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Regulating Small Modular Reactors in Uzbekistan: Early-Stage Implementation of IAEA Standards

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Abstract

This article analyses the early-stage implementation of International Atomic Energy Agency (IAEA) safety standards in Uzbekistan's nascent regulation of small modular reactors (SMRs). Using the planned Jizzakh SMR project as a case study, it employs doctrinal legal analysis and a structured gap-mapping of international and domestic instruments. The study finds rapid formal alignment with key IAEA conventions and safety standards, the establishment of a separate regulatory authority, and growing technical cooperation. However, detailed SMR-sensitive secondary regulations on licensing, defence-in-depth, emergency preparedness, public participation and nuclear liability remain incomplete, leaving significant reliance on vendor documentation and project-specific arrangements. The article argues for a sequenced reform strategy that consolidates regulatory independence, codifies graded, technology-neutral requirements and strengthens institutional capacity, and suggests lessons for other newcomer countries and for the further evolution of IAEA guidance on SMRs.

Keywords: Small Modular Reactors, Uzbekistan, IAEA Safety Standards, Nuclear Regulation, Energy Transition, Nuclear Liability, Emergency Preparedness

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I. Introduction

Over the last decade, small modular reactors (SMRs) have moved from a largely conceptual technology to a central element of many states' long-term decarburization strategies. Defined by the International Atomic Energy Agency (IAEA) as nuclear power reactors generally producing up to about 300 MWe per unit and designed for serial factory fabrication, SMRs promise enhanced flexibility reduced upfront capital costs and siting options that differ markedly from those of large conventional plants. Advocates emphasize that these features can facilitate the integration of nuclear power into smaller grids, remote regions and industrial applications, thereby widening access to low-carbon base load and dispatchable generation. At the same time, SMRs raise a series of novel regulatory and governance questions, especially concerning multi-module operation, the extensive use of passive safety systems and the possibility of cross-border deployment of standardized designs.

Uzbekistan exemplifies this challenge in an acute form, as it is simultaneously building its first nuclear power plant and exploring broader options for nuclear deployment as part of an ambitious energy transition agenda. Following the adoption in 2019 of the Law "On the Use of Atomic Energy for Peaceful Purposes" (Law No. ZRU-565), the government formally committed to developing a civilian nuclear sector to diversify away from natural gas and to meet rapidly growing electricity demand. In partnership with the Russian state corporation Rosatom, Uzbekistan has embarked on the construction of a small modular nuclear power plant in the Jizzakh region, based on six RITM-200N reactors of 55 MWe each and a total planned net capacity of about 330 MWe, representing the first export project for this SMR technology.

Construction works at the selected site commenced in 2025, with current plans envisaging the commissioning of the first unit in the late 2020s. In parallel, Uzbekistan and Rosatom have agreed to assess the feasibility of a larger-capacity plant using VVER-1000 reactors, indicating that SMRs will operate within a broader, multi-tiered nuclear program rather than as a stand-alone technology choice. The institutional landscape has also evolved rapidly, with the Agency for the Development of Nuclear Energy (UzAtom), the State Committee on Industrial Safety and, more recently, the Ministry of Energy assuming core responsibilities for nuclear policy, safety regulation and oversight of hazardous installations.

The IAEA has responded to the emergence of SMRs by clarifying the applicability of its existing safety standards and by issuing additional guidance on topics such as defence in depth, design safety and the licensing of innovative and multi-module reactors. Core documents include the IAEA Safety Standards Series, notably the General Safety Requirements on the governmental, legal and regulatory framework for safety (GSR Part 1) and the Specific Safety Requirements on the design and operation of nuclear power plants (SSR-2/1 and SSR-2/2). In 2023, the Safety Reports Series No. 123, Applicability of IAEA Safety Standards to Non-Water Cooled

Reactors and Small Modular Reactors, assessed how SMR-specific "areas of novelty" affect the completeness and application of existing standards and identified gaps requiring additional consideration. Complementing these, a Technology Roadmap for Small Modular Reactor Deployment (IAEA Nuclear Energy Series NR-T-1.18) and reports on the application of defence in depth to SMRs provide guidance on issues ranging from site selection and multi-unit layout to emergency preparedness, safeguards and long-term waste management in the SMR context.

Uzbekistan has already engaged with this framework through an Integrated Nuclear Infrastructure Review (INIR) mission in 2021 and a Site and External Events Design Review Service (SEED) mission in 2023, which assessed the maturity of its nuclear infrastructure and site evaluation processes and generated recommendations for further alignment with international safety standards. Officials have also agreed on priority areas for cooperation with the IAEA, including strengthening the national regulatory system, developing human resources and organising joint events on nuclear technologies, including SMRs. Yet, while these initiatives demonstrate a strong political and technical commitment to "building in" IAEA guidance from the outset, the specific question of how SMR-relevant standards will be translated into binding national rules, procedures and licensing criteria for the Jizzakh project remains open.

