020, p. 150.
[765] Id., pp. 145–149.

Another critical document of the commissioning phase is the finalised version of the Nuclear Accident Response Action Plan, initially submitted during the implementation licensing stage. This plan has to be updated according to the commissioning process and submitted as part of the licence application prior to the arrival of the first nuclear fuel at the site.[766] The statutory duration of the commissioning licensing procedure is 11 months, and the licence is valid for 12 months. However, in view of the inherently time-consuming nature of the requisite testing and the staged nature of the initial operational activities, the authority is entrusted with discretion to extend the duration of the licence, provided that a well-founded justification is duly submitted.

While the commissioning licensing stage allows for test operation, it does not permit commercial operation; for that purpose, the operation licence must be obtained. This licence is sought on the basis of the operational insights gained during the commissioning phase, which serve to inform and substantiate the licence application. As with earlier stages, the central document of the operation licence application is the final iteration of the Safety Analysis Report (SAR). This definitive version consolidates the findings and experiences accrued during the commissioning stage, elaborates on the changes that have occurred compared to the commissioning stage, and demonstrates that the safe operation of the plant is provided under it. The approach that the operation licence is based on the commissioning experiences aligns with the obligations under the Convention Nuclear Safety,[767] which prescribes that operation must be predicated on a prior commissioning program. In addition to the SAR, in order to obtain the licence, it is equally important to prove that the radioactive waste and spent fuel originating from the plant is going to be stored. This requirement entails providing evidence that such materials will be handled in accordance with the latest scientific knowledge and in compliance with internationally accepted standards – whether through final or interim storage solutions. Although the CNS does not explicitly prescribe such storage as a condition for licensing, it does require that due consideration be given to waste disposal as part of operational planning.[768] The statutory duration of the operation licensing procedure is eleven months, mirroring that of the commissioning licence. Upon completion of the review, should the authority determine that all criteria are met, the operation licence is granted. This licence entitles the licensee to operate the unit in accordance with the terms and conditions therein, for a defined operational period. This operational period is determined by the authority based on the specifications of the plant. Although it may vary from plant to plant, but it cannot exceed the reactor's operational lifespan. In essence, the operation licensing stage is the final step before commercial operation. It is during this phase that all documentation of the plant is brought to its final form, and the experiences of the commissioning stage are evaluated.

3.13.2. Finland, with commissioning split between the construction and operation licences

Unlike in the Hungarian licensing framework, Finland has no dedicated commissioning licence, and, consequently, the commissioning plan is not assessed as part of a specific licence

[766] HAEA, 2018, p. 19.
[767] IAEA, 1994, section 19(I).
[768] Id., 19(VIII).

application. Commissioning in Finland naturally serves the same purpose as in other countries – to verify that the facility's systems, structures and components and the functions they serve meet the design requirements, and that the plant's human resources are capable of ensuring its safe operation.[769] The commissioning plan is submitted to STUK as part of the construction licence application, either as part of the PSAR or as a separate document; however, since it is drawn up and submitted long before the actual commissioning work begins, it must be updated and supplemented prior to the commencement of commissioning, and this updated version is also submitted to STUK for approval.[770] Tests, which are naturally carried out as part of commissioning to verify the adequacy of systems and structures and their capability of fulfilling their intended function, are themselves divided into different phases.[771] The Finnish system follows an approach whereby the non-nuclear commissioning of the facility takes place under the construction licence, while nuclear commissioning – meaning the first fuel loading – occurs under the operation licence, as the loading licence necessary for the first fuel loading can only be issued once an operation licence has been granted.[772] In this respect the Finnish approach differs considerably from the Hungarian, where commissioning activities are no longer ongoing at the operation licence stage, the operation licence in Hungary rather confirms that commissioning, including testing, was successful and that the plant may commence regular operation. The Finnish approach instead divides the process between the two major licences, since no dedicated commissioning licence exists and the construction licence does not mandate tests with fuel loaded. This is in principle a rather interesting approach, as the plant's operation licence is essentially granted at a stage where the operability of the plant has not been fully verified – the results of which would ultimately affect the operational limits and conditions of the plant.[773]

The second installation level licence in the statutory licensing stage is the operation licence, which unlike in the case of Hungary follows directly after the construction licence phase, as there is no dedicated commissioning licence. The operation licence application can unsurprisingly only be considered once a construction licence has been granted and other conditions are also met. Similarly to Hungary, the main document at this licensing stage is the Final Safety Analysis Report, which is an updated version of the PSAR reflecting the as-built facility.[774] The operation license as articulated before primarily concerns the fuel-loaded commissioning of the facility and setting the operation conditions. The duration of the period for which the operation licence is issued is not set in legislation in Finland; rather, its duration is proposed by the applicant, though if it extends beyond 10 years then periodic safety reviews are carried out every 10 years.[775] Inspections, as a critical task of the regulator, serve to assess compliance with the regulations and the licensing conditions, but these periodic safety reviews are only one of the tools at the authority's disposal, alongside others such as resident inspectors and unannounced inspections.[776] If an operation licence expires, a new operation licence would

[769] STUK, 2019b, 401–403.
[770] Id., 409–410.
[771] Id., 411.
[772] Id., 431.
[773] Id., 449.
[774] STUK, 2020, A18.
[775] STUK, 2020, 420.
[776] STUK, 2020, 425–427.

have to be obtained following the same procedure as for the first operation licence application – an approach that differs considerably from that followed in Hungary.

3.13.3. France, where commissioning is split between the creation and commissioning authorisations, the latter also covering operation

In France, which similarly to Finland adopts a more comprehensive licensing process, the second licence that has to be obtained by the operator is referred to as a commissioning licence rather than an operation licence. Nevertheless, the term commissioning is defined very similarly to how operation is defined in Finland, as it refers to the first use of radioactive substances in the facility.[777] The commissioning authorisation is initiated by the operator, again through the submission of a comprehensive file – this time not to the responsible minister but directly to ASNR, which also acts as the licensing authority for this particular licence. The main document is again the safety report, but this time in an updated format, accompanied with the information necessary to assess how the facility complies with the concrete prescriptions issued by ASNR following the creation authorisation.[778] Along with the updated safety report, several other documents are submitted, such as the general operating rules, the internal emergency plan detailing the interventions to be taken in case of an emergency, and an updated impact study if necessary. While EIA procedures are clearly not staged as early as in the Finnish legal framework, they are still conducted relatively early in the licensing process, meaning that changes may still occur to the project that would necessitate the modification of the EIA – which is acknowledged in the Code. In relation to the updated EIA, the same authorities referred to in the earlier section on the EIA process are again required to provide their opinion on the study, which is then resubmitted for public participation by electronic means.

Commissioning tests, as the scope of this licensing application indicates, focus on the presence of radioactive substances; like in the case of Finland, the French approach distinguishes between fuel-loaded and non-fuel-loaded commissioning tests the latter of which already takes place under the umbrella of the creation authorisation.[779] The radioactive commissioning principally takes place after the commissioning licence has been issued, however, since the commissioning licensing stage also takes a considerable period of time – with a processing time of one year, extendable to two years if the complexity so warrants,[780] subsequently there is a possibility for partial commissioning upon the decision of ASNR which may concern carrying out specific operational tests with radioactive substances and bringing nuclear fuel to the reactor without loading it.[781] Notwithstanding this stage, ASNR in its decision sets the deadline by which the commissioning tests must be conducted, at the end of which the operator must submit the final commissioning report, which assesses the start-up tests, the operational experiences and the final safety assessment report.[782] In its authorisation, ASNR also addresses the operation of the plant, establishing operating conditions and the schedule for replacing certain

[777] Code de l'environnement *[Environmental Code]*, art. R593-29.
[778] Id., art. R593-30.
[779] Arrêté du 7 février 2012 fixant les règles générales relatives aux installations nucléaires de base *[Decree of 7 February 2012 laying down the general rules for basic nuclear installations]*, arts. 2.5.1–2.5.7.
[780] Code de l'environnement *[Environmental Code]*, art. R593-36.
[781] Id., art. R593-35.
[782] Id., art. R593-34.

components, however, since the concept of a design lifetime is not employed, no end date is set for the plant's operation.
In the case of the Flamanville project, the application for authorisation was submitted in June 2021, and, following consultation with the public, the commissioning authorisation was issued in May 2024, exceeding the statutory timeframe.[783]

3.14. Recent efficiency-oriented licensing reforms

3.14.1. Efforts in Hungary

One reform which, while it may not be considered recent, having taken place a decade ago, in preparation of the Paks II. deployment was the introduction of the concept of long-lead manufacturing licensing into the Hungarian licensing framework, which as mentioned before allowed licensees, at their own risk, to obtain licences for components with long manufacturing lead times prior to obtaining the implementation licence. This is an efficiency-enhancing measure, also found in the Finnish framework, which poses no risk to nuclear safety, yet still allows the project to progress while the most complex licence is being evaluated.
The second licensing reform worth highlighting was not adopted in advance but rather stemmed from the realisation, in the course of the Paks II project of how overly demanding the licensing requirements were for both the authority and the licensee. Unlike in general administrative procedures, in Hungary summary and automatic decision-making procedures are expressly precluded in the nuclear field due to the complexities and risks associated. However, the recent amendments to the Atomic Energy Act have introduced simplified licensing procedures during the implementation stage, specifically for systems and system components deemed to pose lower risk. These new procedural avenues – namely the 'notification acknowledgment' and the 'derogation notification acknowledgment'[784] mechanisms – seek to alleviate regulatory burdens by avoiding lengthy licensing procedure in case of less safety important systems and system components of which there are approximately 16 to 17 thousands and by obviating the need to duplicate licensing efforts at the manufacturing or procurement stages. Historically, such components were subject licenses issued by the HAEA and went through repeated evaluations up until the commissioning or operational phase of the plant, placing a significant burden upon the regulatory authority without yielding commensurate gains in nuclear safety.[785] For lower safety significant components the notification acknowledgment procedure enables the authority, through providing information – towards which the same requirements exist as in the previous individual licensing procedures, – to review a component before its manufacturing commences. The process is subject to a strict 15-day timeframe, during which no possibility for a deficiency clearance may be undertaken, and it may result in one of five determinations: the authority may acknowledge the notification; decline it; impose conditions for acknowledgment; set hold-back and inspection points; or combine conditional acknowledgment with such hold-back and inspection points.[786] In practice, this new procedural construct is designed to provide the regulator with timely insight at an early stage, without the lengthy initial licensing

[783] Décision n° 2024-DC-0780 de l'ASN du 7 mai 2024 *[ASN Decision No. 2024-DC-0780 of 7 May 2024]*.
[784] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 15.
[785] Kádár and Majoros, 2024, p. 710.
[786] 1996. évi CXVI. törvény az atomenergiáról *[Act No. CXVI of 1996 on Atomic Energy]*, section 15.

procedure, while recognising that the relevant components will eventually undergo formal licensing during the commissioning and operation licensing stages.[787] Accordingly, the integrity of the permission principle remains intact. This amendment is based on the HAEA's new supervisory concept programme, which also expanded the role of authorised inspection organisations – independent from both the authority and the licensee – and assigned the HAEA responsibility for their registry. The participation of these authorized inspection organizations in verification of conformity are either prescribed under law or they can also be involved by the licensee and or with the consent by the licensee by the vendor, moreover their verifications may be accepted by the authority without further review.[788] These organizations are also involved in the notification acknowledgment procedures, either when required by law for certain components, when engaged by the licensee, or when the authority mandates inspection and hold points as part of the procedure, in such cases, the activity may only proceed after approval by the authorised inspection organization.
In the spring of 2026, a further major reform of the licensing framework was carried out; however, as this reform was specific to SMRs and intended to support their envisaged deployment, it will be discussed later in this work, in the section dedicated to the licensing of advanced nuclear power plants.

3.14.2. Finland and its comprehensive reform effort

As mentioned, the Finnish licensing framework is currently undergoing a considerable reform. The proposed reform will mostly affect the licensing stages that precede the construction licence application, but due to the introduction of certain new stages the construction licence will also be affected in terms of its content and the prerequisites for the application. One general observation regarding the Finnish reforms that cannot be emphasised enough is that while they contain certain institutions that are particularly relevant for the deployment of standardised smaller reactors, the proposed changes are technologically neutral and make no differentiation between conventional and advanced technologies – both would equally have to go through the same licensing procedures.

3.14.2.1. Changes in the decision-in-principle stage

The reform of the decision-in-principle stage was one of the most frequently discussed and fundamental areas where change was considered necessary. Consequently, the reform of this stage was also at the centre of attention of the working group established by the Ministry of Economic Affairs and Employment, which also took part in laying the groundwork for the reformed Act. As can be seen from the analysis of the current framework, the decision-in-principle stage in Finland – very differently from the Hungarian approach – is of considerable detail according to the statutory requirements, which is naturally burdensome given that projects at this stage are, at least in international comparisons, not at the same level of maturity. The working group took note of this challenge and in their proposal suggested framing the

[787] Kádár and Majoros, 2024, p. 711.
[788] 1/2022. (IV.29.) OAH rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről *[Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities]*, section 29/A.

decision-in-principle stage in the new licensing system as a more general evaluation, shifting the current level of detail to subsequent licensing stages when the level of detail on the project is more refined.[789] This new approach represents a shift towards how decisions-in-principle are generally understood – as a high-level political commitment at an early stage of the project – and in the author's opinion this change also aligns more smoothly with the Finnish approach of limited political involvement in decision-making on the establishment of nuclear energy, by removing these rather technical matters and assigning them exclusively to the competence of technocratic bodies. One further issue raised in the working group's proposal, which closely relates to the level of detail of the decision-in-principle, is what changes in the details of the project would constitute a deviation from the decision-in-principle and thus require a new parliamentary approval, or merely a governmental supplementation of the decision.[790] Naturally, by reducing the level of detail required at the decision-in-principle stage, the scope of what may be considered a change to the project equally shrinks.

Closely related to reducing the level of detail at this stage is the question of the scope of installations that may be covered by it – a matter that is also relevant to the interpretation of the Hungarian decision-in-principle for SMRs, as will be discussed later. Under the current provisions the situation is rather clear, as projects under the decision-in-principle may comprise one or more facilities, but for operational or other reasons these must constitute an integrated whole, suggesting that it could be applicable to a multi-module plant on a single site but not to plants deployed across the country – particularly given that the provision states the application may concern multiple alternatives, though since the term "alternatives" is used, it is difficult to envisage that ultimately multiple of these would materialise.[791] Industry representatives argued that the reform should allow for more overarching decisions-in-principle in the case of SMRs, making it possible to deploy multiple units either at the same or at different locations under the same decision-in-principle.[792] Such an approach is naturally reasonable given the fundamental differences between SMR and conventional plant deployments. While the former may entail different applications and sites, the latter is usually limited to a single site and application. An overarching decision-in-principle could therefore alleviate the administrative burden stemming from the smaller size of SMRs, which for the same output as a conventional plant would entail more deployments, possibly at various locations. However, the more overarching the decisions-in-principles are, the less they may fulfil their justification function – not in a strict radiological protection sense. In the case of the current Finnish legislative framework, this is not a concern given its very detailed nature, but under the proposed amendment it will become considerably more general, and this shift towards more general content, combined with a broader scope, as argued for by industry representatives, may, in their view, result in a situation similar to that in Hungary, where the purpose of this stage is somewhat lost

Against this background the new Act proposal[793] retains the decision-in-principle stage to assess the project from the perspective of the public interest, but removes from this stage the technological and site-related assessment. In addition, the decision-in-principle would equally

[789] Anja, Outi and Minna, 2020, pp. 75–78.
[790] Ibid.
[791] Decree No. 161/1988 of the Ministry of Economic Affairs and Employment on Nuclear Energy, section 23.
[792] Kojo et al., 2023, p. 4.
[793] Government Proposal No. HE 24/2026 to Parliament on the Nuclear Energy Act and related acts, chapter 29.

be required in the case of SMRs that may not reach the 50 MW threshold, extending the scope of this stage – though in such cases it would not be the government that makes the decision but rather the Ministry of Economic Affairs and Employment. This change is a crucial recognition of what the future of the nuclear industry may bring. Smaller reactors, even if they are smaller, are nevertheless nuclear reactors and as such their deployment should be justified. It is commendable that the new approach, taking into account the lesser societal impact of these facilities, introduces a differentiation in the procedure for their justification. The purpose of the decision-in-principle would not change under the new regime despite the reduced level of detail; it would equally serve to evaluate the overall benefits and disadvantages of the project, paying particular attention – among other matters – to the need for the project from an energy supply perspective, its economic and environmental impacts, the feasibility of the project in light of the legal framework, and the developer's and future licence holder's competences and financial capabilities.[794] One additional factor that will have to be considered at this stage – and which from the perspective of the Finnish experience with Hanhikivi is particularly relevant – is the geopolitical risk assessment of the nuclear power plant project.[795] The requirement of such content can serve to prevent the above raised concerns with a too general approval at this stage. One factor which under the draft Act no longer forms a prerequisite of the decision-in-principle process is the environmental impact assessment procedure. While this procedure will no longer be required at this stage, the application for the decision-in-principle will instead have to be supplemented with a report on the strategic environmental assessment within which the facility fits; although not a full-fledged EIA report, this still requires these issues to be considered as part of the political green light.

A further change would be that the Government in the reformed version will only submit the decision-in-principle to Parliament as a report; while Parliament will retain the possibility of issuing statements on it, it will no longer hold the same decision-making role as it does now. Furthermore, this stage would only be required in the case of the Government's decision-in-principle and not in the case of decisions made by the Ministry.[796] The draft argues that such an approach better respects the separation of powers, and generally accepts that it is sufficient to inform parliament of such a decision.[797]

3.14.2.2. Stages preceding the construction license application

The aforementioned working group, in their recommendations pertaining to the reform of the licensing framework, expressed that in order to mitigate risk in the construction licensing phase, certain considerations could be more front-loaded through the introduction of pre-approval procedures concerning the facility and the site – the scope and depth of this stage's evaluation is proposed to be flexible depending on the case – the subject of which approvals would not be reassessed in the construction licensing phase if there are no deviations from them in the subsequent licence applications.[798] Consequently in the new Act proposal, two pre-approval stages were introduced: the safety concept evaluation and the site evaluation. The first notable

[794] Id., section 297.
[795] Ibid.
[796] Government Proposal No. HE 24/2026 to Parliament on the Nuclear Energy Act and related acts, pp. 22–28.
[797] Id., pp. 313–316.
[798] Anja, Outi and Minna, 2020, pp. 75–78.

question the working group left unanswered at that stage is how these stages relate to the decision-in-principle – whether they are prerequisites to it, or subsequent to it. The new Act proposal did not adopt either of these approaches, instead it opted not to prescribe the order of these pre-approvals, not only in relation to the decision-in-principle but also with respect to each other. It would naturally not have been ideal to require these pre-approvals before the decision-in-principle, since doing so would have necessitated detailed data, inspections and evaluations – themselves outside the scope of the decision-in-principle – prior to the political green light, effectively reproducing the current system's approach and failing to alleviate the level of detail required at the project's early stages. Mandatorily staging them after the decision-in-principle could potentially also have improved the efficiency of project development, but it would then have been more difficult to take full advantage of the plant's safety concept evaluation: even if the design were found to be approvable, the decision-in-principle itself – which naturally takes into account far more wide-ranging aspects than the design alone – would still have been evaluated as a whole and might not have been granted, owing to other considerations, thus essentially requiring approval of the entire project for the design itself to be approved. In this respect, from a vendor perspective, an approval process in which the conceptual approval of the design could precede a concrete project-related step – in this case the decision-in-principle – would be welcomed, as the approved design could be utilised more efficiently and simultaneously across multiple projects, each of which would require their own decisions-in-principle, thus not being dependent on the first decision-in-principle being adopted in order to approve the design in general.

A crucial novelty of the pre-approval and the decision-in-principle is that the applicant for these decisions does not have to be the same – they can all be different applicants. This bears particular relevance from the perspective that it allows capitalising on an assessment carried out on the initiative of a different applicant, thus not only may the same applicant reuse the general assessment in particular construction applications at different locations, but other applicants also have the opportunity to build on already conducted pre-approvals. In practice, this means that a given applicant for a construction licence may reuse a design approval conducted by a different applicant – possibly one already used in a different concrete project – and/or a site approval also already conducted by another applicant, meaning that their efforts can focus on what is specifically required as part of the construction licence application. Across the actors involved in the sector, this significantly reduces the burdens associated with construction licence applications where pre-approvals have already been obtained. The pre-approvals could include restrictions regarding the general attributes of the technology or the site of the plant, so that the licensee may apply a given pre-approved technology fitting these requirements, and the size constituted by the modular units would also correspond to what is set out in the pre-approval when the project-specific construction licence application is made.

3.14.2.3. Design concept approval

The design concept approval as proposed in the amendment will be a mandatory general assessment of the facility by STUK to determine whether the design complies with the legal requirements and to identify where potential modifications might be necessary; in essence, the introduction of this stage can be equated to the assessment that STUK conducted as part of the

decision-in-principle stage, but in this case carried out in a more project-independent manner.[799] On the basis of the application, STUK would issue a statement determining whether the concept meets the nuclear safety requirements contained in the Act and whether the concept has been developed in sufficient detail to initiate the construction licence application; where certain changes to the design concept are needed, these will also be highlighted.[800] If the authority's statement identifies certain deficiencies in the application, it is possible to reapply for the statement.[801] Such an approach may be familiar to those interested in how SMR licensing may be facilitated, and indeed the portrayed change clearly indicates an intention to open the door to standardised SMRs; however, the approach is not particular to SMRs and would be equally applicable to conventional large-scale technologies.

3.14.2.4. Site approval

It has been argued that, in the current licensing architecture siting issues are already informally assessed as part of the decision-in-principle stage but are formally only approved at the construction licence stage,[802] which means that significant resource requirements arise upfront for the decision-in-principle, while considerable uncertainty ultimately remains as to whether the construction licence will be issued. What the separate site pre-approval alleviates is precisely this risk inherent in the current procedure and the repetitive use of resources without contributing to a higher level of safety. While addressing siting as part of the construction licence may resolve the repetition of the same efforts, it would still not mitigate the fact that significant resources would be devoted to the construction licence application without certainty that the site will be approved – which is particularly relevant in the case of SMRs proposed to be sited at multiple locations. The argument behind adopting a separate site approval is that suitable sites could be approved without a specific design in mind, thereby reducing the risk of sunk efforts through project-specific licensing.[803]

In the new draft Act, Chapter 8 contains provisions pertaining to the siting of nuclear facilities, which is a rather important change as these aspects were previously laid down in lower-level legislation. According to its provisions, a site suitability statement procedure is introduced, under which STUK will be entrusted with issuing statements on the suitability of the site based on the assessment supplied by the applicant, addressing compliance with safety and emergency planning zone requirements, security and transport aspects of the plant. On the basis of this statement, the design criteria arising from the site must be determined so that a nuclear facility designed with these criteria in mind is safe at that site; these are confirmed by STUK in a binding statement.[804] This latter stage is particularly important in mitigating the licensing risk associated with siting a facility at a given location, as the project developer would then be fully informed as to what type of facility may be planned for that site. For a site to be approved for a

[799] Government Proposal No. HE 24/2026 to Parliament on the Nuclear Energy Act and related acts, section 81 and the pertaining explanatory parts.
[800] Ibid.
[801] Ibid.
[802] Ydinturvallisuusneuvottelukunta, 2019, p. 2.
[803] Id., p. 16.
[804] Hallituksen esitys eduskunnalle ydinenergialaiksi ja siihen liittyviksi laeiksi, HE 24/2026 vp *[Government Proposal No. HE 24/2026 to Parliament on the Nuclear Energy Act and related acts]*, explanatory section pertaining to sections 68–71.

nuclear power plant, among other requirements, the consent of the municipality and the reservation of the site in the local land-use plan are needed.[805]

3.14.2.5. Changes to the staging of the environmental impact assessment procedure

As mentioned, the EIA under the draft Act is no longer required as part of the decision-in-principle stage, however since such facilities are subject to an EIA procedure, the obligation for these processes shifts to the construction licensing stage.[806] The EIA report and the reasoned conclusions will have to be submitted as part of the construction license application.[807] This new approach will mean that if the applicant conducts the EIA after the site and concept assessment, it will be employed to analyse the environmental impacts of not just a more concrete project, but one where some preliminary considerations concerning the safety acceptability of the site and the design have already been assessed, and the information gained in these two stages can be brought together as part of an evaluation that functions more meaningfully in light of those two factors. It must be emphasised, however, that the relationship of the EIA to the pre-approval stages is not clarified – it may come after them, prior to them, or simultaneously with them, and furthermore it may also precede the decision-in-principle stage. In essence the process is rather flexible, it is for the applicant to stage it as is most appropriate in the given case, the only limiting factor being by when it must be completed.

3.14.2.6. Changes to the construction license

While the construction licence regarding its overall function will largely remain the same, it will also be affected by the reformed Act in several respects. Under the reformed Act, the content requirements for a construction licence application are also changed as a result of the abovementioned changes to the licensing process. Firstly, with regards to the applicant for the construction licence, further clarification is needed given that the applicant for the decision-in-principle and the other pre-approvals may not be the same entity. This is resolved in the draft by connecting the construction licence application to the decision-in-principle stage – which compared to the pre-approvals may be the most project-specific – by requiring that the applicant must be the entity to whom the decision-in-principle is addressed or the licence holder referred to in it. The second criterion concerns the municipality's consent, which under the old system was required as part of the decision-in-principle stage; however, as site-specific aspects are proposed to no longer be considered as part of the decision-in-principle, the municipality's participation – which can only be based on the site of the plant – loses its relevance at that stage. Since the drafters wished to maintain municipalities' discretion in determining whether they would like a nuclear power plant project in their vicinity, they moved the requirement for their consent to the point in the licensing process at which site and design considerations are first assessed together. Consequently, under the new regime, the municipality's consent will be required to be obtained by the applicant as a prerequisite for the submission of the construction

[805] Id., explanatory section pertaining to section 68.
[806] Id., pp. 22–28.
[807] Id., explanatory section pertaining to section 316.

licence application.[808] It is equally required, as part of the application, that the applicant present, concerning the site, both STUK's site suitability assessment and its binding statement on the design criteria – criteria whose implementation the applicant must also ensure. Design-related aspects in the form of the nuclear facility concept also form a prerequisite for the application. In essence, the prerequisite for the application is the demonstration that the site-specific and design-specific pre-approval stages have been fulfilled, together with the municipality's consent.

The content of what must be presented in order to have the construction licence granted is rather similar to the current state of affairs. Among these criteria, some concern the suitability of the applicant and its suppliers and subcontractors, the financial aspects of the facility, and issues connected to the previously discussed pre-construction approval stages. As mentioned, the pre-approval stages still require the consent of the municipality and the reservation of the site in the local land use plan, these additional measures must be concluded for the construction licence to be issued.[809] As part of the construction licensing process, before the licence may be granted, the approval of further documentation by STUK would be required – among them, from a nuclear safety perspective, the approval of the overall and system design of the plant, bears particular relevance. This stage would comprise a detailed technical approval of the facility and its systems; these would not have to be assessed as part of the application but would rather be approved by STUK as a condition for the construction licence to be issued.[810] The final element to be highlighted here as a new condition for the licence to be issued is that the applicant's ownership structure and other relevant factors would have to be taken into account from the perspective of not endangering the energy supply from the facility.[811] The introduction of such a requirement responds to the potential internationalisation of operators that SMRs could bring about in the rather market-oriented Finnish system; under this consideration, it may be required that majority ownership is held by domestic or European Economic Area operators, which in the drafters' view would provide reassurance regarding supply security.[812]

Similarly to the Act to be repealed, when it comes to the construction stage – including the inspection of detailed technical designs, conformity assessments and commissioning inspections of such facilities – the new proposal does not depart from the approach of limiting STUK's inspection activities to more safety-significant issues, while otherwise taking advantage of the efficiency offered by the involvement of authorised inspection organisations.[813]

3.14.2.7. Reforms in the operation license stage

The operating licence procedure will generally remain the same as in the current Act, though the draft argues that it introduces certain clarifications and simplifications in the process.[814] As a reoccurring evaluation, at this stage, if the government grants the licence – which is the case

[808] Id., pp. 36–38.
[809] Id., section 306.
[810] Id., section 83.
[811] Id., section 306.
[812] Id., explanatory section pertaining to section 306.
[813] Id., section 103.
[814] Id., explanatory section pertaining to section 307.

for nuclear power plants – it is also required to assess the applicant's ownership structure from the perspective of supply security. Regarding the validity of the operation licence, it is issued for a fixed period, however, the draft introduces a new procedure under which, rather than a new licence being required after the expiration of the period set in the licence, the existing operation licence may be extended for a fixed period of time.[815] According to the draft what is considered the commencement of operation is somewhat changed, as it will no longer be the fuel loading into the reactor but rather the first start-up, however, this first start-up would still form part of the commissioning programme, approved under the operation license.[816] In this respect it is interesting to observe that in the reform of the Finnish licensing system the drafters did not propose establishing a separate commissioning licensing stage to bring the currently split commissioning phase under a single dedicated licence.

3.14.2.8. General observations on the reform

One thing that should be pointed out regarding this reform is that the Finnish drafters have in their practice already implemented the approach this thesis argues for – particularly that during the reform of national frameworks, drafters should take note of foreign approaches and their potential reforms, which in Finland was done with regard to several other European countries.[817] It may be observed that, by removing specific considerations from the decision-in-principle stage, the drafters aim to reduce the risk associated with licensing such a project – a point also reflected in the explanatory sections of the proposal. This is a matter of particular importance for SMRs intended for deployment in multiple units, since the new stages can help to mitigate precisely such risks.[818]

As mentioned, the current guidelines issued by STUK are generally rather prescriptive; taking note of the different technological solutions presented by advanced nuclear technologies, the intention with the reform is also to revise these guidelines and move towards more goal-oriented provisions, so that applicants have greater flexibility in presenting their safety case. In practice this would be executed by increasing the level of detail at the level of the Nuclear Energy Act while significantly reducing – according to the reasoning of the proposal by 70–80% – the provisions contained in STUK regulations and guidelines. An equally important change introduced by the reform is the move towards a more risk-informed approach, where the stringency of regulatory oversight aligns more closely with the associated risks.

A further critical issue introduced by the reform, worth noting here, relates to the fact that SMRs are factory-produced for the international market, meaning they are not intended to be significantly altered for various national deployments; the proposal therefore intends to provide for deviations from regulatory requirements set under the Construction Act that may necessitate the redesign of the facility, and similar derogations from STUK regulations concerning technical requirements will also be possible.[819]

Yet another observation concerns the authorised inspection organisations; under the draft Act a new requirement – although it has been present in different Acts – is introduced, namely that

[815] Id., explanatory section pertaining to section 312.
[816] Id., explanatory section pertaining to sections 330–331.
[817] Id., pp. 51–52.
[818] Id., pp. 22–28.
[819] Id., p. 46.

these bodies must be registered in Finland, which to a degree may later constitute a barrier to the internationalisation of these inspection organisations, which could come to play a globally more important role in the deployment of new nuclear power plants. It should be noted, however, that testing bodies may be located outside of Finland.[820] The process for approving these bodies is rather similar to the current procedure: they must obtain an accreditation – though STUK may accept other assurances – and in the case of testing laboratories located outside of Finland, the mutual recognition of foreign accreditation is also an option under the draft, after which they must be approved by STUK.[821]

An additional issue apparent from the preceding discussion is that whether the facility serves the overall interest of society is not assessed solely at the decision-in-principle stage; rather, although the subsequent construction and operation licensing stages naturally focus on evaluating whether statutory requirements are met, this consideration remains present throughout those stages as well, meaning it may also serve as grounds for refusing the licence at those later stages.[822] Recognising, however, that such a rejection – which would not be based on the facility's non-compliance with statutory requirements but rather on the public interest – could take place after the very costly construction has been carried out, the applicant may claim compensation for the costs associated with the construction.[823] Interestingly, such compensation is not available if the construction licence is rejected on this basis, even though the preparatory works for a construction licence application may themselves amount to a significant investment; on the other hand – also taking into account that the decision-in-principle is less detailed under the reformed Act – the construction licence stage is the first point at which site and technology considerations come together, meaning that the true societal impacts of the facility can be evaluated for the first time.

3.14.3. France and its rather project specific reform efforts

Amid the renewed interest in nuclear power, France also adopted the Acceleration Act, which not only terminated the cap on the share of nuclear energy but also introduced measures intended to accelerate deployment, however, it represents a rather distinctive approach, one that differs considerably from streamlining measures adopted elsewhere.[824] The underlying idea behind this specific approach relates fundamentally to the history of the French nuclear industry, which saw at the end of the 1980s and 1990s a rapid expansion into one of the most ambitious nuclear programmes in the world; however, this also means that the decommissioning of these reactors, due to their similar age, will occur more or less simultaneously. In order to combat the resulting deficit in electricity generation capacities upon the retirement of the existing fleet, the law foresees the deployment of six EPR2 reactors, with eight more to be studied.[825]

[820] Id., explanatory section pertaining to section 437.
[821] Id., section 437.
[822] Id., pp. 313–316.
[823] Id., pp. 313–316.
[824] LOI n° 2023-491 du 22 juin 2023 relative à l'accélération des procédures liées à la construction de nouvelles installations nucléaires à proximité de sites nucléaires existants et au fonctionnement des installations existantes *[Act No. 2023-491 of 22 June 2023 on Accelerating Procedures for the Construction of New Nuclear Facilities Adjacent to Existing Nuclear Sites and for the Operation of Existing Facilities]*.
[825] Guillot and Rigail, 2024, p. 87.

Similarly to Finland, France's approach to accelerating the deployment of nuclear capacity was not limited to SMRs but covered both large-scale and SMR technology. Interestingly, however, the French approach set two requirements for the expansion: first, that the facility to be built must be located in the immediate vicinity or within the perimeter of an existing nuclear installation, and second, that the creation authorisation must be made within 20 years of the promulgation of the Acceleration Act, that is by 2043.[826] Of these two requirements, the first is the more interesting, requiring siting in the vicinity of existing installations, which allows for the utilisation of existing infrastructure, human resources and knowledge about the site and its environment – factors that can be important in accelerating such projects compared to those on entirely new sites. Regarding this criterion, the Act provides that the government will prepare a report within five years on the feasibility of extending this geographical scope and the installations that may be covered, which according to experts would mostly favour hydrogen production purposes.[827]

The first change brought about by the Act concerned the Energy Code, though it must be stressed that this particular change was not conditional on the plant being sited in the vicinity of an existing installation. Under the old system, nuclear power plants were required to obtain an operating licence under the provisions of the Energy Code, which introduced a further administrative step and, moreover, prescribed that, in the case of plants with multiple units where the capacity of these units exceeds 800 MW, such operating licences had to be obtained unit by unit. This naturally imposed a particular burden on large-scale nuclear power plant projects, which are now proposed to be deployed in multiple units, making their operation conditional despite the substantial investments involved. If, in practice, this operating licence amounts to little more than a further administrative step that is granted as a matter of course, then this stage is arguably unnecessary; but if it constitutes a genuinely substantive licence that may not be granted, it represents a further, significant licensing risk. Recognising this situation and taking into account the public interest in these nuclear installations, the provision requiring operating authorisation by unit was repealed and nuclear power plants were removed from the scope of the Energy Code-based operating authorisation, as this authorisation is granted as part of the creation authorisation under the Environmental Code, no separate licensing stage is therefore required, alleviating administrative burdens and shifting this potential operational risk to an earlier point in the project when the investments made are not yet as significant.

Local planning rules were also subject to change under the new law. Nuclear projects are no longer designated as projects of general interest – a status intended to streamline their deployment – by prefectural order,[828] but rather by the Council of State, which naturally allows for swifter alignment of planning documents, moreover, this occurs not through a lengthy public inquiry but through public participation provided by electronic means.[829] Regarding this status,

[826] LOI n° 2023-491 du 22 juin 2023 relative à l'accélération des procédures liées à la construction de nouvelles installations nucléaires à proximité de sites nucléaires existants et au fonctionnement des installations existantes *[Act No. 2023-491 of 22 June 2023 on Accelerating Procedures for the Construction of New Nuclear Facilities Adjacent to Existing Nuclear Sites and for the Operation of Existing Facilities]*, art. 7.
[827] Léger, 2023, p. 755.
[828] Code de l'urbanisme *[Urban Planning Code]*, art. R102-1.
[829] Guillot and Rigail, 2024, p. 88.

it must also be emphasised that a project is, by default, considered to hold this status if it receives a declaration of public utility, which allows for certain expropriations.[830]
Furthermore, the licensing procedure and the actors involved are also simplified and harmonised, as the Acceleration Act exempts nuclear power plants from licensing procedures such as building permits under the Urban Planning Code bringing them within the creation authorisation procedure,[831] where their compliance with the relevant provisions is nevertheless verified.[832] By bringing these procedures under a single process, this simplification intends to limit the additional burdens associated with conducting them before several separate authorities, without compromising these plants' compliance with statutory requirements.
Further deviations are provided from environmental protection measures,[833] and in response to the delays in these projects that may be caused by legal challenges, the Acceleration Act also introduces certain changes as it allows for partial annulments where a defect affects only part of the application, limits the annulment to that part, and where a defect is capable of being remedied sets a time limit for such remedies, halting the proceedings in the meantime.[834]
Unlike in the two other countries, the French framework did not previously address the possibility of carrying out works before obtaining an authorisation, as this is a newly introduced element. Early works under this change – limited to works that do not involve the construction of buildings that will house nuclear fuel or safeguarded equipment – may be carried out under the regular environmental licensing procedure, subject to a decree based on environmental impact assessment, rather than a prefectural order.[835] This measure naturally also serves to allow preparatory works to begin as early as possible, without waiting for the conclusion of the creation authorisation procedure, which can take years; however, in this respect it may still be more limited in scope than other solutions that allow for such early works. This procedure has already been utilised in practice, with the Penly site receiving this environmental authorisation in 2024, while the Gravelines site received it in August 2026.[836]
Finally, one last element must be mentioned, one already addressed in the section on the institutional framework. In addition to these measures, France also took the view that streamlining could not be achieved solely by intervening in the licensing process itself, but equally required a streamlined institutional framework – one capable of supporting these efforts through its independence and its adequate expertise and human resources.

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[830] Déclaration d'utilité publique.
[831] Guillot and Rigail, 2024, p. 88.
[832] LOI n° 2023-491 du 22 juin 2023 relative à l'accélération des procédures liées à la construction de nouvelles installations nucléaires à proximité de sites nucléaires existants et au fonctionnement des installations existantes, *[Act No. 2023-491 of 22 June 2023 on Accelerating Procedures for the Construction of New Nuclear Facilities Adjacent to Existing Nuclear Sites and for the Operation of Existing Facilities]*, art. 9.
[833] Id., art. 12.
[834] Id., art. 16.
[835] LOI n° 2023-491 du 22 juin 2023 relative à l'accélération des procédures liées à la construction de nouvelles installations nucléaires à proximité de sites nucléaires existants et au fonctionnement des installations existantes *[Act No. 2023-491 of 22 June 2023 on Accelerating Procedures for the Construction of New Nuclear Facilities Adjacent to Existing Nuclear Sites and for the Operation of Existing Facilities]*, art. 11.
[836] Décret n° 2026-807 du 20 août 2026 portant autorisation environnementale relative à la réalisation de travaux nécessaires à l'implantation d'une paire d'unités de production nucléaire de type EPR2, sur les communes de Gravelines, Craywick, Loon Plage et Bourbourg *[Decree No. 2026-807 of 20 August 2026 granting environmental authorisation for the carrying out of works necessary for the construction of a pair of EPR2-type nuclear power units in the municipalities of Gravelines, Craywick, Loon Plage and Bourbourg]*.

