**THE ROLE OF REGULATORY OVERSIGHT IN THE EMERGING ERA OF SMALL MODULAR REACTORS**

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**Abstract**

Small Modular Reactors (SMRs) herald a transformative era in nuclear technology, characterized by enhanced safety, cost efficiency, and adaptability. These reactors, which the International Atomic Energy Agency (IAEA) recognizes in over 80 designs and concepts worldwide, stand at various stages of development [1]. Some are nearing deployment readiness, positioning themselves as viable, low-carbon alternatives within future integrated energy systems. Particularly for middle-income countries like Kenya, which aims to scale its power capacity incrementally, SMRs offer a strategic fit due to their modular nature.

This paper examines the regulatory landscape as framed by the Nuclear Regulatory Act, Cap 243 of the Laws of Kenya [2], focusing on the safe and secure adoption of SMRs. By navigating through the unique regulatory challenges these innovative nuclear technologies introduce, the paper identifies and elaborates on the significant opportunities for regulatory adaptation and innovation. Through this exploration, it aims to provide insights into how tailored regulatory frameworks can not only accommodate but also advance the deployment of SMRs, ensuring their role as a cornerstone of sustainable energy strategies in emerging economies.

1. **INTRODUCTION**

The Nuclear Energy Agency defines an SMR as “Nuclear reactors with a power output between 10 megawatts electric (MWe) and 300 MWe. They integrate by design higher modularization, standardization and factory-based construction in order to maximize economies of series. The different modules can then be transported and assembled on site, leading to predictability and savings in construction times” [3].

1. **WHY ARE SMRS LIKELY TO BE WIDELY ADOPTED?**

Small Modular Reactors (SMRs) are likely to be widely adopted due to their compact size, scalability, and flexibility. They generate electricity for remote industrial operations, such as mining and oil extraction, reducing reliance on diesel generators and supporting eco-friendly practices. Certain SMR designs also provide high-temperature outputs for industrial heat applications, including desalination and chemical processing. SMRs offer significant safety advantages with reduced emergency planning zones and inherent safety features, minimizing the risk of accidents and radiological releases [4]. This allows SMRs to be sited closer to urban areas or in regions where larger EPZs are impractical, broadening their applicability and easing public safety concerns.

1. **CURRENT REGULATORY LANDSCAPE**

A critical aspect of SMR deployment is the development and implementation of a structured regulatory oversight program. This is essential not only for ensuring the safe and secure operation of SMRs but also for bolstering confidence in this emerging technology. However, even if the Nuclear Regulatory Act, Cap 243 of the Laws (NRA, Cap 243) is relatively new, having being enacted in 2019, the it seems the regulatory frameworks was largely designed with large-scale reactors in mind, focusing extensively on site-specific construction and operational safety. The introduction of SMRs challenges this framework, as they encompass new technologies, deployment strategies, and operational models.

The NRA, Cap 243 of the Laws of Kenya define nuclear facility" as any civilian facility where nuclear material is produced, processed, used, handled or disposed of, including a nuclear installation, premises, nuclear power plant, research reactor, fuel fabrication plant, spent fuel storage facility, enrichment plant, reprocessing facility or any other facility determined by the Authority. An interpretation of this definition will imply that SMRs are provided for under the Act.

1. **GRADED APPROACH**

Graded approach is defined by the IAEA Safety Glossary [5] as a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control. The use of a graded approach is intended to ensure that the necessary levels of analysis, documentation and actions are commensurate with the magnitudes of any radiological hazards and non-radiological hazards, the nature and the particular characteristics of a facility, and the stage in the lifetime of a facility.

However, the understanding and application of a graded approach process could differ across Member States and may result in varied recommendations or suggestions in most peer reviews. In addition, Member States have also stated that they are still experiencing difficulties in applying graded approach in a systematic and documented way, within their organizations. Apparently, the concept of graded approach is not one of the concepts explicitly provided for under the Act, but one may argue that the concept is implicitly provided for.

Some of the key issues which may be encountered include: Licensing Processes: Traditional reactors undergo a lengthy and complex licensing process. The standardization and smaller scale of SMRs necessitate a more streamlined approach to avoid prohibitive costs and delays. Safety Standards: While SMRs are designed to be safer than traditional reactors, regulatory bodies must adapt safety standards to account for new reactor technologies and the potential for closer proximity to urban areas.

Moreover, the introduction of SMRs presents other unique challenges. These include their novelty and the significantly shorter construction time as compared to the longer periods required for traditional nuclear power plants. From available data It is clear that the technologies close to near-term deployment are primarily water-cooled designs. Therefore, more regulatory investments may need to be channeled to these technologies.

Regulatory bodies often lag behind industry innovations, particularly in sectors where technology evolves faster than the legal and ethical frameworks can adapt. A notable example of this phenomenon is Uber, the ride-sharing service that dramatically transformed the transportation industry. When Uber first launched, there was no existing regulatory framework specifically addressing ride-sharing. This oversight allowed Uber to operate in a legal gray area, rapidly expanding into new markets before local governments could establish appropriate regulations. This lag in regulation led to various challenges, including disputes over licensing, the status of Uber drivers (independent contractors versus employees), and concerns over passenger safety and data privacy. The initial regulatory vacuum highlighted the struggle of traditional regulatory approaches to keep pace with novel business models and technologies that disrupt established industries and practices.