An expanding body of international literature has begun to examine the legal and regulatory implications of SMR deployment, often framing SMRs as a test case for the adaptability of existing nuclear safety regimes and for the harmonisation of licensing practices across jurisdictions. Recent analyses on deploying SMRs in newcomer countries discuss how the IAEA "milestones" approach, originally developed for large nuclear power plants, can be adapted to SMR-specific deployment pathways and infrastructure needs. IAEA publications, including the Technology Roadmap for Small Modular Reactor Deployment and the 2023 Safety Report on the applicability of safety standards to SMRs, describe generic roadmaps that stress the importance of applying established safety principles to innovative designs without creating parallel or fragmented regulatory systems. Policy studies from other regions, such as assessments of SMRs in national energy transitions, highlight issues of vendor–host state responsibility, allocation of regulatory functions between central and sub-national authorities, and the interface between nuclear safety rules and environmental and planning law.

Academic commentators have explored potential advantages of SMRs in terms of passive safety, smaller emergency planning zones and incremental grid integration, while also warning of new risk profiles linked to serial manufacturing, transport of fuelled modules and the clustering of units on compact sites. However, this literature has thus far concentrated mainly on technologically advanced nuclear states or on generic models of newcomer countries, and empirical case studies focusing on concrete national legal systems remain comparatively rare. For Central Asia in particular, most scholarly work on nuclear governance has focused on uranium

mining, nuclear-weapon-free-zone arrangements and legacy remediation, rather than on the design of domestic regulatory architectures for civilian power reactors and especially for SMRs.

Within Uzbekistan itself, policy documents, governmental statements and national reports prepared in cooperation with the IAEA outline broad commitments to align with IAEA safety standards, to establish effective regulatory oversight and to ensure transparency and public participation in nuclear decision-making. The 2019 Atomic Energy Law and subsequent by-laws on licensing and state supervision define general principles such as the priority of protecting life and health, environmental protection, security and the prohibition of nuclear weapons, and they assign competence to a set of newly created national institutions. Yet these instruments largely pre-date the concrete decision to adopt the RITM-200N SMR design for the Jizzakh project and do not spell out in detail how SMR-specific safety issues such as modular construction, transport and installation of large pre-assembled modules, or the management of integral reactor vessels should be addressed in regulations, guidance and licence conditions. Furthermore, while IAEA review missions have offered recommendations on general infrastructure development, there is limited publicly accessible analysis of how those recommendations intersect with the distinctive characteristics of SMR technology now being implemented.

Against this background, the aim of this article is to analyse the early-stage implementation of IAEA standards in the regulation of small modular reactors in Uzbekistan, using the Jizzakh SMR project as a focal case study. More specifically, the article pursues four interrelated objectives: first, to map the core IAEA safety standards and guidance documents that are most relevant to SMR deployment; second, to examine the current Uzbek legal and institutional framework for nuclear safety and its capacity to give effect to those standards; third, to identify gaps, overlaps and ambiguities that could impede effective regulation of the Jizzakh plant; and fourth, to propose a sequenced set of legal and regulatory measures to strengthen alignment with international best practice.

The central research question can be framed as follows: how, and to what extent, can Uzbekistan integrate IAEA SMR-related safety standards into its domestic regulatory regime during the initial phase of SMR deployment, while preserving the core principles of independence, transparency and responsibility that underpin international nuclear safety law? This overarching question gives rise to several subsidiary questions, including the degree to which existing general nuclear and administrative legislation can accommodate SMR-specific requirements, what new secondary regulations and technical codes may be needed, and how institutional roles between policymaking, regulation and operation should be delineated. The analysis will also explore how Uzbekistan might position itself in emerging international discussions on the harmonization of SMR licensing approaches, particularly with respect to the possible use of vendor states' design approvals and operating experience

as inputs into domestic decision-making.

The significance of this study is both national and international. For Uzbekistan, clarifying how IAEA standards will be operationalized in the context of SMRs is essential to ensuring a high level of nuclear safety, building public trust in a technology that is new to the country and underpinning the long-term sustainability of its energy transition strategy. Sound regulatory design at this formative stage can help avoid path-dependencies that might later constrain technological choices, complicate international cooperation or undermine compliance with global safety and non-proliferation obligations. For the wider community of newcomer countries and for international institutions such as the IAEA and the World Bank, Uzbekistan's experience offers a valuable test case of how SMR projects can be embedded in legal systems that are still in the process of developing comprehensive nuclear governance frameworks. Insights from this case can inform ongoing efforts to refine IAEA guidance for innovative reactors, to design financial and technical assistance instruments that take regulatory capacity into account, and to promote responsible nuclear expansion consistent with the objectives of the Convention on Nuclear Safety and the Sustainable Development Goals.

II. Methodology

This study adopts a qualitative, doctrinal and policy-oriented research design centered on a single-country case study of Uzbekistan's emerging small modular reactor program. It combines classic legal doctrinal analysis of international and domestic sources with elements of comparative public law and regulatory studies. Rather than testing hypotheses through statistical inference, the research aims to develop a structured, conceptually grounded account of how IAEA safety standards relevant to SMRs are reflected in, and operationalized by, Uzbekistan's evolving nuclear regulatory framework. The case-study focus on the Jizzakh SMR project is justified by its status as the first concrete SMR deployment in Uzbekistan and in Central Asia, and by its explicit positioning as a reference project for future nuclear development in the country. The study therefore proceeds on the assumption that the regulatory choices made for this project will have path-shaping implications that extend beyond the initial units to the wider architecture of nuclear governance.