These efforts initiated in France present a third approach to facilitating the streamlining of nuclear power plant deployments. Interestingly, what can be concluded regarding these measures is that they intervene little in the actual nuclear safety licensing procedures, unlike the approaches adopted by the other two countries; instead, France adopts an approach that intends to harmonise and streamline the procedures supplementing the nuclear safety licensing procedure.

3.15. Observations and partial conclusions on the licensing frameworks for conventional nuclear power plants

After analysing these three different licensing frameworks, it is imperative to draw some observations on their functioning. The following section aims to address certain systematic similarities and differences among these differing national procedures, while the second part will seek to address more specifically the streamlining initiatives and what conclusions may be drawn from them that could be valuable for countries embarking on a similar mission. In order to provide clearer takeaway messages, the author will use bullet points to present these observations.

1. The first issue to address concerns the legal frameworks themselves. Each of the three countries has a rather complex and fragmented legislative framework made up of high-level requirements contained in acts and codes, supplemented by lower-level regulatory requirements usually contained in decrees, and each system also relies on guidelines that further detail certain questions. Of the three countries, two employ a specific nuclear act, while under the French system the provisions that in the other countries would constitute a separate act are consolidated in the Environmental Code. In Hungary, the lower-level binding instruments are contained comprehensively within the Nuclear Safety Rules, while in the other two countries, these aspects are addressed through more fragmented instruments. Guidelines, as mentioned, are employed in all three countries; however, they are considerably more systematised and substantive with regard to the licensing of a new nuclear power plant in Hungary and Finland, whereas in France certain issues addressed by guidelines in the other two countries are left unaddressed, while other matters unrelated to licensing are covered instead. There is also a difference regarding the legal effect of guidelines across the countries. Finland and Hungary both specifically attach legal effects to these instruments – Finland stating that they are generally binding but that derogations can be accepted, while Hungary states that they are not binding but still attaches a legal effect to them by providing that if they are followed the authority will not evaluate the applied method – whereas France remains rather silent on this topic.
   All three licensing procedures are rather difficult to navigate, but of the three frameworks the Finnish one is – regarding the procedure itself – the easiest to follow, with the high-level requirements more or less clearly presenting how the licensing process for nuclear power plants works with the implementing legislation further detailing it. In France the process is set out in the regulatory part of the Code – which incorporated lower-level legislation into it – but it is not always clear how the procedures function, what follows what, and there are several cross-references to other parts of the Code. The situation in Hungary is rather

similar, it is the Nuclear Safety Rules and their Annexes that set out how the licensing procedure is structured, though the sheer size of these Annexes makes the overall procedural framework rather difficult to grasp. In all cases it is a considerable challenge to understand how these procedures function even in broad terms.

The licensing procedures for nuclear power plants in all three countries extend beyond the nuclear-specific regulatory framework and are, as such, also affected by other areas of legislation. This presents further challenges to understanding these authorisations as a whole, particularly with regard to how other licences relate to the course of the nuclear safety licensing procedure.

2. The second matter to address concerns the regulatory authorities. The structure of the regulatory authorities differs among the countries; Finland and Hungary employ a structure headed by a single director, while France employs a commission-type structure. The powers and roles of the regulators are rather similar across the three nations, yet some differences exist relating to licensing powers and the issuance of lower-level regulatory instruments. In this regard, in its independent regulatory authority format, the HAEA is the authority with the most powers vested in it, as it is solely responsible for deciding on authorisations without the need for governmental approval, while also holding broad legislative powers to adopt the implementing legislation of the Act on Atomic Energy. While the other two countries also provide their respective authorities with a strong mandate, their licensing powers are in some cases more limited, requiring the participation of the government, and their powers to adopt implementing regulations are also more constrained. Naturally, not too far-reaching conclusions should be drawn from this observation, as how these statutory powers function in practice is a separate matter.

   The second important consideration regarding these authorities is their independence. This is a topic on which significant developments have been made at the Euratom level following the Fukushima incident, and as such all three analysed countries – especially considering their historical roots – have made significant progress in this regard; while they may differ in the details, all three countries similarly seek to ensure the independence of these bodies through institutional arrangements and financial means.

   From the perspective of the nuclear renaissance, it is commendable that none of the three countries examined has overlooked the critical role of regulatory authorities in the efficient deployment of nuclear power plants; each has, through its reforms, sought either to relieve the burden on the authority or to empower it with further expertise.

3. A political green light for nuclear power plant projects as a separate stage in the licensing process exists in two countries – Hungary and Finland – while France does not employ such an explicit stage. Of the two countries that have such a stage, the Finnish approach is rather demanding, with many aspects of the proposed project already being assessed at that stage, which naturally also makes it a considerable undertaking for the applicant. In Hungary, while such a stage is required under the Act on Atomic Energy, the Act does not set detailed requirements as to what must be presented or what evaluations are needed to make the decision, and thus it places less of a burden on the applicant. France, by contrast, does not have a single political approval to be obtained; rather, there are several instruments which also serve the purpose of expressing political support for nuclear energy projects, but these are less project-specific and more general in their orientation towards nuclear energy as

such. The less project-specific these green-light decisions are, the less burden they place on the applicant in a given case – which is naturally preferable from an applicant's perspective – but in that case the weighing of the benefits and hazards of that given project in a given location becomes less represented in the process.

4. Licensing procedures in terms of the content of the assessments conducted before the responsible authorities are very similar. Naturally, regardless of where the plant is built or what design it may be, the interests that need to be protected in the case of a nuclear power plant construction are very similar across countries, and thus the information that may be required from the applicant to determine whether the facility and the protected interests can coexist is essentially the same. Soft law instruments and industry standards play an important role in making this determination, being implemented within national frameworks to assist in reaching such decisions. In essence, the information needed for the authority to determine at the national level whether the facility can operate safely is very similar across jurisdictions, given that such an evaluation naturally presupposes certain information that is necessary regardless of the national context – notwithstanding that certain questions may carry differing weight among countries.
5. Where the differences among these countries rather lie is in how the licensing procedures are structured, their sequence, the content of the individual stages and, very importantly, how the requirements regarding the information – which we have observed to be similar – that must be presented to the authority are set out.

   Addressing first the question of the staging and sequencing of these processes: at the time of writing, of the three countries analysed only Hungary has a staggered approach to licensing, while the other two countries adopt a more comprehensive approach to staging. Hungary in this sense follows more closely the approach set out by the IAEA, while the other countries address these considerations as part of broader licensing stages. Nevertheless, the countries that have adopted more comprehensive approaches also employ regulatory hold points within these broader stages, which to a degree fulfil the role that an individual stage in a staggered licensing approach would. In terms of content, all three cover the same lifecycle stages of a new nuclear power plant deployment, simply because the deployment stages are the same regardless of the country; thus even if the Finnish and French systems do not have a separate site licensing stage, siting considerations are still taken into account. It is very difficult to draw any observation on which of these procedures is more efficient or more adequate for the streamlined deployment of nuclear power plants, as clearly each may have its own benefits. The staggered approach distributes the regulatory workload and focuses attention on specific aspects at each stage; as such, the risks from the perspective of the licence are distributed more evenly among these subsequent stages that build on each other. However, it requires more bureaucratic formal procedures and the regulator does not evaluate the facility as comprehensively – although to combat this, in practice there is a certain degree of overlap among given stages, such as certain design information being required at the site licensing stage as in Hungary, though this also generates a level of redundancy. The more comprehensive licences, by contrast, adopt approaches where the facility as a whole may be addressed together, giving the authority a comprehensive overview of the entire project. Moreover, as ultimately what will decide whether the facility will be built is the determination of whether it can safely be constructed

and operated at that given location – which is naturally a comprehensive evaluation – even systems that employ site licences at the construction licensing stage still have to evaluate the design in respect of the site. One difficulty in interpreting the legislation of comprehensive licensing systems is that certain activities which would constitute a separate stage in staggered systems are instead spread across different licensing stages; for instance commissioning tests being divided according to whether they involve the use of radioactive material. Furthermore, in comprehensive systems, due to covering stages that may be separated by longer periods of time, the documentation submitted in comprehensive licence applications may in many cases be subject to change owing to a temporally preceding lifecycle stage assessed within the same licensing stage; for example, operational limits may be set in an operation licence application despite the fuel loaded test not yet having been conducted by that time, which may well alter these conditions. Consequently, if the initial licence applications for comprehensive licences have a broad and detailed coverage, redundancies may arise due to changes occurring within that same stage. In a staggered approach, the conclusions and changes prompted by the preceding stage may be more easily taken into account in a given licence application, with lesser risk that developments within that stage would render the conditions obsolete and require updating. Nevertheless, it is rather difficult to say which approach would be best, and as will be seen, this question may be easier to answer with regard to certain plants such as SMRs.

The second consideration in which these countries' licensing procedures may differ relates to what regulatory approaches are employed. Each of the three countries, while prescriptive elements are present, in their binding instruments generally establishes safety goals and objectives that must be met rather than prescribing in all cases concrete requirements and methods by which these must be met. Despite this general similarity, differences remain among them. Of the three countries, France applies a goal-setting approach most broadly, as reflected in the comparatively limited technical requirements set out in its legal framework, whereas Hungary and Finland include more substantial prescriptive requirements in their implementing legislation and guides.

Additionally, the issue of technological neutrality may be worth addressing. Technological neutrality among the high-level legislation exists equally across the countries, but some of the implementing legislations contain technology specific requirements for example the nuclear safety rules in Hungary.

6. Generic design and pre-licensing questions constitute another interesting topic on which some observations should be made. None of the countries have a generic design licensing stage – applicable to large-scale plants – that would, prior to a project-specific deployment, review the design and give a general opinion on it, requiring only the assessment of site-specific design issues in the construction licensing phase. On the contrary all the analysed jurisdictions have adopted pre-licensing institutions. What is more France and Hungary have adopted systems that beyond the benefits of consultations have some tangible effects on a subsequent construction licensing stage. Finland's pre-licensing in contrast remains a consultative stage, which has no determined effect on the construction licensing stage but rather helps the licensee obtain feedback on the planned design. Hungary's preliminary safety information stage can be highlighted among the pre-licensing measures which has a significant tangible effect on the implementation licensing procedure by providing the

authority early on with the necessary information and thereby also automatically benefiting the licensee by shortening the length of the subsequent implementation license proceeding. In France, the entity that may later request a creation authorisation can initiate a consultation stage with the authority, in which the authority may deem the proposed solution to be in conformity with the regulatory requirements but may also establish further requirements; while this does not automatically shorten the licensing period when the creation authorisation is applied for, but by providing information on this previous assessment and implementing the authority's requirements it can potentially facilitate the licensing process, though the authority is not bound by its previous assessment. In essence, this procedure stands somewhere between the Hungarian and Finnish approaches, resulting in neither a concrete procedural advantage nor a mere consultation. Pre-licensing stages even in a purely consultative format are crucial for new and novel designs, but they are less significant for designs where the applicant is reasonably certain of meeting the regulatory requirements, in those cases institutions with more tangible effects are reasonable to offset the procedural burden.

7. The expectations regarding the length of time required to licence a new nuclear power plant differ among the countries. Of the three countries, Hungary and France employ set timeframes for the licensing stages, whereas in Finland no such timeframe is prescribed.
   In France, the nuclear safety licensing procedure sets a maximum review period of three years for the creation authorisation, which may be extended by two years, and one year for the commissioning authorisation, which may be extended by another year. Consequently, the authorities have four years by default to process licence applications, a period that may be extended to seven years. By contrast, in Hungary the site licensing stage takes a maximum of 120 days for each of its two steps, that is, 240 days (approximately eight months) in total. The implementation licensing stage that follows takes 12 months if the preliminary safety information (PSI) has been obtained and 18 months if not, a period that can be prolonged by a further three months. The commissioning and operation licensing stages then take 11 months each. In total, if the PSI has been obtained and the implementation licence is processed on time, the evaluation takes 42 months, whereas if the PSI has not been obtained and the implementation licensing stage is prolonged, it takes 51 months. In both scenarios, therefore, the Hungarian timeline is shorter than the maximum periods available to the French authorities: 42 months is below the default four-year period, and 51 months is still well below the seven-year maximum. In practice, however, the comparison is less clear-cut, as these deadlines concern only installation-level licences, while other licences may also have to be obtained. The picture is further complicated by the fact that authorities may not always keep these deadlines, and a missed deadline does not automatically result in the licence being granted.
   The approach where no timeframe is set signals that the authority should not be bound by a temporal frame that would rush it to make a decision; instead it should generally be required to act efficiently but may take as long as is necessary. While on the surface timeframes would provide a licensee with more reasonable expectations as to when the licence may be granted, the experience of Hungary showed that despite set time limits delays may still occur in the licensing procedures, whereas the Finnish experience with licensing in the case of Olkiluoto was rather streamlined. As regards how efficiency may be increased, setting

short timeframes for the authority to evaluate licence applications is not the right approach; that said, authorities should be incentivised not to take longer than necessary to evaluate them.

8. How environmental impact assessments are incorporated in the licensing procedures is a further consideration that should be addressed. In the context of nuclear power plants among the three countries examined, only Hungary has established a dedicated environmental licence incorporating the EIA. France, by contrast, notwithstanding the reforms applicable to particular nuclear plants, adopts an integrated model in which EIAs are addressed within the creation authorisation procedure, whereas Finland follows yet another approach, incorporating such considerations at the decision-in-principle stage. The EIA Directive prescribes that the EIA must be completed by the development consent stage, a deadline to which both the Hungarian and French approaches extend to, by contrast, the Finnish model places the EIA at the very outset of a project not waiting until the development consent. Another important factor to consider is the authority responsible for evaluating the EIA. France and Finland have adopted centralized systems: in France, the evaluation is conducted by the General Inspectorate of the Environment and Sustainable Development, whereas in Finland the competent authority is the Ministry of Economic Affairs and Employment. In contrast, Hungary has adopted a decentralized approach, in which the environmental licence based on the EIA is issued by either the county or capital government office. Both approaches have potential benefits and drawbacks. Scholars have noted that decentralization may create a "race to the bottom," where competition among local authorities could result in lower environmental protection,[837] conversely, it has also been argued that local institutions possess better knowledge of regional environmental conditions and are more motivated to ensure efficient use of natural resources.[838]

   In none of the three countries is the EIA the only means by which environmental aspects are taken into account; each also employs distinct environmental licences that must be obtained separately from the nuclear authorisation process.

9. Finally, the last element that needs to be discussed concerns the streamlining efforts initiated by the countries. All three countries examined here adopted measures to streamline licensing procedures, yet the motivations behind them, the scope of these measures and the approaches adopted are rather different. The measures in Hungary – notwithstanding the amendment of the Act on Atomic Energy in the spring of 2026 that introduced a separate licensing procedure for SMRs – originated from the experience of the Paks II project, which highlighted that the current licensing framework is extremely demanding on both the licensee and the regulatory authority. It was rather this practical experience than a strategic decision that sought to refresh the licensing framework. Contrary to this, the French and especially the Finnish approaches were or being adopted less specifically in response to a given project and are rather preparations for future deployments in general – although the French approach may to a degree also be a preliminary reaction to the planned EPR2 deployments, though it is not exclusive to them. The second matter to address is how these measures were or are planned to be introduced into the legal systems. In Hungary and

[837] Luo et al., 2019.
[838] Cistulli, 2002.

France the streamlining efforts were conducted through amendments seeking to reform given elements of the licensing frameworks, while in Finland a complete reform of the licensing framework is underway. Another aspect in which these procedures differ is their coverage of installations. The Hungarian amendments were introduced to the Act with the aim of advancing the licensing of conventional nuclear power plants, recently followed by an SMR-specific amendment. The Finnish approach, while general in its application to all nuclear power plant types, contains elements that will be particularly relevant for SMRs, though equally applicable to large-scale plants. The French approach also covers both SMRs and conventional plants, but the limitations it introduces relate to a temporal scope and a geographical one, envisaging the siting of these plants in the vicinity of existing installations. The content of the measures introduced also differs: the Hungarian amendments seek to address inefficiencies in the nuclear safety licensing procedures through the notification and derogation notification acknowledgement procedures and via the authorised inspection organisations. The Finnish approach substantially reforms the nuclear safety licensing procedure with the introduction of new licensing stages and changes to the roles of existing ones and also changes the content of regulatory requirements. The French approach, by contrast, mostly contains streamlining efforts regarding procedures that fall outside the nuclear safety licensing process but still fundamentally shape the deployment of new installations. In this regard, the most recent French approach also deserves mention, as it sought to facilitate the institutional framework supporting new deployments. All of the measures adopted are rather different, as they respond to nation-specific problems and challenges; nevertheless, the differences among national systems may mean that solutions already exist in one country for problems that another country faces – such as the limited reliance on authorised inspection organisations, which Hungary sought to resolve but for which examples already existed in Finland and France.

4. The licensing of advanced nuclear power plants particularly Small Modular Reactors

Within the nuclear industry, most innovation efforts currently concern SMRs, a technology which, although argued to be revolutionary, is, as explained before, not as new as one might think; nor is its economic underpinning,[839] which, instead of relying on economies of scale, seeks to take advantage of economies of multiples.[840] Despite these conceptual foundations, such plants are, in most cases, not yet readily commercially marketed, and, as such, in the perceived materialisation of the nuclear renaissance, SMRs and other advanced technologies – as also reflected in the projections of several international organisations – are expected to contribute last, behind both LTO and the construction of new conventional large-scale nuclear power plants. In enabling the broad deployment of these plants, legal frameworks are required to evolve,[841] so as to reflect their innovative technical solutions and novel application possibilities, and to support their economic strengths.[842] Compared to the inefficiencies of current licensing frameworks previously showcased in the case of conventional nuclear power plants, the legal challenges posed by SMRs are more fundamental in nature, arise at different levels of governance, and generally require greater efforts to resolve.

Unlike conventional plants, the first fundamental question that arises in relation to SMRs is whether the international framework governing the nuclear sector applies to them at all, and whether there are cases in which they may be treated differently under these instruments. While the existing frameworks form a common minimum basis of nuclear law, they were generally negotiated and adopted at a time when the widespread civilian deployment of these installations was not yet a central concern; consequently, although largely technology-neutral, these instruments' scope are, in certain respects, stretched by SMRs' particular characteristics. As these treaties form the basis of the balancing mechanism between the benefits and risks of nuclear energy, signalling an international commitment to it and thereby positively contributing to the shaping of global public perception of nuclear energy, it is difficult to envisage the deployment of SMRs outside these frameworks. Furthermore, even where the interpretative challenges of generally covering SMRs are overcome, certain open issues remain with regard to instruments that draw differentiations among nuclear power plants, since in such cases the classification of SMRs must still be resolved, and the factors guiding that classification must be clarified. Resolving these issues is a primary consideration, as they fundamentally shape national approaches and are decisive for SMR projects: some instruments require that licensing procedures be in place, while others concern, for example, the question of liability and what liability arrangements must be adopted to address SMRs deployed in unconventional locations. Leaving such questions unresolved could, in turn, hinder deployment altogether, meaning these matters need to be resolved before national frameworks are adapted to accommodate SMRs and their licensing can begin. The first part of the section dedicated to SMRs will address how smoothly SMRs – and, in some cases, other advanced technologies – integrate into the existing international legal framework governing the nuclear sector, where adjustments to these instruments may be necessary and how such adjustments might be resolved, as well as, in cases

[839] Behrens, 1985, pp. 360–370.
[840] Hanna et al., 2024.
[841] Policy and subsequent legislative changes are at the front of row of efforts needed to facilitate SMR deployment. See: Sam et al., 2026a, p. 65.
[842] Sam et al., 2026b, p. 192.

where instruments provide for flexible approaches to installations, how SMRs might invoke special treatment.

The second major topic to be discussed in this part of the thesis relates particularly to the licensing of SMRs. The general efficiency deficits of licensing frameworks, as a matter to be resolved in the nuclear renaissance, are equally applicable to SMRs, and many of the advancements made with respect to conventional plants would equally facilitate the licensing of SMRs; however, some considerations are crucial for SMRs but not particularly relevant to large-scale nuclear power plants. Thus, while generally transforming the nuclear law framework of a nation may greatly contribute to their deployment, certain specific approaches could further help in taking advantage of their proposed benefits. In this respect, this part will address the particular challenges that the deployment of these plants poses for current licensing frameworks, the possible resolutions to these challenges, and how such resolutions might be developed. Since national legal frameworks were developed before SMRs were broadly discussed, countries in many cases face similar challenges in adequately deploying these installations within their national contexts; in many cases, this is because they lack – aside from some miscellaneous solutions that happen to fit SMRs – the procedural solutions and regulatory approaches specifically suited to SMR deployment. Consequently, great advantage can be taken of introducing similar legal solutions across jurisdictions, reflecting the unique features and standardised deployment strategies of SMRs. As such, in the case of these plants, the thesis also intends to devote special attention to the international tools and ongoing efforts that seek to facilitate or support their efficient deployment across countries.

4.1. The applicability of the international nuclear law framework to SMRs

The international framework governing the nuclear sector was established to address key areas where international cooperation and common understanding were required and where traditional legal solutions were ineffective in responding to the specialty of this field.[843] Although advanced reactors can differ greatly from the technologies available when these instruments were adopted, the objective set out in them to establish minimum requirements remains applicable today. Disregarding these requirements and exempting new technologies from these frameworks can backfire, providing substantial leverage to anti-nuclear arguments. Additionally, adequately applying these instruments to advanced technologies also has serious practical implications that must be resolved before the deployment of these plants.

In this section, the author analyses selected instruments of international law that could significantly influence the course of a nuclear renaissance encompassing advanced nuclear technologies. Since SMRs are the most widely discussed advanced nuclear technology, the analysis will be carried out using them as an example, supplemented in some cases by reference to micro-reactors.

The author will first address the interpretation of international treaties, since the concepts of interpretation bear particular importance in determining whether SMRs could be covered by these instruments. These interpretative tools will then be applied to the principal instruments of the nuclear field, elaborating on the interpretative challenges raised by SMRs and how these might potentially be resolved.

[843] The case of liability is a perfect example, see Lamm, 2020, p. 31.

While the author recognises that the interpretation of these instruments will not be decided by academic deliberations, such perspectives can contribute to discussions that may ultimately inform decisions on how these technologies should be treated within the international legal framework governing the use of nuclear energy. A common understanding of the issue is paramount to the successful deployment of these technologies, as it enhances public confidence and addresses practical implications, thereby removing any ambiguity surrounding these technologies.

4.1.1. Interpretation of international treaties

The first matter to be addressed is how treaties are interpreted, and how interpretation can help adapt them to evolving circumstances.[844] Treaty interpretation is not as straightforward as it may seem; a wide range of methodologies exist,[845] however the Vienna Convention on the Law of the Treaties stands out as the primary instrument for treaty interpretation.[846] The Convention was adopted following the extensive work of the International Law Commission,[847] and it is considered as the codification of customary international law, as also acknowledged by the International Court of Justice.[848] Although Article 4 of the Convention[849] states that it applies only to treaties concluded after its entry into force in 1980, however since it represents the codification of customary international law, the methods of interpretation can be applied to instruments that preceded it.

The Convention addresses treaty interpretation in three articles. Article 31 concerns the general rule of interpretation; Article 32 contains the supplementary means of interpretation and Article 33 addresses the interpretation of treaties authenticated in two or more languages.

The relationship between the general and supplementary means of interpretations requires an explanation. The separation of these categories is not incidental as the International Law Commission (ILC) deliberately made this distinction and established a hierarchy among them.[850] While some scholars advocate for the 'pro-preparatory-work position' which claims that there is no hierarchy among the general and supplementary means and emphasizes that the preparatory works of a treaty should have the same importance as the general means when interpreting a treaty, this view remains a minority.[851] In fact this opinion is challenged by the preparatory works of the Convention, which reflects a clear dedication to establish a hierarchical order between these means.[852]

Article 31(1) provides that "A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose."[853] The first element to be addressed is good faith, a fundamental principle of contract law requiring parties to perform their obligations in a manner consistent with the

[844] Moloo, 2012, p. 261.
[845] Etinski, 2017, p. 1178.
[846] The convention opened for signatures in 1969 and by now it has 116 parties.
[847] Stanford, 1970, pp. 18–19.
[848] Gardiner, 2017, pp. 13–19.
[849] UN, 1969, Art. 4.
[850] Etinski, 2017, p. 1180.
[851] Linderfalk, 2007, p. 136.
[852] Id., pp. 150–152.
[853] UN, 1969, art. 31.

nature of their agreement rather than merely its literal text.[854] Although the principle of *effet utile* was deliberately omitted from the Convention, the inclusion of good faith as an overarching principle nevertheless allows interpretation to move beyond a strictly textualist approach and consider the parties' intent.[855] The second part of the paragraph requires interpretation in accordance with the ordinary meaning of the terms of the treaty, considered in their context and in the light of its object and purpose, the latter reflecting a teleological approach. Regarding the notion of context, paragraph (2) clarifies that it includes not only the text of the treaty but also its preamble, annexes, any agreements relating to its conclusion, and other instruments related to its conclusion. Furthermore, paragraph (3) requires that, in addition to this context, subsequent agreements between the parties regarding interpretation and their subsequent practice in applying the treaty – which evidences a common understanding on interpretation – must also be taken into account. All these factors have to be considered in a given case in a single combined operation where the interaction of these elements sheds light on the adequate interpretation.[856] Although, in court practice the first two paragraphs generally receive predominant emphasis,[857] this does not take anything away from the significance of the parties' agreement or their subsequent practice. Within the general rules of interpretation, there is no hierarchy among the means.[858]

Two aspects of interpretation that deserve particular attention are the good faith principle and the possibility of evolutive interpretation through the use of paragraph (3). The principle of good faith in the nuclear field carries even more weight, which deserves explanation. Without prescribing the interpreter to use a teleological approach, good faith requires an interpretation that does not overlook the purpose and object of a treaty and it thus safeguards it from being leveraged unfairly.[859] Such a principle, in the nuclear field where there are clear objectives, motives, and expectations behind the adopted treaties, but where technological developments are inevitable, can serve to preserve the application of the treaties despite developments that would stretch their literal interpretation.

Coinciding with the role of good faith the possibility of evolutive interpretation through paragraph (3) has to be explained. Adopting new treaties is generally a difficult task, and it is even more so in the nuclear sector, as the seventy years of experience demonstrate the many hurdles and challenges that preceded the adoption of existing instruments. Therefore, adopting entirely new treaties to address novel technologies does not seem realistic, especially considering also their many specificities and differences. Amending a treaty might appear to be an easier option to cover previously unconsidered areas, but again, if we look at the experience in the nuclear field, such as the Vienna Declaration, we see that it is also not an easy feat and not always successful. However, time passes regardless, and to a certain degree, instruments adopted in the past have to keep up with technological developments. This is especially true in highly technologized areas, where an evolutive interpretation can be the key to the survival of the treaty at hand. The Convention does not explicitly state that evolutive interpretations should

[854] Mahoney, 2007, p. 849.
[855] Reinhold, 2013, p. 62.
[856] UN, 1966, art. 27., comment 8.
[857] Gardiner, 2017, p. 123.
[858] Berner, 2016, p. 71.
[859] Villiger, 2011, pp. 108–109.

be adopted due to the passage of time, but through subparagraphs (3)(a) and (3)(b) it gives the parties to the treaty the opportunity to adopt more dynamic interpretations and thereby possibly extend the scope of the treaty.[860] Although, it has to be mentioned that even in this case, it must be done in good faith.

Evolutive interpretation of treaties is not a new concept, and without extensive practice, one very prominent example is the interpretation of the European Convention on Human Rights. Regarding the importance of subsequent practice and agreement as means for an evolutive interpretation, it can be argued that in a highly technologized area such as the nuclear sector, an interpretative approach that keeps pace with technological developments is very much needed. The view that a given method of interpretation should be more prominent depending on the subject matter of the treaty is not unfounded – within the ILC there have been discussions suggesting that certain features of treaties may make specific interpretative methods more appropriate than others, although contrary views have also been expressed.[861] Nevertheless, this perspective is worth considering in a sector as specialized as nuclear. Article 31(3)(a) and (b) of the Vienna Convention enshrine that treaties are to be interpreted taking into account subsequent practice and agreements, and such practice and agreements can reflect developments and thus support an evolutive interpretation. In this way, parties to a treaty can, through their practice or through agreements, alter or clarify the meaning of the text without the hurdles of adopting an entirely new treaty or even formally amending it. The difference between subsequent practice and subsequent agreements lies primarily in their level of formalization, as the latter are considered to entail a higher degree of formality, however, some for example as Judge Weeramantry explained in his dissenting opinion in the Kasikili case,[862] even silence could, in some circumstances, be considered as agreement – although this interpretation arguably stretches the meaning of agreement.[863] Agreement is certainly less formal than an amendment procedure, but it should still reflect the "genuine shared expectation of the parties" [864] and, according to the ILC, must amount to a "common understanding."[865] Regarding subsequent practice, however, the ILC has not excluded the possibility that silence may, in certain cases, constitute acceptance – thereby setting a lower threshold for shaping interpretation than in the case of agreements.[866]

This method of interpretation, which takes into account subsequent agreements and practice, provides an opportunity to recognize how the parties themselves understand the treaty through their actions. It opens the door to an evolved interpretation that reflects the parties' practical application of the treaty, without binding them to a strictly textual approach.[867] which is a crucial consideration in this highly technologized area where novel technologies were not foreseen at the time of the treaties adoption. The ILC has emphasized that subsequent agreements and practice do not serve as mechanisms to formally amend or modify treaties – for which special procedures exist – but it has also acknowledged that they can nonetheless result in a widening

[860] Id., p.111.
[861] Etinski, 2017, p. 1186.
[862] Kasikili/Sedudu Island (Botswana/Namibia), Judgment, ICJ Reports 1999, p. 1045.
[863] Fox, 2010, p. 63.
[864] Ibid.
[865] UN, 2018, Conclusion 10.
[866] Ibid.
[867] Crema, 2013, p. 23.

or narrowing of a treaty's interpretation.[868]
Article 32 addresses supplementary means of interpretation, which involves examining the preparatory work of a treaty and the circumstances surrounding its conclusion. Recourse to these factors should only be undertaken either to confirm the meaning derived from Article 31 or when interpretation under Article 31 is ambiguous, obscure, or leads to a manifestly absurd or unreasonable result.
After looking at the rules of interpretation, it is clear that interpretation is potentially a tool that can keep treaties intact while also reflecting the intentions and aims of the parties in an evolving environment. In the following section, special attention will be devoted to how the interpretation methods enshrined in Article 31 of the Vienna Convention can help keep the fundamental treaties of the nuclear sector alive and relevant in a time of technological development.

4.1.2. SMRs and the international legal framework governing the nuclear field

In the next section, the major pillars of the international nuclear law framework will be examined, with particular attention to the issues and challenges that arise when applying them to small modular reactor technologies. The primary challenges will be identified, followed by an assessment of whether interpretative approaches can offer viable solutions. This analysis will be carried out by examining the major international treaties governing the nuclear sector in a manner that reflects the areas they intend to cover within the sector.

4.1.2.1. Nuclear safety

4.1.2.1.1. Convention on Nuclear Safety

In the area of nuclear safety, the instrument to be highlighted is the Convention on Nuclear Safety. Article 3 defines its scope of application, stating that the Convention applies to nuclear installations. Article 2 defines these installations as "any land-based civil nuclear power plant under its jurisdiction including such storage, handling and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant".[869] From the perspective of SMRs, the first issue that must be addressed is whether they are all considered nuclear power plants, as some experts argue that certain types are not.[870] The CNS does not define what a nuclear power plant is. However interpreting the treaty in good faith, taking into account its object and purpose – namely, to achieve and maintain a high level of nuclear safety worldwide, establishing and maintaining effective defenses against radiological hazards, and preventing and mitigating accidents,[871] – and considering in addition that the preamble states that the Convention seeks to establish fundamental safety principles for nuclear installations rather than detailed guidelines, since such detailed safety guidelines are periodically updated to reflect contemporary issues, a broader understanding can be supported. This objective of the Convention – to establish only fundamental requirements – takes into

[868] UN, 2018, Conclusion 7.
[869] IAEA, 1994, Art. II.
[870] NEA, 2021b), p. 33.
[871] IAEA, 1994, Art. 1

account potential developments in the sector, setting up a framework that can stand the test of time and not become obsolete because of technological advancements. Subsequently, it could potentially be contrary to the principle of good faith to exclude power-generating SMRs from the Convention's scope, as the requirements it contains are fundamental in nature and can be applied to these more advanced technologies without unduly burdening them, particularly given that the CNS is specifically focused on power generation, while complementary instruments, such as the Code of Conduct on the Safety of Research Reactors,[872] covers non-power generating reactors.[873] New technologies should not fall between these categories merely because of their reduced power output or novel applications; the purpose of the reactor should remain the guiding principle in deciding which international instrument covers them. Continuing with the definition of the CNS, one category that clearly cannot be covered is military SMRs, as the definition explicitly refers to civil nuclear power plants. The second issue is the reference to "land-based" civil nuclear power plants. Some authors, in line with the ordinary meaning of the word land-based,[874] conclude that floating SMRs are excluded from the scope of the CNS, while others argue that if an SMR is close to shore and connected to a land-based grid, it could be considered a land-based nuclear power plant.[875] This second interpretative approach relies on the idea that, when considering the ordinary meaning of the term "land-based" in good faith and in light of the object and purpose of the treaty, a less restrictive application is appropriate, given that such near-shore applications connected to land-based grids or facilities were not foreseen at the time of adoption and in many respects resemble land-based plants on the shore. This interpretation can be considered legitimate, though one may argue that it stretches the ordinary meaning of the term too far through the context, object and purpose of the treaty. It remains challenging to determine in which situations floating nuclear power plants (FNPPs) could be considered covered under the Convention. It is clear that SMRs far from land and not connected to land-based grids or facilities would not fall under the CNS; however, the subsequent practice and agreements of the parties could help clarify this ambiguity in the interpretative process regarding FNPPs close to shore and connected to the grid. Further concerns can also be raised regarding transportable SMRs (TNPP) – specifically, whether the term "land-based" refers to a fixed land-based position or simply to being located on land. The second, broader interpretation would seem more appropriate in light of the object and purpose of the Convention, as the transportable nature of the installation should not prevent the fulfilment of its core objectives – namely, to establish a high level of nuclear safety worldwide and to prevent accidents. That said, in this particular case, the potential clarifying role of subsequent practice or agreement cannot be emphasised enough. Regarding how a clearer interpretation be achieved the sometimes-criticized incentive nature of the CNS could in fact prove helpful in reaching a common understanding on this issue.

It can therefore be concluded that SMRs can fall under the scope of the Convention, however questions remain open with regards to transportable and floating nuclear power plants.

[872] IAEA, 2000.

[873] Meaning that it is complementary to the scope of the CNS thus covering installations that the CNS was not adopted to cover. In the sphere of nuclear safety, there is no such other complementary instrument that covers other installations thus the CNS could be interpreted broadly covering installations other than research reactors and the limitations found in the text.

[874] Van Kalleveen, 2022, p. 4.

[875] Trajano and Chew, 2023, p. 5.

4.1.2.2. Nuclear waste and spent fuel management

4.1.2.2.1. Joint Convention on the Safety of the Spent Fuel Management and on the Safety of Radioactive Waste Management

In managing nuclear waste and spent fuel, the most important international binding instrument is the Joint Convention on the Safety of the Spent Fuel Management and on the Safety of Radioactive Waste Management, which can be considered as the sister convention of the CNS. Although both are incentive conventions, there are differences in how broadly they cover the fields addressed under their respective frameworks. Article 3 of the Joint Convention sets out its scope of application, stating that it applies to two areas: first, the safety of spent fuel management when it results from civilian nuclear reactors, and second, the safety of radioactive waste management when it results from civilian applications. The Convention clearly declares that it does not apply to spent fuel or waste resulting from military applications, unless a Contracting Party declares otherwise. This civilian–military distinction ceases to apply once such materials are permanently transferred to, and managed within, an exclusively civilian program.

Regarding spent fuel, the definition of which is contained in Article 2(n)[876] the Convention appears applicable to it even if originating from SMRs. Arguments similar to those raised under the CNS – such as whether SMRs qualify as nuclear power plants – are irrelevant here, as the Joint Convention uses the term "nuclear reactor", which naturally encompasses SMRs and moreover it makes no geographical distinctions.

As for the other category of nuclear waste defined in Article 2(h)[877] the Convention uses an even wider formulation, referring to waste "resulting from the operation of civilian applications", making the civilian nature of the application the only relevant criterion and thus being applicable to waste originating from SMRs.

The first sentence of the preamble further supports this broad interpretation, by stating that "the operation of nuclear reactors generates spent fuel and radioactive waste", thereby generalizing that such spent fuel and waste arises from the operation of all reactors regardless of their type.[878]

Moreover looking at the objectives set out in Article 1 – such as maintaining a high level of safety worldwide in spent fuel and radioactive waste management, and protecting society and the environment from the harmful effects of ionizing radiation while taking into account the needs of future generations – these further reinforce the view that fuels and waste originating from novel technologies are to be covered by the Joint Convention. There are also no limiting provisions in the Convention regarding floating or transportable SMRs either.

As can be seen, the Convention has a broad scope, focusing not primarily on the installations that generate spent fuel and waste, but on the spent fuel and waste themselves. This approach, together with the objectives it contains, makes the Convention applicable to these technologies

[876] "Spent fuel" means nuclear fuel that has been irradiated in and permanently removed from a reactor core.

[877] "Radioactive waste" means radioactive material in gaseous, liquid or solid form for which no further use is foreseen by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party, and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework of the Contracting Party.

[878] Moreover, the 8th point of the preamble has to be highlighted discussing the exclusion of spent fuel and waste regarding defence programs, but it still states that these should nevertheless be managed according to the Convention even though its not binding in respect of them.

without requiring any further specific consideration. Similar broad conclusions have also been reached by other authors regarding the applicability of the Convention to fusion reactors, arguing that the definition of nuclear waste in the Joint Convention is broad enough to cover them as well.

