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## Stand-Off Nuclear Safeguards and Monitoring for Remote Micro-SMRs

Remotely located Small Modular Reactors (SMRs) at the low end of energy production (on the order of 10 MWe, referenced here as Micro-SMRs) present unique challenges to nuclear safeguards and security [1]. These challenges include geographic isolation and distribution, lack of strong thermal or radiation signature, lack of access to core for monitoring, aqueous fuel forms, and harsh environmental conditions. Addressing these challenges in the most efficient manner will be necessary for the timely development of Micro-SMR technologies. Incorporation of safeguards considerations early in the design process (safeguards by design) along with safety, security, economics and other key drivers, is of importance. The array of advanced fuel cycles under consideration for SMR implementation present little experience base in the international safeguards and security community [2]. Safeguards by design raises the possibility of increased monitoring of operational data for verification purposes (operational transparency), with associated cyber security, unattended monitoring, and stand-off verification requirements.

This paper discusses and presents the possibility of stand-off monitoring of sealed core SMRs with the use of large-area neutron detectors outside shielding at distances of 10 to 100 m from the reactor core to track changes in reactor power and fissile isotope inventory. The state of the art of this novel technique will be described, along with perspectives on how this technique could address the IAEA's timeliness goals to detect the movement of significant quantities of undeclared nuclear material. Suggested methodologies for implementing this technique in an effective manner will also be provided.

References:

[1] J. Whitlock and J. Sprinkle, "Proliferation Resistance Considerations for Remote Small Modular Reactors", CNL Nuclear Review, vol.1, no.2, Dec 2012.

[2] Ontario Ministry of Energy, "SMR Deployment Feasibility Study Feasibility of the Potential Deployment of Small Modular Reactors (SMRs) in Ontario", June 2, 2016.

### Which "Key Question" does your Abstract address?

NEW1.1

### Which alternative "Key Question" does your Abstract address? (if any)

NEW1.2

### Topics

NEW1

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