In line with this design, the study follows an iterative, three-stage research process. In the first stage, the relevant body of international nuclear safety standards and guidance applicable to SMRs is identified and systematized, with particular attention to those instruments that articulate general regulatory principles and requirements for national legal frameworks. In the second stage, the national legal and institutional framework of Uzbekistan is reconstructed as it relates to nuclear energy in general and to the Jizzakh SMR project in particular, focusing on primary legislation, secondary regulations and official policy documents. In the third stage, the relationship between the international standards and the national framework is

analyzed through a structured comparison that seeks to identify convergence, divergence, silence and ambiguity. Throughout these stages, the study design remains flexible enough to incorporate new documents and interpretive materials as they become available, reflecting the dynamic nature of both IAEA standard-setting and Uzbekistan's nuclear law reform.

The empirical basis of the study consists entirely of documentary sources that are publicly available or officially published, ensuring transparency and verifiability of the analysis. At the international level, the corpus includes IAEA safety standards and guidance documents that define the governmental, legal and regulatory framework for safety, the design and operation of nuclear power plants, and the specific consideration of SMRs and innovative reactors. This corpus also encompasses multilateral treaties relevant to nuclear safety and responsibility, such as the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and selected soft-law instruments and reports produced by the IAEA and other international organizations. At the national level, the documentary base comprises the Law "On the Use of Atomic Energy for Peaceful Purposes," other primary legislation touching upon environmental protection, industrial safety and emergency management, presidential decrees, governmental resolutions and by-laws that shape the nuclear governance architecture.

The selection of documents is guided by substantive and temporal criteria designed to ensure that the material reflects both the most authoritative and the most recent developments relevant to the research questions. Substantively, the study includes only those international and national instruments that directly address nuclear safety, regulatory frameworks, or the deployment of SMRs, alongside closely related areas such as environmental impact assessment and land-use planning where they condition nuclear licensing. Documents of a purely promotional, commercial or political nature are excluded unless they contain legally relevant commitments or institutional mandates. Temporally, the analysis focuses on instruments in force or officially proposed as of the time of writing, while also considering earlier texts where they illuminate the development of regulatory approaches or remain formally applicable. Within the academic and policy literature, preference is given to works published in reputable journals, books from established academic presses and reports issued by recognized international organizations or research institutes.

The core analytical technique employed in the study is doctrinal legal analysis, understood as the systematic interpretation and ordering of legal norms and principles. At the international level, this involves examining the text, structure, purpose and context of relevant IAEA safety standards and related instruments in order to distil the regulatory expectations placed upon national authorities in the governance of SMRs. At the national level, doctrinal analysis is used to clarify the legal status, hierarchical relationships and internal coherence of Uzbek laws and regulations that bear on nuclear safety and the Jizzakh SMR project. Particular attention is devoted to the

allocation of competences among state bodies, the formulation of licensing criteria and procedures, and the mechanisms for oversight, enforcement and public participation.

Building on this doctrinal foundation, the study employs a structured comparative and "gap analysis" framework to assess the degree of alignment between IAEA standards and Uzbek regulation. For this purpose, a matrix is constructed in which core requirements and recommendations derived from the international standards are grouped into thematic clusters, such as regulatory independence, licensing basis, defense-in-depth, emergency preparedness and stakeholder engagement. Corresponding provisions in Uzbek legislation and regulations are then mapped against these clusters, and their content is qualitatively coded according to whether they provide full, partial or no implementation of the relevant international expectations. The coding is carried out manually, based on close reading of the texts, in order to ensure that contextual nuances and cross-references are adequately captured. Where the mapping reveals divergences or silences, these are further analyzed in terms of their practical significance for the regulation of the Jizzakh SMR project, drawing on policy documents and secondary literature to infer likely implications.

Although the research is primarily qualitative and legal-doctrinal, it does make limited use of quantitative and descriptive information, particularly in relation to Uzbekistan's energy mix, projected electricity demand and the planned technical characteristics of the Jizzakh SMR plant. Such information is drawn exclusively from official statistical publications, governmental energy strategies and technical documentation released by project partners and international organizations. The role of these data in the study is contextual rather than inferential: they are used to motivate the policy relevance of the regulatory analysis and to illustrate the practical environment in which legal rules will operate. No original quantitative data are collected and no statistical tests or econometric models are employed, which is consistent with the primarily normative character of the research questions. Any numerical figures cited in subsequent sections are treated cautiously, with explicit indication of their provenance and, where appropriate, of uncertainties or ranges. This approach ensures transparency regarding the modest and illustrative role of quantitative information within an otherwise doctrinal and institutional analysis.

The study is subject to several methodological limitations that are acknowledged at the outset. First, reliance on publicly available documents means that internal administrative practice, informal coordination between institutions and unpublished draft regulations may not be fully captured, even though they can significantly influence regulatory outcomes in practice. Second, the rapidly evolving nature of both IAEA guidance on SMRs and Uzbekistan's nuclear legislation implies that some developments may occur after the cut-off date for document collection, potentially affecting the currency of specific findings. Third, while the comparative component of the study draws selectively on experiences of other states that are

developing SMR projects, it does not attempt a full comparative survey, which would require a separate research design. These limitations are mitigated, insofar as possible, by careful cross-checking of sources, by indicating where the analysis is necessarily provisional and by focusing recommendations on structural features that are likely to remain relevant across future legal updates. From an ethical perspective, the research involves no human participants and no confidential data, relies solely on publicly accessible materials and respects standard academic norms of accuracy, transparency and proper attribution, so that formal approval by an ethics committee is not required under commonly accepted criteria for desk-based legal research.