4.1.2.3. Emergency preparedness and response

In this aspect, two major instruments should be highlighted, both of which were adopted in the wake of the Chernobyl catastrophe: the Convention on the Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

4.1.2.3.1. Convention on the Early Notification of a Nuclear Accident

The Notification Convention, as its name suggests, addresses how signatories should carry out notifications in the event of nuclear incidents. Article 1 of the Convention sets out its scope of application, stating that it applies "in the event of any accident involving facilities or activities of a State Party or of persons or legal entities under its jurisdiction or control, referred to in paragraph 2 below, from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State."[879] The facilities from which such a release can occur are listed in Article 1(2), where the first listed facility is "any nuclear reactor wherever located". As previously concluded in the case of the Joint Convention, the term nuclear reactor naturally encompasses SMRs, and the wording "wherever located" covers installations beyond those located on land. Moreover, there are no indications in the Convention that it would not cover transportable reactors, which is especially relevant given the reference to 'jurisdiction or control,' a concept that does not necessarily require these facilities to be located on the territory of the state. The only critical issue with this definition is the requirement of an international transboundary release that could be of radiological safety significance for another state. Owing to the inherent safety features of SMRs and their smaller size, they might not result in significant releases if located far from borders, and might therefore not trigger the notification obligation under the Convention in the event of an incident.[880] As to what qualifies as being of radiological safety significance for another state, the Convention does not provide direct guidance, although the preamble offers some context by stating that notifications are necessary so that transboundary radiological consequences can be minimized – without setting any specific threshold implying that even small consequences should be minimized as much as possible. Nevertheless, this requirement for notification remains somewhat ambiguous; this ambiguity however, is not unique to SMRs – although perhaps more relevant – and applies equally to large-scale nuclear plants.

4.1.2.3.2. Convention on Assistance in the Case of a Nuclear Accident or

[879] IAEA, 1986, Art. I.
[880] Van Kalleveen, 2022, p. 5.

Radiological Emergency

The other instrument, the Assistance Convention, covers the cooperation of States Parties and the IAEA in the event of a nuclear incident or radiological emergency. The Convention refers generally to cooperation "in the event of a nuclear accident or radiological emergency"[881] and does not establish any further requirements regarding location or other limiting conditions. Article 2 of the Convention clarifies the scope referenced in Article 1 by stating that assistance can be requested in the case of a nuclear accident or radiological emergency "whether or not such accident or emergency originates within its territory, jurisdiction or control".[882] This explicitly confirms that assistance may be requested not only when such emergencies occur in the territory of the requesting state, but also when they originate in the territory, jurisdiction, or control of other states. From this, it can be concluded that there are no limiting factors preventing the application of the Convention to SMRs, including floating and transportable nuclear power plants, even if they are not in the territory of the state but under its jurisdiction or control. Such an approach – covering all possible incidents and emergencies – is in line with the objective enshrined in the preamble, which is to mitigate the consequences, without requiring that the accident be significant in scale.

4.1.2.4. Nuclear security

Nuclear security for a long time was regarded as an issue falling exclusively within the national sphere, but over time it became increasingly evident that states must cooperate in this area.[883] In this regard, the most important binding international instrument to be discussed here is the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment (A/CPPNM).

4.1.2.4.1. Convention on the Physical Protection of Nuclear Material

The CPPNM applies to nuclear material used for peaceful purposes while in international transport, and – with respect to certain provisions, such as the criminalisation of specific acts – its application also extends to nuclear material used for peaceful purposes while in domestic use.[884] The definition establishes quite broad coverage, explicitly excluding only nuclear material intended for military applications, and imposing no further limitations – besides, of course, the international transport requirement discussed above – since the decisive factor is the nuclear material itself, not the installation in which it will be used. Article 1 of the Convention provides a broad definition of the covered fissile materials, which includes those intended to be used in SMRs. Some have argued that moving floating nuclear power plants and transportable SMRs could be considered as nuclear material in international transport and thus fall under the CPPNM.[885] However, counterarguments can be raised against this view, pointing out that it disregards the definition of international nuclear transport in the Convention, which describes

[881] IAEA, 1987, Art. 1.
[882] Id., Art. 2.
[883] Németh, 2024, p. 117.
[884] IAEA, 1980.
[885] Fialkoff, 2020, pp. 103–147. Karcz, 2024, p. 45.

it as "departure from a facility of the shipper in that State and ending with the arrival at a facility of the receiver." This implies three distinct 'facilities' where the material is located: the departure facility, the international shipping means, and the receiving facility. If an FNNPP or a TNPP were treated as international transport, there would be only one facility – the FNNPP or the TNPP itself. Nevertheless, it is also true that an FNNPP or TNPP crossing borders would factually constitute international transport of nuclear material. This issue, however, still requires resolution, as the Convention provides no clear interpretation.

4.1.2.4.2. Amended Convention on the Physical Protection of Nuclear Material

The Amended CPPNM extended the scope of physical protection to nuclear material used for peaceful purposes in use, storage and transport – without any requirement that this be international. Moreover, and more interestingly for present purposes, it also introduced the protection of nuclear facilities used for peaceful purposes.[886] The Convention defines a nuclear facility as "a facility – including associated buildings and equipment – in which nuclear material is produced, processed, used, handled, stored or disposed of, if damage to or interference with such facility could lead to the release of significant amounts of radiation or radioactive material."[887] This broad definition of nuclear facility, which is based on its link to nuclear material, could be applied to all types of SMRs, thereby establishing the physical protection of the facilities themselves. However, the part of the definition referring to the release of "significant amounts of radiation or radioactive material" could be argued not to apply to all SMRs. The Convention does not give an answer to what can be considered the release of "significant amounts" of radiation, but looking at it in light of the objectives of the Convention contained in Article 1A – which is to "maintain worldwide effective physical protection…of nuclear facilities used for peaceful purposes" – and knowing that the definition of facility is very broad, also including disposal facilities and other facilities from where there could be very small amounts of radiation releases, it seems unlikely that reactors would be excluded from the scope on this basis. Nevertheless, in this regard, the agreement of the parties or their subsequent practice could help clarify these ambiguities; and it has to be mentioned that even if certain SMR facilities would not be considered covered as facilities, the nuclear material within them would still remain subject to the Convention's protection.

4.1.2.5. Safeguards

One of the general challenges posed by the proposed nuclear renaissance is the associated proliferation risk. The more plants there are, the more nuclear material will be in use, and, naturally, the risk of proliferation increases correspondingly.[888] From this perspective, SMRs can pose even greater challenges to the existing non-proliferation framework, since their reduced size and smaller capacity mean that they are likely to be deployed across multiple smaller sites rather than concentrated at a single large one. It stands to reason that accounting

[886] Vez Carmona, 2005, pp. 40–41.
[887] IAEA, 2005, Art. 1.
[888] Prasad, 2015, pp. 102–109.

for nuclear material at a single site is considerably easier than carrying out this activity across numerous sites, without even considering the transportation of such material to and from those sites.[889] Moreover, certain SMR designs propose the use of higher enrichment levels, which must be noted as making these fuels significantly more attractive for the fabrication of nuclear weapons.[890] What is more, in the case of transportable SMRs, these could be more difficult to detect and could potentially be converted to non-peaceful uses.[891] Although SMRs offer certain features to enhance proliferation resistance – such as sealed designs[892] and high burn-up rates[893] – the international non-proliferation framework must nevertheless address them, since their potentially widespread deployment could pose a considerable proliferation risk if not adequately addressed.[894]

4.1.2.5.1. Treaty on the Non-Proliferation of Nuclear Weapons

The fundamental treaty in the field of safeguards is the Non-Proliferation Treaty (NPT),[895] which was adopted to put an end to the nuclear arms race.[896] Although it has not been entirely successful putting an end to the development of nuclear weapons according to some estimates, without its adoption, there would be at least 30–40 nuclear-weapon states today.[897] The treaty establishes the foundations of the safeguards system, under which the IAEA concludes safeguards agreements with states depending on their status: nuclear-weapon states can have voluntary safeguards agreements, non-nuclear-weapon states have comprehensive safeguards agreements, and states not party to the Treaty can have item-specific safeguards agreements. The scope and content of these agreements vary according to the type of agreement. The safeguards system is set forth in Article 3 of the Treaty, which requires that safeguards be applied to "source or special fissionable material whether it is being produced, processed, or used in any principal nuclear facility, or is outside any such facility", in all peaceful nuclear activities within the territory of such a state, under its jurisdiction, or carried out under its control anywhere.[898] As we can see, the NPT definitions specifically refer to peaceful activities, and therefore it cannot be applied to military SMRs; however, apart from that limitation, it has a broad scope. The reference to special fissionable material also seems to apply to SMRs, as they are nuclear facilities containing fissionable material. Moreover, the reference to activities under a state's jurisdiction or control means that the Treaty would also apply to floating and transportable SMRs not strictly located within the territory of the state. Such a broad coverage is consistent with the object and purpose of the Treaty, as reflected in its preamble, which emphasizes "the need to make every effort to avert the danger of such a war and to take measures to safeguard the security of peoples".

[889] Whitlock and Sprinkle, 2012, pp. 9–12.
[890] Prasad, 2015, pp. 102–109.
[891] Christoph et al., 2023, p. 6.
[892] Prasad, 2015, pp. 102–109.
[893] Virgili, 2020, p. 17.
[894] Siegel et al., 2018, p. 242.
[895] IAEA, 1968.
[896] Lamm, 2013, p. 81.
[897] Id., p. 82.
[898] IAEA, 1968, art. 3.

4.1.2.5.2. INFCIRC/153 (Comprehensive safeguard agreement)

The most relevant of the safeguards agreements, for present purposes, is the Comprehensive Safeguards Agreement (CSA), since under this agreement the IAEA ensures that safeguards apply to all nuclear material in the country, whereas under the other two types of agreements, states retain broad discretion in determining the scope of the safeguards. The INFCIRC/153 document, titled "The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons," sets out the basis on which such agreements are concluded. Under the section titled "Application of Safeguards", the document states that safeguards shall be applied "on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction, or carried out under its control anywhere."[899] Non-peaceful activities are excluded from the scope, and there is a specific reference to the use of otherwise safeguarded material in non-peaceful activities. Apart from this exclusion, the scope of the document is quite broad. The document itself does not define what special fissionable material is, as it refers to "nuclear material" which it defines by reference to special fissionable material as set out in Article XX of the IAEA Statute.[900] Given this definition, it follows that the material used in SMRs falls within the agreement's scope.[901] Moreover, the document referring to jurisdiction and control means that the same conclusions can be drawn here as in the case of the NPT in respect of the location of the plant.[902] Such a broad interpretation of the safeguards' coverage aligns with the objectives of safeguards contained in Paragraph 28, which states that "the objective of safeguards is the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection". The conclusion that the CSA covers SMRs was also reached at an IAEA conference, where experts in the field stated that in countries having comprehensive safeguards agreements, all nuclear reactors must be safeguarded regardless of their size or technology, including SMRs.[903] Nevertheless, in practice, the IAEA's verification procedures under the CSA might face challenges – such as cases where SMRs are fuelled in one country and then transported to another for operation[904] – but these can be addressed through cooperation between the IAEA and vendors at an early stage of development to ensure that the verification process can be effectively carried out in the future.[905]

Although the safeguards system has generally worked well for declared activities, the IAEA recognized that it could not fully verify whether additional undeclared nuclear material or activities existed beyond what states had reported.[906] To address this concern, the Model Additional Protocol (AP) was adopted. Under this instrument, the IAEA is granted expanded rights to information and access, enabling it to obtain a more comprehensive picture of all

[899] IAEA, 1972, para 2.
[900] IAEA, 1956, para 112.
[901] Id., art. XX.
[902] This could potentially mean that it applies to floating SMRs in international waters when under the control of the state.
[903] Cabañas, 2021.
[904] Nriezedi-Anejionu, 2024.
[905] Id., p. 97.
[906] *IAEA Additional Protocol*, no date.

nuclear-related activities and materials within a state, not just those declared under the CSA.[907] Article 2 of the AP elaborates on its scope,[908] which in essence is similar to that of the CSA but encompasses an even broader range of activities. Consequently, it can be concluded that SMRs also fall within the scope of the AP.

4.1.2.6. Nuclear liability

Liability issues connected to SMRs pose one of the most challenging questions, consequently these have also been the most discussed. The settlement of liability matters – such as determining the liability amounts for inherently safer plants, or addressing the situation where they are manufactured in one country and transported to another – will significantly impact the success of their deployment. As a short introduction to the liability conventions that will be addressed in this section, it should be noted that two concurrent liability regimes emerged: one was established under the auspices of the IAEA, and the other within the predecessor of the OECD Nuclear Energy Agency. The countries intended to be covered by these conventions was different; the convention under the auspices of the NEA mostly covered Western European countries, while the convention under the auspices of the IAEA aimed for global coverage. Since it became apparent that there would not be a single convention covering all countries, the international community recognized that the issue of accidents occurring in a country party to one convention and having effects in another country party to the other convention had to be resolved. To address this, a Joint Protocol was adopted to link the two separate regimes.[909] In the following section, the two liability regimes will be elaborated upon regarding their applicability to SMRs, supplemented by the Joint Protocol and the Convention on Supplementary Compensation for Nuclear Damage.

4.1.2.6.1. Paris Convention on Third-Party Liability in the Field of Nuclear Energy

The first liability regime established was the Paris Convention on Third-Party Liability in the Field of Nuclear Energy (Paris Convention). The Convention covers "nuclear damage originating from nuclear installations". From the perspective of SMRs, the Convention defines nuclear installations, among others, as "reactors other than those comprised in any means of transport".[910] The term reactor is not further defined in the Convention and can be interpreted broadly, potentially encompassing a wide range of SMRs. However, when considering the context, the *Exposé des Motif*s[911] clarifies that this definition does not include sub-critical assemblies,[912] as has also been noted by other commentators.[913]

Regarding the territorial scope, the Convention applies to the territory of the party, including its territorial sea. This definition of territory is particularly important from the perspective of

[907] Ibid.
[908] IAEA, 199.
[909] Burns, 2022, pp. 94–95.
[910] OECD, 1960, Art. 1.
[911] Id., art. 1(a)(ii), (v), 1(b).
[912] Sub-critical assemblies: which are not capable of maintaining a self-sustaining chain process of nuclear fission.
[913] Roland, 2023, p. 17.

SMRs, as highlighted before.[914] Under international public law, the generally accepted view is that a state's territory comprises the area under its effective control, which extends into maritime zones and even outer space. With regard to maritime zones – especially relevant for floating SMRs – the territory of a state includes its internal waters – behind the baselines – and its territorial sea – up to 12 nautical miles, – both of which are considered part of the state's territory.[915] Accordingly, SMRs located within a state's territorial sea could fall within the scope of the Convention.

Importantly, the Convention excludes from its scope reactors comprised in any means of transport, which covers a wide range of transport modes such as water, rail, or truck. The *Exposé des Motifs* adds further explanation, stating "used or incorporated for use in a means of transport as a source of power for any purpose". This statement clearly indicates that, beyond the propulsion of the transport means, other purposes for which a reactor is used in the transportation means are explicitly excluded. The interpretation of these transport means, and whether this exclusion also applies to floating and transportable SMRs, is quite challenging. Examining the objective of the Convention does little to resolve this issue.[916] One can interpret "any purpose" broadly, potentially including a FNPPs that only supplies power outside the scope of the transport means, or narrowly, referring only to use within the transport means itself; in the latter case, FNPPs or transportable SMRs would be covered by the Convention. The narrower interpretation, considering the time of adoption of the Treaty[917] which did not foresee applications such as an FNPP supplying power externally but was aware of potential use of reactors in transport for propulsion – may seem more appropriate, however a conclusion reached on the basis of the broader interpretation seems equally reasoned.[918][919]As will be seen with the Vienna Convention, secondary means of interpretation might come suggest a correct interpretation but this is not the case with the Paris regime. Nevertheless, subsequent practice and agreement remain crucial tools that could help overcome this interpretative challenge.

As stated in the *Exposé des Motifs*,[920] the Convention – besides the preamble, which notes "whilst taking the necessary steps to ensure that the development of the production and uses of nuclear energy for peaceful purposes is not thereby hindered" – does not make any explicit reference to the scope of application based on the distinction between peaceful and non-peaceful uses. Thus, from the instrument alone it cannot be conclusively stated that the Convention excludes military applications, as the preamble does not explicitly connect the reference to peaceful uses with liability issues.[921]

From the perspective of SMRs, another interesting aspect is the possibility of reduced liability amounts. In this case, states must make available funds to cover damages exceeding these lowered amounts.[922] Furthermore, Article 1(b) provides the possibility of excluding

[914] Van Kalleveen, 2022, p. 7.
[915] UN, 1982.
[916] Id., para 3.
[917] Also reassured by the adoption of the Convention on the Liability of Operators of nuclear ships which aimed to cover a specific area although never it entered into force.
[918] Same conclusion was reached by others. See Roland, 2023, p. 20.
[919] OECD, 1960, art. 13c. (Possibly outside the territory.)
[920] Id., exposé des motivs 18(d).
[921] Roland, 2023, p. 35.
[922] OECD, 1960, Art. 7(b).

installations if the small extent of the risk involved so warrants.[923] These two factors, which bring flexibility to this instrument, can be particularly important from an SMR perspective.[924] However, the determination of how and to what extent these reduced liability amounts apply rests with each state. There is no one-size-fits-all solution for SMRs; reduced liability amounts must be evaluated on a case-by-case basis, taking into account the specific features, size, and location of the individual SMR.

4.1.2.6.2. Brussels Convention Supplementary to the Paris Convention

The primary reason behind adopting the Brussels Convention was to provide additional funds in the event of nuclear accidents.[925] The Brussels Convention uses the same definitions as the Paris Convention; however, there are differences regarding its scope of application. The Convention covers nuclear installations as follows: "applies to nuclear damage for which an operator of a nuclear installation, used for peaceful purposes, situated in the territory of a Contracting Party to this Convention is liable under the Paris Convention."[926] The conclusions regarding the definition of territory are equally applicable here. Moreover, the definitions concerning nuclear installations are the same as those applied in the Paris Convention and must be followed in the context of the Brussels Convention. However regarding its applicability to non-peaceful uses, the Convention makes a clearer distinction: the preamble states that it seeks to "increase the amount of compensation for damage which might result from the use of nuclear energy for peaceful purposes," explicitly limiting its coverage to peaceful applications. Furthermore, Article 13 stipulates that "all nuclear installations used for peaceful purposes situated in its territory, and falling within the definition in Article 1 of the Paris Convention, appear on a list," again excluding military applications. Moreover the Annex to the Convention, which according to Article 20 is an integral part of the Convention, specifies that for those installations not included on the list, compensation in the event of nuclear damage should not be less than 1,500 million euros. The *Exposé des Motifs* explicitly states in paragraph 8(b) that it applies to nuclear installations not used for peaceful purposes, thus establishing a minimum liability amount for such cases.

4.1.2.6.3. Vienna Convention on Civil Liability for Nuclear Damage

The Vienna Convention covers nuclear damage caused by a nuclear incident, one possible origin of which is the nuclear installation itself.[927] A nuclear installation is defined, among other things, as "any nuclear reactor other than one with which a means of sea or air transport is equipped for use as a source of power, whether for propulsion thereof or for any other purpose."[928] Firstly, the term "source of power," encompassing propulsion and any other purpose, must be addressed. In line with the ordinary meaning of the text, this can be interpreted as referring to using this power in connection with the operation of the means of sea or air

[923] Such an exclusion in the case of SMRs does not seem too likely.
[924] Sharp and Blahoudková, 2025, p. 285.
[925] Kecskés and Oláh, 2024, p. 671.
[926] OECD, 1963, Art. 2.
[927] IAEA, 1963a.
[928] Id., art. 1.

transport, and not as sourcing this power externally as also concluded by the International Expert Group on Nuclear Liability (INLEX).[929] As we can see, the exclusion here is less broad than in the case of the Paris Convention, where transport was generally excluded from the scope of application. Here, there is only a specific reference to sea and air transport; reactors transported over land are not excluded. There is a reason behind this, during the negotiation of the Convention, the US delegates sought to clarify the text. The US was testing trailer-mounted reactors for disaster relief, which would only be used in a stationary position to supply power externally. Therefore, they proposed to change the wording from "any nuclear reactor other than one with which a means of transport is equipped for use as a source of power" – as in the Paris Convention – to "any nuclear reactor other than one with which a means of sea or air transport is equipped for use as a source of power." This secondary interpretation method, based on the preparatory works, indicates that land-based transport was deliberately left out, and thus the Convention clearly covers transportable land-based SMRs when they are stationary and generating power.

However, as we have concluded previously regarding the meaning of source of power – that it only refers to sourcing power for operating reasons in line with the opinion of INLEX and that external sourcing is not excluded from the scope – was it really necessary to specifically refer to excluding sea or air transport and to not mention land-based transportation, when from the intention of the signatories we can see that only stationary external operations were intended to be included regarding the land-based applications? This issue was raised by the Russian delegation, which preferred the previous clearer terminology, stating that if these transportable plants would only operate when stationary, they would have been covered by the initial wording as well. In effect, this clarification only created more confusion, as at first reading the text suggests that land-based transportable SMRs used for propulsion thereof or for any other purpose could be covered since they are explicitly not included in the exclusion. This confusion could be further elevated if one considers that only sea applications are excluded, not other waterways; however, in light of the overall interpretation also supplementary means this distinction is not that relevant anymore.

As mentioned, the definition of installation includes nuclear reactors, which are defined in the Convention as "any structure containing nuclear fuel in such an arrangement that a self-sustaining chain process of nuclear fission can occur therein without an additional source of neutrons." This definition is very inclusive and would generally cover SMRs; however, the same conclusion as in the case of the Paris Convention can be made here as well – that subcritical reactors would not be covered under this definition.[930]

The next issue that has to be addressed are the military applications. The preamble, serving as context during the interpretation of the Convention, states that the treaty seeks to establish "minimum standards to provide financial protection against damage resulting from certain peaceful uses of nuclear energy", which suggests that military applications are not included in the scope of the Convention. This reference directly links the applicability of the liability rules to peaceful uses so in this case unlike in the Paris Convention, by primary means of interpretation, a clearer conclusion can be reached regarding what the Convention intends to

[929] McIntosh, 2022, p. 260.
[930] Roland, 2023, p. 16.

cover. This intention is further reinforced by the IAEA Statute,[931] and, as a secondary means of interpretation, by the negotiations leading up to the adoption of the Convention, which explicitly referred to peaceful uses several times.[932]
The final issue that should be discussed regarding the Convention is reduced liability and small quantities of nuclear material. Unlike the Paris Convention, the Vienna Convention does not have provisions on reduced liability amounts for low-risk installations, but it includes a provision on small quantities of nuclear material, which states can exclude from the application of the Convention "if the small extent of the risks involved so warrants", though this exclusion applies only to the material and not to the installation.[933]

4.1.2.6.4. Revised Vienna Convention

The Vienna Convention was amended in 1997 to provide increased funds and to cover previously excluded areas.[934] The amended version did not change the definitions regarding nuclear installations or nuclear reactors in a way that would affect the previously reached conclusions about scope.
However, regarding the applicability of the Convention to non-peaceful activities, the revised Vienna Convention explicitly declares that it does not apply to installations used for non-peaceful purposes, as Article 1(b) was introduced stating this exclusion. Thus, SMRs involved in non-peaceful activities are not covered by the Convention.
Furthermore, the possibility of excluding installations and allowing reduced liability amounts for low-risk installations was also revised. In terms of exclusions, beyond the already existing possibility to exclude certain materials, the amendment made it possible, "if the small extent of the risks involved so warrants", to exclude any nuclear installation from the scope of the Convention, provided that this exclusion by the installation state satisfies the exclusion criteria established by the IAEA Board of Governors. As for low-risk installations, contrary to the original Vienna Convention being silent on this matter, the revised version introduced a new provision in Article 5(2) stating that the installation state, considering the nature of the installation and the likely consequences of an incident originating from it, may establish lower liability amounts with a minimum of 5 million SDR, but the state must make available the difference between this lower amount and the regular minimum amount. As in the case of the Paris regime, it remains an open question whether SMRs will fall into this category of installations or not, but deciding on this matter rests with the installation state.

4.1.2.6.5. Convention on Supplementary Compensation for Nuclear Damage

The Convention on Supplementary Compensation for Nuclear Damage (CSC) is an independent convention, created in the wake of the Chernobyl catastrophe through a rethinking of the Vienna Convention.[935] It provides supplementary compensation via the national laws of

[931] Id., pp. 34–35.
[932] IAEA, 1963b, pp. 66, 99–100, 107, 250, 277.
[933] IAEA, 1963a, art. 1.
[934] *Vienna Convention on Civil Liability for Nuclear Damage*, no date.
[935] Kecskés and Oláh, 2024, p. 673.

Vienna Convention states, but non-Vienna states can also become parties.[936]
Regarding its scope, the Convention covers "nuclear damage for which an operator of a nuclear installation used for peaceful purposes situated in the territory of a Contracting Party is liable under either one of the Conventions referred to in Article I or national law".[937] In terms of the installation state's territory, the Convention also covers installations that are not on the territory of the state but are under its authority.
As for the definition of nuclear installations, the definitions used in the Vienna and Paris Conventions are applicable, and the definitions contained in the CSC's Annex can also be used. The Annex provides two definitions: the first is identical to that found in the Vienna Convention, while the second – used to assess the conformity of national legislation with the Convention – employs a different definition referring specifically to civil installations, and, with respect to reactors, closely resembles the Vienna Convention's definition, while also explicitly including civil processing, reprocessing and storage facilities. Consequently, the same conclusions can be drawn here as for the previously discussed definitions.
As the Convention uses the same reactor definition as the Vienna Convention the same conclusion applies that aside from sub-critical reactors it is very broad and would encompass SMRs.
Concerning military applications, Article II of the Convention declares that it applies only to damage originating from peaceful purposes.
Finally, regarding the exclusion of installations and lower liability amounts, the Convention contains provisions similar to those in the revised Vienna Convention, setting the minimum amount at 5 million SDR for low-risk installations.[938] Concerning the exclusion of installations, the Convention also repeats the text of the revised Vienna Convention, so the same conclusions can be drawn here.

4.1.2.6.6. The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention

The last instrument within the scope of nuclear liability to be addressed is the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, which seeks to establish a connection between the two liability regimes so that, in cases of transboundary damage, the coverage is extended geographically.[939] The Joint Protocol, in Article 2, declares that an operator of a nuclear installation situated in the territory of a Vienna state or a Paris state is liable, according to their respective conventions, for nuclear damage suffered in the territory of a state party to the other convention and to the Protocol. The Protocol refers only to the territory of a state and does not refer to jurisdiction or control, so ambiguities could arise in relation to SMRs that are located outside a state's territory but are under its control.[940] Article 4 of the Protocol makes articles of the Vienna and Paris Conventions applicable to parties to the other convention and to the Protocol, and these include the definitions. Therefore, the

[936] Roland, 2023, p. 16.
[937] IAEA, 1997, art. 2.
[938] Id., Annex to art. 4.
[939] Lamm, 2013, p. 21.
[940] Roland, 2023, p. 31.

definitions regarding nuclear installations and reactors – and the conclusions previously reached regarding their applicability to SMRs – also apply under the Protocol.
Regarding the applicability to peaceful or non-peaceful activities, the Protocol itself remains silent. Thus, through the use of Article 4, we must refer to the original conventions and their scope regarding these installations. However, the problem with this method is that Article 4 refers only to specific articles of the two regimes and does not include their preambles, whereas in both the original Vienna and Paris regimes the only references to these installations were found in the preambles. Consequently, there is a great deal of ambiguity regarding non-peaceful applications This highlights the possible important role of subsequent practice – which, in this case, would obviously be undesirable as it would imply a nuclear incident – or agreement in overcoming this issue.
Finally, regarding the reduced liability of low-risk installations, the possibility of exclusions or reduced liability amounts depends on which convention the installation state is party to. For example, if it is a party to the original Vienna Convention, there is no possibility for reduced liability amounts, whereas if it is a party to the revised Vienna Convention, there is an option to allow reduced amounts for low-risk installations.

4.1.2.7. Instruments addressing environmental considerations

4.1.2.7.1. Espoo Convention on Environmental Impact Assessment in a Transboundary Context

The Espoo Convention plays a crucial role in the deployment process of nuclear power plants, primarily in European countries. Under the Convention, contracting parties must ensure that they carry out transboundary environmental impact assessments before granting a license to any activity likely to cause a significant adverse transboundary impact.[941] Nuclear power plants and reactors – except research ones – are covered by Appendix I of the Espoo Convention, and state parties to the Convention acknowledge that such nuclear installations are capable of causing significant adverse transboundary impacts.[942] However the situation might be more complex in the case of safer SMRs that are sited in remote locations and have smaller fuel inventories.[943] The terms nuclear power plants and nuclear reactors appear broad enough to encompass many if not all SMRs. However, the key question is whether they are capable of causing a significant adverse transboundary impact. There is no comprehensive definition of this phrase, but Appendix III of the Convention gives guidance for interpreting significant and adverse, while transboundary and impact are defined in Article 1 of the Convention. This question must be decided by the country of origin, taking into account the characteristics of the activity, its location, and its potential impacts. The combined evaluation of these factors will determine whether a transboundary EIA is required.[944] In the case of SMRs, this means they cannot be categorically excluded from the scope of the Convention; instead, they must be evaluated on a case-by-case basis considering their design features, location, and potential impacts. It is possible, for example, that SMRs located in very remote regions may not require

[941] Emmerechts, 2008, p. 96.
[942] Raetzke, 2013, p. 72.
[943] Sexton Nick, 2023, pp. 14–15.
[944] Tesli and Husby, 1999, pp. 72–74.

a transboundary EIA, however considering the decision of the Implementation Committee it seems highly unlikely that SMRs in practice would not be required to conduct a transboundary EIA. Regarding the geographical scope of the Convention, the definition of party of origin is important, as it establishes the connection between the activity and the state based on jurisdiction rather than territorial location. In this way, SMRs not located in the territory of the state but under its jurisdiction would also theoretically be covered.
Besides these issues, SMRs may raise additional questions in the case of multi-module plants specifically, whether the addition of further modules on an existing site would require new EIAs or not?[945]

4.1.2.7.2. Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters

In the field of public participation regarding environmental issues, the Aarhus Convention plays a very significant role, as it grants crucial procedural rights.[946] The Convention has three pillars: access to environmental information, public participation in environmental decision-making and access to justice. The Convention's scope with regards to access to environmental information is very broad, there are possibilities to refuse information, but these have to be interpreted restrictively. Information relating to SMRs could be covered here, as there is no specific reference to the activities it covers. Regarding public participation in decision-making, Article 6 refers to Annex I of the Convention, which lists the activities, among them installations of the nuclear sector. More interestingly from our perspective, it specifically mentions nuclear power stations and other nuclear reactors. The categories contained here seem broad enough to cover a wide range of SMRs regardless of their type and location, as the decision process relating to these plants is the decisive factor. Moreover, contrary to the Espoo Convention, in the case of the Aarhus Convention the possibility of significant adverse transboundary effects is not required, thus even remote SMRs would fall under its scope. Finally, the third pillar comes into play when rights under the first or second pillar are violated. Its scope derives from the previously addressed two pillars and, subsequently, it can cover SMRs.

4.1.3. Summary of SMR-specific challenges faced by the international legal framework

By analysing these main international instruments governing specific areas of the nuclear sectors, several conclusions can be drawn. The first very apparent thing, as was also concluded in the European Commission Study, is that SMRs are not addressed explicitly in the existing international legal framework, naturally, as most of these instruments were adopted long before SMRs became a hot topic.[947] Subsequently, as these do not explicitly address SMRs, interpretation plays a key role in concluding whether these instruments apply to them or not. Through this interpretative procedure, it can be concluded that SMRs are generally covered under the previously evaluated instruments, since they are more or less technology neutral.

[945] Sexton Nick, 2023, p. 16.
[946] Sexton Nick and Bowden, 2022, p. 260.
[947] Van Kalleveen, 2022, pp. 11–12.

However, this doesn't mean that certain attributes of these reactors don't raise issues. The first group of challenges relates to issues that arise in the practical application of the conventions, while the second, more complex category concerns questions about the fundamental applicability of the conventions to SMRs, particularly in relation to specific design or operational characteristics.

In the first category we can find issues such as the requirement of a "significant adverse transboundary effect" under the Espoo Convention which may not be met for certain SMRs located in remote regions, and the multi-module SMRs which could raise additional questions regarding Environmental Impact Assessments. Similarly, in the Early Notification Convention, the criterion of a transboundary release "of radiological safety significance" remains an open question for SMRs. Furthermore, the reduced liability provisions for low-risk installations – present in all liability conventions except the original Vienna Convention – also raise uncertainty as to the conditions under which SMRs might qualify for such treatment. These issues were unprecedented in case of conventional nuclear plants, but they are relevant to be answered for SMRs. Resolving these is not primarily an interpretative task aimed at establishing a common understanding; rather, it is a practical matter. The conventions use this terminology and provide for special categories on purpose; determining whether a particular SMR falls within such a category requires a case-by-case evaluation that cannot be fully determined in advance.

The second category involves fundamental interpretative challenges arising from specific features of SMRs. One such feature stems from their reduced size compared to conventional plants, which allows for a much broader range of siting options. Some SMRs are proposed for remote locations, while others are intended for floating platforms, and these characteristics can, in certain cases, stretch the applicability of existing treaties. Significant issues arise in this context concerning the Convention on Nuclear Safety, which refers specifically to land-based plants, as well as the liability conventions. In these cases, evolutive interpretation – as a tool for bringing the application of these instruments in line with current technological developments – can play a crucial role. Addressing these issues through interpretation is particularly urgent, given that some SMRs, such as the floating Akademik Lomonosov, are already deployed in such novel locations.

Another feature related to the smaller size of these plants is their transportability, which raises issues under several of the regimes discussed. For instance, again regarding the CNS, it remains to be clarified whether the term land-based refers strictly to a fixed location on land or whether it can also encompass movable reactors. Similarly, under the liability conventions, it is unclear whether the exclusion of reactors incorporated in transport applies only to reactors that supply power for use on the means of transport itself, or also to reactors on a means of transport that supply power externally. Additionally, the CPPNM raises questions as to whether transportable SMRs can be considered as nuclear material in transport or not. Although some interpretative efforts have been made to address these questions, they remain open, and further clarification through tools such as subsequent practice or agreement among the parties could provide more definitive answers.

Another overarching, problematic area – not specific to SMRs, but generally challenging in the nuclear field – is the potential military application of these plants. As mentioned, this is a general concern; however, in the case of transportable SMRs, which could supply power

initially for civilian purposes and potentially later for military ones, or vice versa, additional concerns arise compared to conventional plants. Since such reactors can serve a variety of functions, their small size also makes it possible for them to be used exclusively for military purposes going beyond propulsion which could result in the proliferation of such applications. Most of the instruments addressed here explicitly exclude non-peaceful applications from their scope. However, the liability conventions – particularly the original Paris Convention – may raise questions regarding their applicability to SMRs that are not used in civilian applications and are not comprised in a means of transport. Additionally, the Joint Convention offers an interesting solution, allowing spent fuel and waste previously used in non-peaceful applications to be declared as covered by the Convention.

4.1.4. Concluding thoughts on the challenges that SMRs raise to the current international legal framework

To overcome the fundamental challenges of fitting SMRs into existing frameworks, various solutions have been proposed, including the adoption of a convention specifically dedicated to SMRs. However, this idea faces two main types of problems – one substantive and the other procedural. The substantive issue is that such a solution is not truly necessary. As the analysis of the existing instruments has shown, the areas where the applicability of SMRs raises serious challenges are limited, and only a limited number of questions remain open. Creating an entirely new comprehensive SMR treaty to address these few issues would appear excessive. As a procedural problem the previous practice in the nuclear sector has to be highlighted, which addressed certain areas through separate conventions. Such a practice is, of course, not without reason and is very much rooted in the characteristics of international law. It is highly unlikely that a comprehensive convention addressing SMRs specifically would gain enough support, as it would cover a highly fragmented area where states naturally have differing interests, or it would be too vague in nature. Moreover, even if we disregard these arguments, it must be considered that adopting a new convention in the nuclear sector is a challenging task that might not achieve the anticipated result.

If we abandon the idea of adopting a new comprehensive convention covering SMRs and decide to adopt new individual conventions on SMRs regarding the challenging fields such as nuclear safety or liability, then the arguments of that it is simply unnecessary since the omissions in the current systems are not that major and the fact that how difficult it is to adopt a new instrument still stand.

If this idea is also set aside and we turn to the possibility of amending the existing instruments, a very similar conclusion can be drawn as with adopting entirely new treaties: achieving such formal changes would be extremely difficult.

While challenges undeniably exist, the previously discussed solutions do not appear adequate to address them. Therefore, the author argues that an evolutive interpretation of the current regimes would be a more effective approach. This method would allow these fundamental instruments of the nuclear sector to remain relevant by being brought in line with technological developments. In essence, these instruments establish the basic rules governing certain areas – with some exceptions – and these rules have not become obsolete despite the sector's ongoing technological progress. The obligations set out in these treaties are generally not overburdening,

and where they might be considered so, the treaties themselves already provide mechanisms such as exclusions or special provisions to address such cases. The interpretative approach is practically more feasible due to its less formal nature: states can reach such an evolutive understanding through subsequent agreements or practice. Some conventions even contain mechanisms inherently designed to support this, such as the incentive-based nature of the CNS and its review meetings. Nevertheless, even for instruments that lack such features, pursuing evolutive interpretation would still be far easier than attempting formal amendments or negotiating an entirely new treaty.
These conventions should be preserved and kept applicable to SMRs, with using the tailored approaches provided by the instruments where necessary to account for their specific features. Such an outcome is crucial from the perspective of public perception, which is a particularly important and sensitive aspect of the nuclear field.

4.2. What are the SMR-specific licensing challenges

Although SMRs seem like an up-and-coming energy source and, in many cases, there is a strong interest in them, multiple issues stand as an obstacle to their licensing. Multiple authors highlighted the restrictive nature of the current legal frameworks, and it is seen as one of the major challenges that SMRs have to overcome.[948] The general inadequacy of current legal frameworks in coping with SMRs stems from several distinct problem areas in which improvements are needed, ranging from time constraints to limited regulatory experience with novel technologies. Most of the obstacles identified below are interrelated, and some are direct consequences of one another. The following section discusses the licensing challenges that SMRs face under current regulatory frameworks, each in relation to the specific novel feature of the technology that gives rise to it. Listing the challenges associated with the legal frameworks is crucial to finding adequate solutions to these problems, but the author would like to go beyond it and also elaborate on how these hurdles may be resolved. Regarding these solutions, no concrete pathways can be presented; rather, these are ideas that are generally discussed in the sector. The reason why such a definitive answer cannot be given is that while in theory such solutions may look very promising, we have very limited experience of how they may work in practice, due simply to the fact that very few SMRs are currently under licensing. Nevertheless, in order to create accommodating legal frameworks by the time SMRs are deployed, we need to begin thinking about what solutions may work in the future, and this section intends to contribute to that by connecting SMR novelties with licensing challenges and offering proposals for their resolution. In order to illustrate the practical implications of these licensing challenges associated with SMRs, the author will seek to present how these problems arise in the context of Hungary, which is interested in deploying SMRs. Such an elaboration is particularly relevant as just very recently an amendment was adopted in Hungary which aims to create an accommodating legal framework for SMR deployment by answering these challenges. Consequently, as the amendment will be discussed later in the work, the elaboration on the obstacles in licensing framework prior to its adoption will be particularly relevant, as it will be possible to observe how the reform aimed to resolve these obstacles and what areas it did not address.

