

BETWEEN INNOVATION AND RISK MANAGEMENT: EXPLORING NUCLEAR LIABILITY STANDARDS FOR SMALL MODULAR REACTORS

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Abstract: Recent developments in the energy sector have underscored the critical role of innovation, with small modular reactors (SMRs) emerging as a key player in this transformation. Even though SMRs are expected to offer enhanced safety compared to traditional reactors, particularly due to passive safety systems that eliminate complex components and reduce the likelihood of failure, their anticipated deployment in more populated areas raises pressing questions about liability in the event of nuclear damage. Since an inadequate liability regime can significantly undermine public trust, potentially not only jeopardizing the social acceptability of SMRs but also fueling broader skepticism toward innovation in the energy sector, it is necessary to approach the issue of nuclear liability associated with SMRs with due care. This evolving context presents the core research problem: to what extent does the existing international and national nuclear liability framework provide an adequate and future-proof legal basis for the deployment of SMRs, and what adjustments may be necessary to reconcile innovation with effective risk management and public trust? This article examines the legal framework governing civil liability for nuclear damage in light of SMR deployment and analyses whether the general international law regime, based on instruments such as the Vienna Convention on Civil Liability for Nuclear Damage and its 1997 Protocol, and the national implementation of such regime and country-specific regulation adequately accommodate the distinctive risk profile and operational characteristics of SMRs. Particular attention is paid to whether foundational principles of strict liability remain fit for purpose in this evolving technological landscape. Using the Czech legal framework as an illustrative case, the article also considers the implications of the recent amendment to the Czech Atomic Act (executed through Act No. 83/2025 Sb.), which introduced the possibility of granting ad hoc exemptions from standard requirements: a legislative development with significant potential to shape the national regulatory approach to SMRs in the future.

Resumé: Nedávný vývoj v energetice zdůraznil klíčovou roli inovací, přičemž klíčovými hráči v této transformaci se staly malé modulární reaktory (SMR). Přestože se očekává, že malé modulární reaktory nabídnou ve srovnání s tradičními reaktory vyšší bezpečnost, zejména díky pasivním bezpečnostním systémům, které eliminují složité komponenty a snižují pravděpodobnost selhání, jejich předpokládané nasazení v obydlenějších oblastech vyvolává naléhavé otázky týkající se odpovědnosti v případě jaderné škody. Vzhledem k tomu, že neadekvátní režim odpovědnosti může významně podkopat důvěru veřejnosti a potenciálně ohrozit nejen společenskou přijatelnost SMR, ale také podnítit širší skepsi vůči inovacím v energetice, je nutné přistupovat k otázce jaderné odpovědnosti spojené s SMR s náležitou opatrností. Tento vyvíjející se kontext představuje hlavní výzkumný problém: do jaké míry poskytuje stávající mezinárodní a vnitrostátní rámec odpovědnosti za jadernou škodu přiměřený a do budoucna odolný právní základ pro zavádění SMR a jaké úpravy mohou být nezbytné pro sladění inovací s účinným řízením rizik a důvěrou veřejnosti? Tento článek se zabývá právním rámcem upravujícím občanskoprávní odpovědnost za jaderné

škody ve světle zavádění SMR a analyzuje, zda obecný mezinárodněprávní režim založený na nástrojích, jako je Vídeňská úmluva o občanskoprávní odpovědnosti za jaderné škody a její protokol z roku 1997, a vnitrostátní provádění tohoto režimu a regulace specifická pro jednotlivé země přiměřeně zohledňují odlišný rizikový profil a provozní charakteristiky SMR. Zvláštní pozornost je věnována tomu, zda základní zásady objektivní odpovědnosti jsou i nadále vhodné pro tento vyvíjející se technologický prostor. Na příkladu českého právního rámce se článek zabývá také důsledky nedávné novely českého atomového zákona (provedené zákonem č. 83/2025 Sb.), která zavedla možnost udělování ad hoc výjimek ze standardních požadavků: legislativní vývoj s významným potenciálem utvářet národní regulační přístup k SMR v budoucnosti.

Key words: small modular reactors; liability; nuclear law; energy law; innovative nuclear technology

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1. Introduction¹

The ongoing decarbonization of the energy sector, coupled with the need to ensure reliable energy supplies and meet growing demand, represents a key driver of its current transformation. The primary sources of energy today include fossil fuels (coal, oil, natural gas), renewable energy sources (solar, wind, hydro, biomass), and nuclear power.² While fossil fuels continue to play a significant role in the global energy mix, the current European political setup is prompting a gradual shift away from their use. In contrast, renewable energy sources are experiencing rapid development, although their deployment is often constrained by variability in output and dependence on geographic and weather conditions.³

While nuclear energy serves as a relatively stable and efficient source of electricity, it also remains a source of public concern, primarily due to the potential for severe accidents (as exemplified by the extreme cases of Chernobyl and Fukushima) and the challenges associated with the safe management of radioactive waste. These concerns translate into stringent regulatory requirements, lengthy approval processes, and often, public resistance to the construction of new nuclear facilities.

When exploring pathways to enhance the safety and social acceptability of nuclear energy, one of the most promising technological innovations was the widespread expansion of small modular reactors (commonly referred to as the “SMRs”), offering the potential to

¹ *The research presented in this article was conducted as part of the research project titled ‘A fleet of small modular reactors on the horizon! Do we need a new nuclear law?’ funded by the Czech Science Foundation (No. GA24-10062S).*

² Eurostat. *Shedding light on energy in Europe – 2024 edition*. Available at: <https://ec.europa.eu/eurostat/web/interactive-publications/energy-2024> [accessed 21 June 2025].

³ European Commission. *Renewables Hit Record Growth in 2024, but Global Gaps Remain*. Available at: https://cvvm.soc.cas.cz/media/com_form2content/documents/c2/a5472/f9/oe211119b.pdf. [accessed 21 June 2025].

address many of the traditional concerns associated with nuclear power. The findings of an economic and sensitivity analysis on a notional SMR project conducted by Rachael E. Josephs and others assessing the feasibility, profitability, and long-term viability of SMRs, suggest that SMRs could account for 3% to 9% of the energy market by 2050, with a base case of 4,5%.⁴ This underscores the importance of coordinated efforts among policymakers, industry stakeholders, and regulatory bodies to ensure the successful integration of SMRs into the energy grid.

The deployment of SMRs is not only a technological endeavor but also a societal challenge, in which public trust plays a decisive role. Given the historical skepticism surrounding nuclear energy, particularly regarding safety and accountability in the event of accidents, a credible and transparent liability regime is essential to foster public acceptance. This includes clear rules on strict liability, mandatory insurance or financial security, and accessible compensation mechanisms, all of which signal that adequate protections are in place for individuals and communities potentially affected by a nuclear incident.

Ensuring public confidence through robust legal safeguards must be carefully balanced against the need to create a workable and predictable framework for operators and investors. Excessively rigid or open-ended liability provisions may discourage SMR deployment, especially among new entrants or in smaller markets, thereby undermining the broader goals of energy transition and innovation. Achieving this balance requires regulatory clarity, risk-based differentiation, and flexibility, such as allowing calibrated liability caps or conditional exemptions under well-defined circumstances, while maintaining core principles like victim compensation and financial responsibility. Only a liability framework that is both credible in the eyes of the public and manageable from a commercial perspective can support the successful and socially accepted rollout of SMR technology.