III. Results

The mapping of Uzbekistan's nuclear infrastructure against the IAEA "milestones" framework shows substantial progress in establishing the core elements of a national program, alongside persistent gaps in several SMR-relevant areas. Presidential Decree No. PP-4165 approving the Concept for the Development of Nuclear Power for 2019–2029, together with Law No. ZRU-565 "On the Use of Atomic Energy for Peaceful Purposes," provides a coherent policy mandate and primary legal basis that broadly corresponds to Phase 2 expectations under the IAEA Milestones approach. The 2021 Integrated Nuclear Infrastructure Review (INIR) mission confirmed that Uzbekistan had made "significant progress" in developing its nuclear infrastructure and in preparing for construction of its first power plant, while simultaneously identifying outstanding tasks in the legal and regulatory framework, human resources and stakeholder engagement.

Subsequent developments, including the launch of construction activities for the Jizzakh SMR plant in April 2025 and the definition of a detailed siting plan for six RITM-200N units with a total capacity of 330 MW, indicate that the country has effectively moved into the implementation phase of its nuclear program. However, the analysis reveals that while program-level planning documents frequently refer to IAEA safety principles and standards, there is still no consolidated secondary legislation that translates these principles into detailed, binding requirements specifically tailored to SMRs. The overall picture is therefore one of formal convergence with IAEA guidance at the level of strategy and primary law, combined with an incomplete and uneven transposition of that guidance into the regulatory instruments that will govern the Jizzakh project in practice.

INIR-related documentation and subsequent government statements show that Uzbekistan has responded to several of the IAEA's key recommendations, particularly those concerning accession to international conventions and the establishment of an independent regulatory body. The INIR team in 2021 recommended that Uzbekistan accede to a set of core safety and liability instruments, including the Convention on Nuclear Safety, the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological

Emergency and the Vienna Convention on Civil Liability for Nuclear Damage, as part of consolidating a "consistent and complete" national legal framework. By mid-2025, Uzbekistan had acceded to the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and had deposited instruments of accession to the Early Notification and Assistance Conventions, thereby aligning its international commitments with the IAEA's recommendations. In September and November 2025, the country adopted and implemented a law on accession to the Vienna Convention on Civil Liability for Nuclear Damage, formally joining the global nuclear liability regime. These developments close an important portion of the gap identified in 2021, and they provide an explicit international legal frame within which national SMR regulation must now operate.

The results of the institutional mapping show a clear evolution towards a more distinct separation between promotional and regulatory functions, consistent with the expectations of IAEA GSR Part 1 regarding the independence of the regulatory body. Initially, the State Committee for Industrial Safety (later the State Committee for Industrial, Radiation and Nuclear Safety) combined regulatory supervision of hazardous industrial activities with the nascent role of nuclear safety regulator, while the Agency for the Development of Nuclear Energy (UzAtom), created in 2018 and subsequently integrated into the Ministry of Energy, was tasked with leading nuclear program development and policy. Following INIR recommendations to strengthen and adequately resource the regulatory authority, Uzbekistan in 2024 and 2025 redefined the status and functions of UzAtom and the Committee for Industrial, Radiation and Nuclear Safety through presidential and governmental acts. The Committee is now recognized as an authorized governmental body reporting directly to the Cabinet of Ministers and mandated to implement unified state policy in industrial, radiation and nuclear safety, with its decisions binding on ministries, agencies and enterprises. In parallel, UzAtom has been repositioned as a policy, coordination and project implementation agency, responsible for developing nuclear energy and preparing proposals on legislation, but no longer combining regulatory and promotional roles.

From the perspective of IAEA standards, this restructuring represents a significant move towards formal compliance with the requirement that the regulatory body be functionally separated from any organization promoting or operating nuclear facilities. However, the analysis of normative acts and official descriptions of institutional mandates suggests that the division of roles is not yet fully reflected in secondary regulation and practice. Certain acts continue to assign UzAtom responsibilities related to the development of "norms and rules" in the field of atomic energy use, blurring the line between policy formulation and standard-setting and raising questions about the locus of technical regulatory authority. Moreover, the INIR mission and subsequent public statements emphasized that the regulatory authority still requires strengthened human and financial resources, as well as enhanced technical support capacity, to perform its expanded remit effectively, particularly in

areas such as safety assessment of innovative reactor designs and oversight of complex construction projects. The establishment in 2025 of a Scientific and Technical Centre for Radiation and Nuclear Safety under the Committee is a step towards addressing this need, but its detailed mandate and operational capacity remain to be fully defined in regulation.

The examination of Uzbekistan's legal and regulatory instruments reveals a layered but incomplete licensing basis for the Jizzakh SMR plant. At the top level, Law No. ZRU-565 sets out general principles for the peaceful use of atomic energy, including the priority of safety, the need for licensing, state regulation and supervision, and the responsibility of operators for nuclear safety and security. This law is complemented by the Concept for the Development of Nuclear Power for 2019–2029 and a series of presidential decrees and governmental resolutions that approve the nuclear power development roadmap and authorize the construction of nuclear facilities, including the SMR plant in Jizzakh region. However, the analysis of available by-laws shows that detailed regulations specifying licensing stages, documentation requirements, safety assessment criteria and decision-making procedures for nuclear power plants are still under development or not publicly accessible. Where such detail exists, it often takes the form of general provisions on hazardous industrial facilities and radiation sources rather than nuclear-power-specific rules, and it does not explicitly address the distinctive features of SMRs.