[948] Sam et al., 2023, p. 4.

4.2.1. Technological innovation and the proliferation of designs

While the large number of SMR designs currently under development is advantageous in allowing the selection of plants best suited to specific applications – whether in terms of size, site conditions, or intended use – the sheer diversity of proposed designs and their innovative technological features pose significant regulatory challenges. As noted earlier, approximately 127 SMR[949] designs are in development many of which incorporate advanced solutions. Several licensing challenges arise from these advanced reactor technologies and their diverse designs.

4.2.1.1. How does technological innovation challenges existing frameworks?

Firstly, the incorporation of these novel technologies will often require new regulatory approaches and adjustments to existing licensing requirements, many of which contain technology-specific provisions.[950] Traditionally, light water technology was prevailing, and many regulatory regimes were set up to accommodate such reactors.[951] However, from these conventional technologies, SMRs can differ greatly, be it regarding the cooling of the reactors the fuel used, the location or the purpose. A technology-specific framework where the requirements were established to host certain type of reactors have benefits, such as the accumulating regulatory experience, but from the perspective of advanced technologies such as SMRs, they establish requirements that simply mandates excluding given designs.[952] Thus if in the nuclear renaissance countries retain these elements in their national legal frameworks then the potential for more advanced nuclear reactor designs to reach marketability decreases, despite that they may offer significant benefits over the reactor technologies we are most familiar with today. While Hungary's high-level legislative framework is technology-neutral, the implementing legislation was developed to reflect the then-prevailing pressurized water reactor technology.[953] As a result, several SMR technologies are fundamentally incompatible with the existing licensing requirements, which would require adjustments if their deployment is planned, however since these matters fall under the implementing legislation they are not addressed in the amendment.

Another critical consideration is that how the national legal framework foresees the use of nuclear reactors. The prevailing purpose of these reactors was electricity generation, but SMRs propose a lot more diversity in this regard particularly when it comes to heat generation. National legal frameworks can also reflect such uses as in Hungary the legislation preceding the amendment defined nuclear power plants as electricity generating installations, thus heat generation purposes were excluded limiting the plants that could be deployed in Hungary.

A second way in which the diversity of these designs challenges existing licensing procedures is that regulatory authorities have very limited experience in assessing novel designs. Generally, the IAEA suggests opting for those nuclear power plant designs that were already licensed in

[949] NEA, 2025b.
[950] Ramana, Berzak Hopkins and Glaser, 2013, p. 557.
[951] Segarnick and Desai, 2019, p. 37.
[952] Sam et al., 2023, p. 4.
[953] Adorján and Rétfalvi, 2022, p. 4.

the country of origin.[954] Some countries even take this one step further, such as India, where the regulator demands a technology that was licensed in the country of origin.[955] Besides providing reassurance that a design licensed in its country of origin, and deemed safe there by the regulator, can be considered safe for use elsewhere, prior licensing in the country of origin also has essential practical value, as the regulatory experience already gained can prove useful to other regulators faced with licensing the design. From an SMR standpoint, regulatory experience is virtually non-existent at this moment. When undertaking SMR licensing, regulators may therefore, depending on the design, be confronted with technologies with which they have limited or no prior experience,[956] a situation that creates uncertainty as to the licensability of SMR designs[957] and constitutes a significant investment risk. First-of-a-kind designs – which will most likely be the case for SMR deployment – may also necessitate more extensive review processes, leading to longer licensing timelines,[958] to ensure a thorough understanding of the designs and the adoption of well-founded regulatory decisions. Moreover, due to the versatile range of potential applications of SMRs, a single country may be required to assess multiple, radically different reactor designs simultaneously, thereby potentially further overburdening regulatory authorities. As the deployment of technologically innovative designs proliferates, the limited resources of regulators are likely to be challenged,[959] to an unprecedented degree. In Hungary the case is very much similar those working in the nuclear sector are predominantly familiar with pressurized water reactors and particularly with the VVER design which has been in use in Hungary for more than 40 years, in fact it is not a secret that in case of Paks II this familiarity with the VVER reactors played a crucial role in selecting them for the second nuclear power plant project. Subsequently, if licensing requirements are adjusted to allow for the deployment of advanced technologies, it will remain a challenge – without criticizing the expertise of professionals currently working in the sector – for them to familiarize themselves with these new concepts to a degree that allows for adequate regulatory decisions. While it may be challenging to resolve this issue from a regulatory perspective, it is equally relevant to ask whether the licensee possesses the human resources to build and operate such novel technologies, an area where the same challenges regarding a lack of industry experience exist.[960]

4.2.1.2. How could the licensing challenges stemming from technological innovation be resolved?

[954] Ramana, Berzak Hopkins and Glaser, 2013, p. 556.
[955] Ibid.
[956] Black et al., 2023, p. 15.
[957] Nian et al., 2022, p. 3.
[958] With the technological leap, deployment costs also increase, see M. Cooper, 2014, p. 166.
[959] Magwood IV, 2018, p. 65.
[960] One other aspect in which SMRs may be challenged by this design variety is that if many units are deployed, but of many different designs, it is extremely difficult to take advantage of the standardisation of designs, which can only be achieved – also enabling the cost reduction – if sufficient number of units are ordered of the same design. However, from a legislative perspective, it is a rather difficult matter to resolve, and it is not strictly related to licensing considerations. It is most likely that many of the designs currently under development will not reach design maturity and that politics will also play an important role in the fate of the options, but international cooperation among alike-minded countries may also influence which designs could secure enough orders to capitalize on standardisation.

In order to enable the deployment of SMRs best suited to specific applications, licensing frameworks should be transformed to be more inclusive of advanced technologies. This may be achieved in several ways. While these challenges could be addressed through exemptions from existing regulatory requirements,[961] a more sustainable long-term solution lies in removing the technology-specific provisions that currently constitute barriers and fostering a technology-neutral regulatory approach. Technology-neutral legislation is not designed to suit a particular type of technology; rather, it contains more generic requirements and, in principle, allows any type of technology to be licensed. Adopting technology-neutral requirements functions in conjunction with several other regulatory approaches discussed in the following sections. Together, these create licensing frameworks that offer greater flexibility in how a licensee presents its safety case, without compromising the rigor of the evaluation itself. The value of such an approach has long been acknowledged by the IAEA, which has issued a proposal on adopting a technology-neutral safety approach,[962] furthermore, several countries, such as the United States – which historically had technology-specific requirements – are moving toward a more technology-neutral framework.[963] It has been argued that, at least at the highest level of the national nuclear law hierarchy, the law should be technology-neutral, while the implementing acts or regulatory guidelines can be modified, or new ones adopted, to fit the different technologies.[964] However, this process of developing codes and standards for the deployment of specific technologies would also be very time consuming and inefficient, thus for the long run especially in case of countries which could see the deployments of SMRs for various purposes by various actors it seems to be a better option to move towards a generally technology neutral framework that incorporates the regulatory solutions discussed in the following section.

Inexperience with the novel designs of SMRs can have several ways how it may be resolved, options both in the forms of those in a national context and those that involve international efforts may exist. On the international level a promising method to improve the understanding of SMR designs, are joint or collaborative reviews of the same design by regulators, which are already taking place and showing promising results.[965] In a less formal manner, straightforward exchanges among regulators regarding specific designs – sharing information about their technical characteristics – can also prove useful. In the national context similarly, the establishment of institutional solutions that support early engagement between vendors and regulators – prior to the initiation of a specific project – may facilitate the identification of licensing constraints and promote the comprehension of emerging technologies. Such an approach, which can involve non-formal, early-stage design reviews while a design is still subject to adjustment, offers insights into regulatory compliance outside the scope of a lengthy and complicated licensing procedure and is considered highly desirable. This stage is beneficial for regulators, as it provides an opportunity to familiarize themselves with designs early on; it also helps reduce investment risk, contributes to design maturity, and ultimately accelerates deployment. Finally, this early interaction between the regulator and the licensee, facilitated by

[961] Segarnick and Desai, 2019, p. 45.
[962] IAEA, 2007.
[963] Righetti and Lewis, 2025, pp. 359–401.
[964] Burns et al., 2022, pp. 185.
[965] Such as the Joint Early Review of the Nuward SMR design, which will be discussed in more detail later on.

mutual feedback and experience, can also contribute significantly to enhancing nuclear safety.[966]

4.2.2. Standardisation

The second key feature of SMRs which challenges existing licensing frameworks is their standardised nature. The economic viability of SMRs depends on the ability to benefit from repetitive manufacturing without substantial modifications to reactor designs, an advantage that cannot be sustained if regulatory divergence necessitates design modification. If SMRs cannot capitalise on standardisation, they hold no substantial advantage over conventional nuclear power plants. Indeed, they may be even less viable as investments since they cannot benefit from economies of scale, and their higher cost per MW cannot be offset by the savings from repetitive manufacturing. According to the OECD NEA, adapting nuclear power plant designs to country-specific requirements can account for around one-third of the engineering, procurement, and construction costs.[967] Costs of this magnitude would not be financially viable for SMRs and would ultimately hinder the success of their deployment.

It should be noted that standardisation is not linked exclusively to the reactor design, the concept of standardised deployment may also extend to the siting of these installations. If a design is intended for industrial heat generation or district heating, it generally presupposes siting close to densely populated areas. If such siting is not possible across different jurisdictions, the potential advantages of standardisation are similarly undermined.

Furthermore, the standardised design of these reactors also presupposes in-factory manufacturing[968] to a degree, that was not precedented in case of conventional technologies. Units that make up the SMR may be preassembled at the factory and tested before they are shipped to the location to be assembled, some smaller designs also propose to be fully factory assembled and then shipped to the site. While in factory manufacturing in a cross-border context was also present in case of conventional technologies this solution will be a lot more dominant in case of SMRs.

4.2.2.1. How does standardisation challenge existing licensing frameworks?

The fact that SMR designs are not intended to be tailored to the specific licensing requirements of individual countries poses a significant licensing challenge. Existing licensing frameworks often contain divergent requirements that necessitate design modifications when moving from one jurisdiction to another.[969] While this process was standard for large-scale nuclear power plants – since conventional plants were enormous, tailor-made projects where meeting nation-specific regulatory requirements via design adjustments was feasible – it conflicts with the international deployment of standardised SMR designs.[970] Since licensing is within the remit of national authorities the requirements were developed by them reflecting the national interests, and these tailor-made procedures ensure that those areas are the most scrutinised,

[966] Burns, 2017, pp. 22–24.
[967] NEA, 2020, p. 98.
[968] Ingersoll, 2009, p. 592.
[969] Tronea, 2010, pp. 159–163.
[970] Iyler, 2014, p. 151.

which are the most important from the perspective of national interest.[971] These requirements in many cases might not even reflect superior safety outcomes or SMR-specific considerations, but rather persist as legacy elements of regulatory frameworks developed for conventional technologies. The general regulatory approach in which these differing national regulatory requirements are framed is the prescriptive regulatory approach.[972] This form of regulatory approach contributes to generating regulatory experience by determining the compliance with set requirements moreover such a philosophy also eases the job of the regulator as their task is based on verifying compliance with methods and requirements rather than evaluating the adequacy of methods and results proposed by the licensee. Additionally, the reduced subjective evaluation from the side of the regulatory authority can speed up the licensing procedure.[973] This approach could also be beneficial for licensees due to the legal certainty that comes from the pre-determined rules and methods; they can have a legitimate expectation that if they comply with the requirements that are also known by them, the license will be issued. However, due to its detailed requirements and methods which were often established to reflect conventional technologies, this approach is much more restrictive towards innovation that derogate from the established requirements in presenting their safety case. For example, if the requirements set that the number of the control room staff has to be six people it does not matter if the reactor capacity is much smaller than in case of a conventional plant or its inherently safer due to the passive safety features the number is the same regardless. Prescriptive regulatory requirements cannot smoothy adopt to the innovations presented by SMRs. Prescriptive regulatory approaches are actually challenged by both the diversity of SMRs – the previous category – and the standardisation of these designs as such systems may inherently render certain technologies incompatible, but they can be of that nature to not make these designs incompatible but set requirements which require design altercations. While the Hungarian licensing framework leans more toward a goal-setting approach, it still contains prescriptive elements that may require design alterations for SMRs,[974] and as such hinder taking advantage of the economic advantages promised by the standardisation of these plants.

Currently the national requirements towards siting nuclear power plants are divergent. For example, regulatory limits on population density may prevent the deployment of SMRs intended for specific applications, such as industrial heat generation, which typically requires proximity to more densely populated areas. Such siting restrictions may therefore limit deployment opportunities in certain jurisdictions and, in turn, undermine the potential economic benefits associated with large-series standardised manufacturing. One particular area related to the siting of these installations concerns emergency planning zones. In general, the IAEA recommends that emergency planning zones extend between 5 and 25 km from the plant; however, even the lower end of this range is unacceptable to SMR vendors, who argue that it is excessive relative to the hazards associated with SMRs.[975] This also has a financial dimension, since the larger the EPZ, the higher the associated costs.[976] Additionally, there are some other

[971] NEA, 2021b, p. 30.
[972] Defiend in the definitions section.
[973] Sainati, Locatelli and Brookes, 2015, p. 1093.
[974] Such as those concerning the control rooms and the subsidiary control rooms NBSZ. 3.4.4.0100.
[975] Ramana, Berzak Hopkins and Glaser, 2013, p. 558.
[976] Sam et al., 2023, p. 4.

issues related to the nature of SMR technology, which can be challenging from the perspective of traditional EPZs. The first issue relates to the bigger number of SMRs. If they are deployed in large numbers, then the EPZs could potentially intersect each other, causing regulatory challenges, which, of course, were not that common in the case of conventional plants.[977] In case of the Hungarian legislation, these issues associated with EPZ sizes were very much present. The legislation prescribed a traditional, large-scale EPZ of 30 km, a requirement that SMR proponents may reasonably argue is unnecessarily burdensome and by its nature such a requirement would rule out the deployment of SMRs for certain applications, not because of any limitation of the technology itself but merely because of the limited number of locations where a zone of this size can be accommodated, which in turn would hinder the standardised manufacturing of these installations.

The factory-manufactured, standardised nature of SMRs or SMR modules raises crucial questions regarding the exercise of regulatory oversight during the manufacturing stage, a challenge that also stems in part from the modular design of SMRs, the third category of issues to be discussed here. This issue becomes particularly pronounced when the complex modules which make up the SMR are fabricated in jurisdictions other than the installation state.[978] In such cases, it remains unclear whether these activities should be classified as construction or as procurement, thereby necessitating a shared regulatory understanding for the categorization of these processes.[979] A further departure from established practices concerns the conduct of system functionality tests during fabrication and assembly in a different jurisdiction.[980] How regulators and licensees can ensure adequate oversight throughout these process when it takes place in a foreign jurisdiction, particularly given the potentially shorter timeframes associated with factory-based production? The situation in Hungary pertains to these described above as the benefits of recognizing in-factory system functionality tests by the Hungarian regulator remain limited, as they are not adequately acknowledged under the current commissioning licensing stage, which remains site-specific.

4.2.2.2. How could standardisation related licensing challenges be resolved?

Among the solutions that may support the standardised deployment of SMR units, we can again differentiate between those at the international level and those limited to national contexts. In the international sphere, several concepts exist, the most prominent being the harmonization of licensing frameworks. Harmonization – which will be discussed more extensively later in the work – intends to both remove nation-specific requirements that would necessitate design alterations from one country to another,[981] and to create licensing frameworks in which SMR deployments would face similar regulatory requirements and approaches,[982] specifically ones that accommodate the unique features and deployment strategies of these plants. Harmonization can be envisaged at a bilateral or multilateral level among a few countries that have similar licensing frameworks, but also model licensing frameworks could be developed under the

[977] Rosa Blul, 2021, p. 7.
[978] Lloyd, Roulstone and Lyons, 2021, p. 3.
[979] IAEA, 2019, p. 9.
[980] Mignacca and Locatelli, 2020, p. 6.
[981] Sainati, Locatelli and Brookes, 2015, pp. 1093–1094.
[982] NEA, 2022, p. 7. For more on the modular construction of SMRs, see Lloyd, 2020.

auspices of international organisations active in the sector, which countries can decide to adopt. A further new international approach that has been suggested is the reliance-based approach, that leverages on the evaluations of foreign regulators, a prerequisite for which is that the units must be identical. This approach involves recognizing foreign regulatory decisions after ensuring that the standards against which the plants were evaluated provide protection equivalent to those in the national context.[983] This reliance can naturally be best utilized if the regulatory frameworks are more harmonized, so the criteria against which the other regulator evaluated the plant is more similar to the national contexts, and as such the evaluation on its adequacy is more straightforward.

In the national context also, various pathways may exist how to support the standardised deployment of these units. One option, for regulators that wish to retain prescriptive approaches while still reflecting the innovative features of novel technologies, is to adopt new standards and codes for the new designs, but this would place a heavy burden on regulators, given that SMR designs themselves vary significantly.[984] Instead of this, many experts suggest moving towards more goal-setting/performance-based[985] approaches, as these are more flexible and thus not only are they open to a variety of technologies, but they also contain no requirements that would impede the standardised deployment of SMR units. To evaluate the applications, they use a graded approach, and the risks are not determined by concrete standards, but they strive to check whether they are as low as reasonably possible.[986] Returning to the control room example, in such a system the authority's generic goal would not be a concrete number of staff, it would instead require an adequate staffing level in the control room and leave it to the licensee to demonstrate that, in the case of a smaller, safer reactor, less people are sufficient. Generally speaking, even systems which tend to be more goal-setting include prescriptive elements. However, moving toward a predominantly goal-setting approach can better accommodate the advanced features of SMRs, such as their enhanced safety systems.[987] However, on the other hand, the performance-based approach contains a great deal of ambiguity as the requirements are less concrete, and the regulator enjoys a way broader discretion[988] subsequently, the applicants don't have the same level of reasonable expectation towards the success of their application. Moreover, such an approach also puts greater burdens on the licensee to prove their safety case, but in case of SMRs which are deployed across countries without modifications this may not be as challenging as they can leverage on their previous licensing documentations. This approach also increases the regulatory burden, since licensees may use divergent and novel methods of demonstrating safety. To address this challenge, the greater involvement of certified inspection organisations can be beneficial. While the responsibility for licensing decisions remains with the regulatory authority when assessing license applications, the opinion of an independent third-party expert body, particularly in relation to lower-risk components, as is the case in Hungary, or Finland can be valuable.

[983] Młynarkiewicz, 2025.
[984] Ibid.
[985] Defined in the definitions section.
[986] Sam et al., 2023, p. 4.
[987] Id., pp. 4–5.
[988] Sainati, Locatelli and Brookes, 2015, p. 1093.

One of the fundamental approaches that can play a crucial role in the more goal-oriented licensing of SMRs is the use of graded approach.[989] It is essential to emphasise that applying a graded approach does not imply a relaxation of safety requirements. Instead, it involves tailoring them to reflect the characteristics of a facility and its associated risks,[990] which may be different for SMRs than for conventional plants. In fact, using a graded approach can result in more stringent requirements if the risks involved or the nature of the facility justify it, as determined using risk-informed approaches such as probabilistic risk assessment.[991] In the case of SMRs, the graded approach could more accurately reflect their enhanced safety features, helping to avoid redundant requirements that were appropriate for reactors with less advanced safety features and higher fuel inventories, which pose inherently higher hazards. One particular area where such an approach may play an important role is the determination of EPZs,[992] as it could adequately reflect, in smaller zones, the passive safety features of SMRs, their smaller size, the lower quantity of radioactive material and, consequently, the reduced potential for radiological consequences stemming from these installations.[993]

4.2.3. Modularity

Another feature of SMRs that may give rise to licensing challenges is their modularity. As previously described, modularity refers not only to the modular construction of these plants but also to the proposal that they be deployed in multiple units, either connected together or sited at various locations. This modularity is inherently linked to standardisation, as the multiplication of modules enables standardised factory manufacturing. In the following section, the author will discuss modularity, particularly in the context of deploying multiple units of the same standardised plant within a single country. Historically, plants of the same design were deployed at a single site – except in sufficiently large countries, such as the United States or France, where similar large-scale units have been deployed repeatedly.[994] This practice is challenged by SMRs, as countries interested in the technology are in many cases considering deploying multiple units not as part of a single plant but in a decentralised manner.

4.2.3.1. How does modularity challenge existing licensing frameworks?

While modularity is an essential characteristic of SMRs, its licensing implications are not consistently addressed, due divergences among jurisdictions as to whether and to what extent it presents difficulties.[995] Licensing systems historically have been designed – with some exceptions – to accommodate large-scale nuclear projects deployed at a single site and as a result, licensing stages are generally site-specific. In case of site-specific licensing procedures essentially the same licensing evaluations must be repeated despite having standardised modules. This challenge persists not only at the international level, where cross-border regulatory cooperation and learning remain limited, but also within many national nuclear law

[989] Defined in the defintions section.
[990] IAEA, 2018, p. 36.
[991] Holmberg and Julin, 2024.
[992] Rosa Blul, 2021, p. 5.
[993] Id., p. 2.
[994] *Design Certification Applications for New Reactors*, 2025.
[995] Some jurisdictions, such as the US, already employ institutions to respond to modularity.

frameworks, which lack legal instruments enabling leveraging on the licensing experiences of previous domestic projects or general licensing procedures such as design certification. Although some jurisdictions, such as Bulgaria, have introduced dedicated design licensing procedures,[996] the site-specific nature of it significantly constrains its potential to enhance regulatory efficiency for SMRs.[997] In the absence of institutional arrangements capable of reducing project-specific licensing requirements,[998] repeated regulatory reviews become unavoidable, leading to increased costs and timelines, placing unnecessary burdens on regulatory authorities, and undermining the modular benefits of SMRs. An additional challenge for SMRs is how to license multiple modules at a single site. Although these modules are proposed to be identical, many existing licensing frameworks evaluate and issue licenses unit-by-unit, potentially disregarding their standardised features.

The multi-module nature of SMRs can also have implications regarding the determination of EPZs. The generally accepted view is that the worst-case scenario approach should be applied where the EPZ has to be established in the light of the emergency spreading from one module to all the others,[999] which could have important implications in case of multi module SMRs.

Hungary also belongs to the group of countries[1000] that until recently lacked generic licensing instruments, whether site or design related, a situation that did not constitute a significant constraint as our large-scale nuclear power plants were deployed exclusively at a single location. However, in the context of SMRs – where domestic discussions envisage the deployment of multiple units of the same design at different sites – new regulatory approaches that allow for capitalizing on the modular nature of SMRs were required to facilitate the execution of these plans.

4.2.3.2. How could modularity related licensing challenge be resolved?

In order to capitalise on the standardised design of SMRs when deploying multiple modules in a country and to avoid redundant, costly and lengthy licensing procedures for each subsequent deployment, design certification has been proposed as a solution. Desing certification procedures – such as the one being proposed in Finland or recently adopted in Hungary – allow regulators to evaluate the general design of a plant and if it complies with the regulatory requirements approve it prior to an actual deployment. The advantage of this approach would be in case of SMRs is that in the different project specific licensing procedures – it is mostly advantageous if the given design is proposed to be deployed at numerous sites – regulators could focus their evaluation on site and application-specific matters and potential design deviations, rather than re-evaluating standardised aspects that have already been approved.[1001] This would mean that, while the additional, optional design certification stage could prolong the process the first time it is used, significant time savings could be realised in the subsequent project-specific stages. Moreover, such a stage may also be introduced in manner that the

[996] For more about the Bulgarian nuclear law framework, see Borisova, 2025, pp. 9–46.
[997] Regulation of the Council of Ministers on the Procedure for Issuing Licences and Permits for the Safe Use of Nuclear Energy, 2004, arts. 34, 37, 39.
[998] Söderholm et al., 2014, p. 7.
[999] Rosa Blul, 2021, p. 6.
[1000] This can also be the case for mature nuclear jurisdictions, such as France or Finland.
[1001] World Nuclear Association, 2015, p. 9.

licensee for this and for the project specific license would not have to be the same, meaning that even vendors may engage in such generic licensing procedures to prove that their designs meet the regulatory requirements, leveraging on such assessment would further ease the burdens of project specific licensees. However, to take advantage of this approach, designs must be mature enough at this stage and no major modifications should occur in them after their generic licensing so they can be well leveraged later on. Such generic licences may concern not only the design itself but also sites, which could be licenced in advance subject to certain design limitations that would determine, in broad terms, what kinds of plants may be sited there. Generic licences can be crucial contributors in mitigating the risks of project specific licences as the applicant would enjoy a lot more certainty regarding the outcome of the licensing due to the general acceptance of the design and the fact that they plan to site the plant in a location that has been approved in principle to host such installations.

In answering to the fact that SMRs may in cases also be deployed in a way that several units are connected together at a single site it would therefore be worth considering including a provision on multi-module licensing. It is a very complex matter,[1002] as the appropriate approach depends on several factors such as the plant's configuration, the design's safety systems and whether the units are deployed simultaneously or on different occasions.[1003] One discussed solution is the development of a master facility licence – a comprehensive permit covering the entire facility, potentially supplemented with sub-unit licences that focus on the characteristics and implications of the unit. For standardised reactors, such an approach could help reduce unnecessary repetition and thus increase efficiency. The targeted regulatory oversight at both stages would not compromise safety.

4.2.4. Time-constraints

The final fundamental feature of SMRs that warrants an elaboration in this context is their shorter deployment timeline. One of the proposed benefits of SMRs is that, due to factory manufacturing, these plants are expected to have a significantly shorter deployment time than conventional technologies. Civil works at the site – which are notoriously prone to delays – will be less extensive, both due to the smaller size of the plant and the fact that units are factory-fabricated, making on-site assembly more streamlined than is typical for conventional plants. This shorter deployment timeline makes SMRs particularly appealing for certain applications; consequently, the factors that enable developers to capitalize on this advantage must be a primary focus.

4.2.4.1. How do shorter deployment timelines challenge existing licensing frameworks?

Although issues relating to the potential prolonging of the licensing of SMRs were mentioned as a negative consequence of certain regulatory approaches, prolonging can also occur when the licensing process is fundamentally open toward advanced technologies, and the regulatory approaches and stages indicated above are implemented. In the case of SMRs, efficient

[1002] IAEA, 2021b, pp. 34–47.
[1003] Hidayatullah, Susyadi and Hadid Subki, 2015, pp. 132–133.

licensing processes are of paramount importance, as under current frameworks the evaluation of licence applications, particularly at the construction stage, may be one of the most time-consuming elements of their deployment, potentially taking longer than construction itself.[1004] What is more, beyond these time constraints, one must also consider the potential delays in these procedures caused by the novelty of the plant, as illustrated by the protracted situation in South Korea concerning the SMART reactor, which took an unnecessarily long time to be licensed.[1005] An additional factor with the potential to prolong the licensing procedure is public participation. Such participation is required by instruments such as the Espoo Convention in connection with the assessment of a plant's environmental impacts,[1006] but it may also be required on different grounds and at several points during the deployment procedure, and this can take a considerable amount of time.[1007]

The length of the licensing procedure is not only a hindrance to the project schedule but also has a financial dimension, since delays in licensing translate directly into higher costs. The situation in Hungary is rather similar despite the developments made in recent years, the licensing procedures still reflect the longer timelines associated with conventional plants, offering only limited options for manufacturing components before the completion of lengthy regulatory reviews.

4.2.4.2. How may the time-related licensing challenges be resolved?

To facilitate the shorter deployment schedules of SMRs, more efficient and streamlined licensing procedures are necessary. The strategies previously highlighted for improving the efficiency of conventional nuclear power plant licensing are equally applicable to SMRs; however, certain SMR-specific attributes necessitate a reconsideration of existing procedures that remains underexplored by experts. Regarding SMRs produced in a factory environment, a critical question arises: how should the modules constituting the unit be approved if they are already manufactured by the time a construction licence is granted? Could the licensing approach currently employed for long-lead manufacturing items in some countries be applied to SMR modules or to SMRs as a whole to allow manufacturing to proceed concurrently with the evaluation of the construction licence? It may be an option, but such an approach also carries risks if the facility at the site is not approved, however one should consider that design certifications and site approvals can greatly contribute to limiting these risks so in given licensing systems encompassing such stages might not be such a risky endeavour. Further ideas may concern streamlining the numerous system- and component-level approvals that follow the construction licence, particularly in light of the fact that, in the case of a non first-of-a-kind (FOAK) deployment in a given country, these evaluations have already been conducted; moreover, owing to factory manufacturing, the likelihood of deviation among these systems and components is reduced, provided that the same standards can be maintained during factory manufacturing. The commissioning stages may also be the subject of streamlining especially if certain commissioning works may occur in the factory where the module is produced. In these

[1004] Sainati, Locatelli and Brookes, 2015, p. 1093.
[1005] Ramana, Berzak Hopkins and Glaser, 2013, p. 560.
[1006] UNECE, 1991.
[1007] Sam et al., 2023, pp. 6–7.

cases, it may be worth reconsidering separate commissioning licensing stages – or, more generally, the assumption that commissioning must be envisaged solely as a step following the completed construction of the plant. Equally certain elements of commissioning stages such as the approval of their programs could be leveraged on from previous projects.

4.2.5. Summary of the SMR licensing challenges and solutions

As can be seen from this chapter, the novel features of SMRs raise several licensing challenges. The categorisation indicated above is, as already mentioned, not exclusive – the challenges within legal frameworks may not simply stem from the single SMR novelty under which they were categorised, but rather several of their novel features may contribute to these issues simultaneously. Nevertheless, the categorisation above is crucial in indicating what new challenges the advancement of SMRs over conventional technologies raises for nuclear power plant licensing. As the analysis has shown, the hurdles are varied and appear throughout the deployment process of an SMR.

Among the discussed challenges, a further categorisation can be made as to whether they constitute an outright barrier to SMR deployment or merely hinder the realisation of the benefits SMRs are expected to offer. The first category comprises technology-specific provisions that render the deployment of certain SMR designs impossible, as well as prescriptive requirements embedding legacy provisions based on conventional technologies that are generally incompatible with the SMR designs currently under development. Both of these attributes can prevent SMRs from entering a given national market and thereby prevent the potential expansion and development of the SMR industry, these should therefore be the primary considerations when discussing the necessary reforms of licensing frameworks. As has been articulated by certain authors and politicians in the context of climate change mitigation, at this point we do not have the comfort of excluding energy sources that can contribute to climate change mitigation – and this is equally true for nuclear energy. While nations naturally enjoy the freedom to decide whether to utilise nuclear energy or not, those that are open to advanced technologies should also adopt a technologically neutral approach to allow the deployment of the nuclear power plants best suited to given purposes, be it a large-scale plant, a light water SMR or an SMR intended for heat generation. Licensing frameworks in this regard cannot serve as a barrier to technological innovation, nor can they prevent the standardisation efforts of the industry.

Among those licensing hurdles that do not outright prevent the deployment of SMRs but equally cannot fully reflect the developments brought by SMRs – and thus slow their deployment – we can find the lack of generic licences and time-consuming licensing procedures. While the challenges belonging to the previous category undermine the very concept of SMRs, these hurdles prevent the efficient harnessing of the benefits these installations offer. While it could be argued in general that the prerequisites to SMR development are the steps towards more technologically neutral and less prescriptive licensing procedures – and thus that efforts to combat these inefficiency hurdles would only follow those efforts – this is not entirely correct. Firstly, some legal frameworks may not be that restrictive to begin with; secondly, certain SMR designs may in principle not differ greatly from the technologies employed in conventional plants. Consequently, if the licensing system is generally open to these technologies, or if an

SMR using a well-understood technology is being pursued, then in those cases efforts to combat the inefficiency hurdles may take precedence.

Countries that consider nuclear energy – particularly SMRs – as part of their energy mix should, while evaluating their current practices to understand what reforms are needed, also review these practices from an SMR-specific perspective. This step should be taken very seriously, as if issues emerge only once the plant is already under licensing, it is too late to address them and the financial implications are serious. This evaluation may be carried out by the regulator itself or by other entities, but it should extend to the entire licensing process of nuclear power plants in order to identify the critical parts. One methodological possibility is to test these frameworks using a given SMR design. The results of these evaluations should bring forward those elements of the existing frameworks which could potentially pose obstacles or hurdles to SMR licensing; the nature of these findings will also be decisive in determining what new approaches need to be adopted. For some of the problematic areas that may arise there are clear answers at present, while for others less so, but from the elaboration above a general guidance takes shape as to what interventions may be undertaken to create more accommodating licensing procedures for SMRs.

When systematically addressing these considerations, regulators have several possibilities, not only in terms of content but also regarding the structure within which they incorporate these elements. For now, the two most likely frameworks are: altering the current regulatory frameworks, which is the most straightforward option, and establishing separate licensing procedures for SMRs that are compatible with these reactors' novel characteristics and allow for timely and cost-effective deployment, or they can adopt a common licensing framework which can adequately host SMRs and conventional technologies at the same time. A frequently discussed but less realistic possibility is vesting responsibility in the vendor state's regulatory authority to license the plant, or transferring the licensing procedure to an international organisation.

The internationalisation of these procedures may also take different forms. For example, in working out the details of certain new approaches, countries faced with similar obstacles and hurdles may cooperate in developing adequate solutions; in this process, particular attention should also be paid to those countries that have already adopted such approaches, especially where they have been tested in practice. One additional benefit of internationalising this process is that countries which believe in the benefits of nuclear expansion will, on the other hand, need to ensure – given the sensitive nature of the topic – that their decisions are not arbitrary and that the general public trusts the chosen path and does not perceive it as a relaxation of safety standards. One of the most frequently discussed ways in the industry to reach such conclusions is through international cooperation, which can generate greater public trust if more countries are seen to be participating in the effort.

One critical observation that must be made is that while these legal innovations are crucial, they only establish a framework – one that may in some cases be more demanding on the regulatory side – and in order to function well in practice, other, not necessarily legal, interventions are needed, such as equipping regulatory authorities with sufficient expertise, funding, and resources to be able to evaluate drastically different designs, possibly simultaneously, in a timely manner. If these additional reforms are not made, it will be very difficult to take full advantage of goal-setting, risk-informed approaches. Although considerable work remains to

be done on the industry side to establish certain design standards, industry itself may also contribute to capitalising on reformed frameworks through greater standardisation among designs.

4.3. SMR deployment in Hungary

After uncovering what licensing challenges may exist with SMRs stemming from their novelties compared to conventional plants, and how these are suggested to be resolved in the literature pertaining to SMR licensing, it is very important to put this issue more into perspective by discussing how Hungary a country that is interested in the deployment of SMRs sees their licensing in the current national context and how it aims to create a more accommodating regulatory environment for SMR deployments.

4.3.1. Hungary's SMR ambitions

Despite the challenges associated with the Paks II project, as mentioned before Hungary remains committed to nuclear energy and has expressed interest in incorporating SMRs into its energy mix.[1008] SMRs are widely regarded as a suitable solution for supplying additional electricity to emerging industrial hubs scattered across the country. This observation has been articulated by several stakeholders, including the former Minister of Energy, who stated in 2023 that SMR deployment could be envisaged around 2030 in regions experiencing increased electricity demand.[1009] Similar intent is expressed in the 2035 strategy of the state-owned Hungarian Electricity Works Company (MVM), which envisions the potential deployment of a 300 MWe SMR.

Besides high-level expressions of interest, Hungary, through various stakeholders, has participated in several international initiatives related to SMRs. Notably, the Hungarian Atomic Energy Authority (HAEA), as the national regulator, has been actively involved in the IAEA's SMR Regulators' Forum. Equally important are bilateral cooperation efforts, in the context of which the HAEA signed a Memorandum of Understanding with its British counterpart to facilitate the sharing of experience in the field of SMRs, with particular reference to the Rolls-Royce design.[1010]

Preparations for SMR deployment in Hungary were significantly launched forward following a meeting between the former Prime Minister of Hungary and the President of the United States in early November 2025, where the two parties agreed on multiple areas of cooperation in the nuclear sector, one of which concerned the deployment of 10-12 SMRs in Hungary. While the specific technology has yet to be selected and several potential vendors – such as Westinghouse and GE Hitachi – have been mentioned, the then CEO of the MVM Group announced that an agreement had been concluded with Holtec International to assess the integration of its SMR design into the Hungarian electricity system, including its potential benefits and financial implications. Unlike earlier expressions of interest, this high-level agreement has been also accompanied by concrete steps aimed at establishing the enabling conditions for SMR deployment in Hungary as explained in the following sections.

1008 Directorate-General for Communication, 2024b, p. 80.
1009 B. Horváth, 2023.
1010 *Megnézi az atomhivatal a brit kis moduláris reaktor szabályozási környezetét*, 2024.

4.3.2. Preliminary consent of the National Assembly for the deployment of SMRs

The first major step was granting the preliminary consent necessary for the future application of SMRs in Hungary.[1011] As mentioned before the Act on Atomic Energy,[1012] stipulates that, in order to commence preparatory activities for the implementation of a new nuclear facility, the preliminary consent of Parliament is required. However, the Act stops here and does not specify the content of this preliminary consent, nor does it define the level of detail required for the proposed project. While, as mentioned, the preliminary consent for Paks II was notably concise – attracting considerable criticism – both the location and the general purpose of the project were nevertheless identifiable. By contrast, although the consent for SMRs is more extensive, it provides no information as to which specific project or projects it applies to.

The consent begins with a general justification, emphasizing the contribution of nuclear energy to economic competitiveness, and that, in order to maintain this role, it is necessary to become familiar with novel nuclear technologies. Subsequently, the consent continues with its substantive provisions. The parliamentary resolution, notes that the National Assembly recognizes the necessity of monitoring the development of these technologies and gaining experience with them, and instructs the Government, in cooperation with the HAEA, to develop the legal framework necessary for the establishment of SMRs in Hungary. In addition, the resolution states that it grants preliminary consent, pursuant to Article 7(2) of the Act on Atomic Energy, to commence preparatory activities for the installation of a new SMR and subsequently mandates the Government to carry out preparatory activities aimed at familiarizing itself with SMR technologies and vendors' offers.

From the resolution, it is not entirely clear to what, the National Assembly has granted consent for. The Act requires the consent for the commencement of preparatory activities related to the implementation of a new nuclear power plant, thereby linking such preparatory work – to some extent – to a concrete project.[1013] Consequently, if the intention at this stage was limited solely to monitoring sectoral developments or establishing an appropriate legal framework, the parliamentary consent would not have been necessary. However, the consent explicitly states that the National Assembly grants approval for preparatory activities related to the installation – which terminology is not consistent with that in the Act using implementation – of an SMR in Hungary. In this sense, the consent appears to be connected to a concrete deployment, yet its substance remains unclear. It is even challenging to grasp the broad concept of the potential project under this consent. The provision of the consent refers to an SMR in singular, which may be interpreted either as consent for a single unit, a single multi-module project at one site – which may contradict with harnessing deploying modules at various sites – or as a general consent applicable to SMR projects. It's further confusing that by contrast, the title of the consent uses the plural form, SMRs. As a result, it remains uncertain whether the consent

1011 Resolution 73/2025 (XII.10.) of the National Assembly on granting preliminary consent for the future use of SMRs in Hungary pursuant to section 7(2) of Act CXVI. of 1996 on Atomic Energy.