This paper aims to explore the interplay between the international legal regime for nuclear liability and the emerging deployment of SMRs, identifying potential gaps and proposing solutions that ensure both public protection and regulatory support for innovation. Given the current state of knowledge in this field, the authors identified the research question of whether the existing model of nuclear liability is fit vis-à-vis SMRs and their specifics, and what changes could be made in this regard. In order to answer this question, the authors first explore the technical nature of SMRs and their unique features when compared to other nuclear installations, then isolate the specific regulation-relevant features which will create a foundation for further assessment, thereafter carry out an analysis of legal implications of those specifics, followed by an assessment of the most appropriate regulatory approach and its confrontation with the existing regulation. It must be noted that this article by no means intends to answer all the related questions surrounding the complex topic of regulation of SMRs, but rather to establish a framework for further research and detailed policy recommendations.

⁴ JOSEPHS, R. E., YAP, T., ALAMOOTTI, M., OMOJIBA, T., BENARBIA, A., TOMOMEWO, O. and OUADI, H., 'Regulation of Small Modular Reactors (SMRs): Innovative Strategies and Economic Insights' (2025), 6 (4), *Eng.* p. 61.

2. Technological and operational profile of SMRs

Conventional large-scale nuclear power plants often face significant challenges, including high construction costs, prolonged permitting and commissioning processes, and complex safety and liability frameworks. These obstacles have driven increased interest in advanced nuclear technologies that provide more flexible, scalable, and cost-effective solutions. Among these innovations, SMRs stand out as particularly promising.⁵

SMRs are generally defined as nuclear reactors with a power output of less than 300 MWe⁶ and can be divided into several categories based on their technological nature. For instance, Vincent Jérôme H. Roland distinguishes between different groups of SMRs based on either reactor technology, or their operational and legal characteristics.⁷ From the viewpoint of technological types of SMRs based on their reactor design and core features, Roland distinguishes light-water small modular reactors (LWR-SMRs),⁸ high-temperature gas-cooled reactors (HTGRs),⁹ or liquid metal-cooled fast reactors.¹⁰ These technology-based categories serve to illustrate the diversity of SMR designs and the corresponding variations in fuel, coolant, and refueling methods.¹¹

More central to the Roland's argument is a second typology that classifies SMRs based on their deployment models, mobility, and the implications these features have for the application of international liability law, where Roland introduces two broad categories: SMRs installed and operated at a fixed site, and SMRs that are transportable or mobile. The first category SMRs are constructed, licensed, operated, refueled, and ultimately decommissioned at a single, well-defined location. They do not move during their lifecycle, and all nuclear activities are confined to a designated site. In legal terms, this type of SMR closely aligns with the traditional model of a nuclear installation as envisioned by the existing conventions.¹² The second category encompasses reactors that are designed to be

⁵ European Commission. Small Modular Reactors explained. Available at: http://energy.ec.europa.eu/topics/nuclear-energy/small-modular-reactors/small-modular-reactors-explained_en [accessed 21 June 2025]; See also LOCATELLI, G., Why Are Megaprojects, Including Nuclear Power Plants, Delivered Overbudget and Late? Reasons and Remedies (Report MIT-ANP-TR-172, Center for Advanced Nuclear Energy Systems, Massachusetts Institute of Technology 2018).

⁶ SCHLEGEL, J. P. and BHOWMIK, P. K., 'Small Modular Reactors' in WANG, J., TALABI, S. and BILBAO Y LEON, S. (eds), *Nuclear Power Reactor Designs: From History to Advances* (Elsevier Academic Press 2024) pp. 283–308; See also International Atomic Energy Agency. What are Small Modular Reactors (SMRs)? Available at: <https://www.iaea.org/topics/design-safety-nuclear-power-plants/passive-safety-features> [accessed 10 June 2025].

⁷ ROLAND, V. J. H., 'Applicability of the Existing Nuclear Liability Conventions to Different Types of Small Modular Reactors Currently under Development' (2023) 2023/1(110) *Nuclear Law Bulletin* pp. 9–13.

⁸ These reactors use ordinary (light) water as both coolant and moderator, similar to traditional nuclear power plants. Examples cited include designs like NuScale, SMART, and CAREM. They are generally understood to fall well within the current liability conventions, as they resemble scaled-down versions of established technologies.

⁹ These designs utilize gas (such as helium) as the coolant and typically involve graphite-moderated cores. Notable examples include the Xe-100 and the HTR-PM. These reactors often have modular designs and high outlet temperatures, enabling their use in industrial heat applications in addition to electricity generation.

¹⁰ These reactors use a liquid metal—commonly sodium or lead—as the coolant and often have fast neutron spectra. Examples include the PRISM and Natrium reactors. These SMRs may introduce more significant legal uncertainties, particularly if they involve novel fuel types or closed fuel cycles.

¹¹ Ibidem.

¹² Ibidem.

manufactured off-site, transported to an operational location (e.g., a remote community or industrial site), and potentially returned to the vendor for refueling or decommissioning. Examples include floating reactors or skid-mounted microreactors. These designs introduce a range of legal ambiguities, particularly in terms of their legal qualification, the designated responsible operator, and the allocation of liability.¹³

In addition to their compact size, SMRs are typically factory-fabricated and modular, which allows for standardization, improved quality control, and potentially faster deployment times. They are designed with simplified, enhanced safety systems and incorporate passive safety features that reduce reliance on active mechanical components and human intervention. These design efficiencies not only lower capital investment but also facilitate installation in non-traditional settings, including remote locations, industrial sites, or even urban and densely populated areas — environments that would be impractical for conventional reactors due to their larger footprint, greater cooling requirements, and more complex infrastructure needs.¹⁴

Now that we have established the technical parameters of SMRs, it is vital to understand how those specifics translate into their economics. SMRs are designed for centralized manufacturing and modular deployment (thus the name). Unlike traditional large-scale reactors that are typically constructed on-site over many years, SMRs are largely fabricated in factory settings under controlled conditions. This approach enables higher standardization, improved quality assurance, and cost efficiency through serial production. Once manufactured, the reactor modules are transported by road, rail, or sea to their designated installation sites, where they can be assembled and commissioned much more rapidly. This streamlined deployment model significantly reduces construction timelines and minimizes on-site complexity, making SMRs particularly attractive for flexible and scalable energy solutions. Similar to conventional nuclear reactors, SMRs require periodic fuel replacement, with many SMR designs seeking to reduce the frequency of refueling by utilizing advanced fuel technologies and achieving higher burn-up rates. Some SMRs are engineered to operate continuously for 3 to 10 years without needing refueling, a significant extension compared to the typical 12–24-month fuel cycles of large reactors.¹⁵

3. Policy-relevant specifics of SMRs

Given the specific nature of SMRs, it is evident that several vital differences distinguish them from other nuclear installations. On the other hand, not all the technical specifics will necessarily be relevant from the regulatory viewpoint. Testing individual specifics against their potential impact on regulation, the authors isolated as relevant (i) the technical and economic lifecycle of SMRs, (ii) the potentially lower risk profile, and (iii) the unique

¹³ Ibidem. Ronald also points out that these reactors may also be subject to overlapping legal regimes, such as maritime law or national transport regulations, which further complicates the application of nuclear liability conventions. As such, the author emphasizes that additional legal interpretation or supplementary guidance may be necessary to ensure these reactors are adequately covered under the existing regime.

¹⁴ European Commission. Small Modular Reactors explained. Available at: http://energy.ec.europa.eu/topics/nuclear-energy/small-modular-reactors/small-modular-reactors-explained_en [accessed 21 June 2025].

¹⁵ International Atomic Energy Agency. What are Small Modular Reactors (SMRs)? Available at: <https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs> [accessed 21 June 2025].

distribution of roles and responsibilities among individual actors taking part in SMRs production and operation.