In terms of the graded approach advocated by the IAEA, the current framework displays both strengths and weaknesses. On the one hand, the distribution of competences between the Committee, UzAtom, environmental and emergency authorities provides a basis for differentiated regulatory scrutiny across the nuclear facility lifecycle. On the other hand, the absence of published regulations that explicitly operationalize a graded approach for different reactor types and configurations means that the criteria for adjusting regulatory requirements to the specific risk profile of SMRs remain implicit. The analysis also finds that, as of late 2025, the public legal record does not include a comprehensive set of safety regulations or guides that transpose core IAEA requirements such as those in SSR-2/1 and SSR-2/2 into national rules for reactor design, construction, commissioning and operation. Instead, references to IAEA standards appear primarily in high-level strategic documents and in the terms of reference for cooperation with the IAEA, suggesting a reliance on direct application or incorporation by reference at the project level rather than on domesticated technical regulations.

The main findings of this mapping exercise are summarized in Table 1. While such a table inevitably simplifies complex legal relationships, it illustrates at a glance the unevenness of implementation across key thematic clusters.

Table:1 Indicative alignment between selected IAEA regulatory framework expectations and Uzbek legal instruments

Thematic cluster	IAEA expectation (simplified)	Uzbek framework status (late 2025)
Legal and regulatory framework	Comprehensive nuclear law and subordinate regulations; clear hierarchy and scope	Primary law and policy concept in place; several by-laws adopted; detailed SMR-specific regulations under development or not public
Regulatory independence	Functionally and effectively independent regulatory body, separate from promoter and operator	Committee for Industrial, Radiation and Nuclear Safety established as authorized regulator; UzAtom retains some normative roles; resourcing and technical support still developing
Licensing process and decision criteria	Transparent, staged licensing; explicit safety objectives and decision criteria	Licensing obligation established in law; general procedures derived from industrial safety regime; specific nuclear power licensing stages and criteria not fully codified or publicly available
Graded approach and defense in depth	Requirements calibrated to risk; explicit multi-level defense in depth in regulations	Safety principles referenced in law and policy; graded approach and defence in depth largely implicit and primarily referenced through IAEA standards rather than detailed domestic rules
Emergency preparedness and response	Integrated on-site and off-site EPR regime; clear roles and interfaces	General civil protection and emergency laws in force; nuclear-specific EPR arrangements emerging; SMR-specific planning assumptions not yet codified
Public participation and transparency	Public access to information and effective participation in licensing decisions	Environmental and planning laws provide for EIA and public hearings; specific arrangements for SMR plant evolving and not yet fully standardized
Nuclear liability and insurance	National regime consistent with international conventions on civil liability	Accession to Vienna Convention completed in 2025; domestic implementing measures and insurance arrangements at an early stage of development

The analysis of safety assessment and defense-in-depth arrangements indicates

that Uzbekistan has embraced the conceptual framework of IAEA safety standards but has not yet translated all elements into detailed domestic requirements for SMRs. Official presentations on the status of the nuclear program emphasize the intention to apply IAEA standards "in full" and to ensure that design and siting decisions for the Jizzakh plant are consistent with international best practice, including the use of passive safety systems and multiple physical barriers. Nevertheless, there is little publicly available evidence of national regulations that operationalize these commitments by specifying, for example, the structure and content of safety analysis reports, probabilistic safety assessment requirements, or explicit defense-in-depth criteria tailored to SMR designs. Instead, the available documentation suggests that safety assessment processes will rely heavily on vendor documentation derived from Russian regulatory practice for the RITM-200N reactors, supplemented by case-by-case application of IAEA standards under the supervision of the Committee. While such an approach may be practical in the early stages of a first-of-a-kind project, it carries the risk of creating a fragmented regulatory basis that is difficult to generalize to future plants or alternative SMR designs.

Emergency preparedness and response (EPR) arrangements for the Jizzakh site are shaped by Uzbekistan's general civil protection framework and by the country's recent accession to the IAEA conventions on early notification and assistance. National energy and security policy documents acknowledge the country's seismicity and the need to integrate nuclear emergency planning into the broader disaster-risk management system, including arrangements for earthquakes and floods. However, the review of available legislation and policy statements reveals that nuclear-specific EPR rules, such as requirements on emergency planning zones, criteria for sheltering and evacuation, and arrangements for cross-border notification and assistance, are still in the process of being elaborated in cooperation with the IAEA. The absence of published regulations clarifying how SMR-specific characteristics such as lower source term, smaller core inventory and potentially reduced off-site emergency planning zones will be taken into account in emergency planning underscores the preliminary nature of current arrangements. At the same time, the 2025 Integrated Work Plan between Uzbekistan and the IAEA, which identifies safety issues, environmental considerations and public hearings as priority areas, indicates that EPR will be a central focus of upcoming review missions and capacity-building efforts.