1012 Act CXVI. of 1996 on Atomic Energy, section 7(2).

1013 It does not merely refer to examining the feasibility of a nuclear power plant, as past practice – such as the Teller Project – has shown that such preliminary studies do not require it. Rather, in Hungarian nuclear law, the term 'implementation' is widely used to denote the stage when there is already a licensed site and at which stage after licensing the selected design the construction begins.

applies to the deployment of a single unit of SMR at a one site or multiple units at one site, to a design-level approval reflecting the possibility that multiple units of the same design could be deployed at different locations – but then to which design it refers to – or to a broad, open-ended consent for any SMR project. While the latter interpretation appears to be unlikely, it cannot be excluded alone on the basis of the text of the consent. The more broadly this consent is interpreted and applied, the less effectively it fulfils its function once the preliminary works result in an actual project – namely, to determine whether the project serves the overall interest of society. Even under the most restrictive interpretation – that the preliminary works will lead to the deployment of a single unit of SMR – the lack of information, may result in similar, though arguably more justified, criticisms than in case of Paks II. To adequately fulfil its purpose, which also plays a significant role in shaping public perception, it may be necessary to reconsider this preliminary consent stage and apply this consent in relation to more concrete projects. While early political support is understandably critical for such projects, and while this may justify a lower level of detail at an early stage some degree of information concerning the broad scope of the project may nonetheless be important to ensure the fulfilment of its function, even if the preliminary efforts might not ultimately lead to deployments.

4.3.3. Amendment of the Act on Atomic Energy

Reflecting the intention of the preliminary consent, at the same time a proposal to amend the Act on Atomic Energy was submitted with the aim of introducing the high-level legislative changes necessary for SMR deployment,[1014] this has since been adopted in April of 2026.[1015] The amendment first introduced into the Hungarian legislative framework the definitions of small modular reactor blocks and small modular reactor installations. The definition of SMR blocks does not refer to a specific electrical output,[1016] acknowledging that such reactors may be used for non-electricity application, but it rather identifies SMRs as Generation III+ or Generation IV technologies, composed of one or more modules, with their key distinguishing characteristic being their standardisation. The definition of an SMR installation, as a specific category of nuclear power plant, builds upon this concept by defining it as a facility composed of multiple SMR blocks – which may be at different lifecycle stages – located at a single site. Since then existing statutory definition of nuclear power plants refered exclusively to electricity-generation – thereby conflicting with the multipurpose nature of SMR blocks – the amendment also modified this definition to explicitly include heat generation.

The amendment's second major innovation concerns reducing the scope of the impact area where site-related inspections and assessments are carried out during the two-stage site licensing procedure and that of the security zone in the implementation license stage from the previously minimum 500 meters – for nuclear power plants – to minimum 50 meters for SMRs. The minimum size of 50 meters represents a substantial departure from previous practice, given that the minimum impact area for research reactors was at least 100 meters. As a further novelty it will be the authority who will determine the concrete size of the impact area and the security

[1014] T/13047 on the amendment of the Act CXVI of 1996 on atomic Energy to enable the establishment of small modular reactors and the creation of an official supervisory authority.
[1015] Act No. XI of 2026 Amending Act CXVI of 1996 on Atomic Energy for the Purpose of Establishing the Construction and Regulatory Supervision of Small Modular Reactors.
[1016] As for example the definition of the IAEA does.

zone on a case-by-case basis. This change is justified on the grounds that it introduces greater regulatory flexibility by enabling the use of a graded approach to reflect the specific characteristics of SMRs. This provision also affects the determination of who may be considered a client under the Act, as client status is linked to the impact area.[1017]

As highlighted earlier, providing the regulatory authority with information about the design at an early stage, and obtaining feedback regarding its licensability thereby front-loading regulatory risks is important for reactors employing advanced technological solutions. In recognition of this need, the amendment went beyond the general duty to provide information set out in the General Administrative Procedural Code,[1018] and introduced two new pre-licensing procedures the professional consultation and the preliminary opinion. The professional consultation procedure, which is not limited to SMR projects, is intended to provide a more substantive and practical forum for exchanges on regulatory compliance between the user of atomic energy and the regulatory authority; however, the authority is not bound by any opinion expressed at this stage. The preliminary opinion by contrast, is available exclusively in relation to solutions or documentation proposed for use in an SMR block or SMR installation and entails a more consequential mechanism. Although a preliminary opinion does not replace a licensing decision and is, in principle, not binding on the authority, an important exception applies. Where, within the validity period of the opinion – determined by the authority in accordance with graded approach – the party requesting the opinion initiates an administrative procedure and requests it to be assessed in conformity with the preliminary opinion, the authority is bound by its opinion, provided that the underlying facts and documentation remain unchanged.[1019] This mechanism allows for the effective use of work already carried out by the authority and helps to avoid unnecessary duplication of reviews. These two procedural innovations were intended to address the regulatory challenges arising from the technological novelty and complexity of SMR designs while also making licensing procedures more efficient.

Finally, the last innovative feature of the amendment, aimed at addressing two critical characteristics of SMRs – their standardised nature and the need for more timely deployment – is the creation of an alternative licensing avenue specific to SMRs. While the licensing stages related to the site remained unchanged, the amendment introduced two instruments that may alter the subsequent licensing process the design certification and the implementation and commissioning program. Design certification, as can be inferred from the amendment – although its detailed rules are to be set out in a decree of the President of the HAEA – constitutes a generic, non-site-specific approval of the design; the licensing procedure for it has a duration of 15 months and may subsequently be leveraged in site-specific implementation licensing procedures. Under the general provisions the implementation licensing procedure has an 18-month duration,[1020] however, if design certification has been obtained, the implementation licence may be limited to the site-specific aspects of the design, thereby reducing its duration

[1017] Hegyes and Farkas Csamangó, 2021, p. 410.
[1018] Act CL of 2016 on the General Administrative Procedural Code.
[1019] It is not binding in cases where the applicant has submitted false information, where the conditions and facts on which the opinion was issued have significantly changed, where the relevant provisions have changed, or where the conditions set out in the opinion are not met.
1020 Can be 12 months if a preliminary safety information has been submitted.

to six months. The implementation and commissioning program replaces the traditional commissioning licence and bring under a single program the numerous system and system-component level licences, as well as the notification acknowledgement, and derogation notification acknowledgement procedures – the possible application of which is extended in case of SMRs – along with the commissioning program. This program may be submitted either as part of the implementation licensing procedure – in which case the combined procedure may take up to nine months – or as a separate procedure, which would have a maximum duration of three months. Consequently, for an SMR design that has obtained design certification, the implementation and commissioning phases – currently requiring up to 18 months and 11 months, respectively – could be completed within a total of nine months, which would be crucial for standardisation and timely deployment.

4.3.4. Short reflections on the amendment

In the context of the projected nuclear renaissance, it is important for stakeholders to examine both how these regulatory ideas are transposed into national law and how they perform in practice during actual SMR deployments, with a view to identifying best practices. In this regard, the amendment in particular, but also the preliminary consent – highlighting the potential difficulties of applying traditional approaches to novel projects, as it resulted in uncertainty regarding the scope of projects to which it applies to – serve as good examples. Overall, the amendment represents an innovative and systematic response to several licensing challenges raised by SMRs. Its most significant contribution is the introduction of SMR-specific licensing stages, the design certification and the implementation and commissioning program, which aim to increase procedural efficiency and support the deployment of multiple modules. Nevertheless, important questions remain regarding further tailoring the legislative framework to SMRs such as: can elements of the implementation and commissioning program – specifically those related to manufacturing and procurement of standardised modules – be leveraged across projects; whether the non-site specific site inspection and assessment license be reused across projects; how regulatory authorities can be incentivized to adhere to statutory deadlines in practice and whether new provisions on EPZ sizing should be introduced. Since the deployment of such plants extends beyond the scope of strictly national nuclear law, further questions arise, including how the decentralized Hungarian environmental authorities with limited experience in nuclear projects will effectively conduct environmental licensing?
While the true benefits and potential shortcomings of the amendment will only become evident in practice, it nonetheless sends a strong and positive signal to the SMR industry and constitutes a meaningful step toward the realization of a nuclear renaissance.

4.4. International cooperation as a means of advancing SMR licensing, with a primary focus on harmonisation

As the preceding discussion demonstrates, significant efforts are currently under way to reform licensing frameworks to be more receptive to SMRs. However, as was also apparent in the case of Hungary, the question of how a licensing framework can reflect the internationally standardised deployment of SMRs was not addressed in the amendment – neither the removal of country-specific requirements necessitating design modifications, nor the question of how

reviews carried out by foreign regulators might be leveraged was discussed. If these questions are not addressed more directly, the standardised global deployment of SMRs will continue to face significant challenges, despite the more streamlined licensing procedures.
International cooperation can, on the one hand, help to identify national solutions that impede SMR deployment, and coordinated efforts along with information and experience sharing can also contribute to developing solutions to support national approaches – indeed, some elements of the amendment reflect these best practices. In addition, international cooperation is not merely helpful but necessary in discussing how these reforms might adopt a perspective that takes into account not only national deployment but also the international standardised deployment aims of SMRs.
Among the ways in which international cooperation may contribute to creating more enabling licensing frameworks for SMRs, the most frequently discussed is the harmonisation of licensing frameworks. Accordingly, the next section will address this idea and evaluate how such an approach might be adopted within the Euratom framework, with a view to the Community taking a leading role in harnessing SMRs. This will be supplemented by a discussion of various ongoing international initiatives aiming to achieve such harmonisation in practice, extending in some cases to other means of leveraging international cooperation to facilitate SMR deployment.

4.4.1. The concept of harmonisation

A proposed solution to overcoming the challenges posed by standardised designs across fragmented licensing frameworks is their harmonisation.[1021] Harmonisation of licensing primarily entails converging safety standards, along with aligning regulatory approaches regarding the methods licensees may use to demonstrate compliance with these standards. A further aspect worth considering for harmonisation is the licensing stages, which currently differ between countries.[1022] Harmonising the requirements and the methods for demonstrating compliance across otherwise fragmented licensing frameworks would enable the development of designs standardised to meet the requirements of the harmonised framework as a whole; consequently, when deploying the same design elsewhere, there would be reasonable certainty regarding its licensability. In addition, the harmonisation of licensing stages would ease the licensee's task of determining which elements of the plant must be presented at each stage, and would also enable greater use of previous licence applications and their accompanying demanding documentation. A harmonised framework may bring further benefits still: on its basis, procedures to leverage generic reviews conducted under the same harmonised framework in other countries could ultimately be adopted, so as to avoid redundant reviews.
It is worth noting that, at a substantive level, significant progress has already been made towards harmonisation through the cooperation of regulators under the auspices of the IAEA, WENRA, and other relevant bodies. However, these efforts were built on experience with conventional technologies, which may not be fully applicable to SMRs. Furthermore, these efforts focused

[1021] Sainati, Locatelli and Brookes, 2015, pp. 1093–1094.
[1022] For example, see: Teles Da Silva, 2025, pp. 157–192. Penttinen, 2025, pp. 91–121. Berghaus, Ferčič and Drnovšek, 2025, pp. 123–155.

primarily on harmonising high-level safety principles, in the national application of which significant differences still exist.[1023]

In an era of standardised reactors, harmonisation is more pressing than ever. Harmonisation should not only aim to converge regulatory frameworks, but also ensure that they are open to new technologies, capable of reflecting enhanced safety features, and efficient enough to meet their shorter deployment timelines.[1024] Harmonisation in other industries, such as the aviation sector, through the Chicago Convention on International Civil Aviation,[1025] demonstrated that these efforts can boost sectoral development while also contributing to increased sectoral safety.[1026] Achieving a similar mutual recognition of licences in the nuclear sector – akin to the recognition of airworthiness certificates in the aviation sector[1027] – will still take time; but the harmonised framework itself, as its necessary foundation, must come first, and will already advance licensing even before mutual recognition is achieved.

Harmonisation of these frameworks may be achieved in several ways: through bilateral cooperation between countries that already have similar nuclear licensing regimes – though this presents the limitation of whether their markets are sufficiently large for a standardised design – or through direct multilateral cooperation, potentially under the auspices of one of the international organisations engaged in the nuclear sector. All of these approaches have their respective benefits and challenges, but one that is particularly interesting concerns the Euratom Community due to the powers vested in this institution. In the following sections the basis the potential pathways and these efforts' main focus areas will be discussed.

4.4.2. The role of Euratom[1028]

Initially, the European Atomic Energy Community was intended to promote the development of the nuclear industry. While some may argue that this objective is no longer relevant, current developments in the wake of decarbonisation and energy security challenges suggest a possible turning point, where industrial advancement may once again become a goal.

The following section seeks to address the dormant harmonising power of the Euratom Community, which could support the deployment of standardised reactors. While existing international cooperation efforts – as presented later – are crucial for SMR deployment,[1029] and some of these are at a considerably advanced stage, the Community possesses a unique toolset which, although currently unexploited, could meaningfully support the Community-level deployment of SMRs.[1030]

The potential importance of these plants has been recognised at the Community level, as reflected in the already mentioned Declaration on EU SMR 2030, which, among other things,

[1023] Carson and Mayoral, 2025.
[1024] Josephs et al., 2025, pp. 27–28.
[1025] ICAO, 1944.
[1026] NEA, 2022, p. 7.
[1027] In their case standardised products also had to be deployed in different jurisdictions, but their cross-border use further necessitated the harmonization of authorization procedures.
[1028] This section largely builds on the author's previously published manuscript: M.V. Mádl (2025) The Euratom Treaty as the Foundation of a Harmonised Licensing Framework for SMRs in Europe, *Czech Yearbook of Public and Private International Law* (16), pp. 295–311.
[1029] Tonhauser, Wetherall and Thiele, 2022.
[1030] Gorzkowski, 2024.

highlights the potential benefits of SMRs for Member States that choose to include nuclear power in their energy mix; however, it makes no mention of harmonisation.
The Community constitutes a sufficiently large market for SMRs, while its Member States, owing not only to the common standards they follow in the nuclear field but also to the broader homogeneity of EU law generally, possess comparatively more homogeneous legal frameworks then the diverse countries cooperating under international organisations. As a result, adopting common approaches and ultimately leveraging the work of other Member States' regulators would be considerably more straightforward in practice than within the more heterogeneous international organisations. This is complemented by the fact that, as will be explained below, if binding measures were adopted, they could be enforced and interpreted by the Court of Justice of the European Union. While this may result in clearer interpretation and more predictable procedures, it may also raise counter-arguments related national sovereignty.

4.4.2.1. The Euratom Treaty

The vision behind the Euratom Community and the role of nuclear power was ambitious; however, the execution quickly revealed a curtailment in both the role of nuclear energy[1031] and the scope of the Community's powers. This particularly concerned installation safety, which as originally conceptualized in the Spaak Report would have enabled the Community to prescribe minimum safety standards and oversee installation safety.[1032] Nonetheless the idea of harmonizing safety standards continued to be raised by the Commission,[1033] and authors – albeit based on different provision of the Treaty then those discussed today,[1034] – but as the original industrial development objective of the Treaty gradually started to fade away, owing in part to the impact of nuclear incidents,[1035] these ambitions were also sidelined. The Treaty failed to evolve through amendments, and it was said to be incapable of pursuing other objectives beyond industrial development; consequently, some argued that it should be phased out. Yet attempts to abolish it were also unsuccessful.
This 'relic' from the past has survived the test of time, and the principal reason for its endurance lies in the fact that, despite the absence of amendments, the Treaty has been able to evolve, find new rationales, and, as a living instrument,[1036] respond to contemporary challenges.[1037] The most prominent new rationale finding of the Treaty concerns the field of installation safety, and as such, it has also paved the way for the potential harmonisation of licensing.

4.4.2.2. The Nuclear Safety Case

As mentioned, the Treaty was not substantively amended, which raises the question: how was it able to acquire a new rationale? The answer lies in its interpretation,[1038] entrusted to the Court of Justice of the European Union. The case that gave rise to this new rationale was Case C-

[1031] Mayne, 1967, pp. 80–81.
[1032] Intergovernmental Committee created by the Messina Conference, 1956, pp. 109–110.
[1033] European Commission, 1969, pp. 30–32.
[1034] Kuhnt, 1977.
[1035] Burns, 2018, pp. 7–30.
[1036] Handrlica, 2024.
[1037] Södersten, 2022, pp. 788–817.
[1038] On the evolutive interpretation and its role in finding new rationales, see Dupuy, 2011, pp. 123–137.

29/99, which concerned the declaration of competences of the Community upon its accession to the Convention on Nuclear Safety.[1039] While the Community's accession to the Convention was not in dispute, the Community's scope of competences,[1040] to be outlined in the accompanying declaration, was.[1041] According to the Commission, the competencies of the Community were broad, whereas the Council viewed them as somewhat limited. The Court was tasked with assessing whether the Community has competencies in the areas covered by the CNS, one such area being whether the Community can establish a legislative framework regarding the safety of nuclear installations.[1042] In view of the Advocate General,[1043] and ultimately the Court, radiation protection and the safety of nuclear installations, at the time of the Treaty's drafting, were distinct domains, the latter not expressly being addressed in the Treaty. This meant that the health and safety provisions – traditionally covering radiation protection – of the Treaty had to be interpreted to determine whether they also cover installation safety. The Court after reciting its earlier case law – where subsequent practice lead to broad interpretation,[1044] – considering the Community's obligation under Article 2(b) of the Treaty and in light of the following scientific developments, it stated that "it is not appropriate, in order to define the Community's competences, to draw an artificial distinction between the protection of the health of the general public and the safety of sources of ionising radiation."[1045] Furthermore crucially for the idea of a harmonized licensing framework the Court concluded that while the "Treaty does not grant the Community competences to authorize the construction or operation of a nuclear installations, under Article 30 to 32, of the Euratom Treaty the Community possesses legislative competence to establish, for health protection, an authorisation system which the Member States must apply."[1046] This meant that although the Community cannot issue licenses, as that competence remains strictly with member states, it can still establish harmonised licensing regimes and safety standards applicable in the Member States. Some authors go further, arguing that the Community not only has the possibility of establishing such a licensing framework but, under Article 7 of the CNS, which prescribes the establishment of safety requirements and a system of licensing for nuclear installations, is in fact obliged to do so.[1047] However, a counterargument holds that licensing procedures are already in place in the Member States, and that there is no obligation to establish a unified or harmonised framework merely to ensure they remain so – a requirement already reflected in the Nuclear Safety Directive.[1048]

4.4.2.3. The Nuclear Safety Directive

[1039] IAEA, 1994.
[1040] Södersten, 2018, p. 177.
[1041] The CNS in art. 30 requires regional organisations to declare their scope of competencies.
[1042] Dehousse, 2014, p. 14
[1043] Opinion of Advocate General Jacobs in Commission v. Council, Case C-29/99 ECLI:EU:C:2002:734, 11257–11264.
[1044] *Commission v. Council* (C-29/99) ECLI:EU:C:2002:734, judgment of 10 December 2002, paras 79–80.
[1045] Id., para 82.
[1046] Id., para 89.
[1047] Olajos, 2017, pp. 372–373.
[1048] Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations, 2009, art. 4.

Following this landmark judgement, the Commission began working on adopting secondary legislation concerning installation safety. The first outcome of these efforts was the 2003 package,[1049] one proposal of which specifically concerned installation safety. The proposal was ambitious,[1050] aiming to establish common safety standards for nuclear installations within the Community, along with mechanisms for their verification. Regarding the common safety standards, the explanatory memorandum noted that although the Community has made efforts towards harmonisation, these efforts relied on non-binding means, leaving persistent discrepancies. Furthermore, after highlighting the importance of installation safety through the example of Chernobyl, the proposal argued that, in light of enlargement towards Central and Eastern European states, a common framework in the field of nuclear safety would be necessary for nuclear installations before their accession.[1051] As installation safety has traditionally been a domain where states were reluctant to relinquish their competencies – an approach that remained essentially unchanged even after Chernobyl[1052] – this proposal was met with resistance from Member States,[1053] particularly concerning the development of binding safety standards and the Commission's supervisory role.[1054] Consequently, in 2004, an amended proposal was introduced, clarifying that responsibility for nuclear safety rests with operators and Member States,[1055] and removing the Commission's supervisory function.[1056] This amended proposal failed to achieve greater success. Eventually in 2008 a further amended proposal was introduced,[1057] reflecting a scaled-down approach to common safety standards,[1058] requiring only respect for the IAEA safety fundamentals, and observing the obligations set out in the CNS,[1059] additionally for new plants it stated that Member states shall aim to develop additional safety requirements in line with the developments of WENRA and the European High Level Group on Nuclear Safety and Waste Management, which later became ENSREG.[1060] The final text of the Directive adopted an even more restrictive approach, merely requiring, in its recitals, consideration of the IAEA Safety Fundamental principles and the WENRA safety reference levels for power reactors.[1061]

As can be observed, the initial 2003 proposals – reflecting the mandate of the CJEU – were the most ambitious as they envisioned the development of common safety standards under Title III of the Euratom Treaty. Subsequent proposals reflected a progressively diluted approach to common safety standards, and ultimately, the Directive parted with the idea of the Community taking an active role in developing common safety standards for installations, which could serve as a basis for harmonised licensing. The powers entrusted to the Community remained largely dormant under the Directive, which primarily drew upon the CNS, to which Member States

[1049] European Commission, 2003a.
[1050] Kuş and Emmerechts, 2009, p. 20.
[1051] European Commission, 2003a, pp. 2–3.
[1052] The CNS took a long time to be adopted after the accident, unlike the Assistance and Notification Conventions
[1053] Pouleur and Krs, 2010, pp. 8–33.
[1054] Ferro, 2009, p. 297.
[1055] European Commission, 2004.
[1056] Van Hecke**,** 2007, pp. 131–155.
[1057] European Commission, 2008.
[1058] Södersten, 2012, p. 5.
[1059] IAEA, 1994, Article 6.
[1060] European Nuclear Safety Regulators Group.
[1061] Council Directive 2009/71/ Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations, 2009, recitals 13–14.

were signatories, and the IAEA Safety Fundamentals, which had generally already been followed. Its added value was limited to areas such as transparency,[1062] regulatory independence, and the enforceability of its provisions, leading some to question the necessity and purpose of the Directive.[1063]

In March 2011, prior to the implementation deadline for the Directive, the Fukushima Daiichi accident occurred, prompting the European Council to call for a stress test jointly developed by ENSREG and the Commission to evaluate the safety of nuclear plants in the Community.[1064] The tests have revealed significant discrepancies among Member States and shortcomings in their national safety regimes, ultimately leading to a call for Community action.[1065] In the following years, intense work began on revising the Directive with various proposals emerging from DG Energy, ENSREG,[1066] and the Commission.[1067] A central element of the discussion was the establishment of a mechanism for developing harmonised nuclear safety guidelines within the Community.[1068] The Commission's proposal included an article on nuclear safety guidelines intended to be created through the collaboration of national authorities following peer reviews. Still, it ultimately did not make it into the Directive, along with other critical reforms, the omission of which attracted considerable criticism.[1069] While the amended Directive[1070] made improvements regarding the independence of regulatory authorities and set a safety objective for nuclear installations, the idea of common safety standards – on which common licensing procedures can be built – remained unrealised.

Looking back at both the original and the amended Directives, a common feature during their negotiation was that their adoption was shaped in response to nuclear accidents, with the setting of safety standard viewed as a tool for achieving a higher level of nuclear safety within the Community,[1071] – a goal aligned with the rationale of the Community found during the Nuclear Safety Case.[1072]

4.4.2.4. Harmonisation in contemporary times

What might distinguish attempts today towards the harmonisation of licensing is the changing attitude towards nuclear energy. At the time of the negotiations of the original and amended Directive, the legacy of devastating nuclear accidents cast a shadow over nuclear energy, and harmonisation efforts[1073] were driven by the desire to prevent such accidents rather than by an ambition to expand the nuclear industry. However, today, this attitude is changing; the number of countries in favour of nuclear energy is growing, and the original rationale of the Treaty – to support the development of the industry – is becoming increasingly realistic and needed. Some

[1062] Ferro, 2009, p. 299.
[1063] Ibid.
[1064] Alvarez-Verdugo, 2015, p. 171.
[1065] Dehousse, 2014, pp. 28–29.
[1066] Their participation in the legislative process is not mandatory.
[1067] Woitecki, 2014, pp. 53–55.
[1068] Faross, 2014, p. 45.
[1069] Proelss, 2021, pp. 92–93.
[1070] Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, 2014.
[1071] Stanič, 2010, pp. 151–152.
[1072] Södersten, 2022, pp. 805–807.
[1073] Barnes, 2002, p. 123.

may argue that this renewed interest concerns only advanced technologies; however, even if that is the case, supporting a specific segment of the industry by developing common approaches tailored to it would not diminish the potential value of Community action.
A harmonized approach based on the promise of economic development and prosperity, may prove to be a more compelling rationale then one based on improving nuclear safety for accident prevention, which to a degree implies that Member States do not have sufficiently stringent nuclear safety regimes,[1074] – an implication they deliberately sought to avoid during the formulation of the proposals – and consequently sparks apprehension among pro-nuclear states that their national measures might be challenged by opponents before the CJEU.[1075] Today, it is a careful interplay between the original Treaty intention – namely, industrial development – and the competence recognised in the Nuclear Safety Case, which provides the Community with the possibility to be a relevant tool in advancing the deployment of standardised reactors. The Community has historically demonstrated, in other fields such as radiological protection,[1076] its capacity to exceed international standards; yet, this step has not been taken in relation to the nuclear safety of installations, but it is not due to a lack of possibility.
A crucial step within the Community, which might strengthen the argument that motivations regarding nuclear energy are changing today, is the Commission Communication on the strategy for the development and deployment of SMRs in Europe. The strategy lists nine actions needed to facilitate the roll-out of SMRs, which also includes proposals on the licensing of such plants, as the document rightly points out that adequate licensing frameworks can help de-risk SMR investments. The strategy does not refer to the potential role of Euratom in establishing harmonised licensing frameworks. Although it recognises the possible benefits of harmonised licensing procedures and the possibility of leveraging foreign assessments of SMR designs, it instead refers to an SMR coalition, in which Member States would cooperate to facilitate the deployment of a selected SMR design through policy and regulatory cooperation – which could involve the harmonisation of their licensing frameworks and the leveraging or mutual recognition of foreign regulatory reviews.[1077] Interestingly, the action also refers to limiting "locally customised solutions", the meaning of which is not entirely clear from the document, but which could be of significant relevance for licensing if it concerns limiting those differing national licensing elements that would necessitate the modification of a design from country to country. Additionally, the commission will provide a grant to support EU regulators to develop regulatory sandboxes to carry out joint safety assessments.
While the strategy when it comes to high level ideas reflects some of the most important detriments to SMR licensing and aims to promote ideas which can resolve them, it frames this in a very *ad hoc* setting under the denomination "regulatory coalition of the willing". The strategy lacks an institutionalisation, it rather seems to promote the idea of bilateral and multilateral cooperations among Member States, the form and content of which is decided by the parties. Looking at the original idea behind the Euratom Community from today's renewed interest in atomic energy it is rather surprising that the Commission does not see a prominent role in advancing SMR deployment for the Community, by entrusting it with an institutional

[1074] Garribba, Chirteú and Nauduzaite, 2009, p. 29.
[1075] Berthélemy and Lévêque, 2011, p. 133.
[1076] Ferro, 2009b, p. 151.
[1077] European Commission, 2026, Action 7.

role in this process. The important directions for development are already established; what is needed is a platform and a coordinator – one that brings together the several interested countries which, as Members of the Community following similar standards, could more easily adopt harmonised procedures. Such a platform naturally cannot be one that brings only independent regulators together, since regulators alone cannot promote this kind of policy development – one driven by several considerations, such as decarbonisation, energy security, or competitiveness; rather, it must be one capable of promoting policy change in its own right, a role for which the Community could be well suited. The Community could provide a platform where willing countries come together; it could also supply additional expertise to this process. Public perception may be more favourable towards efforts undertaken under the auspices of the Community, where further expertise is involved in devising adequate solutions, framed within the Community's nuclear safety framework. Furthermore, from the perspective of traditionally anti-nuclear states, if these efforts were to focus on SMRs, they might attract fewer reservations, since some of these countries are not as fiercely opposed to the idea of deploying SMRs specifically.

4.4.2.5. How could harmonised licensing be achieved in the Community?

If this now unlikely option were to be pursued the path, in principle, to achieving binding harmonised licensing frameworks in the Community would be very similar to that followed in the case of the Nuclear Safety Directive. Article 2 of the Treaty mandates that, to perform its tasks, the Community shall establish uniform safety standards, a requirement further substantiated by Article 30. The definition of basic safety standards in Article 30, at first glance, appears rather restrictive, as it applies only to radiation protection; however, as explained above, this interpretation has been superseded in the Nuclear Safety Case, and it also applies to installation safety.[1078]

Article 31 outlines the procedure for adopting these standards. The Commission plays the central role in developing a proposal; however, two other bodies must be consulted. This provision requires the European Economic and Social Committee, which represents the interests of different groups in the Community, to deliver its opinion on the issue's social policy implications.[1079] The other is the Scientific and Technical Committee, which, according to the Treaty's wording, appoints scientific experts, particularly from the field of public health, whose opinion has to be obtained. This reference to public health experts reflects the earlier, narrower interpretation of safety standards pertaining to radiation protection. If these standards were to establish harmonised licensing procedures, the composition of experts involved must be reconsidered.[1080] Experts to be involved should possess expertise in installation safety, particularly regarding advanced technologies; equally important is the involvement of those familiar with the licensing procedures. Although Article 31 only requires the opinion of these committees, the Commission should also, as it did before, consider the standards developed by the IAEA, or WENRA. If a new harmonisation measure were adopted under Article 31, a key

[1078] Grunwald, 2014, pp. 25–27.
[1079] Zellentin, 1962, p. 26.
[1080] Grunwald, 2014, p. 27.

question would be how it would relate to the existing Nuclear Safety Directive. Would it be a *lex specialis* directive, amend the current Directive or take a different form?
Even though harmonised binding licensing could offer economic benefits to proponents of nuclear energy, and potentially a more supervisable framework – one in which, were a common design review framework adopted, the reviews of other Member States could be more reliably leveraged – there remains a strong possibility that a directive pursuant to Article 31 would not secure sufficient support in the Council, given that a non-binding framework may bring very similar benefits for SMR deployment. For developing standards that are not binding on Member States, the Euratom Treaty offers an alternative under Article 33, which allows the Commission to issue recommendations for harmonisation. Substance-wise, these could be the same as for binding measures, potentially even more ambitious, while not carrying the same burdens associated with their adoption and enforcement in cases where certain approaches are challenged by anti-nuclear actors. However, such an approach would not carry the same supervisory role, which could, from a public perception perspective in particular, undermine support for relying on other Member States' reviews. If the countries in question are dedicated and motivated to participate in this cooperation, significant benefits could nonetheless be realised for SMR deployment. In such a case, the Community could still assume a role in overseeing the implementation of such a framework and contribute to resolving disputes.

4.4.2.6. Elements of a harmonised licensing framework

Firstly, the scope of a proposed harmonised licensing framework should be carefully assessed. Harmonisation can proceed in two directions: it can either be limited to certain advanced technologies or take a general approach encompassing both conventional and advanced reactors. As was seen in the comparative sections, some countries opt for reforms encompassing both conventional and advanced reactors alike. While pursuing a generally applicable licensing system – as explained with regard to Finland – has benefits at the national level, adopting such an approach at the Community level would also signal that Member States would need to change the standards and approaches they have long been familiar with applying to conventional technologies. This could generate considerable reluctance and thereby undermine the purpose of a harmonised system, without yielding extensive benefits from incorporating conventional plants, since in their case the benefits of standardisation are not as pronounced as in the case of SMRs deployed in large numbers.
There is also the option to adopt a targeted approach, for example, focused on SMRs. In their case, the importance of harmonisation is unquestionable, and specific regulatory approaches appear more adequate than others. Thus, there is a clear incentive to adopt new approaches and standards without compromising existing regulatory experience, which is largely absent for them at present. In the case of SMRs, efforts to create enabling licensing conditions may evolve beyond merely advocating for more harmonised, SMR-supporting licensing frameworks implemented separately within each country's own national context – where, although these national systems do not interact with one another, each individually becomes more open to SMRs than before – towards establishing common design review procedures, enabling Member States to leverage reviews across borders. Nevertheless, an SMR specific approach also raises several unresolved questions. For instance, how these new frameworks could be transposed into

national legislation, and what their relationship would be with the existing frameworks, remain open questions. In this regard, it may also be worth considering whether such a proposed harmonised framework may appear as a regulatory sandbox – used for testing innovative technologies – in the licensing frameworks of member states. Using regulatory sandboxes in the context of SMRs is not a unique idea,[1081] but utilising a similar framework across countries in their case could also contribute to proving if such a common approach may contribute to taking advantage of their more standardised nature.

The following section outlines some of the considerations that should be kept in mind when developing a harmonised licensing framework for Member States that particularly seeks to resolve the blocking points in SMR licensing.[1082] Developing such a framework is a demanding task that requires significant attention to be devoted to it; nevertheless, there are ideas as to how SMR-associated licensing challenges could be resolved in national contexts, and such a framework should primarily adopt approaches that reflect these proposed solutions. Since these means have already been discussed in detail, the author wishes to limit the discussion here to listing them and offering some brief comments relevant from the Community's perspective.

4.4.2.6.1. Technological neutrality

During the development of the Community framework, one of the general principles that should be kept in mind is technological neutrality. While the development of such an approach at the Community level may attract lobbying from SMR manufacturers seeking to adopt licensing frameworks that favours them, technological neutrality should nevertheless prevail, so as to allow the best-suited designs to be found for a given application and to future-proof these systems.

4.4.2.6.2. Performance-based requirements and the use of graded approach

The adoption of standards that reflect a performance-based philosophy should also be considered when developing a licensing or review framework that allows greater flexibility for SMRs in presenting their safety case. Complementing the goal-setting philosophy the use of a graded approach in the Community framework would be equally important, but in this regard its establishment at Community level could bring further benefits. As highlighted by the SMR Regulators' Forum, discrepancies persist among states in the interpretation and application of this principle. A common understanding and consistent implementation of this concept would enhance its effectiveness.[1083] In this regard, the Community could play a leading role by establishing a common interpretation of the graded approach and defining the methodologies for its consistent application among Member States.

Since these approaches may, in some cases, result in more demanding licensing reviews for the regulatory authority, the previously highlighted certified inspection organisations could potentially play a more pronounced role for less safety-significant matters. The Community approach could contribute to the internationalisation of these inspection organisations by

[1081] Petri and Vikas, 2026.
[1082] European Nuclear Safety Regulators Group, 2024b, p. 21–23.
[1083] IAEA, 2018, pp. 11–12.

facilitating their operation as across Member States, which would ultimately allow for more streamlined evaluations and enable greater leverage of experiences gained in other projects involving the same standardised plant.

4.4.2.6.3. Community design review and design certification

The most interesting issue to be pursued, also raised as an idea by the Strategy, is whether a community design review system could be adopted. The answer is most likely yes; however, this would require a rather detailed basis. Such a review system would allow regulators to focus their evaluation on site- and application-specific matters and potential design deviations, rather than re-evaluating standardised aspects that have already been approved,[1084] – in this case, by a different Member State's regulator. As will be discussed, similar efforts are pursued under the IAEA; however, in this respect, the Community appears well positioned to adopt such a system, owing in part to its tradition – albeit not in the nuclear sector specifically – of recognising licences granted by other Member States, as well as to the efforts already made to strengthen national regulators.

If there is reluctance towards such a review framework, the development of a model licensing framework – one that instead focuses on making individual national licensing frameworks more accommodating – could still promote adopting meaningful pre-licensing procedures and national design certification procedures in the Member States.

4.4.2.7. National sovereignty implications of harmonisation

As mentioned earlier, concerns of nuclear-armed states over national sovereignty have played a significant role in hindering progress towards harmonisation.[1085] While it is unclear how such a system would infringe on national sovereignty, given that it would not affect Member States' rights provided under the Treaty on the Functioning of the European Union to choose their energy mix, these concerns still warrant a brief elaboration. First, the aim of harmonisation this time is not in response to inadequate national nuclear safety measures, but rather an effort to harness the economic advantages of certain advanced reactors – an objective better aligned with the interests of nuclearised states. Moreover, as concluded in the Nuclear Safety Case, the Community does not have the competence to license nuclear power plants; this remains strictly a national prerogative. Even under a common licensing framework or a community design review process, Member States will have free choice over their energy mix, and their authorities will retain complete discretion as to whether to license a given plant.

Furthermore, the previous reluctance to change national approaches due to concerns of compromising domestic regulatory experiences may be less relevant if the Community framework is introduced as an alternative licensing pathway, mainly if it is targeted toward SMRs, where no state has established experience to lose. Finally, it is worth mentioning that many existing or former licensing frameworks were initially modelled on the regulatory

[1084] World Nuclear Association, 2015, p. 9.
[1085] See Axelrod, 2006, p. 5.

frameworks of vendor countries,[1086] so reluctance towards adopting an 'external' framework to accommodate novel technologies would be disputable.

4.4.2.8. Concluding thoughts on harmonization in the Community

The Community's rationale has shifted once before; it is argued that, in the current climate, it could return to its original rationale of supporting the nuclear industry through the means of harmonisation – a rationale to which, interestingly, the Community's later, somewhat contradictory shift towards safety regulation paved the way, by enabling the Community to legislate in the sphere of installation safety. As the beneficial role of SMRs becomes ever more widely accepted, the Community should not hesitate to support Member States in deploying these plants. The Community is the ideal organisation for pursuing such efforts: why should Member States have to rely on the efforts pursued under international organisations, when these objectives could be equally achieved within the Community – possibly even more effectively – with the added benefit of enhancing the Community's overall competitiveness by taking an early step? While opponents of nuclear energy exist, they exist equally within the IAEA, and yet nuclear energy supporting projects continue to be conducted there; this should therefore not be an impediment to efforts pursued under the Euratom framework. The question of why such efforts are not being pursued is most likely a complex one; however, even within this changing climate towards nuclear energy, the Commission remains reluctant to take even the minimal step of advocating for such harmonisation among Member States under the Community's umbrella.

4.4.3. Ongoing international efforts facilitating the deployment of SMRs

As mentioned before, pursuing harmonisation may not be limited to the Euratom Community what is more, international efforts in advancing SMR deployment may not be limited to harmonisation alone.