The nuclear regulatory sector can glean valuable insights from established sectors like aviation, particularly in standardization practices. In aviation, a Boeing, Airbus, or any other aircraft can land at virtually any airport in the world because international standards govern everything from aircraft design to pilot training and airport operations. This universal standardization ensures a high level of safety and operational efficiency that can be consistently maintained across global borders. Similarly, the nuclear industry could benefit from adopting a more unified approach to regulatory standards. By harmonizing safety, construction, and operational guidelines for technologies such as SMRs, the nuclear sector could facilitate smoother international collaboration, enhance safety outcomes, and streamline the deployment of nuclear facilities worldwide. Such an approach would not only simplify the regulatory process but also bolster public trust and international cooperation in nuclear energy development.

Furthermore, the introduction of SMRs raises the critical question at the outset of any nuclear power program: What will be done with the nuclear waste? Each new technology introduces potential for different waste streams, complicating the waste management landscape. Additionally, the challenge extends to harmonizing and standardizing regulatory frameworks to accommodate these innovations.

1. **OPPORTUNITIES IN DEPLOYING SMRS**

The deployment of Small Modular Reactors (SMRs) offers numerous opportunities for regulatory innovation that can significantly enhance both national and international nuclear energy landscapes. These innovations include:

**6.1 Harmonized International Standards:** Establishing a global consensus on SMR standards can streamline the international deployment and foster cooperation across borders. This approach mirrors the successful standardization seen in aviation safety. By aligning with international standards, Kenya can reduce the complexity and cost of developing its own regulatory framework from the ground up. Leveraging globally recognized guidelines for SMRs would streamline the adoption of this technology, allowing Kenya to bypass some of the hurdles that come with creating a wholly new set of regulations. Furthermore, harmonization enables smoother cooperation with other countries on SMR projects, as consistent standards foster collaboration and knowledge-sharing across borders. This alignment with international best practices could also attract foreign investment, as investors would be more comfortable operating within familiar regulatory environments, thus accelerating the country's nuclear energy goals.

**6.2 Risk-Informed Regulation:** Risk-informed regulation can significantly assist Kenya in regulating Small Modular Reactors (SMRs) by optimizing the licensing process and making it more efficient and adaptive. SMRs have unique characteristics, such as smaller size, advanced safety features, and modular designs, which reduce their risk compared to traditional large-scale reactors. A risk-informed approach allows Kenya's regulatory framework to focus on the specific risks posed by SMRs, avoiding the imposition of unnecessary or overly stringent requirements on areas where risks are minimal.

By tailoring regulations to these specific risks, Kenya can streamline the approval and oversight processes, reducing delays and making the regulatory process more flexible to accommodate the innovative designs and deployment strategies of SMRs. This approach ensures safety is maintained without stifling innovation or imposing regulatory hurdles that could slow down the adoption of SMRs. In turn, this would promote the growth of nuclear energy in Kenya by allowing for faster and safer deployment of SMRs, contributing to the country’s sustainable energy goals.

**6.3 Collaborative Regulatory Platforms:** Collaborative regulatory platforms can play a vital role in assisting Kenya with the regulation of Small Modular Reactors (SMRs) by fostering greater transparency, trust, and efficiency in the regulatory process. By bringing together industry stakeholders, regulators, and public representatives, these platforms provide a space for open dialogue and knowledge sharing, addressing concerns from various sectors and building public confidence in nuclear energy.

Such collaboration enables Kenya to pool expertise and resources, which is crucial for the development of best practices tailored to the unique aspects of SMRs. These platforms also ensure that Kenya’s regulatory framework remains up-to-date with the latest technological advancements in SMR technology. As nuclear technology evolves rapidly, a collaborative approach helps the regulatory environment keep pace, promoting innovation while maintaining safety. Additionally, by involving public representatives, these platforms can help address societal concerns and improve the public’s acceptance of nuclear energy projects. This trust-building is key to ensuring smooth implementation and long-term sustainability of SMR deployment in Kenya.

**6.4 International Cooperation through IAEA Initiatives:** The IAEA plays a pivotal role in facilitating international cooperation through projects focused on SMRs [6]. Collaboration with the International Atomic Energy Agency (IAEA) can significantly benefit Kenya in regulating Small Modular Reactors (SMRs) in several key ways.The IAEA provides extensive technical expertise and guidance on nuclear safety, security, and regulatory frameworks. By collaborating with the IAEA, Kenya can tap into global best practices for SMR regulation, ensuring its regulatory framework is aligned with international standards while benefiting from the latest research and developments in nuclear technology.

In addition, the IAEA offers training and capacity-building programs to enhance the skills of regulatory bodies. For Kenya, this means equipping regulators and nuclear professionals with the knowledge and tools needed to effectively oversee the safe and secure deployment of SMRs. Such capacity building is crucial for ensuring Kenya’s regulatory framework can handle the specific challenges posed by SMRs.

Lastly, through its peer review programs, the IAEA can assess Kenya’s regulatory framework and provide recommendations for improvement. These reviews can identify gaps in Kenya’s nuclear regulatory practices and suggest modifications to better accommodate SMRs, ensuring continuous improvement of regulatory oversight.

Facilitating International Cooperation: Collaboration with the IAEA connects Kenya with other countries and stakeholders involved in nuclear energy development, promoting knowledge-sharing and collaboration on SMR projects. This international cooperation can help Kenya stay abreast of technological advancements, regulatory innovations, and global trends in nuclear energy.

Together, these opportunities not only address the immediate challenges posed by the introduction of SMRs but also leverage these challenges as catalysts for significant advancements in regulatory practices and international nuclear governance. This proactive approach in regulatory innovation will be crucial in harnessing the full potential of SMRs in the global energy mix.

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