A central finding of the study is that the distinct technological and operational features of SMRs are only partially reflected in current Uzbek regulation and policy documents. The Jizzakh plant is explicitly described in official sources as a "small nuclear power plant" based on six land-based RITM-200N units adapted from marine icebreaker reactors, each with a net electrical capacity of 55 MW and an expected design life of 60 years. Public statements highlight advantages commonly associated with SMRs, including compactness, modular construction, enhanced safety and flexibility for grid integration. However, neither Law No. ZRU-565 nor accessible secondary regulations contain specific provisions addressing multi-module operation,

factory fabrication and transport of large pre-assembled modules, or the potential for serial deployment of standardized units at multiple sites. Instead, the legal framework treats the SMR plant in broadly the same terms as any nuclear power plant, without distinguishing between different reactor types or sizes.

The site approval process for the Jizzakh plant provides a partial illustration of how SMR-specific considerations might be incorporated into national decision-making, albeit in a largely ad hoc manner. In May 2025, the government approved a siting plan for the SMR plant near Lake Tuzkan in Jizzakh region, specifying the planned capacity and number of units and indicating that Rosatom would act as general contractor with significant participation of Uzbek companies. Public information emphasizes factors such as seismic safety, water availability and proximity to industrial consumers, but there is limited detail on how siting criteria drawn from IAEA standards particularly those related to multi-unit sites and SMRs have been translated into quantitative or qualitative requirements in domestic law. For example, no national regulation has yet been identified that defines specific siting requirements for SMR clusters, such as minimum distances between modules, shared or independent safety systems, or combined radiological impact assessment for all units on the site. The absence of such detail does not imply that these issues are being ignored in practice, since they may be addressed through project-level documentation and direct application of IAEA standards, but it does point to a gap in the codified regulatory framework that could complicate future projects involving different SMR technologies or alternative vendors.

The results also highlight a mixed picture in terms of public participation and transparency in SMR decision-making. Uzbekistan's general environmental legislation and procedures for environmental impact assessment (EIA) provide for public disclosure of information and public hearings for major industrial projects and these mechanisms are being used, to some extent, in the nuclear context. The 2025 consultations between Uzbekistan and the IAEA on the Integrated Work Plan specifically emphasized the organization of public hearings and stakeholder engagement as priorities in the development of nuclear infrastructure. Nevertheless, the analysis reveals that there is no SMR-specific or nuclear-specific act that systematically integrates public participation requirements into the licensing process, or are there published guidelines on how technical safety information should be presented to the public or how comments should be taken into account in regulatory decisions.

The final set of results concerns the capacity of Uzbek institutions to implement the regulatory framework for SMRs in practice. Official documents and press releases highlight extensive cooperation with the IAEA, including participation in training, workshops and review missions, as well as bilateral cooperation with experienced nuclear countries and with Rosatom as vendor and general contractor. The INIR mission in 2021 and its follow-up communications stressed the importance of

providing adequate human and financial resources to the regulatory body and of developing a long-term human resource development strategy for the nuclear sector. In response, Uzbekistan has adopted strategies for nuclear education and training and has expanded programs at universities and research institutes to train specialists in nuclear engineering, radiation safety and related fields. The creation of the Scientific and Technical Centre for Radiation and Nuclear Safety under the Committee, together with plans to engage technical support organizations, suggests an awareness of the need for independent expertise to support regulatory decision-making on SMRs.

Despite these advances, the analysis underscores that the scale and novelty of the SMR project pose significant challenges for a regulatory system that is still accumulating experience with nuclear power plants. The reliance on vendor documentation and external expertise is understandable at this stage but may limit the regulator's ability to act as a fully "knowledgeable customer" in line with IAEA expectations, particularly in areas where SMR-specific issues diverge from conventional reactor practice. The scheduled INIR follow-up mission and the Integrated Work Plan for 2025–2027, which explicitly identifies SMRs as a topic for cooperation, indicate that both Uzbekistan and the IAEA recognize this challenge and are seeking to address it systematically. Nevertheless, from a regulatory perspective, the current situation can be characterized as one in which the basic institutional and legal scaffolding for SMR regulation is in place, but the depth of technical capacity and the completeness of implementing regulations will need to increase substantially over the coming years to ensure effective, independent oversight of the Jizzakh plant and any subsequent SMR projects.

Taken together, the results show that Uzbekistan's early-stage implementation of IAEA standards in the regulation of SMRs is characterized by strong political commitment, rapid progress in international legal alignment and significant institutional reforms, but also by incomplete domestic codification and constrained implementation capacity. The decision to deploy RITM-200N SMRs as the country's first commercial nuclear units has catalyzed the creation of an independent regulatory body, accession to core international safety and liability conventions, and the initiation of extensive cooperation with the IAEA and vendor states. At the same time, the absence of comprehensive, publicly available secondary regulations that translate IAEA safety standards into detailed, SMR-specific domestic requirements leaves important aspects of reactor design, safety assessment, emergency preparedness, public participation and liability to be addressed through project-level arrangements and future legal acts. The findings therefore point to a transitional regulatory landscape in which SMR deployment is moving faster than the consolidation of the underlying normative framework, creating both risks and opportunities for legal and institutional innovation.

IV. Discussion

The results of this study show that Uzbekistan's trajectory broadly reflects the international narrative that frames SMRs as both an opportunity and a stress-test for existing nuclear safety regimes. International analyses emphasize that SMRs promise modular construction, passive safety and flexible deployment, yet simultaneously introduce "areas of novelty" that challenge the direct application of standards designed for large light-water reactors. The IAEA's Safety Reports Series No. 123 explicitly identifies issues such as multi-module configurations, factory fabrication and new operational concepts as requiring particular regulatory attention, without suggesting that entirely new safety principles are needed.