In the following section, some of the most important international initiatives seeking to facilitate SMR deployment will be discussed. There are discrepancies among these efforts both in terms of their institutional frameworks and their content. Some are conducted under the auspices of international organisations active in the nuclear sector, while others take the form of direct bilateral or multilateral arrangements between specific countries; in the next section, the discussion of these efforts will be organised according to these institutional settings. Different categorisations may also be drawn along the lines of whether the initiatives concern regulatory harmonisation, industry standardisation, or a better understanding of SMR innovations through cooperation between industry and regulators. The list presented here will not be exhaustive the author limited itself the to the most important initiatives.

4.4.3.1. Cooperations involving the OECD Nuclear Energy Agency

The first effort that must be mentioned here is the Accelerating SMRs initiative, a platform launched at COP28 to bring together different stakeholders in support of SMR deployment. The platform is a rather pragmatic one which, by utilising the resources of the NEA and its network,

[1086] Such as the case of Hungary.

seeks to contribute to providing the enabling conditions necessary for SMR deployment. Accordingly, the NEA works on the key conditions by researching these questions, while at the same time acting as a facilitator connecting interested governments, the private sector, and industry representatives.[1087] Among the several enabling conditions that the NEA acknowledges, legal issues and licensing stand out as one; on this basis, the "Bridging Law and Technology" International Workshop was organised in 2025 to assess how legal frameworks must adapt to the changing technology. The Workshop – attended by the author – placed significant weight, among the legal challenges of SMR deployment, on licensing issues, including those related to environmental matters, siting, and public participation. While the workshop offered valuable insight from experts, it did not present a clear solution to SMR licensing issues – one that is not to be expected, given the current lack of practical experience; rather, a variety of challenges were discussed, along with some potential pathways for resolving them. What was also clear from this event is that the field remains largely in the phase of mapping out the full spectrum of licensing issues associated with SMR deployment, with some ideas emerging as to how these might be resolved – thus clearly indicating the need for greater attention to these questions. While, according to the NEA, SMRs will only significantly contribute to the expansion of nuclear capacity in the second half of the 21st century,[1088] seemingly suggesting that there is still ample time, this is not in fact the case if one takes into account the deployment timelines, the necessary first-of-a-kind projects, together with the fact that licensing-related issues need to be settled well in advance. The strength of the platform lies in the fact that it channels various stakeholders towards resolving the interdisciplinary challenge of deploying SMRs.

Under the auspices of the NEA, a promising example of a platform for cooperation among national regulatory authorities – one that may contribute to harmonisation – is the Multinational Design Evaluation Programme (MDEP). The project initiated by the US NRC as the Multi Design Approval Program but soon the support of the program was taken over by the OECD NEA and it became the MDEP.[1089] The MDEP was established with the aim to bring together the regulatory authorities to establish new approaches that can facilitate the experience resource and knowledge sharing among regulators that review new designs.[1090] It essentially seeks to provide a platform through which national authorities can cooperate on the review of new reactor designs,[1091] with three aims: to contribute to reviewing these plants against a shared, high level of safety standards; to increase the harmonisation of regulatory requirements and practices; and, critically from the perspective of this thesis, to increase the efficiency of licensing procedures[1092] by leveraging cooperation in the review of the same designs.[1093] While the MDEP is a valuable platform for regulatory authorities engaged in the licensing of the same designs, and through this aims to achieve a higher degree of harmonisation, it also has its limitations, being, in this respect, mostly connected to particular designs. In addition, however, generic common positions may also be issued, which are not tied to particular designs but are

[1087] A*ccelerating SMRs Initiative, no date.*
[1088] NEA, 2026c, p. 11.
[1089] Tronea, 2010b, p. 161.
[1090] *Multinational Design Evaluation Programme (MDEP)*, no date.
[1091] Burns et al., 2022, p. 186.
[1092] Sexton Nick, 2022, p. 13.
[1093] IAEA, 2025a, p. 44.

generally applicable to certain areas. Nevertheless, these generic common positions likewise relate to specific areas touched upon within licensing reviews, and as such do not constitute overarching, generic best practices for licensing frameworks more broadly – practices that would seek to make these procedures more efficient or better suited to advanced technologies – particularly considering that the most recent such position dates from 2017, making it almost a decade old. The MDEP is currently limited in terms of its membership, and consequently in the designs reviewed. In the wake of SMRs, it remains an open question whether, with regard to SMR designs, it could attract wider participation, and whether broader, more general, efficiency-enhancing measures could be proposed.

4.4.3.2. Cooperations under the auspices of the International Atomic Energy Agency

As the most significant global international organisation in the nuclear field, the IAEA is also actively participating in resolving the challenging issues related to deploying small modular reactors. The IAEA's position in the field of nuclear law is very interesting. They hold a non-binding harmonising position in the field of nuclear safety – though they are not the only organisation to do so – through safety standards that are not mandatory for State Parties; nevertheless, given the respect accorded to the IAEA's expertise in this sector, these standards are very often implemented in national legislation. These standards also touch upon the issue of licensing, which states likewise take into account when framing their licensing processes. This means that, even though these are non-binding standards, the IAEA has been advancing the harmonisation of existing licensing frameworks. With regard to advanced technologies such as SMRs, the IAEA has recently been working on revising the safety guide related to the licensing of nuclear installations. The draft version of this guide is now available,[1094] and the final version is expected to be published in 2027; as a standard developed by the IAEA, it will naturally also shape the approaches of State Parties.

The revised version reflects the growing importance of SMRs, on the one hand, it incorporates, within the general licensing standards, considerations relevant to SMRs, such as how pre-licensing can be beneficial in their case;[1095] on the other, it also dedicates an appendix specifically to SMR licensing issues. The appendix, among other things, touches upon the siting of SMRs, acknowledging that their intended purposes may necessitate siting them closer to industrial or more densely populated areas, and listing numerous considerations that should be incorporated by the regulator when reviewing these arrangements.[1096] In addition, it reflects several concepts already well established in the broader discussion of SMR licensing, such as the graded approach, generic design licences, and multi-module licensing procedures. More interestingly, the appendix also rightly notes that SMR deployment may involve licences specific to factory manufacturing and commissioning. In this regard, the draft guide makes several important points: it stresses the need for off-site commissioning and testing facilities to also be licensed, and that regulators should have oversight over these activities. In relation to the transport of modules, it also raises the crucial issue that the effects of transport on quality must be considered, and that tests should be carried out both before and after transport to the

[1094] IAEA, 2026a.
[1095] Ibid. p. 4.
[1096] Ibid. p. 42.

site.[1097] Finally, the last issue addressed in the draft concerns how information from different regulatory authorities may be leveraged responsibly. In this regard, it highlights the need to understand the information obtained, to understand what it was previously assessed against and what it will subsequently be assessed against, and to take responsibility for one's own regulatory decisions.[1098]

While the draft has not yet been adopted, it is unlikely to undergo major changes; and, coming from the IAEA, which represents a significant level of consensus in the sector, it will most likely also shape national frameworks. While the measures states have already adopted to prepare for SMR deployment have, in many cases, already incorporated these considerations, in certain areas the draft may nonetheless represent some novel ideas.[1099]

However, besides developing standards that reflect SMRs, the Agency also contributes to increasing the necessary international cooperation for SMR deployment.

The Agency already launched the SMR Regulators' Forum in 2014, which seeks to bring together regulators to focus on and address SMR-related regulatory and licensing issues, and to issue subsequent common positions[1100] – which then influence IAEA standards[1101] including those mentioned above. In essence, it serves as a platform for discussing particular SMR-related issues, to which these regulators develop common answers. While, this may ultimately indirectly contribute to more harmonised licensing frameworks, its underlying goal was not to adopt such frameworks in order to reflect the economic rationale of standardised reactors, but rather to discuss and answer questions with which regulators have limited experience.

A platform more directly aimed at harmonisation, launched under the IAEA, is the Nuclear Harmonisation and Standardisation Initiative (NHSI), which was established in 2022 specifically to address the economic rationale of SMRs. The initiative very wisely has two branches one concerns the regulatory segment, and it aims to harmonise the regulatory approaches, while the other industry sphere is seeking greater standardisation.

Structured around three working groups, the first phase of the regulatory track focused on three main issues deemed necessary for establishing a common basis for cooperation among regulators: establishing a platform for information-sharing among regulators; establishing an international pre-licensing design review conducted by regulators; and determining how regulators may leverage one another's reviews.[1102] Along these three lines, the IAEA has published three documents. The first concerns information-sharing among regulators during advanced reactor licensing or pre-licensing procedures, whether as an individual endeavour or as part of collaboration with other regulators, and also presents the associated obstacles and ways to address them.[1103] The second publication on collaborative reviews and effective leveraging describes several means of regulatory cooperation during the licensing or pre-licensing of SMRs: collaborative reviews, meaning independent reviews of the same design against national requirements; joint reviews, where several regulators jointly assess the design

[1097] Ibid. p. 45.
[1098] Ibid. p. 49.
[1099] Additionally, the IAEA is also working and publishing on how its more specific technical documents for example in the case of designs of nuclear power plants may be applied to SMRs, see: IAEA, 2020a, p. 2.
[1100] Jayarajan and Piotukh, 2023, pp. 24–25.
[1101] Trajano and Chew, 2023, p. 7.
[1102] *IAEA sees progress made by SMR deployment initiative*, 2022.
[1103] IAEA 2025a, p. 2.

against common requirements; and leveraging reviews, which likewise involves an independent review against national requirements, but draws on reviews already conducted by foreign authorities.[1104] Essentially the document provides assistance for the states to establish such review procedures and what consideration have to be taken into account in case of leveraging. The final publication – and possibly the most innovative of the three – goes beyond this conceptual discussion of joint reviews, proposing a more concrete procedure: a multinational,[1105] pre-licensing joint review, conducted prior to any actual licensing and facilitated by the IAEA, in which based on the initiative of the applicant a design is assessed against a non-project-specific reference framework, optionally based on the IAEA's own safety standards.[1106] Similar review frameworks are not unprecedented in practice on a multilateral basis, as the next section will elaborate. They have been used because of their benefits: they give the applicant more certainty in concrete applications, since it can react to revealed shortcomings, for example in its documentation. They can also help regulatory bodies adopt new regulatory approaches and familiarise themselves with the designs, and allow regulators that did not participate to see the experiences of foreign regulators.[1107]

As these efforts show, the first phase of the NHSI focused mainly on building the framework, whereas the ongoing second phase concentrates on putting it into practice, notably by testing the multinational pre-licensing framework through the EAGLES-300 pilot project[1108] Ultimately, however, the ambitious goal of the NHSI regulatory track is to develop the Global Framework for Advanced Reactor Reviews (GFARR), a harmonised approach enabling advanced reactors to be reviewed in a technology-inclusive, safe and efficient manner. This aspiration goes beyond both the efforts highlighted above and the largely high-level IAEA safety standards. Since States that adopt IAEA and other standards currently interpret them in differing ways, the framework seeks to overcome these discrepancies through a consensus-based approach to the scope and requirements of reviews, set out in sufficient detail to enable the global deployment of advanced reactors. To this end, the GFARR will comprise a core document in the form of a safety report applicable to advanced plants, supported by guidelines and templates defining common review scope, criteria and their interpretation, together with guidance for conducting the reviews.[1109] The most interesting question regarding the GFARR is therefore not how the common review scope and criteria will be developed, since drawing on the expertise of the IAEA, its Member States and other standard-setting bodies makes this achievable, but rather how a review conducted under the framework may be utilised. Because the scope criteria and their interpretation are fixed, such reviews will be limited to those criteria and will exclude project- and nation-specific considerations. The framework will thus function similarly to national design certification, although, in respect of the national sovereignty of regulators, it will not in itself constitute an authorisation. Building on the outcomes of the first phase of the regulatory track, the GFARR may be applied in three ways to conclude such a review of a design. In a multinational review, representatives of regulators from different States

[1104] IAEA, 2025b.
[1105] Meaning that representatives of different regulatory bodies cooperate.
[1106] IAEA, 2026b.
[1107] Ibid. p. 4.
[1108] *Regulators unite for pre-licensing of European SMR design,* 2025.
[1109] IAEA, 2026c.

jointly review the design against the fixed criteria. In a collaborative review, several regulators assess the design individually against the same criteria and then share and discuss their findings. Finally, in an individual review, a single regulator assesses the design against the fixed criteria on its own. Whichever form is chosen, a further critical objective of the framework is to enable leveraging by States that did not participate in the review, since the plant will have been assessed against the same standards, although, as noted earlier, leveraging does not imply the outright acceptance of such a review.[1110] A further, very crucial and interesting question is how such a frameworks may be integrated into national licensing procedures – relevant in the case of all three review types, and also regarding leveraging. Whether this would occur through clauses allowing the exemption of certain issues already assessed under these procedures, through the creation of separate licensing or leveraging stages, through integration within design certification procedures, or implementing these as a design safety certification procedure, remains an open question – one presumably still subject to discussion, as the blueprint states only that the finished framework will provide guidance on how to integrate the process within national licensing and review procedures, and on how countries may recognise GFARR reviews.[1111] The GFARR is the most impressive and ambitious initiative to date, particularly because of its potential to expand beyond safety into other considerations, such as security – a shift that could ultimately turn it into something closer to a global, generic design certification. Much, however, still needs to be discussed – for example, regarding its recognition or integration within national licensing frameworks, how the cost of such procedures will be handled, and whether it is fair for countries to adopt only leveraging mechanisms, without investing resources in the review procedures themselves. The GFARR also has an ambitious timeline, reflecting the need to speed up SMR deployment, the safety report is due for publication by the end of 2028, to be followed by a pilot project, and then by a revision, to be concluded by 2035.[1112]

The other segment of the NHSI is the industry track, which seeks to establish standardised approaches among industrial actors across the different stages of SMR deployment, be it manufacturing, construction, or operation. Such standardisation is hoped to help industrial actors harness the factory construction of SMRs, meaning that designs would not need to be changed for every application, since the fundamentals among SMRs would remain the same owing to this standardisation. The industry track is also phased, and is organised around four topical groups structured around crucial questions: the harmonisation of high-level end-user requirements, meaning the conditions future users expect a design to comply with; common approaches to codes and standards, covering an understanding of their differences and similarities and the development of common approaches; experimental testing and validation for design safety analysis computer codes; and accelerating the implementation of nuclear infrastructure for SMRs.[1113]

4.4.3.3. Direct multilateral regulatory cooperation

[1110] Ibid., pp. 7–11.
[1111] Ibid., p. 7.
[1112] Ibid., pp. 22–23.
[1113] *NHSI Industry Track*, no date.

In the sphere of direct multilateral cooperation, the most instructive initiative was the one launched in 2022 by three European regulators from France, Finland and the Czech Republic and later joined by the Swedish, Dutch and Polish regulators. Within the initiative, the regulators cooperated to review the NUWARD SMR jointly to see what the potential challenges posed by it would be during a hypothetical licensing.[1114] Even though it was only a theoretical procedure, very valuable conclusions were drawn by both the regulators and the vendor EDF.[1115] On the regulators' side, this provided an excellent opportunity to see what licensing challenges a potential SMR application would raise and also to observe what issues other licensing regimes face.[1116] In the second phase of the review it has been highlighted that generally among the higher level regulatory requirements there are no substantial divergences, but these divergences rather stem from the different guidances, their interpretation and how in the national context the regulatory requirements are implemented.[1117] The reason for such as similarity at the higher level legislations as in part explained above stems from – at least in an European context – following similar standards besides. Despite the joint review's more limited scope compared to initiatives such as the NHSI, it remains a crucial element in contributing to the future deployment of SMRs, by identifying those national regulatory requirements and approaches that currently impede the deployment of such plants – something naturally best achieved by testing these frameworks in a theoretical setting. Nevertheless, it must be mentioned that such tests may not provide an overarching solution for all SMRs, since the impediments faced may also differ among designs; not all those faced by other designs could necessarily be uncovered through such an initiative. From the particular vendor's perspective, the review may be even more valuable, in that it provides information on the challenges its design poses to regulators – challenges that can still be addressed at a stage when the design is not yet finalised.[1118] In this regard, however, one shortcoming of the review may be that some of the requirements and regulatory approaches governing licensing procedures today could change, whether through harmonisation or through regulators' own self-reflection, potentially removing some of the very elements that would otherwise have prompted the vendor to reconsider the design. As such, following such initiatives, vendors must weigh which challenges might be eliminated through the reconsideration of these frameworks, and which design solutions would nonetheless still require reconsideration.

4.4.3.4. Bilateral regulatory cooperation

While, from the perspective of SMRs, harmonisation among a larger group of countries is naturally desirable in order to harness the benefits of a sufficiently large market, multilateral cooperation of this kind is inherently challenging, since it requires coordinating, and reaching a consensus among a larger number of countries with potentially heterogeneous legal frameworks. Given this difficulty of multilateral cooperation, bilateral cooperation may be a

[1114] *Development of small modular reactors: in collaboration with the safety regulators of Finland and the Czech Republic, ASN is initiating an unprecedented joint preliminary examination of the NUWARD™ reactor project*, 2022.
[1115] French Nuclear Safety Authority (ASN), 2023, p. 4.
[1116] Ibid.
[1117] Ibid.
[1118] Ibid.

more effective path for countries that, together, already constitute a sufficiently large market and share similar regulatory frameworks from the outset. In such cases, regulators with comparable systems could cooperate to harmonise their licensing frameworks, take advantage of collaborative reviews, or leverage one another's reviews.

Among bilateral cooperation efforts, one that may be highlighted – though not aimed at harmonisation as such – is the 2019 "Memorandum of Cooperation (MOC) on Advanced Reactor and Small Modular Reactor Technologies between the US Nuclear Regulatory Commission and the Canadian Nuclear Safety Commission".[1119] The purpose of the MOC was to deepen the ongoing information-sharing between the two authorities by extending it to joint reviews of given designs, the results of which are set out in joint reports documenting the agencies' common and differing positions and observations. Since its establishment, this cooperation has been applied to several SMR designs, including the XE-100[1120] and the BWRX-300.[1121] While these joint reviews are currently limited to pre-licensing interactions with the applicant, they may, in future, extend to certain issues within actual licensing procedures as well.[1122]

4.4.3.5. Summary of the existing initiatives

While the Euratom Community could fundamentally be in the best position to pursue such harmonisation activities, owing to the number of countries it covers, it is not utilising this potential. Nevertheless, there are several initiatives in which countries interested in the deployment of SMRs may engage, ranging from opportunities to familiarise themselves with these designs to cooperation on developing harmonised review frameworks.

Arguably the most impressive of these efforts is the GFARR, pursued under the NHSI regulatory track. If developed and adopted by several countries, its harmonised review framework could significantly accelerate the deployment of these standardised technologies. Nevertheless, even where cooperative reviews are conducted or foreign reviews are leveraged, the final regulatory decision will still rest with national authorities, which remain responsible for it. Consequently, while such efforts will greatly assist regulators, they will not entirely eliminate the need for national reviews, which also serve to verify that the generic reviews were conducted adequately.

Furthermore, the importance of initiatives that involve industry must be highlighted. Vendors know their designs best, and without their participation it is difficult to identify the impediments within national systems, let alone devise harmonised solutions to address them.

One shortcoming of today's efforts is that, understandably, they focus predominantly on the design aspects of these plants, whereas deployment as a whole involves several other considerations that may similarly affect the outcome of these procedures. Thus, while the focus remains on design-related issues, other national conditions that must be met to deploy such plants, such as how their siting should be approached, could receive more international attention to share best practices and develop adequate solutions.

[1119] NRC, CNSC, 2019.
[1120] Sexton Nick, 2022, p.14.
[1121] *US, Canadian regulators further SMR collaboration*, 2022.
[1122] Williams, 2025, p. 102.

5. Long-term operation of nuclear power plants

5.1. The concept of long-term operation

Rather than shutting down ageing nuclear power plants, long-term operation (LTO) represents the most obvious and relatively swift response within a nuclear renaissance to keep capacity in operation, since replacing retiring units would otherwise absorb part of the new capacity and thus hinder the scale of net expansion. Accordingly, in line with the holistic perspective on reforming licensing frameworks adopted in this thesis, long-term operation is a further consideration that warrants attention alongside the more obvious focus on expanding generating capacity and its associated challenges. The NEA has likewise emphasised that LTO will have to play a central role in achieving the envisaged increases in installed capacity that embody the nuclear renaissance, estimating that around 50 GWe of OECD nuclear capacity still awaits decisions that could secure its licences for operation until 2040, thereby providing a foundation on which new capacity can build.[1123] Many such decisions will therefore have to be made in the coming years. From the perspective of this thesis, attention should be devoted to whether the procedures governing LTO strike an adequate balance between ensuring the continued safe operation of a plant and avoiding overly demanding requirements that would instead encourage its shutdown.

To understand what such procedures entail, the concept of LTO first needs to be clarified. When a nuclear power plant is constructed and receives its operating licence, most countries set a specific term for that licence, during which the plant may operate. This term varies between countries, and sometimes within them, most commonly lasting around 30 to 40 years; some countries, such as Hungary, tie it to the planned operating lifetime of the plant. Operation beyond this initially planned lifetime is referred to as LTO. As most nuclear power plants were connected to the grid during the 1980s and 1990s, a large share of the reactors in operation today have already reached or are approaching this point.[1124] One might assume that, since LTO has already been granted to many of these plants, the question is largely settled. This is not the case, however, as LTO is not necessarily a one-off decision: once an LTO period ends, continued operation may be granted again through a further decision.

Countries without fixed-term operating licences generally address LTO through periodic safety reviews, whereas those with fixed terms employ a licensing stage specific to LTO, which may take several forms, such as an updated, new or renewed licence, or a ministerial order, but regardless the approach there is always a decision involved.[1125] Regardless of the approach, granting LTO is a challenging task from a regulatory perspective, as the authority must decide to permit continued safe operation while taking into account ageing components and materials, which inherently pose a challenge to plant safety.[1126]

This third part of the thesis is significantly shorter than the two main parts, because LTO, although arguably the foundation of the nuclear renaissance, preserves existing capacity rather than expanding it: while the nuclear renaissance could in principle be realised even without LTO, it could not be realised through LTO alone. Moreover, unlike new nuclear projects, LTO

[1123] NEA, 2026c, p. 10.
[1124] NEA, 2025a, p. 17.
[1125] Id., p. 31.
[1126] NEA, 2012, pp. 13–14.

is relevant only to countries that already operate nuclear power plants, and decisions on it are more plant-specific than those on future deployments, as each plant has its own operating history. In addition, although policy decisions and legal considerations naturally play a part in LTO, they are not as critical as in the case of new deployments. Thus, while the holistic perspective adopted on licensing for the nuclear renaissance makes it necessary to address LTO and its associated licensing issues, they are not discussed in the same level of detail.

5.2. Determining the safety requirements of plants seeking long-term operation

What arises as a primary challenge – a question already settled for countries that have authorised LTO – is what approach regulators should employ in these assessments to guarantee the plant's safe operation.[1127] At the core of this challenge is the fact that safety standards over the past 30 to 40 years – partly in response to nuclear accidents that have occurred – have evolved significantly, and differ considerably from the requirements in place at the time of the plant's initial licensing. The question is how, and to what extent, modern safety standards can be applied to existing plants that were not built according to a design philosophy reflecting these later changes. In resolving this question certain provisions of the Convention on Nuclear Safety may be of assistance.

The Convention requires that the safety of installations be assessed throughout their lifetime and reviewed under the authority of the regulator, to ensure that the plant can continue to operate safely.[1128] This provision of the CNS clearly establishes that the granting of an operating licence does not mean that safety no longer needs to be assessed – quite the contrary – and it also provides the authority with a wide toolset to ensure that safety is maintained throughout the plant's entire operating life, whether before or after LTO. However, the CNS – apart from provisions concerning plants that were already in operation when it was adopted[1129] – does not provide guidance on what safety improvements must be implemented during the operation of these plants. That said, while not a binding instrument, the Vienna Declaration,[1130] which was intended to amend the CNS in response to the Fukushima disaster, may offer some guidance in this regard. The Declaration provides that, on the basis of safety assessments carried out periodically to meet the objective of preventing accidents and mitigating radioactive releases from accidents, reasonably practicable or achievable safety improvements are to be implemented in a timely manner, and that regulations addressing this objective are to take into account IAEA standards and other best practices. While this provision does not refer exclusively to LTO, it bears particular relevance in that context, as it highlights that safety considerations emerging after the initial licensing of a plant should not be disregarded on the argument that they were not a requirement at the time of original licensing. In this regard, several considerations arise as to whether the approval of LTO should be assessed according to the safety standards applicable at the time of initial licensing – the so-called 'maintaining safety' approach – or whether the approval should instead incorporate advancements in safety – the 'improving safety' approach – even where these go beyond what was originally expected of the

[1127] Sexton Nick, 2018, pp. 36–37.
[1128] IAEA, 1994, art. 14.
[1129] IAEA, 1994, art. 6.
[1130] IAEA, 2015.

plant.[1131] The question is not an easy one to resolve, as the more that current safety standards – which have developed significantly compared to those applicable at the time of initial licensing – are applied, the more backfitting work will be required, increasing the costs associated with LTO. In practice, national approaches differ widely. Some countries adopt an approach that more closely resembles the improving safety method, but even in such cases there is generally a degree of flexibility within the system: new standards are not automatically applied with subsequent backfitting required; rather, the system takes into account whether existing solutions may provide comparable safety, and requires backfitting only where this is not the case and where it is commensurate with the safety gain.[1132] The maintaining safety approach, equally, does not mean that no safety improvements may be implemented during the LTO licensing process, but these tend to be more limited than under the improving safety method; among the safety improvements that would constitute new safety obligations, those responding to identified safety deficiencies tend to predominate, though such measures may equally be applied to an installation even during its existing licence period.[1133]

From the perspective of the nuclear renaissance, what makes these different approaches challenging is their cost, the time required to implement them, and the degree of uncertainty that newly applied standards introduce into the outcome of the LTO decision. The maintaining safety approach is clearly more advantageous in the short term for preserving generating capacity, as the new safety measures that may need to be implemented – unless deficiencies concerning the safety of the plant emerge – are potentially more straightforward and, theoretically speaking, more streamlined, owing to the lesser extent of backfitting required and to the fact that the operator may focus, during the procedure, on demonstrating that ageing has not resulted in a decline in safety. By contrast, the improving safety method is more complex, owing to the potentially wider array of new safety measures that would necessitate more substantial backfitting, increasing the cost and timeline of LTO in the short term. On the other hand, such an approach may also carry certain benefits, as it can promote a higher level of safety by further reducing the risk of accidents – accidents which, were they to occur, would seriously harm the acceptance of nuclear energy and the prospects for a renaissance.

The CNS's reference to existing installations at the time of the Convention's adoption, and the Vienna Declaration's similar, non-binding reference to reasonably practicable improvements for all operating plants, could together serve as a helpful balancing instrument in the context of LTO – one that prevents the adoption of improved safety measures that would not bring corresponding safety gains, while promoting the implementation of safety improvements that do yield commensurate benefits. Consequently, in licensing long-term operation in the context of the nuclear renaissance, it would be important to reflect on how national approaches to LTO incorporate the notion of reasonableness. It may also be of interest to examine how the concept of the graded approach – frequently referenced in the context of regulating SMRs – could be incorporated into the concept of reasonableness as one of the guiding instruments for determining what is and is not reasonable in this context. In addition, where new safety requirements are to be set for a plant – whether during the initial period of operation or as part of the LTO process – these need to be introduced with sufficient lead time so that the licensee

[1131] NEA, 2011, pp. 168–170.
[1132] Emmerrechts, Raetzke, Okra, 2011, pp. 56–59.
[1133] Raetzke and Micklinghoff, 2006, pp. 262–263.

may prepare for them. They must equally be predictable, so that once an LTO project has been initiated, there is reasonable assurance that the requirements will not change significantly during the course of the process.[1134]

5.3. Administrative pathways of long-term operation

How long-term operation is administered formally is a less critical question than for the initial deployment stage of nuclear power plants, for the simple reason that applications for LTO can be made while the plant is still operating, and the process – evaluating the licensee's plans for replacements, backfitting and ageing management on the basis of which the decision is made – occurs while the plant is still generating revenue. If the national legal framework can provide a sufficiently long period during which – even if not all, then at least most of – the necessary measures for continued operation, beyond those the licensee would implement of its own accord, can be determined and communicated to the licensee while the plant remains in operation, then a significant step has been taken towards making the LTO-granting procedure more efficient. Naturally, how LTO is granted cannot be entirely disregarded – for example, delays in environmental impact assessment procedures may hold up the entire LTO process – but these delays can be mitigated far more readily by initiating LTO procedures well in advance of the expiry of the initial operating licence, something that is not possible in the case of a plant's initial licensing.

A further consideration associated with LTO carries particular significance from a Hungarian perspective. Previously, the Hungarian procedure appeared to recognise only operation beyond the planned operating period as LTO, thereby providing solely for the extension of operation under the initial operating licence, and not beyond the period of an already extended licence – meaning that it essentially allowed for only a single lifetime extension, at least, that was the understanding before these provisions were amended in 2025.[1135] The planned operating period was interpreted strictly as referring only to the initial period; this, however, conflicted with the intention to further extend the lifetime of the Paks I plant, which, had the legislation remained unchanged, would have been permitted to operate for no more than 50 years – a rather restrictive position by international comparison.[1136] The legislation was amended in response, though the terminology it introduced is rather complex: rather than explicitly allowing for multiple successive lifetime extensions – submissions for which had previously been tied to the operating licence covering the planned operating period,[1137] – the amendment instead provides for an application for continued operation following the period of operation beyond the planned operating period. This raises the same question as before: does the amendment allow for only one further licence extension, namely one based on the first extension? The amendment resolves this concern by tying the application for continued operation to a valid operating licence in

[1134] NEA, 2021a, p. 63.
[1135] Decree No. 1/2025 (III.19.) of the HAEA amending Decree No. 1/2022 (IV.29.) on the nuclear safety requirements applicable to nuclear installations and related regulatory activities, concerning continued operation after operation beyond the planned lifetime.
[1136] NEA, 2021a, pp. 55–57.
[1137] It may have been more simpler to remove the LTO license applications' connection to the valid planned operation period operation license without introducing a different type of LTO that is after the first LTO. Decree No. 1/2022 (IV.29.) of the HAEA on the nuclear safety requirements for nuclear facilities and related regulatory activities (before 2025.04.02. version).

general terms,[1138] – thereby encompassing both an operating licence authorising operation beyond the planned operating period, and an operating licence authorising operation following LTO – meaning that the plant's operation may be extended several times over.
Although delays and challenges in LTO-granting procedures can be more easily mitigated than those affecting initial licensing, this remains an area that offers further opportunities for research, to determine what national approaches exist, and what their respective strengths and shortcomings are in providing an efficient and safe basis for LTO.

5.4. Environmental impact assessments as elements of long-term operation decisions

As in the case of new projects, environmental impact assessments are equally relevant in the case of LTO, though here the more pressing question concerns whether they are a necessary part of these decisions. While the author equally recognises that EIAs are a crucial consideration in decision-making, these procedures may at the same time pose challenges[1139] to the effective continuation of operation, owing to their significant associated costs and time requirements; moreover, certain elements of the process may also give rise to potential delays in granting LTO. This is not an unfounded concern regarding EIA procedures – one need only look at the changes introduced[1140] by the REPowerEU plan to the licensing of renewables, which, although subject to certain safeguards, provides exemptions from EIA procedures and the accompanying public participation,[1141] in order to accelerate permitting procedures. Given that the applicant is responsible for preparing the EIA documentation,[1142] – entailing substantial time and financial resources – and must also account for the procedural implications of public participation, the question of whether such procedures must likewise be conducted for LTO cannot be considered insignificant. While, in the case of the establishment of such installations, EIA procedures are widely applicable, the position is less uniform when it comes to LTO. As an OECD NEA study indicates, some countries employ EIA procedures as part of LTO, while others do not; and even among those that do, discrepancies remain regarding the scope of the assessment.[1143] The following section will examine whether there is a need for an EIA in the case of LTO, through the lens of the Espoo Convention[1144] and the EIA Directive.[1145]

5.4.1. Long-term operation in the context of the Espoo Convention

Under the Espoo Convention, proposed activities requiring an EIA also include major changes to an activity, where such changes are subject to a decision by the competent authority in

[1138] Ibid.
[1139] Sexton Nick, 2022, p. 23.
[1140] Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, 2023.
[1141] Bolonio et al., 2024.
[1142] Szamek and Teszár, 2022, pp. 267–268.
[1143] NEA, 2021a, p. 61.
[1144] UNECE, 1991.
[1145] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, 2012.

accordance with an applicable procedure.[1146] Since the Convention offers no clear answer as to what constitutes a "major change," the practice of the Implementation Committee served, for some time, as the principal point of reference.[1147]

The first case concerning the LTO of nuclear power plants was the Rivne case, which related to the LTO of the plant in Ukraine. Here, the Implementation Committee expressed a clear view: an LTO decision – whether taking the form of a new licence, a renewed licence, or an extension – must be considered a decision within the meaning of the Convention wherever the plant cannot continue operating without it once the initial licence period has expired.[1148] While this reflects a broad understanding of what constitutes a "decision," it also implies, conversely, that no EIA would be required where continued operation requires no decision at all – as might be the case with an indefinite licence that the authority could revoke at any time, but whose continuation requires no affirmative decision to maintain. While this may seem to be a reasonable interpretation, as will be seen, the notion of a decision was interpreted more broadly. On the separate question of whether LTO constitutes a major change, the Committee drew on the Secretariat's background note and concluded that it must be so considered even where no physical works are undertaken.[1149] In doing so, the Committee moved beyond the ordinary meaning of major change, holding that such a change need entail no works at all – let alone major ones – and instead tying the notion to the effects of continued operation as such. Their reasoning was further complicated, however, by the suggestion that the distinction between a new activity and a major change is unimportant, and that the LTO of a nuclear power plant should, in any case, require an EIA.[1150] This understanding of a major change, in effect, means that, in the case of LTO, the only relevant criterion is whether the authority must make a decision on the LTO, which then triggers the EIA requirement.

The Meeting of the Parties to the Convention, while acknowledging the Committee's decision, adopted more restrictive wording, not repeating the Committee's more generalised conclusions.[1151] As several other cases followed, seeking to address the specificities of LTO for nuclear power plants a guidance was adopted[1152] under the Convention to assist signatories in complying with it, and the Committee in applying it.[1153]

The Guidance first addresses what may constitute LTO, adopting a broad interpretation that encompasses straightforward cases – such as the expiry of an operating licence or of the plant's design life, as well as periodic safety reviews specifically connected to LTO – while also extending to cases involving an unlimited operating licence, where the operation is limited in law initially, but then for LTO this limit is changed in the legislative framework either by extending or removing it. The Guidance suggests a very broad interpretation of what constitutes a decision, regardless of its label or of which body issues it, in order to prevent discrepancies between countries that make LTO-specific decisions and those that do not.[1154] In the context of

[1146] UNECE, 1991, Art. 1.
[1147] The Committee reviews the signatories' complicance with the Convention.
[1148] UNECE, 2014, p. 19.
[1149] UNECE, 2012, p. 4.
[1150] UNECE, 2014, p. 16.
[1151] Meeting of the Parties to the Espoo Convention, 2014.
[1152] Emmerechts, and Bourdon, 2021, pp. 15–16.
[1153] UNECE, 2021.
[1154] Sexton Nick and Bowden, 2022, p. 253.

what could constitute a decision, the Guidance makes specific reference to periodic safety reviews (PSRs) indicating that such instruments do not serve the purpose of a decision and would therefore not be considered, under the Convention as triggering an EIA obligation; nevertheless, certain follow-up actions arising from PSR findings could be considered decisions.[1155] In practice, this could mean that where a plant holds an indefinite licence and continues to operate – with upgrades communicated through safety reviews and without the licence ever being revoked – the EIA obligation may not be triggered. The existence of a decision within the meaning of the Convention is thus a mandatory element for triggering the EIA procedure.[1156]

However, unlike the Committee's opinion in the Rivne case, which appeared to associate the concept of a major change very broadly with mere continued operation, the Guidance provides a more elaborate explanation. In line with the ordinary meaning of major change, it first considers large-scale renovation works to be covered, but, more interestingly, also allows that smaller-scale works may, under certain conditions, amount to a major change – a determination for which Annex II of the Guidance provides further support[1157] – though it notes that routine works and ageing management are generally not regarded as a major change. Following this narrowing of the concept, the Guidance then broadens it once again, stating that, where a connection exists among several minor changes, these could together also amount to a major change.[1158] Furthermore, similarly to the conclusion reached in Rivne, the Guidance specifically states that lifetime extension per se could be considered a major change even in the absence of physical works, where the environment itself has changed. In essence, this means that a decision alone is not enough to make the EIA necessary: the major change criterion and the general requirement associated with transboundary impact under the Convention must equally be met, an understanding also explicitly expressed in the Guidance.[1159] While this is, in principle, a narrower interpretation than that adopted in the Rivne case, it remains a concept that broadly extends what can be considered a major change, since the environment would naturally change over the course of 30 to 40 years.[1160] The Guidance thus generally adopts a very broad interpretation of the circumstances in which the Convention would apply to LTO.

The Guidance employs the ordinary tools of treaty interpretation, but, observing the interpretations outlined above, one can argue that, in some cases, this interpretation extends so far beyond the ordinary meaning of the relevant terms that it crosses the boundaries of interpretation altogether, and that other tools – such as formal amendment – would be more appropriate. One may contest this expansive reading of the treaty, though doing so would prove rather difficult, since the Meeting of the Parties endorsed the Guidance; under the Vienna Convention on the Law of Treaties, or customary international law, such endorsement could constitute evidence of subsequent practice or agreement among the parties,[1161] and as such

[1155] UNECE, 2021, pp. 27–29.
[1156] Id., p. 28.
[1157] Ibid. These could include: increased use of natural resources, increased emissions, waste, colling-water discharges, spent fuel.
[1158] Id., pp. 18–19.
[1159] Id., p. 28.
[1160] Id., Annex II. It mentions specifically changes in the surrounding environment due to climate change.
[1161] Concerning the LTO of the Kozloduy nuclear power plant in Bulgaria the Committee expressed that this endorsement could be regarded as subsequent practice of the Parties and thus this evolutive interpretation of the Convention shall prevail. UNECE, 2023a, p. 9.

could provide a basis for the evolutive interpretation of the treaty. The concept of a major change is interpreted so broadly that it even invokes the effects of climate change itself – which, in the author's opinion, is a rather controversial outcome, given nuclear energy's positive contribution to climate change mitigation. Thus, the very phenomenon that nuclear power helps mitigate – climate change – could become the trigger for a time-consuming and economically demanding EIA procedure, even where the change in question is entirely unrelated to the plant's own activity, or where that activity has in fact contributed positively to mitigating it; and even where the works required are not, in practical terms, major, but are instead merely a consequence of conservative past assessments of the plant's operational lifetime. Taken together, the Committee's understanding of the Convention appears excessive.