Regarding the risk profile of SMRs, although it is impossible to provide an accurate and policy-relevant estimate of the exact degree of associated risk, it is generally concluded that their safety is greater than that of larger nuclear installations.¹⁶ This, however, will have only a partial impact on regulatory considerations, as will be explained below. The other two factors, on the other hand, seem to be of greater relevance, with the lifecycle specifics transferring into the distribution of duties between different actors being especially interesting.¹⁷

The economic lifecycle of SMRs involves multiple specialized actors, each with a distinct role and set of responsibilities. Understanding these roles is essential to evaluate how liability for nuclear damage may be distributed or concentrated within this system. Among the most significant actors in this context are the SMR designers and vendors, the manufacturers and EPC (engineering, procurement, and construction) firms, the reactor operators, and the transporters of nuclear materials or components. Each contributes to the safe and lawful deployment of SMR technology, and their activities are shaped by both technical demands and legal frameworks.

SMR designers and vendors are responsible for developing the reactor technology itself. These entities – typically private companies specializing in nuclear innovation – design SMRs to be smaller, more modular, and often safer than traditional reactors. Their primary responsibility is to ensure that the reactor design complies with international and national nuclear safety standards. This includes incorporating passive and inherent safety features, such as self-regulating cooling systems or sealed containment structures, which reduce reliance on external power or human intervention. Designers must also perform extensive safety and risk analyses, provide detailed documentation for licensing processes, and support operators during regulatory review by supplying technical data, probabilistic risk assessments, and other required information. In addition to technical compliance, SMR vendors are often responsible for ensuring their designs can be manufactured and operated economically and safely in varied conditions, including remote or off-grid locations. They may also offer lifecycle services such as training, commissioning support, and design updates.¹⁸

Manufacturers and EPC firms are tasked with turning SMR designs into physical reality. Manufacturers fabricate key nuclear-grade components such as reactor pressure

¹⁶ See e.g., INGERSOLL, D. T., 'An Overview of the Safety Case for Small Modular Reactors' in *Proceedings of the ASME 2011 Small Modular Reactors Symposium* (ASME, Washington DC, 2011) pp. 369–373; VUJIĆ, J., BERGMANN, R. M., ŠKODA, R. and MILETIĆ, M., 'Small Modular Reactors: Simpler, Safer, Cheaper?' (2012) 45(1) *Energy* pp. 288–295; PLAYBELL, I., 'Economy, Safety and Applicability of Small Modular Reactors' (2017) 170(2) *Proceedings of the Institution of Civil Engineers – Energy* pp. 67–79; LEE, J. I., 'Review of Small Modular Reactors: Challenges in Safety and Economy to Success' (2024) 41 *Korean Journal of Chemical Engineering* pp. 2761–2780. International Atomic Energy Association. (2009) *Passive Safety Systems and Natural Circulation in Water Cooled Nuclear Power Plants*. Available: https://www-pub.iaea.org/MTCD/Publications/PDF/te_1624_web.pdf [accessed 14 June 2025]. VIJAYAN, P. K., KAMBLE, M. T., NAYAK, A. K., VAZE, K. K. and SINHA, R. K., 'Safety Features in Nuclear Power Plants to Eliminate the Need of Emergency Planning in Public Domain' (2013) 38(5) *Sādhanā* pp. 925–943.

¹⁷ AHMAD, F. and USMAN, S., 'Advanced and Small Modular Reactors' Supply Chain: Current Status and Potential for Global Cooperation' (2025) *Progress in Nuclear Energy*, 184; LLOYD, C. A., *Modular Manufacture and Construction of Small Nuclear Power Generation Systems*, University of Cambridge (2020); GAO, B., KUZNETSOVA, K., MA, Z. and MILLER, K., *Nuclear Small Modular Reactors: Key Considerations for Deployment* (Johns Hopkins School of Advanced International Studies & International Energy Forum 2024).

¹⁸ *Ibidem*.

vessels, heat exchangers, and control systems. EPC firms manage the broader construction process, overseeing site development, system integration, and coordination with various subcontractors. These actors operate under strict quality assurance regimes and are required to document and verify every step of their work. This includes material traceability, weld inspections, and system testing. Because even minor flaws can have safety implications in a nuclear context, manufacturers must ensure that all parts meet rigorous technical specifications and are free from defects.¹⁹

Transporters play a vital but often overlooked role in the SMR lifecycle. Because SMRs are modular, components or even entire reactor modules may be transported to the deployment site. In addition, nuclear fuel must be transported to the facility and spent fuel or radioactive waste must be transported away for storage or disposal. Transporters are typically responsible for conducting these movements safely, securely, and in full compliance with national laws and international rules such as the IAEA Regulations for the Safe Transport of Radioactive Material.

Transport companies must use specially designed and certified transport containers that are capable of withstanding accidents, radiation leakage, and unauthorized access. They must plan secure routes, coordinate with law enforcement and emergency response agencies, and maintain real-time tracking of shipments. Transporters are also required to train personnel in radiation safety, handling procedures, and emergency response. Their responsibilities include maintaining accurate documentation of shipments, ensuring compliance with import/export regulations where applicable, and implementing safeguards to prevent the loss or diversion of nuclear materials. While they are not typically liable for nuclear damage under strict liability regimes, they may face civil or contractual liability if negligence during transport leads to an incident.

Once the reactor is built and commissioned, responsibility passes to the operator, who holds the operating license and assumes primary legal liability for the facility. The operator is typically responsible for safely running the SMR in accordance with all applicable laws, licenses, and safety protocols. This includes managing daily operations, routine and unplanned maintenance, radiation monitoring, emergency preparedness, and physical and cyber security. Operators must employ and train qualified staff, maintain a strong safety culture, and establish procedures for handling incidents or deviations from normal operation. They are also responsible for ensuring the plant complies with environmental requirements and for managing the spent nuclear fuel and radioactive waste generated during operation.²⁰

In traditional nuclear installations, the construction and operation of a reactor are typically carried out as a unified, centralized project. These reactors are built largely on-site in a highly customized manner, often as one-off installations. The utility or operator that commissions the plant usually oversees the entire project from the early design phases through construction and into operation. This means the operator often has a high degree of influence over the choice of design, selection of materials and suppliers, quality control measures during construction, and integration of systems. The boundaries between design,

¹⁹ Ibidem.

²⁰ See also HARTMANN, J., HYVÄRINEN, J. and RINTALA, V., 'The Operator and the Seven Small Modular Reactors — An Estimate of the Number of Reactors That a Single Reactor Operator Can Safely Operate' (2024) *Nuclear Engineering and Design*, 418.

construction, and operation are therefore more fluid, with the operator maintaining a degree of control over the full lifecycle of the installation.

In contrast, the development and deployment of SMRs are characterized by a far more segmented process. SMRs are conceived as standardized, modular units designed for factory manufacturing. The SMR lifecycle is typically divided into discrete phases handled by different specialized actors. A vendor designs the reactor module, which is then built by an independent manufacturer, often in a factory setting and far from the final deployment site. The completed module is then shipped to the site for installation, where a third party—often an energy utility or industrial end-user—takes over operation.

This modular, supply-chain-driven model means that the operator of an SMR does not usually have oversight or control over the design or manufacturing phases. The reactor arrives largely as a finished product, with its core systems already integrated and quality-checked before delivery. While the operator must still ensure that the installation, operation, and maintenance meet regulatory and safety standards, they are effectively a customer of a manufactured energy product rather than the principal actor in its creation. As a result, the SMR model introduces a more distinct separation between those who design, those who build, and those who operate the reactor.