Uzbekistan's decision to base its first nuclear power plant on six RITM-200N units at a single site in Jizzakh places it squarely within the category of innovative multi-module projects that the report has in mind. At the same time, the updated IAEA Milestones Approach now explicitly integrates SMR considerations into its phased guidance for newcomer countries, confirming that SMRs are no longer peripheral to the mainstream of nuclear infrastructure planning. Against this backdrop, Uzbekistan's early adoption of an SMR as its first power reactor transforms the country into a particularly illustrative case of how the revised Milestones guidance may be applied in practice. Rather than treating SMRs as a niche technology, the Uzbek program suggests that, for some newcomers, SMRs may constitute the default pathway to nuclear power, with significant implications for how international standards are interpreted and implemented.

A striking feature of the findings is the contrast between Uzbekistan's rapid formal convergence with IAEA safety instruments and the more tentative development of detailed, SMR-sensitive domestic regulations. On the one hand, the country has moved swiftly to host an INIR mission, receive recommendations and accede to a core set of nuclear safety and liability conventions, including the Convention on Nuclear Safety and, in 2025, the Vienna Convention on Civil Liability for Nuclear Damage. These steps align closely with IAEA expectations that newcomer states should build a robust international legal foundation for their nuclear programs before or alongside major investment decisions. On the other hand, the analysis reveals that many of the operational aspects of IAEA safety requirements such as detailed licensing criteria, defense-in-depth implementation rules and SMR-specific emergency preparedness assumptions have not yet been codified in publicly available Uzbek regulations. This pattern mirrors concerns in the broader literature that the mere invocation of IAEA standards does not guarantee their effective domestic application, especially where legal systems are still adapting to the complexity of nuclear governance.

The institutional reforms undertaken in Uzbekistan can be read as an attempt to replicate the international best practice of a clear separation between promoter and regulator, yet the study indicates that this separation remains a work in progress. The creation and subsequent empowerment of the Committee for Industrial, Radiation and Nuclear Safety as an independent regulator reporting to the Cabinet of Ministers is in

line with the emphasis on regulatory independence found in IAEA GSR Part 1 and echoed in comparative analyses of SMR regulation. At the same time, some residual overlap of normative functions between the Committee and UzAtom, combined with capacity constraints at the regulatory authority, corresponds to the "capability gaps" and resource pressures identified in comparative reviews as common challenges for SMR licensing. Studies of SMR oversight in established nuclear states, such as Canada, Finland and the United Kingdom, underline the need for regulators to develop SMR-specific expertise and to engage in international collaboration to avoid being overwhelmed by novel design features and multi-module configurations. Uzbekistan's heavy reliance on vendor documentation and external technical support at this early stage is consistent with its newcomer status but underscores the importance of building a "knowledgeable customer" capability within the regulator over time.

The results also highlight a tension between the need for a predictable, codified licensing architecture and the flexibility often associated with SMR deployment. International literature stresses that SMR projects should be regulated on the basis of the same safety objectives as large reactors but with a graded approach that calibrates requirements to the actual risks and design characteristics. In practice, however, many jurisdictions have struggled to embed this graded approach in clear, technology-neutral regulations, leading to concerns about case-by-case licensing that may undermine transparency and investor confidence. The Uzbek framework, as reconstructed in this study, exemplifies this predicament: while primary law and policy concepts provide generic safety principles and mandate licensing, detailed by-laws translating those principles into SMR-sensitive rules for design assessment, multi-module site evaluation and staged authorizations remain incomplete. This places Uzbekistan closer to the situation of several other newcomer countries that are considering SMRs but have not yet fully adapted their licensing processes to multi-unit deployments and serial factory fabrication. The risk is that, absent timely secondary regulation, the Jizzakh project will proceed under a patchwork of general industrial safety rules, ad hoc references to IAEA standards and vendor-country practices, which may prove difficult to generalize to future projects or alternative SMR designs.

Emergency preparedness and public participation emerge from the results as areas where Uzbekistan's early-stage arrangements resonate with international guidance but require further refinement to address SMR-specific features and public trust concerns. Global analyses of SMR deployment note that smaller source terms and engineered safety features may justify reduced off-site emergency planning zones in some designs, but caution that any such adjustments must be grounded in rigorous, transparent safety analysis. In Uzbekistan, the integration of nuclear emergency planning into the broader disaster-risk management system is a logical choice in a seismically active country, yet the lack of published rules on SMR-specific emergency planning parameters leaves open how these design-dependent considerations will be reflected in zoning decisions, protective actions and international notification

arrangements. The same holds for public participation: general environmental impact assessment procedures and occasional public hearings conform to the letter of international expectations but do not yet constitute a dedicated nuclear or SMR participation regime. Comparative studies emphasize that early, structured public engagement and accessible safety information are critical for the social acceptance of SMRs, particularly in countries without prior experience of nuclear power.