The Guidance did not resolve whether EIA procedures should be applied in the case of LTO; rather, there are several factors to be taken into account, meaning that the application of the Convention in these cases depends very much on the circumstances of the case. Practical application since then have shown that even though countries have presented well founded arguments such as Bulgaria did in the case of the Kozloduy nuclear power plant, arguing that replacing equipment of the same type, or modernising elements of the plant, would not, in its view, constitute a major change, being rather part of regular ageing management[1162] the Committee has not necessarily agreed,[1163] arguing that even smaller-scale works could amount to a major change – an explanation that is somewhat self-contradictory – thereby necessitating an EIA; it argued instead that such works should be evaluated by reference to the length of the extension, which, although only ten years, in practice it served the broader goal of keeping the plant operational for longer. In this case, the Committee even extended the scope of the Guidance, going further than the Guidance itself: it argued that maintenance carried out as part of ageing management – which, under the Guidance, was not to be considered a trigger for an EIA – in fact depends on the timing of such works, and that, even where scheduled, such works may be considered a major change if they occur towards the end of the plant's lifetime.[1164] Very similar conclusions were generally reached concerning what could constitute a major change in relation to the Tihange nuclear power plant in Belgium,[1165] and the Tricastine plant in France.[1166] The Tricastin case is particularly interesting in that, in France, the operating licence is unlimited, and the system relies primarily on the concept of PSRs, which focus principally on nuclear safety; furthermore, the concept of design life does not exist as such in the French system, which instead relies on a hypothetical design life for its installations.[1167] The Committee not only concluded not only that the absence of a specific LTO licence amounting to a decision under the Convention was not necessary – emphasising the special role of the asessed PSR, which contains elements that could serve as indicators of its association with LTO – but also declined to examine whether there could be a difference between a design life, which, in its opinion, could also serve as an indicator of the start of the LTO period, and a hypothetical design

[1162] Ibid.
[1163] Id., p. 10. Actually based on paragraph 47 of the guidance, which discussed smaller scale works.
[1164] Id., p. 10–11.
[1165] UNECE, 2023b.
[1166] UNECE, 2026.
[1167] Id., p. 11.

life,[1168] which in France's opinion is something different.[1169] In all these cases, the Committee found the countries concerned not to be in compliance with the Convention, and its approach suggested that the Guidance was to be interpreted even more broadly still. One limitation on this ever-broadening interpretation may lie with the Meeting of the Parties, which could decide not to endorse the opinions of the Implementation Committee; however, the likelihood of this is not significant, given the share of nuclear countries among the signatories.

At this point, a few remarks are also warranted concerning the licence extension of the Paks I nuclear power plant.[1170] The LTO of the plant did not give rise to a case before the Implementation Committee, as Hungary elected to conduct an EIA during the Paks I licence extension process. This does not mean, however, that the licensee and the Authority considered a transboundary EIA necessary; in fact, similarly to the cases discussed above, they did not regard one as necessary for a licence extension.[1171] Nevertheless, owing to significant international interest in the authorisation procedure, a transboundary environmental impact assessment was ultimately initiated in accordance with the provisions of the Espoo Convention, despite the licensee and the Authority's view that it was not required. Some commentators have characterised this particularly rigorous approach to environmental impact assessment as a form of retrospective rectification – a compensatory measure, as it were – for the absence of such procedures during the original licensing of the plant.[1172] However, the rationale behind this approach is arguably more nuanced. On the one hand, this argument signals that there was an omission on the part of Hungary in not conducting an EIA however, at the level of the European Community, the first directive[1173] mandating EIAs was only adopted in 1985, three years after the commissioning of the first unit of Paks I. Prior to that, environmental impact assessments were not yet a standard procedural requirement.[1174] On the other hand, while a full-scale EIA procedure was not carried out initially, certain environmental aspects – such as the plant's impact on air and water quality – were nonetheless subject to scrutiny.[1175]

5.4.2. Long-term operation and environmental impact assessments in the context of the European Union

Besides the Espoo Convention, the other lens through which the long-term operation of nuclear power plants must be examined concerns the EU law framework governing the matter. Within the European Union, the obligation to conduct EIAs in the case of constructing nuclear power

[1168] The Committee referred to the IAEA Glossary which while to a degree entails a hypothetical nature in case of design life by expressing that it is expected: "design life. The period of time during which a facility or component is expected to perform according to the technical specifications to which it was produced." This expectation may rather refer to the hypothesis that there is a certain level certainty that in this period it will perform to the specification and not to the length of the duration itself. For the definition, see IAEA, 2022, p. 114.
[1169] UNECE, 2026, p. 20.
[1170] For more, see Paulovics, 2020, pp. 360–375.
[1171] Elter, Katona and Pécsi, no date, p. 9.
[1172] Emmerechts and Bourdon, 2020, p. 11.
[1173] Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, 1985.
[1174] Bond and Wathern, 1999, p. 234.
[1175] A Magyar Népköztársaság Minisztertanácsának 3296/19876. határozata *[Decision No. 3296/19876 of the Council of Ministers of the Hungarian People's Republic]*.

plants is mandated under the EIA Directive,[1176] however its application to LTO raises very similar issues to those experienced in case of the Espoo Convention – naturally with the exception of the transboundary element – and in practice the solutions adopted by Member States diverge considerably.

In order to determine whether an activity falls under the Directive, two concurrent conditions must be met: first, it must constitute a project under the Directive, which entails construction or installation works, or intervention in the natural surroundings, and, second, it must also satisfy the criterion of being likely to have significant effects on the environment. These conditions are presumed to be fulfilled in the case of nuclear power plants, as these are listed in Annex I of the Directive, which sets out the activities for which an EIA is mandatory. However, with regard to changes to such projects, the Directive mandates an EIA only where the change or extension itself meets the criteria set out above;[1177] in cases where a change would not, by default, fulfil those criteria, Member States may nonetheless require that an assessment of whether an EIA is necessary be carried out on a case-by-case basis.[1178]

The Court at a similar time as the Implementation Committee faced with the Rivne case had to make a decision on a case[1179] involving the prolongation of the operation of the Bruxelles-National Airport[1180] and whether that project – falling in the same Annex as nuclear power plants – would require an EIA. The question at the centre of the case was whether an EIA would be required only where physical works were carried out, or whether the concept of works should instead be understood broadly, to encompass cases where there were no works at all, but merely a prolongation of operation – which, in itself, constitutes an intervention in the natural surroundings.[1181] The Court did not adopt this broad concept of works, establishing instead an interpretation whereby the term would apply only where there was a direct intervention in the environment, as in the case of certain mining activities, but not in the present case.[1182] Similarly, the term construction was confirmed as being understood in its ordinary meaning.[1183] The crucial conclusion of this case was that, in the absence of physical works, the renewal of existing permits cannot be considered a project within the meaning of the Directive. However, a later case, in 2019, also came before the Court addressing continuous operation, but this time concerning nuclear power plants specifically.[1184] The case concerned the ten-year lifetime extension of Units 1 and 2 of the Doel nuclear power plant in Belgium, which units were due to be phased out in 2015, as prescribed by a 2003 law.[1185] However, in 2015, this earlier decision was reconsidered, and the law in question was amended to allow the two units to operate until

[1176] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, 2012.
[1177] Id., Annex I. 24.
[1178] Id., Annex II. 13(a).
[1179] *Brussels Hoofdstedelijk Gewest and Others v Vlaams Gewest* (C-275/09) ECLI:EU:C:2011:154, judgment of 17 March 2011.
[1180] Runways over the length of 2100 meters are Annex I. projects under the Directive
[1181] *Brussels Hoofdstedelijk Gewest and Others v Vlaams Gewest* (C-275/09) ECLI:EU:C:2011:154, judgment of 17 March 2011, para 18–22.
[1182] Id., para. 23.
[1183] Id., para 26.
[1184] *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v Conseil des ministres* (C-411/17) ECLI:EU:C:2019:622, judgment of 29 July 2019.
[1185] Act of 31 January 2003 on the gradual phase-out of nuclear energy for the industrial production of electricity.

2025.[1186] At the outset of this case, the Advocate General had already argued that the conclusion reached in the aforementioned case might be inconsistent with the wording of the Espoo Convention,[1187] and suggested that the Court should interpret Article 1(2)(a) of the Directive – the term project – in conformity with the international meaning of project under the Espoo and Aarhus Conventions,[1188] which would ultimately lead to very similar conclusions as to the cases in which EIAs would have to be conducted for LTO, with the exception of the transboundary element. Nevertheless, the Advocate General[1189] also noted that, even if the Court did not adopt this international meaning of project, an LTO might still be considered a project under the Directive, if the decision on the renewal of consent were taken together with an upgrade programme involving physical works or interventions.[1190]

In its judgment, the Court first addressed the issue of what constitutes a project and found that, given the extent of the works to be carried out – such as the upgrading of the containment structures, renewal of spent fuel pools, and the construction of new buildings for ventilation systems – these reached the level of physical works within the meaning of the Directive and can thus be considered a project; the Court also established a tangible link between the amendment and the investment needed to carry out these works.[1191] However, even where such construction works can be considered a project under the Directive, this does not automatically mean that an EIA must be conducted, but rather, according to the Directive, only in those cases defined in Article 4.[1192] The projects provided for in Article 4 are listed in Annexes I and II of the Directive, of which Annex I includes nuclear power stations, but it also provides that any changes to the projects listed there, "where such a change or extension in itself meets the thresholds," are equally covered.[1193] Consequently the Court had to determine if the change in question would fall into category,[1194] to which it gave an affirmative answer, taking into account both the ten-year temporal aspect of the extension and the works to be carried out.[1195] After establishing that the Directive was applicable to the case, the Court also addressed when the EIA should have been conducted, finding that the amending legislation in effect constituted a development consent; thus, like the Implementation Committee, it too understands consent in a broad sense, not strictly limited to licences.[1196] Regarding the Court's interpretation of the cases that may require an EIA, we may conclude that, although it is also fairly broad, it remains narrower than how the Espoo Convention was understood by the Committee. What was

[1186] Act amending the Act of 31 January 2003 on the gradual phase-out of nuclear energy for the industrial production of electricity in order to guarantee security of energy supply.
[1187] Opinion of Advocate General Kokott in *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v. Conseil des ministers*, Case C-411/17, ECLI:EU:C:2019:622, para 66–67.
[1188] Id., para 124.
[1189] For more on the opinion, see Bechtel, 2019.
[1190] Opinion of Advocate General Kokott in *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v. Conseil des ministers*, Case C-411/17, ECLI:EU:C:2019:622, para 122.
[1191] *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v Conseil des ministres* (C-411/17) ECLI:EU:C:2019:622, judgment of 29 July 2019, para 61–72.
[1192] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, 2012, art. 2(1).
[1193] Id., Annex I. 24.
[1194] Proelss, 2021, p. 86–87, pp. 81–93.
[1195] *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v Conseil des ministres* (C-411/17) ECLI:EU:C:2019:622, judgment of 29 July 2019, para 76–81.
[1196] Id., para 82–94.

expressed regarding the activity in the case law of the Court shows that it is more substantial in nature, than what the Espoo Convention may cover. The Court also takes into account the length of the extension – describing ten years as significant – and the physical works carried out – in the present case characterised as major – assessing both together to determine whether, in scale, they are comparable to the environmental risks posed when the installation was originally constructed. It can be observed that the Court considers these two factors together in determining whether the change or extension meets this condition; this is, in fact, a relatively straightforward comparison, since the general environmental impact of such an installation is already well known. However, this point of reference also means that these factors together cannot appear insignificant relative to the project to which they are compared to.

The final crucial question the Court also had to decide was whether, in the given case, the energy security argument could serve as an exemption from the application of the Directive – a question that, in light of how energy security has evolved into an extremely relevant consideration following the Russia-Ukraine and Iranian crises, is of considerable importance from today's perspective. The EIA Directive allows Member States to exempt specific cases from the EIA obligation where its application would adversely affect the purpose of the project. However, even in such cases, the objectives of the Directive must still be met, and this is without prejudice to the transboundary EIA obligation. The Court in principle noted that supply security considerations may amount to such an exceptional case, but still the cumulative conditions for the exemption[1197] laid out in the Directive, designated to protect its objective, must nonetheless still be met. The Court found that, in the present case, the necessary notification element was clearly not fulfilled.[1198] Moreover the Court also imposed two requirements regarding the supply security exemption: firstly, that the risk to supply security is reasonably probable, and secondly that the project is sufficiently urgent, to justify not conducting the EIA.[1199] Regarding these criteria established by the Court some have argued that, due to the vague terms used and their lack of clarity there is significant discretion provided to Member States to determine whether the given case may give rise to the supply security exemption.[1200] While the Court established that the exemption was not applicable in the given case, it nonetheless provided national courts with the opportunity to maintain the measure in question in effect, in order to prevent a genuine and serious threat of disruption to the electricity supply, until the breach of EU law is remedied.[1201] This opportunity was subsequently utilized by the Belgian Constitutional Court annulling the 2015 law, but maintaining its effect.[1202] While the Constitutional Court's decision concerned only the maintenance of the measure, it nonetheless

[1197] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment, 2012, art. 2(4). Three conditions have to be met to be able to do so, firstly another appropriate assessment has to be considered, the information obtained as a result of which together with the reasons for the exemptions and the reasons for granting it have to be made available to the public, and the Commission has to be informed before the consent of its justifying reasons and the information that was made available.

[1198] *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v Conseil des ministres* (C-411/17) ECLI:EU:C:2019:622, judgment of 29 July 2019, para 100.

[1199] Id., para 101.

[1200] Cenevska, 2021, pp. 372–375.

[1201] *Inter-Environnement Wallonie and Bond Beter Leefmilieu Vlaanderen v Conseil des ministres* (C-411/17) ECLI:EU:C:2019:622, judgment of 29 July 2019, para 182.

[1202] Cenevska, 2021, pp. 379–381.

illustrates the wide discretion Member States enjoy in determining what may constitute a supply security exemption: the Court justified its decision by stating that supply security threats would increase with the plant's shutdown, for which no adequate alternatives exist at present.[1203] As others have also observed[1204] this case suggests that, under the CJEU's approach, if the relevant criteria are met – in the determination of which Member States enjoy wide discretion – supply security considerations can take precedence over environmental objectives. This judgment, in its reasoning, appears in principle to be similar in nature to the exemption of new renewable projects from EIAs, which also essentially stems from supply security considerations.[1205] While this decision was made in the context of a nuclear project concerning the continued operation of an existing installation, it may nevertheless prove to be an important judgment for the nuclear renaissance in Europe, particularly in light of the supply security disruptions that have occurred since, which may drive a general argument in favour of the sustained operation of nuclear power plants as a means of maintaining energy security. Thus, in forthcoming cases concerning the continued operation of such plants, it will be interesting to observe how states invoke this exemption, and thereby also mitigate the burdens associated with such extended operations.

5.4.3. Observations on long-term operation and environmental impact assessments

While the critical role of EIA in helping to make well-informed decisions must be highlighted, it must equally be acknowledged that these procedures impose significant burdens on those obliged to conduct them, and if they form part of LTO procedures they naturally introduce a further factor of uncertainty. This uncertainty relates not only to the outcomes of these assessments, but also to whether such procedures need to be conducted in the given case at all. The outcomes of these procedures will be one of the factors – though not the sole ones – influencing decisions on LTO. In light of energy security considerations, and the increasingly accepted view that nuclear energy makes a positive contribution to climate change mitigation, the public interest in maintaining these installations will generally prevail over their perceived environmental impacts. This is reinforced by the fact that these installations already exist: since EIA reports assess impacts relative to alternatives, the impacts of extending an existing plant's licence – even where this involves certain physical works – will generally be less significant than those of a comparable new-build project. This observation fits well into the general considerations shaping energy markets, especially in the context of the import-vulnerable European Union. The more influential factor in this respect will be the economic viability of LTO relative to potential alternatives; but, as the current energy market stands, it is becoming increasingly difficult to find such economically preferable alternatives. Thus, if such outcomes can be presupposed – whereby EIA considerations will generally be overridden by strategic public interest – the question arises whether, in all cases, such an assessment is necessary, given its resource intensiveness.

In light of the public interest involved in the continued operation of these plants, it should be asked whether somewhat narrower and more concrete interpretations of these instruments – particularly the Convention – are needed, so that EIA procedures are not mere procedural

[1203] Id., p. 381.
[1204] Id., p. 382.
[1205] Devis, 2025, pp. 443–466.

burdens, without any true influence on the eventual decision, triggered simply by how a national system happens to classify such decisions, but rather apply specifically to those cases where environmental considerations are of genuine value to the ultimate decision. Naturally, if such discrepancies decide on the applicability of these procedures, it may spark the reconsideration of those approaches. In this context, a potential reconsideration may involve the initial licence period of new installations, which may rationally promote a shift from shorter licence periods to either applying the concept of design life as a benchmark – as Hungary and Finland generally do – or adopting unlimited licences as France has done; but such transformations are more relevant for the forthcoming new generation of nuclear power plants. However in the context of the Espoo Convention it is important to highlight that these new measures cannot be contrary to the underlying idea of applying EIAs to such installations, as in that cases obligations under the Convention could be breached.[1206] If legal frameworks are more flexible regarding the timing of LTO and from the future operator's perspective these procedures remain something to be apprehensive about – even though such issues would not concern nuclear power plants of the future for a long time – then the industry will aim to respond to this need, potentially with longer design lifetimes, especially taking into account how much longer current nuclear power plants operate than they were originally intended for, demonstrating how pessimistic those timelines were.

In essence what can be said about EIAs is that they are indispensable tools in well-informed decision-making, alongside several other considerations. In light of these various interests, these procedures need to be more flexible so as to adapt to those cases where in practice they will genuinely influence decision-making. If these are merely procedural tasks carried out solely to fulfil an obligation while other considerations dictate decision-making, then they are unnecessary burdens on licensees. In such cases, it is more reasonable and efficient to provide certain exemptions before these procedures are conducted – such as the supply security exemption under the Directive – so as not to necessitate burdensome procedures with negligible relevance.

5.5. Conclusions on long-term operation

If the nuclear renaissance is to be realized in the coming decades than long-term operation will be a crucial asset influencing whether we consider the expansion a success or a failure. If currently operating plants do not predominantly enter into long-term operation and if plants that are already in a long-term operation cannot further continue to operate then the renaissance, due to the declining installed capacity may more seem like a rescue mission for the share of nuclear power then a heroic expansion. Conventional nuclear power plant constructions take a long time, while SMRs may take shorter they are not at that level of maturity – at least form an operator or investor perspective as they are not being currently deployed in masses – to be deployed in masses in the coming years. From the perspective of the renaissance, long-term operation is needed now more than ever to maintain the share of nuclear energy, to proceed with the green transition, and to enhance supply security – at least until the deployment of conventional and advanced plants can be ramped up to a level comparable to that at which long-term operating plants were originally deployed, so that these new deployments can not only

[1206] UNECE, 2026, p. 11.

compensate for eventual decommissioning, but also further expand the role of nuclear energy. Long-term operation, at the outset of the renaissance, may thus play a precious role as a bridge over the period during which new deployments are only just ramping up. However, while more and more experience is accumulating with respect to LTO, a wide range of legal questions still remain to be answered – such as how to determine which safety standards can be applied to existing reactors, and which review procedures are most efficient for administering extended operation without compromising safety, with EIA procedures deserving particular attention in this regard. The resolution of these legal challenges is facilitated, on the one hand, by the experience already accumulated in the Western world, and, on the other, by the fact that these plants are already generating revenue, meaning that the resolution of such issues occurs while they remain in operation.

However, these long-term operation considerations are not only important from the perspective of currently operating nuclear power plants, but equally for those now being deployed – be it conventional or advanced – as part of the nuclear renaissance, as LTO and the initial licensing of these installations are very much interconnected.[1207] The decisions adopted at the initial stage of an installation's life have a decisive effect on its future; this relates not only to how long-term operation reviews are conducted, or to how long licences are issued for, but also, in certain scenarios, to how the design life of these installations is determined. LTO-specific issues should, therefore, equally be considered at an early stage, if the legal framework is to be reformed as an enabling factor for the nuclear renaissance. This early reconsideration provides the opportunity to adopt coherent and clear frameworks with common underlying principles governing the different stages, which may also improve certainty in expectations and thus better direct investment towards such projects.

5.6. Recommissioning of shut down nuclear power plants

One last factor that can also contribute to the materialisation of the nuclear renaissance, although to a more limited degree – and which the author therefore intends only to mention as an area for future research – is the recommissioning of shut-down nuclear power plants.

It is important to highlight that the restarting of shut-down plants does not refer to the controlled, temporary shutdown of a plant, from which it is relatively easy to restart – but rather to cases where an installation has been shut down with the intention of decommissioning it, yet, before decommissioning could begin, this intention shifts, and the plant is instead proposed for restart. Such cases are rather rare, given the limited number of plants for which LTO could, in principle, have been pursued feasibly, but where a decision was nonetheless taken not to do so.

A second condition which further limits the plants that would potentially fall under such considerations is the time between their shutdown and the start of decommissioning works. If the decommissioning works have begun, this is no longer an option; moreover, the longer the plant has been out of operation and the closer it gets to decommissioning, the more difficult and expensive – and thus unlikely – a restart becomes. Consequently, these factors greatly limit the cases in which such restarts would be an option.

In practice, such restarts would most likely occur in the case of plants that were shut down shortly before qualifying for long-term operation, for economic or political reasons; in this latter

[1207] NEA, 2019, p. 13.

category, the shut-down German nuclear power plants could serve as a prime example. The practical relevance of this, however, remains rather limited, as most nations prefer to extend the operation of their nuclear power plants rather than shut them down only to later decide to reopen them. Nevertheless, decisions to shut down plants – in some cases made before the most recent nuclear renaissance – did still occur, and certain examples of this exist.

One of the most interesting examples is the Palisades nuclear power plant in the United States, which was shut down for economic reasons but is now undergoing the process of restart;[1208] the case is very similar for the Three-Mile Island unit, which was shut down in 2019. While the reasons for shutting down the Japanese plants following the Fukushima disaster, are naturally different, in practice their ongoing restarts faces some fundamentally similar challenges.[1209] Discussions in Europe are more limited; most focus being devoted to the potential recommissioning of Germany's recently shut-down nuclear power plants.

Naturally these procedures also entail great challenges, ranging from technical to economic to legal. From a legal perspective, researching how the recommissioning of nuclear power plants may be possible under different jurisdictions would be a particularly interesting question. What licensing stages in different countries would be needed to start operation again – would only an operating licence be required, or would a commissioning licence also have to be obtained, given that the plant has been out of operation and would require extensive testing? Or could countries introduce recommissioning-specific licences? Similar issues to those arising in the case of LTO would also be present here – for example, what safety requirements would be applicable to these plants, potentially requiring upgrading works that could significantly influence the finances of such endeavours. EIA procedures would also be an interesting consideration in their case, but due to the presumably more significant physical works associated with such restarts, and the fact that it is no longer a matter of continued operation but rather the initiation of a new impacting activity, it is more likely that whether such assessments are needed will be less disputed. As food for further thought, it would be interesting to examine how legal frameworks can contribute to making recommissioning an economically viable option in applicable cases, while also protecting the various other interests associated with such a restart.

[1208] Huff and Ryan, 2024.
[1209] Koppenborg, 2021, pp. 115–135.

6. Conclusions and de lege ferenda proposals

1. The first short point, in line with the title of the thesis, is that a holistic perspective on the licensing-related issues of these plants is warranted. First, a holistic perspective is necessary to develop new aims for licensing frameworks – complementary to guaranteeing safety – that can guide the adaptation of these frameworks to enable the renaissance. These should include the principles of predictability and efficiency – efficiency not only in terms of the length of these procedures, but also in the sense that they adequately reflect the different deployment strategies and needs of different plants. Second, a holistic perspective is also needed to encompass the different pathways of the nuclear renaissance – be it new construction, LTO, or recommissioning – and to develop adequate solutions to the challenges of these pathways without singling out one and neglecting the others. Third, a holistic perspective is needed to encompass the potential technological diversity of the renaissance and to develop future-proof solutions. Fourth, a holistic perspective is needed with regard to the licensing procedures themselves. While this thesis focuses on nuclear safety licensing in particular, the licensing of these plants is more complex and varied than that, and these differing procedures may have a decisive effect on a plant's deployment; they should therefore also be considered when adapting licensing frameworks to enable the renaissance. Finally, a holistic perspective means looking beyond national borders when adapting these frameworks, in order to find best practices or develop common solutions to problems that are similar across countries.
2. One overarching observation that must be made at the outset, regarding measures aimed at adapting licensing procedures to enable the renaissance, is that expecting these alone to resolve the delays and hindrances associated with the deployment of nuclear power plants would be mistaken. Adapting licensing procedures to enable the renaissance remains of crucial importance – it provides an adequate and efficient setting within which deployment can take place, ensuring that the framework itself does not hinder the course of expansion. However, one should not forget that while from a statutory perspective, in terms of the legal frameworks governing the sector, it is the most that can be done, several other elements are needed to successfully make use of an on-paper adequate framework. If those elements that would enable the utilisation of adequate and streamlined procedures are lacking, then the benefit of such a revision of frameworks is marginal. Others have pointed out that the cause of delays lies primarily in other factors – ones that would need to be in place to take advantage of more streamlined frameworks – particularly the declining expertise in the sector in the form of both manufacturing capacity and human resources.[1210] Naturally, as interest in or demand for a given sector decreases, the manufacturing capacities supplying it also decline, and with them the human expertise, as it becomes a less and less attractive career path. Resolving these issues – rebuilding manufacturing capabilities and training experts – is not something in which nuclear law can be of great help; nevertheless, even if most of the actions needed in this regard are not legal in nature, law as such may still serve as a tool. The question of how law beyond nuclear law may facilitate the realisation of a nuclear renaissance is something that could, and would be advisable to, explore in further research.

[1210] Léger, 2023, pp. 758–759.

3. International cooperation in the sector, at the time of a nuclear renaissance, is an element requiring particular attention. As will become clear from the more concrete observations that follow, international cooperation takes several forms and involves several different actors, and these may be of assistance across all pathways of the nuclear renaissance. Among regulators, in its most basic form, international cooperation will be needed to share best practices in licensing – practices that are not only theoretically sound, but also practically tested – which alone could be of significant value. More enhanced cooperation will be needed, particularly in the case of SMRs, to pursue the harmonisation of legal frameworks enabling their standardised deployment. Furthermore, new forms of cooperation among regulators may appear, such as carrying out joint reviews or leveraging the reviews of foreign regulators, that also bear particular relevance in the case of SMRs. Among states, international cooperation may also be needed with regard to the applicability and interpretation of the international instruments covering the field. Besides these efforts, cooperation on the industry side – such as among SMR designers, aiming to establish a degree of standardisation across the wide variety of designs – should also not be forgotten, as it could likewise ultimately facilitate the licensing of these installations.
4. A crucial consideration that should go hand in hand with the adoption of more enabling licensing procedures is the position of the regulator within the sector. The main consideration to be addressed in this regard is that regulators must be adequately equipped to carry out their tasks. While this may sound obvious, in practice it is not such a straightforward matter, as several prerequisites are needed for regulators to be in this position. Regulators need to possess the necessary competencies to carry out their tasks efficiently; regulators who serve merely as contact points while delegating the analysis of all substantive matters to other actors are inefficient and overly dependent. In this respect, the French reforms surrounding the establishment of ASNR are particularly interesting, as they are built on the recognition that these processes can function far more smoothly if the regulatory body also possesses the relevant technical competencies, eliminating unnecessary back-and-forth communication between bodies.

   A well-equipped regulator may also hold additional powers, such as the authority to issue implementing regulations and to make licensing decisions independently, thereby enabling swifter adaptation of regulatory frameworks in response to technological advancements and avoiding redundant procedures in which authorities that would themselves be capable of reaching a decision are nonetheless subject to licensing determinations effectively issued again by political actors, even after political decisions have already been made. The ways in which such a well-equipped regulator can be achieved are complex. The first aspect – already mentioned, and one in which law can only be of limited assistance – is having the necessary human resources, particularly qualified experts capable of assessing licence applications in a timely manner; for this, an attractive working environment must be in place to recruit these professionals. While, as will be explained later, the author fully agrees with the concept of inspection organisations, the delegation of tasks should preferably not proceed on the basis that the authority would otherwise be incapable of making the relevant evaluation. On the contrary, regulators should very much possess the competencies to conduct these evaluations themselves, as they must also be capable of identifying whether an unacceptable evaluation has been made, given that ultimate responsibility for regulatory

oversight lies with them. Having a well-equipped regulator is particularly important in the context of the nuclear renaissance, given the potential multiplication of licence applications, the prevalence of FOAK designs – which most planned SMRs will be – and the increased level of back-and-forth discourse between regulators and prospective applicants.

A further consideration that arises is that while the complexity and scale of these projects, which necessitate examining them from several different perspectives, would most likely make it very difficult to adopt an approach in which a single regulator evaluates all aspects of a plant, a one-stop-shop approach – where the nuclear regulator is the central authority contacted in deployment processes, even if it must involve other authorities – may nevertheless be desirable, in order to ease the administrative burden on licensees associated with engaging with several different authorities and coordinating when each must contribute to the deployment process.

As the role of regulators grows with new projects, and as they may in some cases take on several new functions within their competence, their independence becomes an ever more crucial issue, – the French experience having shown that the status of an expert body can be called into question where its independence is perceived not to be adequately ensured. If the competencies of these bodies are extended, it is crucial that their independence – both from industry and from politics – is very carefully safeguarded. Political decisions should be made outside the mandate of these expert bodies; even the slightest impression that they may be subject to influence would undermine trust in them. At this point in time, this concern is most pertinent from the perspective of political pressure to accelerate deployments, but it applies equally in situations where given nuclear projects may face political opposition, with the regulator needing to remain unaffected in its evaluation. However, this may relate not only to the broadening of their competences, but also to the increased procedural efficiency that would be introduced into licensing procedures, which may give the superficial impression of a retreat from safety. When such streamlined procedures are adopted and applied by truly independent expert bodies – independent from both politics and industry – the validity of their decisions is far less open to question. In this regard, for example, the structural reorganisation of the HAEA in 2022 has yielded a favourable situation, as Hungary now benefits from an effectively independent regulator entrusted not only with supervisory but also with legislative competences in the nuclear domain. In general terms, there are several ways to ensure such independence, whether financial or institutional.

Preferably, the budgets of these organisations should not be dependent on the political powers that may decide on energy policy and thus have an interest in either supporting or discouraging the deployment of nuclear power plants; in this respect, the budget of the HAEA being tied to the budget of the National Assembly is a particularly interesting solution. It must be kept in mind that such budgets exist not to support or obstruct the use of nuclear energy, but to support the work of the authority in reaching well-founded decisions in a timely manner. As such, decisions on the budget should take into account indications of the potential increase in regulatory burdens brought about by the nuclear renaissance, and those responsible for the budget should reach their decision without any value judgement either supporting or obstructing nuclear energy, but rather in response to the expectations placed on the authority. Alternatively, regulators may also draw on their

own funds from regulatory fees, licensing fees, and similar sources; however, it is rather difficult to plan adequate human resources in advance if the authority is dependent on licensing fees, since if establishing the necessary human foundations to carry out evaluations only begins once licence applications are submitted, the efficiency of the project can be significantly harmed. Additionally, a system in which nuclear regulators rely on regulatory fees amounting to high costs may only be acceptable if, in relation to other energy sources, it does not impose a disproportionately large burden on nuclear energy compared to its alternatives. While basing such fees on the planned megawatt capacity of the facility would help make them comparable to those of other generating plants, such a system would be unable to reflect the particular benefits of nuclear energy – for example from the perspective of grids that better accommodate stable base-load sources.

Institutional independence is an equally important aspect; experts should be ensured an environment in which they are free from influence either supporting or opposing a given project. There are several ways to achieve such independence, but the appropriate approach depends on the general national administrative system, as well as on the level of public trust in the independence of such institutions. Formal independence – which, in certain countries with lower public trust in public institutions, may be a crucial element – may be less essential in countries where the general perception of public officials' independence is already high, as in Finland, where a formalised separation from government may be a less necessary signal of political independence. One aspect concerns the position of the regulatory authority itself and how it is structured in relation to politically oriented governments; how formalised this separation needs to be depends on the national context. A second institutional factor is how the directors or commissioners of these authorities are appointed. Their personal independence through the appointment process can be a crucial contributor to the independence of these organisations, as well as to public perception of them. Several mechanisms exist by which this may be achieved, such as limiting the executive's role in the appointment of commissioners – as in France, though the executive still retains a dominant position there. Transparency is also a critical aspect in this regard; reporting obligations of these authorities are an important consideration, and the annual reporting obligation of Hungarian regulatory authority to the National Assembly is a good example of how democratic oversight over their work can be exercised in practice.

5. Going through the levels of the legislation pertaining to the sector, we must first address the issue of the existing international legal instruments governing it. It can generally be concluded that these instruments do not constitute barriers to new nuclear power plant projects; nevertheless, the thesis raised two particularly pressing questions that still relate to the materialisation of the renaissance. The first aspect concerns the pressing question of whether the international legal frameworks governing the sector extend to SMRs – a question requiring urgent resolution, possibly through interpretation, so as to bring the scope of these fundamental instruments up to date with recent technological innovations. Secondly, in cases where these instruments allow for special treatment by distinguishing among nuclear installations, the position of SMRs – or the question of what methodology should be applied in answering such questions in concrete cases – warrants a solution. Beyond SMRs, the long-term operation of nuclear power plants also raises particular issues regarding the Espoo Convention, where discussions continue as to whether the triggering

factors for an environmental impact assessment in cases of long-term operation have been extended beyond what was originally intended by the instrument. While the considerations regarding these instruments may appear to pull in opposite directions in these two cases, both in fact seek to respect the objectives and purpose of the instruments.

6. The level of the European Union and the role of Euratom also deserves a short elaboration. The role of the European Union will does not necessarily relate to the streamlined deployment of nuclear power plants but rather to creating an environment in which deploying these plants is a sensible and supported process. As articulated before, the European Union, if it wishes to combat climate change and remain competitive on a global scale, should not politically foreclose green alternatives that may be available to it. Regarding the green transition, a generally technology-neutral approach needs to be adopted, one that allows given green sources to be capitalised based upon on their respective advantages. However, the technology-neutral approach should not be passive, rather than merely permitting the deployment of such installations, it should actively support these potential sources – among them nuclear energy – and shape these efforts to best reflect what interventions are most needed in the case of given sources. Although there are ideas as to how this might be done in the case of nuclear energy, the question warrants further research; support mechanisms adopted in the case of renewables, while not always directly applicable due to fundamental differences, can nevertheless serve as a useful starting point.
   There are also several ways in which the Euratom Community could directly support the adaptation of licensing procedures. The Community could once more become a hub for driving the industrial development of the sector – serving as a platform for researching these questions and disseminating potential best practices, for enhancing cooperation among nations in establishing more harmonised licensing frameworks for the deployment of standardised designs, or for developing frameworks within which states can carry out cooperative reviews or leverage one another's reviews of these designs. A further role it could fulfil is facilitating the Community-wide operation of authorised inspection organisations.
7. A further, less specific observation should be made regarding legislative frameworks. As noted, the legislative frameworks governing the deployment of nuclear power plants are generally very complex. This complexity is present both formally and substantively. Formally, deployments are governed by fragmented frameworks in which even the procedural course of licensing processes must be understood through acts, decrees, and guidelines. In many cases, higher-level legislation does not even provide a broad outline of the procedures – although there are some exceptions, such as Finland. While it is understood why these multi-level legislative structures exist – partly due to the fact that this is a technologically influenced field in which developments can be frequent, making it sensible to place provisions more prone to change in lower-level instruments that can be adapted more quickly – it would nevertheless be preferable to have a clearer and more adequate division among these different instruments. Those provisions that outline the course of procedures and generally constitute the more stable elements of these frameworks should be more comprehensively captured at a higher level, giving a clearer picture of how these procedures unfold. A division among procedures may exist across different levels of legislation, but where this is the case, the less comprehensive procedural elements should

nonetheless appear in a manner that comprehensively corresponds to their procedural scope of coverage.

In terms of substance, the provisions contained in the legislation governing the deployment of new nuclear power plants are also challenging from a lawyer's perspective, as these instruments are in many cases rather technical in nature. Given the specificity of the sector, this is understandable to a degree. Nevertheless, the author believes that while this is not a sector with which the general public will engage through license application, they are very much affected by the activities that are licensed. In this regard, while the depth of technical content in these legislative instruments is duly justified, the process itself should also be comprehensible in its broad outlines to the general public, demonstrating how such a framework protects their interests and ensures their safety. Having complicated technical legislation in place does not necessarily reassure the public that it is adequate to protect their interests – it may only lead to confusion in its interpretation; by contrast, frameworks that clearly present how public interests are protected may be a more effective approach. Professionals seeking to apply for such a licence – who, given the requirements these frameworks generally impose on future operators and licensees, should be well equipped to comprehend them – may nonetheless benefit significantly from the clarification of procedures that are at times confusing, particularly regarding their scheduling and the demands placed on applicants at different stages. Such clarification would help licence applicants avoid confusion that may arise from interpreting complex requirements, and would also relieve authorities of the burden of continuously clarifying those requirements in response to applicants' enquiries. At a time of nuclear renaissance, when there may be a potential multiplication of applications – particularly in larger national markets, and potentially from non-traditional actors in the sector – these questions may become increasingly pressing. In this respect, it would be desirable, in the context of the nuclear renaissance, to have legal frameworks in place governing the deployment of these plants that adequately distribute the different stages across the legal hierarchy, covering the necessary phases in a manner corresponding to their scope and significance, and to have clear and well-clarified procedures and requirements that can be readily interpreted both by potential applicants and, at a more general level, by the public.

One last issue that should be highlighted regarding the legal frameworks governing the deployment of nuclear power plants more generally is that the legal certainty of these procedures – from the point of preparing an application and throughout the process itself – is crucial. As has been highlighted in this work, changes in regulatory requirements can impose significant burdens on the entity deploying the plant, causing delays in the procedure and thereby jeopardising the financial viability of the project. The requirements placed on licensees should be clearly established, and the reasonable expectation of applicants that these will not change throughout the project in ways that impose significant alterations to the design or other aspects should be respected.

8. The first more concrete aspect the author would like to address is the political green light for these projects. Nuclear power, despite the increasingly favourable shift in attitudes towards it, will remain a contested topic. In this regard, political acceptance of these projects – especially as they may be more numerous than before – is crucial. While this may depend on the specific national context, and some nations are generally more favourably disposed

towards nuclear energy than others, the public needs to be aware of how these projects may benefit them relative to potential alternatives, and how those benefits compare to the potential hazards they pose. The nuclear renaissance needs to be transparent about both its benefits and its potential hazards. The energy transition should not be based on political commitment to a given energy source; enabling conditions can be adopted to facilitate this process across different sources – renewables and other low-carbon options alike – but decisions on concrete projects should be made on their merits and should therefore be transparent. If decisions are merit- and fact-based, there is nothing to conceal. A decision in principle, in a sector as contested as nuclear energy, is a valuable tool for conducting this merit-based evaluation while simultaneously ensuring transparency. It is not an unnecessary burden on nuclear projects, but rather a response to the associated opposition and the genuine hazards this technology carries. Nuclear energy – while still debated – will most likely have a place in energy policy given the ambitious climate goals and the limitations of other energy sources in delivering decarbonisation and energy security. In this regard, the author believes that having such a stage in place is not an inherent obstacle to the deployment of these plants; in many cases, the benefits of these installations will be precisely what is clearly needed in the given national context. Rather, it serves as an assurance that this evaluation is in fact carried out and done so transparently, ensuring that the public also understands what it stands to gain from a given project and how those gains outweigh the potential hazards. It should equally serve as a crucial assurance for the applicant that the merits of their project are properly assessed, and that – subject to compliance with regulatory requirements – they can proceed with the project without facing the prospect of a decision based on its merits being reversed, provided those merits remain unchanged.