This separation has practical implications. It introduces a clear division of technical responsibilities, limits the operator's ability to modify or influence design or manufacturing decisions, and creates a more complex supply chain. In the traditional nuclear model, operators play a central role not only in the operation of the plant but also in its design selection, construction management, and quality assurance. This gives them a degree of control and influence that justifies imposing exclusive and strict liability on them. The operator could, in principle, ensure that every aspect of the facility met safety and performance requirements from the ground up. In contrast, SMRs are produced through a modular, supply-chain-based system, where the operator receives a factory-built reactor unit largely as a finished product. The operator has no direct role in the design process, no influence over the technical standards used during manufacturing, and often no visibility into the quality assurance procedures implemented by the vendor or EPC contractor. This means that critical risk-related decisions, such as design philosophy, materials selection, safety margins, and testing protocols, are made by other entities well before the operator takes delivery of the reactor.

This separation of roles creates a potential liability mismatch. Under existing legal frameworks, the operator is strictly liable for any nuclear damage caused by the installation, regardless of fault.²¹ While this simplifies the legal process and ensures a clear channel of responsibility, it does not reflect the actual distribution of risk and control in the SMR model. If a defect in design or manufacturing causes an incident, the operator may bear full legal and financial responsibility, despite having had no opportunity to prevent or even assess the defect during earlier phases. This could potentially lead to unfair liability burdens on operators, particularly in cases where SMRs are used by smaller utilities, municipalities, or industrial users who lack the resources or technical capacity of traditional nuclear licensees. It may also disincentivize the adoption of SMRs, as potential operators could view the liability exposure as disproportionate to their role and level of control.

²¹ See Vienna Convention 1963, Article II(5).

Thus, distribution of liability plays a crucial role in considerations regarding SMRs. Traditional legal frameworks were designed with large, centralized reactors in mind and do not account for the decentralized, mobile, or modular nature of SMRs.²² As such, questions arise as to whether the principles of strict and exclusive operator liability, standard financial security requirements, and uniform liability thresholds remain appropriate for SMRs. While the reduced size, advanced safety systems, and centralized manufacturing of SMRs may lower the probability and potential impact of nuclear incidents, these very features also raise fundamental questions about how they fit within existing international legal structures. Specifically, the incorporation of passive safety mechanisms and extended refueling cycles contributes to a lower risk profile compared to conventional large-scale nuclear reactors. As a result, it is arguable that the current “one-size-fits-all” liability framework may not adequately reflect the nuanced risk landscape of SMRs.²³

4. International legal framework for nuclear liability

The international legal framework for nuclear liability is primarily built upon two key instruments: the Vienna Convention on Civil Liability for Nuclear Damage (1963) and the Paris Convention on Third Party Liability in the Field of Nuclear Energy (1960). These conventions serve as the cornerstones of international nuclear liability law, each developed within a different institutional and regional context, reflecting distinct legal and policy approaches.

The Vienna Convention on Civil Liability for Nuclear Damage (1963) is the primary instrument governing international nuclear liability. It establishes a liability regime in connection with the peaceful use of nuclear energy. It applies its liability regime only to specific categories of nuclear installations. According to the Convention, a “nuclear installation” refers to the following:

- i. Nuclear Reactors – this includes any nuclear reactor except those that are part of sea or air transport vehicles and are used as a power source, whether for propulsion or other purposes.²⁴
- ii. Fuel Processing and Production Facilities – this category covers factories that use nuclear fuel for the production of nuclear material, facilities for processing such material, and plants that reprocess irradiated nuclear fuel.²⁵
- iii. Storage Facilities – the Convention also includes facilities where nuclear material is stored, excluding temporary storage that occurs during transportation.²⁶

²² “Modular” refers to transforming the design and construction of a traditional monolithic plant into one that enables factory fabrication of modules, which can be shipped and installed on-site as complete units. See the Economic Modeling Working Group Of the Generation IV International Forum. Cost estimating guidelines for generation iv nuclear energy systems. Available at: https://www.gen-4.org/gif/upload/docs/application/pdf/2013-09/emwg_guidelines.pdf [accessed 21 June 2025].

²³ See also HANDRLICA, J. and NOVOTNÁ, M., ‘The Feast of Insignificance of Small Modular Reactors in International Nuclear Law’ in *Czech Yearbook of Public and Private International Law* (Czech Society of International Law, Prague 2021) pp. 326–336.

²⁴ Vienna Convention 1963, Article I(1)(j)(i).

²⁵ Vienna Convention 1963, Article I(1)(j)(ii).

²⁶ Vienna Convention 1963, Article I(1)(j)(iii).

On the other hand, the Vienna Convention does not extend to all nuclear-related activities. It excludes so-called *low-risk installations*, which are facilities where nuclear material is present but the likelihood of causing significant harm is minimal.²⁷ These include, for example, uranium mining and milling operations, and medical facilities utilizing ionizing radiation for diagnostics or treatment. The rationale behind this exclusion lies in the low probability of transboundary damage caused by such facilities, which makes the application of a special international liability regime unnecessary.

As a result, operators of these low-risk installations are not subject to the Vienna Convention's strict rules, such as the exclusive liability or mandatory insurance described below. Instead, liability in such cases is generally governed by domestic tort law under national legal systems. It imposes a strict and exclusive liability regime, under which the operator of a nuclear installation is solely liable for nuclear damage, irrespective of fault.²⁸ In the sense of the Vienna Convention, the operator means the person designated or recognized by the installation state as the operator of that installation.²⁹ This designation is not merely administrative—it is foundational to the entire liability regime. The Vienna Convention establishes an exclusive liability model, meaning that only the operator bears legal responsibility for nuclear damage. Other parties, such as suppliers, contractors, or designers, are explicitly excluded from liability, even in cases where their actions may have contributed to the incident. Furthermore, the operator's liability is channeled solely through the Vienna Convention's provisions, excluding recourse to other parallel legal regimes.³⁰ This centralized approach is designed to ensure clarity, simplify compensation claims, and provide a stable foundation for mandatory financial security, but it may also limit flexibility in adapting to emerging technologies like SMRs.

The Vienna Convention allows for only narrowly defined exceptions to the operator's liability. Exoneration is permitted solely in exceptional circumstances, such as when the nuclear incident is proven to have resulted directly from armed conflict, civil unrest, hostilities, or a severe natural disaster of an extraordinary character. Additionally, the operator may be relieved of liability if it is established that the damage was caused, either wholly or in part, by the intentional misconduct of the victim or through their gross negligence. Outside specified exceptional circumstances, the operator remains strictly and exclusively liable, regardless of fault or contributory factors. The operator is also required to maintain mandatory financial security, typically in the form of insurance, to cover potential liabilities.

Notably, the Convention defines a nuclear reactor in general terms and does not differentiate between conventional reactors and SMRs.³¹ The only reactors excluded from its scope are those 'with which a means of sea or air transport is equipped.' The Vienna Convention allows contracting parties to enact national legislation that limits the operator's

²⁷ See HANDRLICA, J. and NOVOTNÁ, M., 'The Vienna Convention on Civil Liability for Nuclear Damage Revisited: Challenges for Updating the Czech and Slovak Legal Framework' (2013), *The Lawyer Quarterly*, 4, pp. 296–310.

²⁸ See Vienna Convention 1963, Article II(5).

²⁹ Vienna Convention, Article I(1)(c).

³⁰ Vienna Convention, Article II(5).