The study's findings on Uzbekistan's extensive cooperation with the IAEA and vendor states raise broader questions about the balance between international harmonization and national regulatory autonomy in SMR governance. Initiatives such as the IAEA SMR Regulators' Forum, the updated Milestones guidance and emerging partnerships with multilateral development banks signal a growing push towards shared approaches and "common positions" on SMR safety and licensing. In parallel, organizations such as the OECD Nuclear Energy Agency and industry bodies have called for greater convergence of licensing processes to facilitate the deployment of standardized SMR designs across multiple jurisdictions. For a newcomer country like Uzbekistan, this environment offers clear benefits, including access to expertise, reference design assessments and potential financing, but it also creates subtle pressures to align domestic regulatory decisions with external expectations. The heavy use of vendor documentation and foreign regulatory precedents in the early stages of the Jizzakh project is understandable, yet it underscores the importance of maintaining a clear national regulatory judgment that is grounded in Uzbekistan's own legal order and accountability structures.

Beyond its national significance, the Uzbek case carries implications for how the IAEA and other actors further develop SMR-related guidance for newcomer countries. The observed pattern rapid formal alignment with international conventions and high-level standards, coupled with slower development of detailed implementing regulations and regulatory capacity may be typical of states that seek to accelerate SMR deployment under energy security and decarburization pressures. If so, the IAEA's future assistance and publications might need to place greater emphasis on model legal provisions, templates for SMR-sensitive licensing regulations and practical guidance on integrating multi-module, factory-fabricated designs into national law. Safety Reports Series No. 123 and the Technology Roadmap for SMR Deployment already move in this direction by identifying specific "areas of novelty" and offering generic roadmaps, but they stop short of prescribing how particular legal systems should codify these insights. Uzbekistan's experience suggests that there is demand for more granular, context-sensitive support that bridges the gap between abstract safety principles and the concrete drafting of decrees, regulations and regulatory guides in newcomer states.

Finally, from a policy-oriented perspective, the discussion of results points to the desirability of a sequenced reform strategy that aligns the pace of SMR deployment with the maturation of Uzbekistan's regulatory framework. In the short

term, priority could be given to clarifying the division of responsibilities between UzAtom and the Committee, adopting SMR-sensitive regulations on licensing stages and safety assessment, and codifying emergency preparedness and public participation arrangements for the Jizzakh site. In the medium term, attention should shift to strengthening the regulator's technical capacity, including through participation in international peer networks, development of independent technical support organizations and systematic training on SMR-specific issues such as multi-module operation and modular construction oversight. Over the longer term, Uzbekistan may consider using the experience gained from the Jizzakh project to develop a more technology-neutral set of nuclear safety regulations, underpinned by the graded approach and defense in depth that can accommodate future SMR designs or large reactors without the need for ad hoc adjustments. These steps would not only enhance domestic safety and accountability but also position Uzbekistan as a reference case for other newcomer countries facing similar challenges in implementing IAEA standards in the context of SMRs.

Conclusion

This article has examined the early-stage implementation of IAEA safety standards in the regulation of small modular reactors in Uzbekistan, using the planned Jizzakh SMR project as a focal case study. Drawing on doctrinal analysis of international and national legal instruments, complemented by a structured gap analysis and selective comparative insights, the study has traced how core IAEA expectations are being translated into Uzbekistan's nascent nuclear regulatory framework. The findings demonstrate a significant degree of formal alignment with international norms, evident in the adoption of a comprehensive atomic energy law, the establishment of a separate regulatory authority and the recent accession to key nuclear safety and liability conventions. At the same time, the analysis reveals that detailed secondary regulations and technical requirements specifically tailored to SMR deployment remain incomplete, with many operational aspects of IAEA standards still implemented through project-level arrangements and reference to vendor-country practice. The current regulatory landscape can therefore be characterized as transitional, in which a robust strategic and primary-law framework coexists with a relatively thin layer of SMR-sensitive implementing rules.

The results have important implications for the future evolution of Uzbekistan's nuclear governance as well as for other newcomer countries considering SMRs. In institutional terms, the separation between promotional and regulatory functions, together with the creation of supporting scientific and technical capacity, emerges as a precondition for the credible and independent oversight of innovative reactor designs. In regulatory terms, the analysis underscores the need to move beyond generic references to IAEA standards and to codify clear, graded and technology-neutral licensing procedures that explicitly accommodate multi-module sites, modular construction and SMR-specific safety features. In societal terms, the discussion

highlights that emergency preparedness, public participation and transparency cannot be treated as peripheral add-ons, but must be integrated into the core of SMR decision-making if public trust is to be built and maintained in a newcomer context. Taken together, these implications suggest that Uzbekistan's experience should be understood not only as a national reform agenda but as an emerging reference model that may inform the design of SMR regulatory frameworks across Central Asia and other regions with similar institutional starting points.

The study also points towards several avenues for future research that could deepen and broaden the analysis presented here. First, more fine-grained comparative work is needed to examine how different newcomer states are adapting their legal systems to SMR deployment, including detailed case studies of licensing processes, regulatory cooperation mechanisms and the use of foreign design approvals. Second, empirical socio-legal research on public perceptions, stakeholder engagement practices and the communication of SMR risks and benefits in Uzbekistan would complement the doctrinal focus of this article and shed light on the social foundations of regulatory legitimacy. Third, further inquiry into the interaction between nuclear safety regulation, nuclear liability regimes and the financial structuring of SMR projects could illuminate the ways in which legal choices influence investment decisions and risk allocation. Fourth, as the IAEA continues to refine its SMR-related safety reports, roadmaps and review services, longitudinal studies tracking the mutual influence between international standard-setting and national implementation in countries like Uzbekistan would help clarify the dynamics of norm diffusion in this field.

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