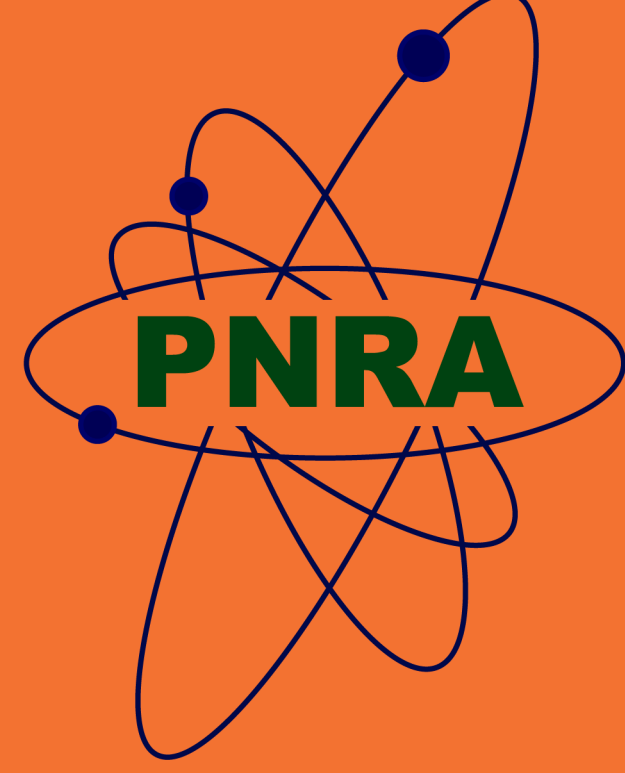


Small Modular Reactors - A Regulatory Perspective

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PNRA is regulating traditional NPPs in Pakistan through a robust nuclear regulatory framework that covers all stages throughout the life cycle of NPP (i.e. siting, design evaluation, construction commissioning, operation and decommissioning). With the advent of Small Modular Reactors (SMRs) technologies in recent years, Pakistan may consider SMRs as future option considering energy mix of Pakistan. The novel approaches in the design and deployment of SMRs can pose challenges to the existing regulatory framework. Considering these novel design features with respect to conventional NPPs, there may be gaps in current regulatory framework / licensing approaches of IAEA member states. The paper provides the description of areas that need to be considered in safety requirements of relevant standards and regulatory processes of regulatory bodies.

INTRODUCTION

PNRA Working Group (WG) performed literature review of ongoing studies related to regulatory challenges in licensing of SMRs including IAEA and academia. The objective is to highlight need to address these challenges in revision of IAEA standards so that subsequently national regulations may be made consistent with IAEA Safety Standards and international practices. The paper describes the activities, insights of the WG related to literature review of existing safety requirements and **way forward for regulating SMRs**.

STUDY OF SAFETY ASPECTS

Design Safety

WG found that most of design requirements in IAEA Specific Requirements SSR 2/1 are generic in nature e.g. requirements are related to safety of design, Defence in Depth (DiD), radiation protection in design, safety assessment, ageing management, human factors in design and likewise. However, there are some **specific areas** which need to be addressed in relevant standards for regulating SMRs.

Specific Areas	Existing Status	Proposed
Control Rooms	Control Room (Requirement 65 (6.39 – 6.40A))	◇ Specific design requirements of MCR for SMRs with focus on controlling multi modules and separate panels for each module in an integrated control room. ◇ Remote operation of SMR;
Multi-Module Interactions, Dependencies and common systems	No existing requirement	◇ Design safety requirements related to multi-module units, ◇ Interconnections among the reactor modules, ◇ Function of control and protection systems of each module or integrated for all (one command or action to shutdown all modules.)
Extension of power through installation of new module at same site	No existing requirement	◇ Capacity enhancement by addition of future modules, plant lay-out, construction and provision for additional panels; ◇ Safety consideration to install modules in different phases (e.g. one module is in operation and other is in commissioning).
Containment structure and containment systems	Requirements 57 (6.25-6.26) are related to access to containment.	◇ Degradation mechanisms of submerged containments and underground construction; ◇ Human access during operational states and accident conditions (for sealed containment with no Or small doors or equipment access hatches;

Safety of Commissioning and Operation of SMRs

Sharing of one control room for several modules may pose concerns on control of the units. Based on IAEA SRS-123, modifications in requirements related operator personnel for multi-module facilities and for common control room for multi-modules or separate control rooms

- ◇ Operator qualification and training of personnel
- ◇ Performance of safety related activities
- ◇ Control of plant configuration
- ◇ Fire and explosion hazard safety
- ◇ Commissioning of SMRs: Offsite / onsite
- ◇ Control rooms and equipment control operations:
- ◇ SMR specific programs
- ◇ Refuelling outage management

Safety of Manufacturing, Transport, Emergency management and Decommissioning

Safety of Manufacturing Equipment, Components and Modules: Need for requirements for regulatory review and inspection of organizational capability for in-factory manufacturing and off-site commissioning of modules.

Transport Safety:

- ◇ Need to cover transportation of SMRs designed to be relocated geographically for manufacturing, assembling and final transportation to destiny for installation;
- ◇ Transportation of commissioned or operating pseudo mobile SMR;

Emergency Management:

- ◇ Building confidence on claims of designers to have low LPZ;
- ◇ Conducting a coordinated regulatory research to verify the claims to revise requirements of emergency management for SMRs;

Decommissioning

WG identified following areas for consideration in requirements in relevant standards:

- ◇ Mechanism or Strategy of decommissioning of SMRs
- ◇ Decommissioning of modules in phases
- ◇ In-situ decommissioning and offsite decommissioning

Potential Regulatory Challenges for SMR

SMR Licensing

Licensing process may involve more cost and a longer licensing process due to capacity building needed for confirmatory safety analysis, for example (i) **less familiarization with design**, (ii) **lack of availability of appropriate regulatory framework**, (iii) **insufficient experience in regulatory oversight**, (iv) **review and assessment**.