³¹ See ROLAND, V. J. H., 'Applicability of the Existing Nuclear Liability Conventions to Different Types of Small Modular Reactors Currently under Development' (2023) 2023/1(110) *Nuclear Law Bulletin* pp. 9–13.

financial liability. However, such limitations are subject to a minimum threshold set by the Convention itself. Specifically, liability cannot be limited to less than the equivalent of 5 million US dollars per nuclear incident.³² This interpretation effectively brings SMRs under the scope of the Vienna Convention, even in cases where the associated risk is demonstrably lower. The exclusion clause for mobile reactors (sea or air-based) was not intended to reflect a reduced risk, but rather to address the jurisdictional complexities of mobile nuclear units operating across state boundaries. As such, the Convention offers no mechanism to exclude low-risk reactors, such as SMRs mounted on stationary terrestrial platforms, from its application.

Efforts to modernize the Vienna framework have led to the adoption of the Protocol to Amend the Vienna Convention (1997), which establishes the Amended Vienna Convention. This revised instrument retains the core principles of strict and exclusive operator liability but introduces two mechanisms that may prove essential for the future regulation of SMRs:

- Graduated liability limits: contracting parties can adjust the operator's liability based on the specific nature of the nuclear installation or the nuclear substances involved, as well as the potential consequences of an incident. This mechanism permits the establishment of a lower financial cap than otherwise stipulated by the protocol, provided that it does not fall below 5 million SDRs.^{33,34}
- Exclusion mechanism: Under conditions to be defined by the International Atomic Energy Agency (IAEA), Parties may exclude certain types of nuclear installations from the Convention's application, should their risk profile warrant such an exemption.³⁵

However, these mechanisms remain largely untested. The IAEA has not yet adopted specific criteria for excluding SMRs or other types of installations, and the number of contracting parties to the Amended Vienna Convention remains relatively limited. In the case of the Czech Republic, although it is a signatory to the Amended Convention, it has not yet ratified it, which currently limits its legal flexibility in addressing SMR-specific liability issues.

In conclusion, it is questionable whether the current framework established by the original Vienna Convention may or may not present a regulatory barrier to the broader deployment of SMRs, due to its rigid liability provisions. Ratification of the Amended Vienna Convention, or alternatively, the development of a tailored liability regime, could certainly offer a viable legal path forward, aligning liability principles more closely with technological innovation and proportional risk assessment.³⁶ Under the current framework of the Vienna Convention on Civil Liability for Nuclear Damage, there is no provision allowing for the exclusion or differentiated treatment of nuclear material used in SMRs. Despite the long-

³² The Convention uses a special unit of account tied to the value of the US dollar based on its gold parity as of 29 April 1963—equivalent to 35 US dollars per troy ounce of fine gold—resulting in a “floating” limit that reflects this historical valuation rather than current currency rates. See Vienna Convention, Article V(3).

³³ SDR is an international reserve asset created by the International Monetary Fund.

³⁴ Vienna Convention as amended by the Protocol, Article V(2). See the document including the explanatory text here https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1279_web.pdf [accessed 30 June 2025].

³⁵ Vienna Convention as amended by the Protocol, Article I(2).

³⁶ See HANDRLICA, J. and NOVOTNÁ, M., ‘The Feast of Insignificance of Small Modular Reactors in International Nuclear Law’ in *Czech Yearbook of Public and Private International Law* (Czech Society of International Law, Prague 2021) pp. 326–336.

standing awareness of SMR technology among the Convention's signatories, no tailored liability mechanism has been established to reflect the unique risk profile of these reactors. As a result, contracting parties are bound by the Convention's uniform standards and cannot adopt a more flexible or less stringent liability regime for SMRs at the national level without breaching their international obligations. This regulatory rigidity may pose a significant barrier to the broader deployment of SMRs.

This means that even an SMR operator who merely installs a ready-made unit supplied by the manufacturer will bear full legal liability for any nuclear damage. Moreover, the operator will be required to meet all financial security obligations (such as liability insurance), even though the potential damage caused by an SMR could in some cases be significantly lower than that of large nuclear power plants. This imbalance between the actual risk and the legal burden makes the Vienna Convention a potential obstacle to the wider deployment of SMRs in countries that are party to it. Furthermore, while SMRs are individually smaller and considered inherently safer, their widespread deployment could lead to a significant increase in the number of nuclear installations globally. This proliferation raises new regulatory and security challenges, including the need for robust oversight, enhanced physical protection, and consistent emergency preparedness at a larger number of sites.³⁷ The Vienna Convention, however, applies a uniform liability regime without accounting for the cumulative implications of distributed deployment. As a result, the legal framework may inadequately address the complex risk landscape emerging from the modular and decentralized nature of SMR technologies.

In contrast, the Paris Convention on Third Party Liability in the Field of Nuclear Energy provides a more flexible legal framework. It allows for the exclusion of certain types of installations—such as decommissioned reactors or low-risk facilities—through decisions of the OECD's Steering Committee for Nuclear Energy. This mechanism enables national authorities to subject such installations to ordinary tort law, rather than the strict liability regime of the Convention, reflecting a risk-based regulatory approach. However, it is important to note that the Czech Republic is not a signatory to the Paris Convention.³⁸ However, it has acceded to the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, which aims to bridge the legal frameworks of the two Conventions.³⁹ This Joint Protocol facilitates mutual recognition and coordination between states party to either the Vienna or Paris Conventions, ensuring a coherent liability regime in cases where nuclear incidents affect multiple countries under different conventions. Nonetheless, since the Czech Republic is bound primarily by the Vienna Convention, it cannot benefit from the Paris Convention's more flexible provisions regarding liability exclusions for certain installations, such as SMRs or low-risk facilities.

³⁷ See CHRISTOPH, J., SAIMUM, O. S. and AMPONFI, A., 'Small Modular Reactors and Nuclear Non-Proliferation: To What Extent Will the Global Spread of SMRs Impact Nuclear Proliferation?' (2023) Institute of Nuclear Materials Management.

³⁸ Nuclear Energy Agency. Latest status of the Paris Convention on Third Party Liability in the Field of Nuclear Energy. Available at: https://www.oecd-nea.org/jcms/pl_31798/paris-convention-latest-status-of-ratifications-or-accession [accessed 21 June 2025].

³⁹ International Atomic Energy Agency. Latest status of Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention. Available at: https://www.iaea.org/sites/default/files/22/06/jointprot_status.pdf [accessed 21 June 2025].

5. Assessment of liability models

A central pillar of the international nuclear liability regime is the principle of strict liability, under which the operator of nuclear installation is held liable for nuclear damage regardless of fault. This foundational principle, enshrined in instruments such as the Vienna Convention on Civil Liability for Nuclear Damage and its 1997 Protocol, has historically served to ensure prompt and equitable compensation for victims, while simplifying legal proceedings by removing the burden of proving negligence. However, in the context of SMRs, which differ substantially from conventional large-scale nuclear facilities in both design and risk profile, the application of strict liability warrants further clarification. Although the principle is intended to guarantee legal certainty and victim protection, questions arise as to its operational limits, especially when SMRs are deployed in a wider variety of environments and potentially by a more diverse set of operators, including smaller private entities and local utilities.

The key question that needs to be answered when it comes to nuclear liability is whether the technical and practical specifics of SMRs give reasons for the differential legislative treatment, and if so, in what regard. For the reasons of further assessment, the analysis will be divided into two separate areas, namely (i) the regime of the liability *per se*, and (ii) the question of distribution of liability amongst different actors taking part in SMRs design, production, and operation.