After establishing that such stages can be advantageous in the nuclear renaissance the subsequent issue that should be addressed is that how this decision should be carried out and what information should be required to carry out such a decision. Although the inclusion of this stage may confer certain benefits, particularly in providing certainty as to political support throughout the process, it nonetheless constitutes, from the applicant's perspective, an additional and time-consuming burden within the licensing of a new installation, and is, as such, generally inconsistent with broader streamlining efforts. Accordingly, the function of this stage ought to be carefully calibrated so as to balance its role in evaluating the benefits and hazards of the project against the imperative of not imposing an excessive burden upon the applicant. This is a rather difficult balancing mechanism. At one end of the scale we may find countries like Finland which makes a rather in depth analysis and as such it is rather demanding – from which process they seek to move away from – while on the other hand we have countries which do not employ such project specific evaluation such as France or Hungary – where while there is project specific evaluation it is very general. Decision-in-principles should be made early on in the projects so that preceding the initiation of licensing procedures that would check the plants compliance with regulatory requirements, moreover it should also precede the investment decision as having this stage after these steps can have challenging consequences for the applicant. However, certain information is needed on the project's planned size, the technologies under discussion, and the potential locations, in order to conduct a well-founded evaluation and to demonstrate

that such a project is beneficial. Without this critical information it is rather difficult to imagine how such a judgement could be made. Presenting alternative designs and sites is not a problem at this stage; no detailed presentations should be required, but rather a broad outline of what is planned. Since the public will eventually be involved in these procedures – at least through the EIA process – the author believes that conducting public hearings on this initial decision may be redundant. Instead, members of the public in the planned locations could submit observations on the projects, and to emphasise the democratic element of the decision, it could be the national assemblies that make the ultimate determination.

The execution of these decision-in-principle stages is particularly interesting in the case of SMRs, raising questions as to what the adequate approach should be for plants that are proposed to be deployed across various locations. What was said above should apply to SMRs, but to also accommodate the standardised nature of these plants, decision-in-principle procedures should allow for multiple projects to be evaluated together within a single procedure. Such an approach could reflect the decentralised deployment plans of SMRs; however, the scope should still be kept reasonable to allow for a meaningful evaluation to be made, especially when it comes to the temporal schedule of the individual deployments being assessed, since the longer the timeline, the greater the risk that conditions would change, potentially rendering a decision made well in advance obsolete.

9. What should also not be forgotten in preparing for a potential nuclear renaissance is to look beyond nuclear safety licensing and to consider what additional licences are required for facilities of such complexity and scale. These procedures may be critical for the course of nuclear safety licensing. The deployment of power plants concerns a variety of interests, each in cases protected through separate authorisations. However, while in the case of non-nuclear smaller-scale projects – both in terms of size and value – the separate protection of these interests is justified, and these measures constitute the principal approvals such plants must go through, this is not the case for nuclear power plants, where the nuclear-specific licensing procedure is clearly the most complex, demanding, and generally decisive element for the fate of the project. In this respect, one may ask how necessary it really is to have separate administrative procedures for licences such as those required for grid connection or for certain uses of the environment. Do these procedures, alongside the particular licensing stages of a nuclear power plant, bear genuine relevance? The answer may not always be straightforward – consider, for instance, how likely it is that a country embarks on a nuclear power plant project, takes a decision in principle, begins the nuclear safety licensing process, construction, and then has a grid connection application declined. For projects of the scale of nuclear power plants, some of these licences are of secondary importance, yet they constitute a significant administrative burden. There are ideas as to how this might be resolved – and practical examples already exist, such as France – potentially by integrating them into the nuclear safety licensing procedures, as also not to disregard the interest these protect.
10. One more area which extends beyond the nuclear safety licensing and should be addressed relates to the environmental impact assessments connected to these projects. As evaluated previously these appear rather differently in the given national contexts. While the content

is rather similar the question when and how these are conducted differs and it has important relevance for the efficient licensing of these plants.

The first thing that should be evaluated is when the EIA is staged in respect of the deployment stages of a new nuclear power plant project. Some countries decided to place EIAs at the very first stage of projects – such as Finland – which given that the EIAs are designed to inform decision-making rather than to function as a yes-or-no decision in themselves, can be regarded as conceptually sound, nevertheless, it poses practical challenges. At this early stage, the project is still under development; if the applicant is considering multiple sites or multiple technologies, an EIA must be conducted for each variation.[1211] Moreover, since the decision-in-principle is not a licence and does not authorise any construction works, later deviations from the project design may necessitate repeating the procedure, as has occurred in practice,[1212] although it must be noted that other approaches are not entirely deviation-proof either. In this regard, it may be more efficient – while still respecting the requirements of the Directive – to avoid repeated procedures caused by subsequent deviations, by placing the EIA at a stage when there is more certain information on the project, especially regarding the site. EIA procedures are generally more closely linked to the siting of a nuclear power plant, since potential environmental impacts cannot be fully assessed without knowing the approximate siting locations.[1213] Design aspects of the installation must also be considered, although often at a more general level; for example, issues such as control room staffing may not be critical for the environmental impact assessment. In this respect, there is greater flexibility regarding design deviations, which do not necessarily require a new EIA, compared to site deviations.[1214] While environmental impact considerations should play a central role in identifying a suitable site early in the project,[1215] from an efficiency perspective – in order to avoid repetition of the EIA procedure, including public participation – it would be desirable first to confirm that a site is suitable from a nuclear safety standpoint, since that is more of a yes-or-no question, and only then to conduct the EIA. In this regard, the Hungarian approach, which requires a specific site licence, may be of interest, however, under the current system, these stages do not always follow a strictly sequential order, and in practice the EIA may even precede site licensing. The French approach that integrates EIA into the nuclear safety licensing procedure could be an interesting solution to consider in systems that do not have separate site licensing.

11. How should the reforms of nuclear safety licensing procedures be implemented? This is not a straightforward question to answer. As we have seen in the case of efforts concerning conventional plants, countries have adopted two different approaches: Finland chose a comprehensive overhaul, while Hungary adopted targeted interventions – France also falls into this latter category, though in their case matters are further complicated by the fact that their efforts paid particular attention to procedures outside the nuclear safety licensing sphere. The shape of such intervention is further complicated by SMRs and the question of

[1211] Ibid.
[1212] Fennovoima, 2013.
[1213] IAEA, 2014b, p. 6.
[1214] IAEA, 2010, pp. 23–24.
[1215] Raetzke, 2013, p. 67.

how their licensing procedures should appear in the national context. As regards the choice between comprehensive and non-comprehensive reform, it is impossible to state what is generally needed, as it very much depends on the national context. In reality, while the Finnish reform is comprehensive – involving the adoption of a new Atomic Act and significant changes to the licensing procedures – in some respects, such as the construction licensing stage and the subsequent operating licence step, it is proposed to remain broadly similar. In deciding whether a new approach is needed, one must keep in mind that the licensing procedures applied today are fundamentally adequate in that they provide a high level of nuclear safety. These procedures, which are capable of protecting the endangered interests, should therefore not be abandoned; instead, certain measures are needed to increase efficiency, and some particular changes may be necessitated by SMRs. However, the degree of these interventions and whether they necessitate a complete overhaul of licensing procedures depends on the national context; some countries already have licensing frameworks in place that employ mechanisms particularly relevant from an SMR perspective. Changing existing licensing stages or adding new ones will not be the measures that necessitate extensive overhauls; rather, it is the general approaches to licensing – such as having prescriptive systems – that will require more substantive changes, albeit ones that will most likely occur at the level of implementing legislation.

One further overarching question regarding the licensing frameworks is how countries plan to implement licensing procedures for SMRs. This is not a question for every country – some have licensing frameworks in which SMRs can be licensed efficiently, at least theoretically. Countries that find their licensing procedures are not fit for purpose may try to establish a specific licensing procedure for SMRs, or change their licensing procedures more generally so as to extend their compatibility to SMRs. The first category includes what Hungary did, and the second category the approach of Finland. The first difficulty of the first approach is that a distinction has to be made between conventional plants and SMRs by prescribing in the national legislation a definition of SMRs, which might not be as straightforward. This matter is sought to be resolved in Hungary with a definition that is not prescriptive, but whose elements were not elaborated upon, so what it would cover in practice is open to interpretation – though naturally that could also raise concerns if the interpretation is not favourable to the applicant, resulting in challenges to the decisions of the authority. The benefit of this approach is that it can preserve the process of conventional plant deployments and the requirements pertaining to their licensing – which is especially important in prescriptive systems – without compromising the experience with that, but it would mean the specific development of SMR-specific requirements. The other solution, planned to be adopted in Finland, is to have a common framework for both conventional and SMR plants. The first possible issue with this approach is that some stages in licensing – particularly general design licensing – may not be necessary in the case of conventional plants that are deployed in one location once in a country, if the generic and project-specific licensing framework together may take longer than the existing procedures for conventional plants. For them there is no practical benefit of possessing a generic licence with regard to subsequent deployments, as these could not be leveraged upon due to the simple fact that in most countries it is unrealistic to expect the deployment of several units of the same conventional technology at different sites. The second consideration is that such a common

system would necessitate the development of more goal-setting approaches to be applicable also for SMRs, but it could potentially make the authority's task more difficult when evaluating applications, as they may no longer be able to check them against prescriptive criteria where compliance would be more straightforward to determine; it would also potentially compromise the experience gained with conventional plants through prescriptive requirements and would in that case necessitate a rather extensive overhaul. In this regard, the consideration of adopting such a common system may also be related to how prescriptive or goal-setting the current systems are. Consequently, in countries thinking of adopting these procedures, if prescriptive provisions are to be retained, it could be easier to adopt SMR-specific licensing procedures in which the authorities could grant certain exemptions from those provisions while retaining the existing procedures for conventional plants – though this could still create challenges regarding the ambiguity of the system and the coherence of its procedures. For countries that would rather move towards a goal-setting system, or already have done so, introducing a coherent common licensing process for SMRs and conventional plants could be a more appealing solution, where certain stages – such as general design licensing – could potentially be made optional if these, combined with project-specific licensing, would impose – at least for the first licensing of that design – more burdens than a project-specific licensing alone. Nevertheless, as noted, it depends on the given national framework to begin with, the size of the country, and the plans for what is intended to be deployed there.

12. After addressing some general questions regarding the efforts to streamline the nuclear safety licensing procedures we shall also go into the some of the elements that may be worth incorporating in the reforms to create a more accommodating environment for the licensing of nuclear power plants:

12.1. The first element that should be considered are the means for early engagement with the regulatory authorities. Early engagement with the authorities, to discuss questions particularly regarding the designs of nuclear power plants, exists across jurisdictions, but the formality and extent of these procedures may vary. Early engagement can significantly contribute to mitigating licensing risks by flagging issues early on with a design that may be problematic in the actual licensing process, or alternatively by highlighting that, broadly speaking, a given design is licensable, thus providing reassurance regarding its licensability later on, when a larger actual investment is made. With regard to avoiding investment risk, it would be adequate to be able to engage in these discussions without a decision-in-principle, and to allow not only future licensees but also potential vendors to conduct these consultations regarding their design. This in turn, when concrete projects are being discussed, could serve as a positive selling point for their designs – either because the authority did not flag any major issues that would hinder licensing, or because any issues that were flagged have since been resolved. However, in this regard, if these evaluations are not only on a general level, it becomes challenging for the authorities to manage these consultations through their resources, especially if SMR vendors – upon hearing of plans of interest in a country towards SMR deployments – start bombarding the authority with consultations to gain an upper hand over competing designs. In this regard, it could be a question for further discussion how authorised inspection organisations may be involved at this stage, but if they are involved then that may also entail non-negligible financial aspects.

A further question concerns what legal effects the matters addressed in this consultative stage should have for the future licensing process. Answering this depends on multiple factors and, as we can see, countries employ different effects – some of these consultative stages are purely consultative while others bear tangible relevance. The first factor is the depth of the analysis; tangible effects – such as the authority not needing to assess a particular solution again if the relevant factors have remained unchanged – are only conceivable if the analysis does not remain on the surface but is rather detailed. In such a case, the effect is justified by not wasting the regulatory efforts invested nor the preceding preparatory work of the party engaging. In systems where generic licensing may exist in the form of design approval, these two stages should not be competing with each other, and consultations should not take the role of design approvals; rather, in such systems there could be generic consultations with non-binding effects on the future licensing procedure, and system- and solution-specific consultations with a narrower scope that may carry such effects, allowing the licensee to obtain early feedback and assurance on solutions they consider most problematic from a licensing perspective. One more consideration is that in a system where a generic licence may exist but is optional in the case of conventional plant designs, a binding generic consultation regarding the compliance of the plant with the regulatory requirements could be valuable.

12.2. The second element that should be considered for incorporation into national licensing procedures is generic licensing stages. Since the benefits of these and what these stages entail have been elaborated on more substantially before, the author would only supplement these with some further observations. Generic licences precede project-specific licensing stages. As the Finnish reform proposal has shown, generic licences can concern both sites and designs. We should first elaborate on generic site licences. Some countries have site licensing procedures, such as Hungary, but these are project-specific. A generic site licensing procedure would entail a process where a site is approved not with a given design in mind, but as suitable for hosting a nuclear power plant, the conditions for which are contained in the site licence. The site is not assessed in light of a particular design; rather, the evaluation of the site determines the conditions that plants must comply with if they are to be sited there in general. The benefit of such an approach is that, while the site will ultimately have to be evaluated to a degree regarding the exact design at a project-specific licensing stage, a large portion of the risk of not having a licensable project due to site-related issues could be alleviated by such a generic licence that sets certain conditions. Such a licence, if adopted, should in the author's opinion be obtainable before the decisions-in-principle – which evaluates concrete projects – is made, as these are not related to the evaluations made at that stage. Moreover, this allows the process to be substantially more streamlined. If generic licences cannot be obtained until a concrete project had been deemed acceptable, that project would itself have to pass through the generic licensing process, which would defeat the purpose of a licence that is meant to be project-independent and to relieve project-specific procedures. Furthermore, who may apply for such a generic licence should not be restricted, so that several stakeholders with an interest in siting a nuclear power plant at a given location could obtain it, potentially attracting the siting of such installations there while at the same time easing the burdens of the applicant engaged in the

project-specific licensing. Such site licensing may also be very beneficial for conventional plants, similarly mitigating project risks at the project-specific licensing stage.

The other more frequently discussed generic licence relates to the design. The benefit of this licence is to mitigate the risks associated with a design when a project progresses to the project-specific licensing stage. Moreover, unlike the site licence, this generic licence should have the benefit of being leveraged across several project-specific licensing stages, which also means, as articulated before, that it is most relevant for SMRs. For conventional plants, its potential benefit would be that it could provide early approval of the design without needing to engage in a project-specific licensing process that could fail due to the site the developer or the operator not being suitable, if these factors and the design are assessed together – as in that case the authority may not have the possibility to leverage what was established in that site-specific project. In such cases, a generic licence could be leveraged even if one site-specific project fails. However, this is mostly a consideration where there is no generic or separate site licensing in the given national framework. What was concluded regarding generic site licensing – its timing and who could be the applicant – is equally applicable to generic design licensing.

12.3. A further possibility that could be incorporated into national licensing frameworks – which in different forms already exists in given jurisdictions, such as long-lead manufacturing in Hungary – is the authorisation of construction and manufacturing works prior to obtaining a project-specific licence. The most significant licensing stage, the construction licence – there are several ways to refer to it – takes significant time to process, what is more it generally does not by itself authorise any specific works; to carry out actual manufacturing or construction, separate licences or approvals must be obtained. This results in the project being unable to progress physically while the construction licence application is being evaluated. To tackle this problem, some jurisdictions have introduced procedures where certain manufacturing or construction works may be initiated before the construction licence is granted. The benefit of this is that the time taken to evaluate this comprehensive licence is not wasted in terms of the physical progression of the project. These works – whether preparatory or certain construction works at the site, or manufacturing activities – would naturally be subject to their own approvals, which should be permitted to be initiated once the licence application for the comprehensive construction licence is submitted. The risk of the project ultimately not being licensed should be borne by the licensee, but this risk, if the above-mentioned consultation stages or generic licensing stages have been conducted, would be less substantial. Moreover, with regard to SMRs that are factory-produced, the benefit of authorising the manufacturing of modules before the construction licence is granted would be even more significant, especially considering that if it is not the first of that SMR type to be deployed in that country, the licensing risk is also lower – and even more so since, if the project ultimately fails, the works would not necessarily be wasted due to the standardised nature of production. Construction works are somewhat more complex to regulate in this regard, as the construction licence may encompass licences needed for those construction works, raising the question of how these would be licensed – whether their general licensing procedures would be applicable to them, or whether the regulator responsible for the comprehensive licence should also issue approvals for these

works; moreover, in that case it remains a question how the site would be reinstated if the project ultimately does not succeed.

12.4. Further issue that relates to the substantive provisions of the licensing frameworks has already been articulated in detail is the move towards more technology neutral legislations to not exclude potential power plants that would otherwise would be suitable to the intended national application, and to adopt more goal-setting frameworks that are risk informed and thus are capable to reflect the novel solutions of the new generation nuclear power plants. When national frameworks are prescriptive and technology specific this change if decided to embark on is going to be the most difficult as this will require the most substantive changes in the existing frameworks.

12.5. Regarding the comprehensive construction licensing stages, as the previous discussions have shown, with the introduction of generic licensing procedures these stages should limit their scope to the analysis of those issues that could not have been addressed in the generic licensing stages, without repeating the same analyses. What also concerns the construction licensing stage are the physical works that follow it. These individual works – be it procurement, manufacturing, or construction – are subject to different approvals in different national contexts. The first consideration that should be made here is that national licensing frameworks should avoid being redundant and approving the same component in different contexts more than once, a situation that was present in Hungary before the reforms introduced during the Paks II licensing process. Some systems in these approval procedures rely predominantly on the regulator, while others allow for a more pronounced role for authorised inspection organisations. What should be procedurally reflected in these approvals is the graded approach, so that the regulatory involvement and the length of the processes correspond to the significance of the given physical work, which presupposes a classification of the safety significance of the given systems and system components. In this regard, the introduction of the Hungarian notification acknowledgement procedure was a notable improvement, but some systems may still give an even more central role to authorised inspection organisations.

12.6. The final element in the licensing process that the author would like to discuss is the commissioning and operation stages. Commissioning, as a stage in a system where third-party inspection organisations have a prominent role, is a particularly important stage, as it provides a comprehensive opportunity for the authority to ascertain that the plant was built according to the approved design and to provide oversight of the work of the inspection organisations. From the perspective of the general public, in systems where they may feel that traditional regulatory roles are delegated to these third parties, the assurance that these approvals as a whole system will eventually be checked can be critical. Furthermore, with regard to commissioning, it is the author's observation that it may be a more comprehensible and logical process if the commissioning stages are integrated into one procedure where the cold, hot and fuel-loaded tests are conducted in sequence based on a common commissioning plan, rather than being divided across two separate major licensing stages. However, this might mean that the commissioning licence need not be obtainable only after construction has concluded, but could instead be obtained during the construction stage, so as to allow commissioning tests to begin as construction progresses and certain systems and components can already be tested. Bringing commissioning under a common umbrella does

not mean that hold points cannot be introduced at this stage, particularly in relation to fuel-loaded tests. This process could be integrated into a broader licensing stage, but the conditions of operation should be settled subsequent to the commissioning being conducted, which would ultimately be decisive for the operation. Also at this stage, leveraging authorised inspection organisations in the commissioning tests in a manner corresponding to the graded approach should be considered. Finally, regarding the operation licensing stages, and particularly what we may consider as the lifetime of a nuclear power plant, it is worth reconsidering this in the context of the nuclear renaissance, as it will also be crucial for the long-term operation of these installations.

13. Regarding long-term operation, extending the holistic perspective to it revealed that decisions on LTO are in a favourable position from the perspective of the nuclear renaissance's materialisation, since the time pressure on these procedures is less significant: they can be conducted while the plant is operating and generating revenue. Nevertheless, this does not mean that certain considerations do not deserve attention during the renaissance. Particular attention should be given to the substance of these procedures, namely what safety expectations countries should set within them. It was argued that, beyond the necessary improvements at these stages, further measures aiming to achieve a higher level of safety should be adopted on the basis of reasonableness, a term that appears both in the CNS and the Vienna Declaration, meaning that the safety gain is proportionate to the investment required. Furthermore, in the context of EIA procedures, it was highlighted that the Espoo Convention's scope has been interpreted rather broadly in the context of LTO. This may deserve reconsideration in the wake of the nuclear renaissance, so that EIA does not become a mere procedural burden in cases where, owing to the overriding public interest and the limited physical works, it does not effectively influence the decision on LTO.
14. A further element that should be elaborated on, which concerns several stages of licensing, is authorised inspection organisations. While these organisations exist in different licensing procedures and countries take advantage of them based on the logic that they relieve the authority of being overburdened and allow it to focus on considerations that are significant from a nuclear safety perspective, their particular role is not perceived equally across national contexts. Nevertheless, the participation of such organisations is clearly something that is generally understood as a measure that could increase efficiency, and as such their participation should be incorporated when reforming licensing procedures. What could be of great benefit – and where international cooperation in this regard may prove valuable – is if approved inspection organisations could work across different jurisdictions, provided that the approval process for these organisations were based on more harmonised criteria, so that the knowledge accumulated could be utilised across different countries, carrying out the same tasks concerning possibly the same design.
15. There are some further miscellaneous considerations that should be taken into account when reforming licensing procedures, such as regulatory deadlines, which as already discussed do not necessarily result in more efficient procedures. Notwithstanding this, regulators should be motivated to conduct these reviews more efficiently and to organise their internal operations to facilitate it, but deadlines and penalties associated with them – while from the industry perspective they may seem appealing – threaten that reviews may be rushed if

regulators are pressured; subsequently, having well-equipped regulators to begin with could be a better solution.

Public participation is a further interesting issue in these deployment processes that carries significant burdens and consumes significant time. Due to the EIA procedures, public participation is mandatory in these processes, but most countries provide the public with further opportunities to engage in the deployment of such projects. These participations should be rationalised so as not to result in presenting the public with the same considerations several times; moreover, these should be timed correctly. In order not to hinder the project at a more advanced stage with public opposition, the public should be engaged early on, which also conveys the message that their voice is to be heard at an early stage, while at later stages they might get the impression that even if their voices are heard, the projects have progressed so far that their input does not carry actual weight. However, in order for the public to form a well-founded opinion, these substantive public inquiries should be conducted at a stage when there is already more information on the projects. This timing may very well align with when the EIA is conducted, but in order to avoid the impression that the project has progressed too far for public input to have an impact, it could be sensible to stage it before a construction licence application is made. However, concentrating public participation – at least in the form understood under the EIA procedure – in one stage in order to increase efficiency does not mean that opportunities for the public to gain information and to submit observations, possibly electronically, should not be provided throughout the licensing process.

The final element worth mentioning in this regard is the language of the documentation. In many cases the vendor is not from the country where the plant is proposed to be licensed, and authorities often require documentation in their national language, which results in extensive translation work that will naturally contain errors and give rise to critical differences in the terminology used. Subsequently, it is worth considering being more open in licensing procedures to the use of English in licence applications, so as not to be lost in terminological issues.

16. Finally, although the research questions admit no black-and-white answers, it is nevertheless imperative to give a concise, general answer to each of them.

16.1. The first issue concerned what the nuclear renaissance is, and whether it is realistic today to discuss its enabling conditions. It was discussed that, while renaissance may not be the best term if understood in its classical sense, in the context of the nuclear sector it refers to the envisaged accelerated expansion of the sector. More interesting was whether this renaissance is more realistic today than before. In this regard, the thesis presented the several new political commitments towards nuclear energy, the positive projections regarding its future role, and the tangible enabling conditions that are being put in place. While it cannot be concluded that the nuclear renaissance will occur, as several enabling factors still need resolution, it can nevertheless be concluded that it is more realistic than ever.

16.2. In what aspects do licensing frameworks hinder the materialisation of the nuclear renaissance, and where might they pose an obstacle to it in the case of conventional nuclear power plants? For conventional power plants, licensing frameworks do not, in broad terms, pose an obstacle to expansion, since they were developed to accommodate such plants.

However, they may in several ways hinder the materialisation of the renaissance. In essence, this hindrance arises from the fact that there was no incentive to adopt licensing procedures supporting the swift rollout of these plants, ever demanding safety considerations have dominated instead. As a result, these procedures are in some cases unpredictable, redundant, and inefficient, without necessarily resulting in a higher level of nuclear safety.

16.3. How can licensing frameworks be transformed to become more enabling of the nuclear renaissance, without compromising safety in the case of conventional nuclear power plants? The thesis presented several ways in which these hindrances may be resolved. Since these have been discussed in detail, the author refrains from listing them again and concludes instead that, besides guaranteeing a high level of safety, complementary considerations should be built into these procedures: namely predictability and efficiency.

16.4. In what aspects do licensing frameworks hinder the materialisation of the nuclear renaissance, and where might they pose an obstacle to it in the case of SMRs? In the parts discussing SMRs, it was concluded that current frameworks, owing to technology- and application-specific provisions and prescriptive requirements, in some cases pose obstacles to the deployment of SMRs, which simply do not fit into these requirements. In addition, they generally hinder SMR deployment by providing only for project-specific licences, by involving time-consuming licensing procedures, and by imposing differing design requirements that do not reflect the standardised nature of SMRs.

16.5. How can licensing frameworks be transformed to become more enabling of the nuclear renaissance, without compromising safety in the case of SMRs? Several ideas were presented in the thesis: some arise in the national context, while others require enhanced international cooperation. Among the national ones, the move towards technology-neutral and goal-setting licensing frameworks, along with the adoption of generic licences, can be highlighted. In the international context, the most critical are the development of harmonised licensing frameworks and enhanced regulatory cooperation in the review of designs.

16.6. In what aspects do licensing frameworks hinder the materialisation of the nuclear renaissance, and where might they pose an obstacle to it in the case of LTO? It can generally be concluded that there are no obstacles to LTO unless it is prohibited in the given country. Nevertheless, overly demanding new safety standards requiring substantial backfitting can hinder it, and if sufficiently demanding, may even pose an obstacle. Furthermore, certain elements of the LTO decision process that may not significantly influence the decision, but nevertheless carry procedural burdens, may also hinder it.

16.7. How can licensing frameworks be transformed to become more enabling of the nuclear renaissance, without compromising safety in the case of SMRs? In the case of LTO, the most important task is to set reasonable safety expectations beyond the necessary upgrades and changes, so that the required investment is commensurate with the safety gain.

16.8. How the fundamental instruments of international law governing the nuclear sector may conflict with the advanced nuclear technologies or give rise to open questions and how the rules of interpretation may contribute to resolving these issues in due course? In this regard, the thesis concluded that these international instruments are mostly technology-neutral and thus, in principle, cover SMRs, but that in some cases certain applications raise interpretative challenges that may be resolved through the evolutive interpretation of these

instruments. Additionally, several practical questions need attention from States Parties, who should develop answers on the cases in which SMRs may receive different treatment under these instruments.

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Hungary

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France

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2. Arrêté du 28 août 2017 portant homologation de la décision n° 2017-DC-0592 de l'Autorité de sûreté nucléaire du 13 juin 2017 relative aux obligations des exploitants d'installations nucléaires de base en matière de préparation et de gestion des situations d'urgence et au contenu du plan d'urgence interne *[Order of 28 August 2017 approving Decision No. 2017-DC-0592 of the Nuclear Safety Authority of 13 June 2017 concerning the obligations of operators of basic nuclear installations regarding the preparation and management of emergency situations and the content of the internal emergency plan]*.
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4. Arrêté du 6 janvier 2022 portant homologation de la décision n° 2021-DC-0714 de l'Autorité de sûreté nucléaire du 23 septembre 2021 relative à l'intégration au sein d'une installation nucléaire de base de certains équipements sous pression nucléaires en cours d'évaluation de la conformité *[Order of 6 January 2022 approving Decision No. 2021-DC-0714 of the Nuclear Safety Authority of 23 September 2021 relating to the integration within a basic nuclear installation of certain nuclear pressure equipment undergoing conformity assessment]*.
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7. Code de l'urbanisme *[Urban Planning Code].*
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13. Décret n°2007-1557 du 2 novembre 2007 relatif aux installations nucléaires de base et au contrôle, en matière de sûreté nucléaire, du transport de substances radioactives. *[Decree No. 2007-1557 of 2 November 2007 concerning basic nuclear installations and the supervision, with regard to nuclear safety, of the transport of radioactive substances]*.
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15. Loi du 31 janvier 2003 sur la sortie progressive de l'énergie nucléaire à des fins de production industrielle d'électricité *[Act of 31 January 2003 on the gradual phase-out of nuclear energy for the industrial production of electricity]*.
16. Loi modifiant la loi du 31 janvier 2003 sur la sortie progressive de l'énergie nucléaire à des fins de production industrielle d'électricité afin de garantir la sécurité d'approvisionnement sur le plan énergétique. *[Act amending the Act of 31 January 2003 on the gradual phase-out of nuclear energy for the industrial production of electricity in order to guarantee security of energy supply]*.
17. Loi n° 2006-686 du 13 juin 2006 relative à la transparence et à la sécurité en matière nucléaire *[Act No. 2006-686 of 13 June 2006 on transparency and nuclear safety]*.
18. Loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte *[Act No. 2015-992 of 17 August 2015 on Energy Transition for Green Growth]*.
19. Loi n° 2023-491 du 22 juin 2023 relative à l'accélération des procédures liées à la construction de nouvelles installations nucléaires à proximité de sites nucléaires existants et au fonctionnement des installations existantes *[Act No. 2023-491 of 22 June 2023 on Accelerating Procedures for the Construction of New Nuclear Facilities Adjacent to Existing Nuclear Sites and for the Operation of Existing Facilities]*.
20. Loi n° 2024-450 du 21 mai 2024 relative à l'organisation de la gouvernance de la sûreté nucléaire et de la radioprotection pour répondre au défi de la relance de la filière nucléaire *[Act No. 2024-450 of 21 May 2024 on the organisation of the governance of*

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23. Rapport au Président de la République relatif à l'ordonnance n° 2012-6 du 5 janvier 2012 modifiant les livres Ier et V du code de l'environnement *[Report to the President of the Republic concerning Ordinance No. 2012-6 of 5 January 2012 amending Books I and V of the Environmental Code]*.

Finland

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2. Act No. 1164/2022 on the Radiation and Nuclear Safety Authority.
3. Act No. 252/2017 on the Environmental Impact Assessment Procedure.
4. Act No. 356/1957 on Atomic Energy.
5. Act No. 416/2002 on Nuclear Liability.
6. Act No. 423/2022 (Climate Act).
7. Act No. 990/1987 on Nuclear Energy.
8. Amendment No. 2015/676 of the Nuclear Energy Act.
9. Decree No. 161/1988 of the Ministry of Economic Affairs and Employment on Nuclear Energy.
10. Government decision on the application by Teollisuuden Voima Oy to obtain a licence, referred to in section 18 of the Nuclear Energy Act, for the construction of a new nuclear power plant unit on the Olkiluoto plant site in Eurajoki, 17 February 2005. [Online]. Available at: https://tem.fi/documents/1410877/2850176/Construction+Licence.pdf/03c2a15f-186e-455b-8cd4-3266bf950185?t=1465369913000 (Accessed: 4 April 2026).
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Scientific publications related to the topic:

1. Mádl, M.V. (2025) 'The EU's Energy Policy From the Perspective of a Central-Eastern European Country: Hungary' in Szilágyi, J.E., Marinkás, Gy. (eds.) *Maastricht 30: A Central European Perspective*. Miskolc–Budapest: Central European Academic Publishing, pp. 653–677. https://doi.org/10.54237/profnet.2025.jeszgymmcep_26
2. Mádl, M.V. (2024) 'The Evolution of Licensing Electricity Generation Capacity in Hungary', *Central European Academy Law Review*, 2(2), pp. 121–142. https://doi.org/10.62733/2024.2.121-142.
3. Mádl, M.V. (2025) 'Hungary's Nuclear Legislation in Light of a Nuclear Renaissance', *Journal of Agricultural and Environmental Law*, 20(38), pp. 47–90. https://doi.org/10.21029/JAEL.2025.38.47.
4. Mádl, M.V. (2025) 'The Euratom Treaty as the Foundation of a Harmonised Licensing Framework for SMRs in Europe', *Czech Yearbook of Public and Private International Law,* (16), pp. 295–311.

Under publication:

1. Mádl, M.V. (2026) 'New Build Nuclear Power Plants and Environmental Considerations in their Licensing: A Complex and Critical Mechanism' in: B. Rakoczy (ed.) *The Interdisciplinary Nature of Environmental Law*, Nicolaus Copernicus University Press. pp. 1–20.
2. Angesti, V., Anggarani, B., Bresolin, E. Chen C-Y, Mádl, M.V. (forthcoming in 2026) 'From Northen Cape to Europe: Feasibility and Challenges of a Green Hydrogen Corridor', *Central European Academy Yearbook of Contemporary Legal Discourse,* 1(1).

Supervisor's recommendation

Recommendation for the Public Defence on the PhD Dissertation of Miklós Mádl Vilmos entitled: "Enabling the Nuclear Renaissance: A Holistic Perspective on Adapting Licensing Frameworks for Conventional and Advanced Nuclear Power Plants"

The dissertation addresses a highly relevant and timely topic, namely the legal enabling conditions of the so-called nuclear renaissance, with a particular emphasis on licensing frameworks and their role in supporting or constraining nuclear energy development. I find the central argument – that renewed interest in nuclear energy can only translate into real capacity expansion if legal and regulatory systems adapt to new challenges – well-founded and convincingly developed; furthermore, the analysis of licensing frameworks as the central component in facilitating the expansion is well-reasoned and justified.

I consider it a major strength of the thesis that it adopts a holistic perspective around licensing, indicating that such questions may arise concerning different installations; as such, it is clearly structured around three key areas: the licensing of conventional nuclear power plants, the legal challenges of advanced nuclear technologies (especially SMRs), and the regulatory aspects of the long-term operation of existing plants. The author consistently examines these topics through a coherent set of research questions, with particular attention being devoted to the first two categories due to their exclusive capacity to contribute to true expansion.

I particularly value the comparative analysis of existing licensing frameworks for conventional nuclear plants in Hungary, Finland, and France, which not only uncovers these rather complex procedures that have not really been undertaken before and highlights structural differences and similarities, but also provides meaningful insights into how licensing procedures influence the feasibility and predictability of nuclear projects – also through practical examples – and presents how these countries seek to address the constraints presented by their own frameworks. The section on SMRs is especially strong in terms of originality and timeliness. The author demonstrates a high level of legal understanding in analysing both domestic regulatory challenges and the applicability of international nuclear law, which requires deep interdisciplinary knowledge, while also offering well-reasoned, practice-oriented proposals.

The discussion of long-term operation is also convincingly integrated, underlining that the nuclear renaissance is not limited to new construction, but also includes the extension of existing capacities, as new units can only contribute to an expansion if old installations are not retired earlier.

From a methodological perspective, I find the dissertation carefully designed and executed with academic rigour. While primarily doctrinal, it is enriched by comparative and interdisciplinary approaches. The author shows strong analytical capacity, independence in research, and appropriate awareness of methodological limitations.

Overall, I consider the dissertation to be a high-quality, original, and scientifically sound contribution that successfully brings the issue of nuclear renaissance into the domain of legal

scholarship, offering a holistic conclusion on how legal frameworks should be reconsidered to facilitate the deployment of these installations. I also find that the dissertation meets the formal and substantive requirements set by the doctoral school.

My final conclusion is that I highly recommend the dissertation for public defence.

Budapest, 2026. October 1.
Supervisor:
Prof. Dr. János Ede Szilágyi

Enabling the Nuclear Renaissance: A Holistic Perspective on Adapting Licensing Frameworks for Conventional and Advanced Nuclear Power Plants

Summary of the Thesis

This thesis examines the holistic licensing aspects of a nuclear renaissance which entails the prospect of significantly expanding nuclear energy generating capacities for electricity generation and for other applications. After decades of stagnation driven by safety concerns and high costs, nuclear energy is again attracting serious attention. Yet the legal enabling conditions for such an expansion remain understudied.

The thesis identifies licensing as the central legal obstacle to the materialisation of the nuclear renaissance and analyses it across three interconnected areas. The first concerns the streamlining of national licensing frameworks for conventional large-scale nuclear power plants, examined comparatively through the Hungarian, Finnish, and French systems.
The second major part of the thesis focuses on advanced nuclear technologies, particularly Small Modular Reactors, whose novel design features, unprecedented variety, and proposed applications pose several challenges not only to existing national licensing frameworks, but also to the international legal frameworks governing the sector. With regards to them the thesis first addresses the applicability of international nuclear law instruments to SMRs, an issue with significant practical consequences that has received little attention. This is followed by a review of those attributes of SMRs that challenge current licensing frameworks, together with a discussion of the regulatory solutions that may help to resolve these challenges. In this regard, special attention is given to the potentially beneficial concept of harmonisation.
The third area which the thesis addressed concerns the authorisation of long-term operation of existing plants, which nuclearised states may increasingly pursue while new capacity is being developed.

Throughout, the thesis pursues two overarching research questions: where do licensing frameworks hinder the nuclear renaissance, and how can they be adapted to support it without compromising nuclear safety? The work adopts a problem-based, interdisciplinary approach and aims to offer both a comprehensive mapping of key licensing related obstacles and concrete *de lege ferenda* proposals for overcoming them.

Miskolc, 2026. October 1.
Miklós Vilmos Mádl

Statement

In accordance with the provisions of the Regulation on the Use of Artificial Intelligence of University of Miskolc and the Guidelines for the Use of Artificial Intelligence of the Deák Ferenc Doctoral School of Law, I, undersigned .....Miklós Vilmos Mádl..... (name), declare that I have used / have not used artificial intelligence in my doctoral dissertation and thesis booklets.

In the case of the use of artificial intelligence (hereinafter: AI), I declare the following:
1. The name of the AI tool used: Deepl Translator (premium), Google Gemini (flash lite), ChatGPT 5.5, Claude AI (Sonnet 4.6, Sonnet 5).
2. The URL and the version number of the AI tool used: https://www.deepl.com/en, https://chatgpt.com/ https://gemini.google.com/app?hl=hu , https://claude.com/
3. The exact date of production of the generated content (year, month, day): I have been using these tools from 2024 until the date of submission in 2026
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