SMR Specific Licensing

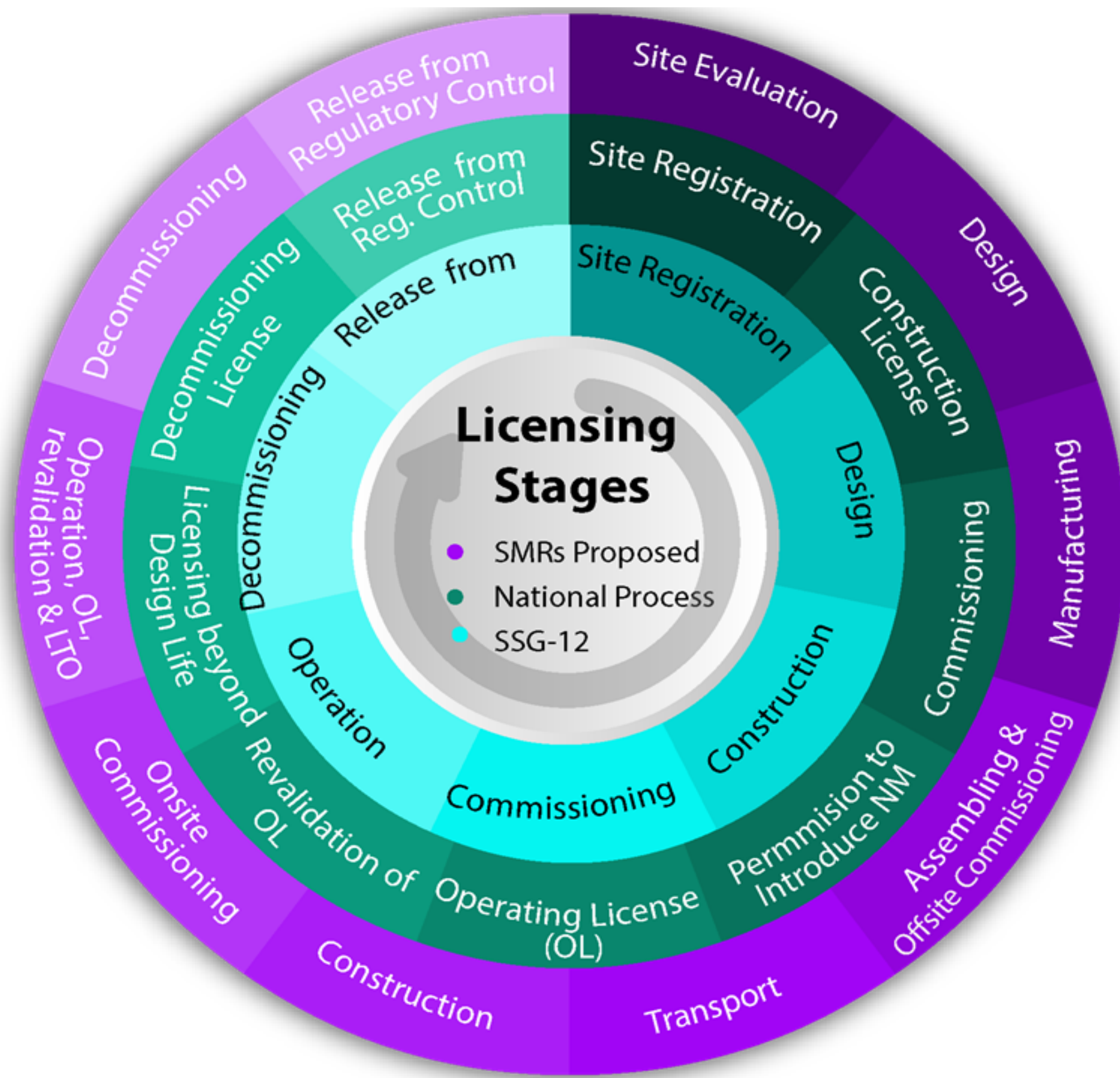


FIGURE 1. Proposed Licensing Process for SMRs

Way Forward for Regulating SMRs

Some of the takeaways from the study are highlighted below:

1. Regulatory bodies need to engage in **early interaction with different stakeholders** (utility, designers, and vendor) to familiarize with design, perform safety analysis, identify the issues for timely resolution and ensure smooth licensing.
2. **National regulations** for design, operation and licensing may change in order to make their applicability for SMRs. The licensing stages, submission requirements, periodic reviews and validity of license in case of SMRs may need to be considered in national licensing process defined in regulations for licensing of nuclear installations.
3. **Joint regulatory research activities** for capacity building of regulatory staff for licensing and regulatory oversight of SMRs. For example safety analysis such as accident analysis, multi-module probabilistic safety assessment (PSA), EPZ, review of advanced fuel, etc.
4. **Some special areas** such as (i) cyber security requirements for SMRs as most part of SMRs is expected to be digitized (man-independent), (ii) waste management consideration and emergency preparedness & response for SMRs and (iii) civil liability for transport able type of SMRs need to be focused.