The liability model established under the Vienna Convention on Civil Liability for Nuclear Damage is, in the authors' view, built on three core elements: (i) strict (objective) liability, (ii) liability assigned to the operator of a nuclear installation, and (iii) a minimum amount of financial security, typically through insurance. The authors of this article recognize that reducing the administrative, financial, and legal burden could significantly facilitate the wider adoption and deployment of SMRs. However, with respect to the first component (objective liability) we consider the existing approach to be appropriate and necessary, for the following reasons.

While SMRs are widely regarded as being safer than traditional large-scale nuclear installations (especially thanks to passive safety systems, lower fuel inventories, and inherent design simplifications), the authors hold the opinion that this enhanced safety profile does not justify exempting SMRs from the strict liability regime that governs nuclear installations. The central function of strict liability is not to measure the probability of an accident occurring, but to ensure clear, reliable compensation if and when an accident does occur. Once nuclear damage happens, the statistical likelihood becomes irrelevant, since the harm has already materialized and someone must be held accountable.

The core misunderstanding in arguments for SMR exemption is the conflation of risk reduction with risk elimination. Proponents of relaxed liability regimes often cite the reduced probability of core damage or radiation release as a reason to limit or abandon strict liability. However, strict liability does not hinge on how likely an accident is, but rather on who should bear the consequences if an accident does occur. Even a very low-risk technology can cause significant harm in the rare cases where failure happens. And when it does, the rarity of the event does not reduce the suffering of victims, nor does it mitigate the cost of environmental cleanup, health care, or lost livelihoods. From a legal and ethical standpoint, the strength of the strict liability model lies precisely in the fact that it decouples

compensation from fault or foreseeability. Victims do not need to prove negligence or design defects; they are entitled to compensation simply because harm occurred. This principle is particularly important in the nuclear sector, where the technical complexity of operations often makes it prohibitively difficult for injured parties to establish causation or identify the responsible party upstream. Relaxing strict liability for SMRs based on their improved safety profile would undermine this principle and reintroduce uncertainty and procedural barriers for victims.

Moreover, such an exemption could set a dangerous precedent: it implies that certain technologies can be deemed *safe enough* to justify hardening victim compensation. This is a fundamental argumentative fallacy. The fact that a reactor is statistically less likely to cause harm does not change the reality that, if it does, the consequences can be just as severe as with traditional nuclear plants. In other words, the severity of nuclear damage is not proportionally reduced by the lower probability of occurrence. Liability frameworks must be built around the potential consequences of failure, not just the likelihood.

Strict liability, which does not require proof of fault, is mostly imposed in Czech legal practice due to the increased risk for others.⁴⁰ Beyond risk, it also reflects practical limitations: in complex cases such as nuclear incidents, the harmed party may be unable to determine exactly who is responsible for the damage and it is particularly difficult to establish negligence.⁴¹ Even if SMRs present lower risk profiles compared to traditional large reactors, reduced risk does not eliminate the need for a robust legal framework. A mechanism must still exist to ensure the public can obtain compensation in the event of damage. Therefore, the authors argue that strict liability should not be relaxed and should remain a cornerstone of nuclear liability law.

What does merit closer examination in the SMR and very small modular reactors (vSMR) context, however, is whether the operator should always be the party held liable under all circumstances. Assigning liability to the operator presumes their full understanding of the installation, including detailed knowledge of all systems and components. In the emerging SMR landscape, this assumption may no longer be tenable. SMRs may increasingly be purchased as complete, factory-built units delivered directly to the deployment site. The operator may not participate in the manufacturing process at all and could lack any meaningful ability to influence the reactor's quality or construction. Moreover, for commercial reasons, manufacturers may be reluctant to fully disclose the reactor's inner workings and functionalities to the buyer.

The authors anticipate significant challenges regarding transferring liability to other actors, such as manufacturers.⁴² Among these is the difficulty a damaged party would face in proving which actor (manufacturer, designer, or supplier) breached their duty and

⁴⁰ MELZER, F., *Občanský zákoník IX. svazek*, § 2894–3081: Závazky z deliktů a z jiných právních důvodů [Civil Code Volume IX, Section 2894–3081: Obligations from Tort and Other Legal Reasons] (Nakladatelství Leges, Praha 2019) p. 2895.

⁴¹ International Atomic Energy Agency. The 1997 Vienna Convention on Civil Liability for Nuclear Damage and the 1997 Convention on Supplementary Compensation for Nuclear Damage – Explanatory Texts. Available: https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1279_web.pdf [accessed 14 June 2025] p. 1.

⁴² It must be noted that this article only deals with the regulatory dimension of the liability, not the contractual one. Nothing prevents the individual actors including the insurance provider to create a contractual framework allowing the ex-post transfer of liability based on different criteria. The only relevant question from the regulatory viewpoint is who will be liable towards the potential victims of a nuclear event.

caused the harm. This aligns with one of the underlying motivations for the adoption of this model under the Vienna Convention, namely, the effort to avoid complex and lengthy legal proceedings aimed at determining individual fault and establishing legal liability through cross-actions.⁴³ From a regulatory perspective, it is also far easier for national authorities to monitor and enforce compliance with financial requirements imposed on a domestic operator, compared to tracking the financial capacity and accountability of potentially foreign-based manufacturers. Strict liability of the operator removes the need for all parties involved in the construction or operation of a nuclear installation, aside from the operator, to obtain separate insurance coverage, thereby helping to contain overall costs through the centralized application of strict operator liability. Additionally, any insurance or liability-related costs borne by a manufacturer would likely be passed on to the operator through pricing mechanisms anyway. In this respect, placing the responsibility for obtaining and maintaining insurance coverage with the operator helps ensure continuous and effective risk mitigation.

While the authors believe that strict liability remains a necessary foundation for nuclear risk management, it is reasonable to consider whether certain elements of the liability regime, such as insurance requirements or financial security thresholds, should be adjusted in light of the unique characteristics of SMRs. One potentially valid argument in this context is that, although SMRs may not eliminate the possibility of an accident, the scale and consequences of such an accident are likely to be significantly lower than in the case of conventional large-scale reactors. SMRs typically contain less radioactive material, operate at lower thermal power, and often incorporate passive safety features that lower the severity of potential core damage. Their design often allows for underground or sealed containment, which could further reduce the potential for environmental release in the event of an incident. Because of these characteristics, even if an accident were to occur, the magnitude of radiological consequences, such as the geographic extent of contamination or the volume of affected population, may be comparatively limited. From this perspective, it is rational to consider whether the financial coverage obligations (e.g., insurance amounts) imposed on SMR operators should be calibrated to the realistic scope of possible damage, rather than set at the same level as those for large reactors designed to produce gigawatts of electricity.

The Protocol to Amend the Vienna Convention sets a general minimum liability threshold of 300 million SDRs, while also allowing for a reduction to as low as 5 million SDRs, provided that the reduction reflects the specific nature of the nuclear installation, the substances involved, and the likely consequences of an incident. In such cases, the remaining amount must be covered by public funds. This approach may offer a more suitable framework for SMRs, particularly vSMRs, which, due to their size and enhanced safety characteristics, may not justify the same financial requirements as larger facilities. For this purpose, SMRs have to be classified as a low-risk installations.⁴⁴ Such flexibility could help tailor liability regimes to the risk profiles of advanced nuclear technologies. It would also allow national legal frameworks to reflect the specific attributes of different reactor types. However, it is essential that any reduction in operator liability is matched

⁴³ Ibidem.

