Flexible Siting Criteria and Staff Minimization for Micro-Reactors (RC-2.3)

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Program: Micro-reactors

ABSTRACT:

The economic potential of micro-reactors is vast and underestimated. Commonly-emphasized applications include niche markets such as remote communities, mines and military bases. However, micro-reactors could be used as flexible energy generators also for larger markets, such as containerized agriculture and manufacturing facilities, district heating, data centers, disaster relief efforts, sea ports and airports, to mention a few. The implication is that micro-reactors may have to be deployed also in non-remote locations. Successful implementation of micro-reactors needs a navigable and predictable licensing process, technology-appropriate siting restrictions, risk-informed emergency and safety requirements, and practical operating and maintenance requirements. The primary goal of this project is to develop siting criteria that are tailored to micro-reactors deployable in densely-populated areas, e.g., urban environments.

To achieve that goal, we will compare the characteristics of the MIT nuclear reactor (MITR) with those of leading micro-reactor concepts (e.g., eVinci, HOLOS), and evaluate whether and how the MITR design basis (e.g., inherent safety features, engineered safety systems, source term, emergency planning and emergency operating procedures) and associated regulations may be applicable to these new micro-reactors as well. Currently 10 CFR 20 limits for radiation exposure to the public are used for evaluating power and non-power nuclear facility license applications. In 1972 the Atomic Safety and Licensing Appeal Board (ASLAB) stated that "as a general proposition, the Appeal Board does not consider it desirable to use the standards of 10 CFR Part 20 for evaluating the effects of a postulated accident in a research reactor inasmuch as they are unduly restrictive for that purpose. The Appeal Board strongly recommends that specific standards for the evaluation of an accident situation in a research reactor be formulated." To date research reactors have been able to conform to the requirements of 10 CFR 20 but considering that micro-reactors are analogous to research reactors in terms of risk, conformance to 10 CFR 20 may be excessively restrictive and consideration should be given to less restrictive evaluation criteria.

What makes MITR a unique analogue in this context is its small power rating (6 MWt) and physical size, mode of operations (24/7 with a somewhat more commercial flavor than typical university reactors), and especially its urban location. Of course significant differences exist, such as mission (power production vs. research) and the reactor design itself. Leveraging the MITR experience, this project will generate criteria that will allow micro-reactors to realize their full economic potential as flexible heat and electricity generators for a diverse portfolio of applications in non-remote locations. As such, the outcome of this project might encourage investment in and use of micro-reactors.

A second goal of the project is to conceptualize a model of operations for micro-reactors that would minimize the staffing requirements, and thus reduce the cost of electricity and heat generated by these systems. Here too our approach will be to systematically review the MITR experience and requirements, as well as survey the innovations in autonomous control technologies (e.g., AI) and monitoring (e.g., advanced sensors, drones, robotics) that would permit a dramatic reduction in staffing at future micro-reactor installations. MIT through its CSAIL and Media Lab organizations is at the forefront of the advanced informatics and robotics communities.

The primary outcome of this work will be a set of siting criteria for micro-reactors that are informed by the MITR experience, and a technical assessment of the staffing requirements for micro-reactors in urban environments. Deliverables will include (i) a report with recommendations for changes to RG 4.7 based on NRC's request in the SECY paper, and (ii) a final report detailing the project work, as well as journal and conference publications, as appropriate.