⁴⁴ VÁSQUEZ-MAIGNAN, X., 'Small Modular Reactors to Decarbonize the Industry: The Impact of Nuclear Liability', *Fourth International Workshop on the Indemnification of Damage in the Event of a Nuclear Accident*, OECD, 2019.

by appropriate state oversight and control mechanisms. The ratification of the Protocol to Amend the Vienna Convention by the Czech Republic would thus not only enable such adaptability but would also represent a forward-looking step toward facilitating nuclear innovation under an effective and balanced liability regime.

This line of reasoning, however, must be weighed against another critical aspect of the SMR deployment model: their intended proximity to population centers or industrial hubs. One of the primary advantages of SMRs is that their modularity and smaller footprint allow for deployment in locations that would be unsuitable for large nuclear plants. This includes urban or semi-urban environments, where they can support district heating, hydrogen production, or microgrids. In such contexts, even a small-scale radiological release or thermal event could affect a larger number of people, businesses, and critical infrastructure than a comparable incident at a remote, purpose-built nuclear site. In effect, while the absolute severity of an SMR accident may be lower in technical terms, the concentration of exposure – due to population density and proximity to valuable assets – could result in higher relative social and economic impacts. For example, the forced evacuation of a dense urban neighborhood, even for a limited time and with minimal contamination, could generate significant costs, legal claims, and long-term disruption. These indirect or secondary consequences must be factored into any reassessment of insurance limits or financial security instruments.

Therefore, a one-size-fits-all approach is unlikely to be appropriate. The emerging diversity in SMR designs, siting strategies, and use cases demands a more granular, risk-informed liability framework. Blanket reductions in insurance requirements based on reactor size alone would be premature and potentially irresponsible. Instead, what is needed is the collection and analysis of empirical data to accurately assess the risk profile of different SMR configurations. This includes probabilistic safety assessments, siting models, population exposure scenarios, and historical performance data as more SMRs are deployed and operated.

In conclusion, while the argument that SMRs may cause less damage in absolute terms is a reasonable basis for reconsidering certain aspects of liability and financial security, it cannot be taken in isolation. The context of deployment, particularly population density and proximity to infrastructure, introduces new dimensions of risk that must also be accounted for. As the global SMR fleet expands, policy decisions regarding insurance limits and liability caps should be based on detailed, case-specific risk evaluations, rather than general assumptions about reactor size or perceived safety. Only with such data-driven approaches can legal frameworks strike the right balance between promoting innovation and safeguarding public and environmental interests.

6. Further outlook on hybrid liability regimes

There is most certainly more than one possible approach to adapting a more flexible liability regime for SMRs, reflecting the evolving nature of nuclear technology and the diversity of deployment models. While the international framework remains rigid, some jurisdictions have already begun to explore more agile, risk-informed regulatory approaches that could account for the specific characteristics of SMRs, while (hopefully) maintaining core safety and accountability principles.

One of the most recent and noteworthy examples can be found in Czech legislation. Act No. 83/2025 Sb., which amends Act No. 263/2016 Sb., the Atomic Act, as amended,⁴⁵ has introduced provisions that offer a more adaptable approach to regulating nuclear activities, including provisions that may have significant implications for how liability and regulatory obligations are assessed in the context of SMRs.⁴⁶ These changes are particularly evident in the newly added Section 228b, which establishes mechanisms for the granting of exceptions from legal requirements under specific conditions.⁴⁷

Section 228b introduces the possibility for an individual or entity, who is subject to obligations under the Atomic Act, such as requirements relating to nuclear safety, radiation protection, technical safety, radiation monitoring, emergency preparedness, physical protection, or nuclear non-proliferation, to apply to the regulatory authority for an exception from such obligations. This provision recognizes that, in certain cases, strict adherence to the letter of the law may not be feasible or appropriate, particularly in light of new technologies or specific operational circumstances.⁴⁸

The authority may grant such an exception, but only under clearly defined conditions.⁴⁹ First, it must be demonstrably impossible to fulfil the given legal requirement in the specific case. Second, the applicant must provide a sound justification for the alternative approach or deviation being proposed. Third, the authority must be satisfied that granting the exception will not result in any reduction of the level of nuclear safety, radiation protection, or any of the other protected interests prescribed by the law. In other words, the alternative approach must maintain the same degree of safety and protection as would have been ensured by compliance with the original requirement. Furthermore, the proposed procedure must reflect accepted good practice in the field.⁵⁰

The section also gives the authority the power to revoke an exception once granted. Revocation may occur if the holder of the exception commits a serious breach of obligations under the Atomic Act, fails to correct serious deficiencies identified by the authority, or if the factual or legal conditions that justified the exception are no longer met. Additionally, an exception can be revoked upon the written request of the person to whom it was granted. This framework introduces a mechanism for case-by-case flexibility while maintaining the overall integrity of the nuclear safety and regulatory system.⁵¹

The reasoning of the legislature behind the introduction of the new exception mechanism in the newly introduced Section 228b is grounded in the recognition that the existing atomic legislation was developed with traditional nuclear technologies in mind and is not always

⁴⁵ Act entered into force on 1 July 2025, except for the provisions of Article I, paragraphs 146 and 147 and 180 to 182, which shall enter into force on 1 January 2026.

⁴⁶ Although the provisions are not tailored specifically for SMRs, we believe that the general provisions provide a good enough foundation for their application on SMRs as well. SMRs are also explicitly mentioned in the explanatory memorandum to this bill (see further).

⁴⁷ See Article I(261).

⁴⁸ *Ibidem*.

⁴⁹ To prevent misuse, the amendment sets strict prerequisites for granting exceptions. An applicant must not only justify the need for deviation but also demonstrate that the proposed approach preserves the required level of safety and aligns with recognized good practice. This includes adherence to international standards, particularly those issued by the International Atomic Energy Agency (IAEA).

⁵⁰ *Ibidem*.

⁵¹ *Ibidem*.

adaptable to the rapidly evolving landscape of new nuclear technologies, particularly SMRs, which are explicitly mentioned in the explanatory memorandum.⁵² The amendment draws on precedents already present in the Atomic Act, which allows for certain specific exceptions (e.g., regarding the categorization of workplaces or sources of ionizing radiation), and extends this logic to a broader set of substantive requirements. The explanatory memorandum highlights that ongoing global efforts to develop and deploy advanced nuclear technologies demand a highly flexible regulatory approach. These technologies, including SMRs, are still under development, and their exact technical parameters are not yet fully defined. However, once their designs are finalized, their deployment and commissioning are expected to proceed rapidly—potentially within just a few years. Given the pace of development, it is neither feasible nor practical to continuously update legislation to keep pace with each technological innovation. At the same time, it is not possible to prepare appropriate legal requirements in advance for technologies that do not yet exist in final form.

The legislature recognizes that if the law were to be updated only after new technologies are fully developed, this would significantly delay their implementation. Such delays could jeopardize the Czech Republic's energy security and negatively impact its ability to meet climate goals. The amendment therefore seeks to create a legal tool that allows for deviations from older requirements designed for traditional reactor types, provided that safety and other essential regulatory objectives remain fully protected. The newly introduced exception mechanism is limited to substantive safety-related requirements—such as nuclear safety, radiation protection, technical safety, emergency preparedness, physical protection, and non-proliferation—and does not apply to procedural rules, sanctioning mechanisms, or institutional powers. The decision to grant an exception lies with the State Office for Nuclear Safety (SÚJB), which is deemed the most competent authority to evaluate such requests. Applicants must provide compelling reasons and demonstrate compliance with the conditions set out in the law.⁵³

In summary, the amendment aims to balance the need for regulatory flexibility with the imperative to maintain a high standard of safety. It does so by creating a structured, tightly controlled pathway for exceptions to legal requirements, primarily in order to accommodate emerging technologies like SMRs, without compromising the core objectives of the Czech atomic regulatory framework. Building on this approach, the Czech amendment could serve as a valuable inspiration for future legislative developments in other jurisdictions grappling with the integration of SMRs into their regulatory frameworks. By introducing a clear, procedurally defined mechanism for granting exceptions, anchored in demonstrable technical need and subject to strict safety conditions, the law offers a model for how to balance regulatory flexibility with rigorous oversight. It provides a way to accommodate innovation without abandoning fundamental safety principles or undermining public trust.

For countries considering how to regulate SMRs, especially in light of their novel designs, siting flexibility, and modular deployment, the Czech experiment could offer a practical tool for managing technological uncertainty in a controlled and responsible manner. It also underscores the importance of forward-looking, risk-informed regulatory

⁵² See Důvodová zpráva k zákonu č. 83/2025 Sb., kterým se mění zákon č. 263/2016 Sb., atomový zákon, ve znění pozdějších předpisů, č. 83/2025 Dz. [Explanatory memorandum to Act No. 83/2025 Sb., amending Act No. 263/2016 Sb., the Atomic Act, as amended, No. 83/2025 Dz.]

⁵³ *Ibidem*.

design, supported by competent and independent regulatory authorities. As SMRs begin to transition from prototypes to commercial deployment, frameworks of this kind may prove essential in ensuring that regulation can keep pace with technological progress while upholding the integrity of nuclear safety and liability systems.

As legal and regulatory frameworks begin to adapt to the unique characteristics of SMRs, it will also be important to closely monitor how insurance markets respond to this shift. The traditional nuclear liability regime depends not only on legislation but also on the availability and structure of nuclear insurance coverage, which plays a central role in ensuring that operators are able to meet their financial obligations in the event of an incident.⁵⁴ In this context, how insurance companies assess, quantify, and price the risks associated with SMRs will significantly influence the practical implementation of liability systems. Given that SMRs differ from traditional nuclear power plants in terms of design, size, siting, and operational models, insurers will likely have to develop new actuarial approaches and underwriting criteria. For instance, they may need to consider whether the smaller core inventory and enhanced passive safety features of SMRs justify lower premiums or policy limits. At the same time, insurers must factor in new sources of uncertainty, such as the lack of long-term operational data, greater variation in design types, and potentially riskier deployment contexts, such as urban areas, industrial sites, or remote locations with limited emergency infrastructure.

Moreover, insurers may be particularly interested in the distribution of responsibility across the SMR supply chain. Since SMRs are designed and manufactured off-site by third parties, the operator may have less control over critical safety aspects. This fragmentation of roles could complicate the assessment of residual risks and the allocation of liability, especially in the event of design or manufacturing defects. Insurance products may need to evolve to cover not only the operator but also other actors in the lifecycle, such as vendors and component manufacturers, through contractual extensions or shared risk arrangements. From a regulatory standpoint, the availability of insurance may itself act as a *de facto* test of risk acceptability. If insurers are unwilling to provide coverage at reasonable terms for certain SMR designs or siting strategies, this may signal unresolved concerns that regulators and policymakers should address. Conversely, strong insurance uptake could help build public and investor confidence in the safety and viability of SMRs.

7. Conclusion

The deployment of SMRs represents both a technological opportunity and a regulatory challenge. As this article has demonstrated, the core features of SMRs such as standardized factory production, modular deployment, and enhanced passive safety, mark a significant departure from the traditional model of large, site-built nuclear installations. These changes, while offering clear advantages in terms of efficiency and safety, also disrupt the foundational assumptions upon which current nuclear liability regimes are built, particularly the model of strict and exclusive operator liability established under the Vienna Convention.

The analysis presented in this article shows that the SMR lifecycle is highly segmented, involving a range of independent actors from design through manufacturing, transport,

⁵⁴ See also LOUAAS, A. and PICARD, P., 'Optimal Nuclear Liability Insurance' (2021) 43(1) *The Energy Journal* pp. 97–115.

and operation. This fragmentation of roles raises critical questions about whether it remains appropriate to assign full liability solely to the operator, especially in circumstances where the operator may have no real influence over the design or construction of the reactor. At the same time, it can be argued that the principle of strict liability should not be weakened simply because SMRs are perceived as safer. Liability must remain focused on consequences rather than probabilities. If an incident occurs, its cause is secondary to the need for effective victim compensation and public accountability. Hence, while SMRs are widely regarded as safer than traditional nuclear installations, the authors believe that this enhanced safety profile cannot justify exempting them from strict liability. The key function of strict liability is not to assess how likely an incident is to happen, but to ensure that when harm does occur, victims are compensated quickly and fairly. Once damage has occurred, the statistical rarity of the event becomes irrelevant. Even low-risk technologies can produce catastrophic consequences, and the legal system must be structured to respond to those consequences regardless of fault. Relaxing strict liability on the basis of reduced risk would blur the line between risk and accountability and potentially undermine the very purpose of the liability framework to provide clear, predictable, and enforceable protection for the public in the face of high-consequence technologies.

While the authors believe that strict liability should be preserved, other elements of the liability regime, particularly financial security requirements, may warrant closer scrutiny. SMRs, especially very small or low-power variants, are likely to cause less damage in absolute terms than conventional reactors. This must be balanced against the fact that SMRs may be deployed closer to population centers, where even minor incidents could have disproportionate social and economic consequences. These trade-offs suggest that a risk-informed, differentiated approach may be more appropriate than the current uniform model. Importantly, such an approach requires robust empirical data on reactor design, deployment scenarios, population exposure, and operational reliability, to tailor liability and insurance standards to real-world risk.

In this context, the recent Czech legislative amendment implemented by Act No. 83/2025 Sb. offers an example of a more flexible regulatory strategy. By introducing a mechanism for granting ad hoc exceptions to certain legal requirements, under strict conditions and with continued oversight, the Czech model provides a possible blueprint for aligning regulation with innovation without undermining core safety principles. It illustrates that legal frameworks can be both adaptive and protective, i.e., capable of responding to emerging technologies while still safeguarding the public interest. Equally, the authors believe that the role of insurers will become increasingly important. How insurance providers assess SMR risks, structure coverage, and adjust premiums will influence both the viability of SMR projects and the adequacy of victim compensation in the event of damage. The insurance market may act as a bellwether of regulatory sufficiency, and its response to SMRs deserves careful attention from both policymakers and regulators.

In conclusion, this article argues for a balanced and forward-looking approach: one that preserves essential legal protections such as strict liability, while allowing greater flexibility in how financial and regulatory burdens are distributed across actors and installations. As SMRs continue to move from the drawing board to deployment, the legal framework must evolve in step, guided by the principles of fairness, technological realism, and public trust. This article is, of course, merely the first step towards a complex policy recommendation

that could shape the future of SMR implementation in different jurisdictions. While this article has outlined the core challenges related to liability, actor responsibility, and regulatory flexibility, many critical questions remain unanswered. For instance, further research is needed to examine how national legal systems might develop tailored liability mechanisms within the constraints of international conventions, how to assess and address shared risk of different actors on the level of public regulation, and how insurance markets will respond in practice to the diversification of reactor types and siting contexts. As SMRs transition from concept to reality, interdisciplinary research combining law, engineering, economics, and public policy will be essential to ensure that innovation proceeds within a robust, adaptive, and publicly trusted legal framework.