Service Provider Licensing and Oversight

An Alternative Conceptual Strategy for Regulating Fleet-wide Small and Mobile Reactors

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EXECUTIVE SUMMARY

The purpose of this document is to illustrate, in brief, a conceptual risk-informed, performance-based (RIPB) licensing and oversight strategy that accommodates deployment of small and mobile reactors for variable durations of time at multiple locations. This model represents the use case for small reactors and considers the national prioritization of mobile nuclear technologies in defense and space applications.[1] As such, this approach likely accommodates deployment models for a wide range of small reactor developers.

The conceptual approach aligns with a modern RIPB regulatory framework that is technology-inclusive, as mandated by the Nuclear Energy Innovation and Modernization Act (NEIMA) of 2019, and reinforced in the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act of 2024. The ADVANCE Act specifically includes provisions for NRC to establish regulatory strategies and guidance to license and regulate microreactors, including but not limited to oversight and inspections; safeguards and security; risk analysis methods, including alternatives to probabilistic risk assessments (PRAs); the transportation of fueled micro-reactors; and siting (relative to population density, mobile deployment and environmental reviews).[2]

In response to NRC's specific solicitation of comments on how Section 208 of the ADVANCE Act can be satisfied under Part 53[3], this brief offers an alternative conceptual licensing and oversight framework for small and mobile reactors (including microreactors) that should be further developed[4] with external stakeholders and included in Part 53[5] for rapid, high-volume, fleet-wide reactor deployment.

[1] https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-promoting-small-modular-reactors-national-defense-space-exploration/
[2] https://www.congress.gov/118/plaws/publ67/PLAW-118publ67.pdf, Section 208, "Regulatory requirements for micro-reactors."
[3] October 31, 2024, *Federal Register Notice* for Part 53, Subparts E and H—Manufacturing Licenses, p. 86982
[4] For example, PB regulatory provisions for rapid, high-volume transportation of reactor units containing activated fuel would need to be developed as part of this conceptual approach.
[5] If the NRC determines this option is not authorized under the Atomic Energy Act (AEA) of 1954, it should notify Congress for review and possible changes to the AEA.

I. NUCLEAR ENERGY IS A NATIONAL PRIORITY

National energy policy developers and lawmakers have prioritized nuclear energy for many reasons, from decarbonizing industries and the economy to protecting environmental quality and national security. Small and mobile reactors provide a portable, clean supply of reliable energy for diverse commercial applications and end uses, including reliable electric power, process heat and propulsion. Alternative sources of energy (e.g., diesel generators and natural gas units) emit greenhouse gases. Despite the harm to human health and the environment caused by their emissions, non-nuclear forms of energy are subject to significantly fewer licensing and permitting regulations. To compete on a level playing field with these less desirable alternatives, the regulated industry needs an agile, RIPB regulatory apparatus.

WIDE RANGE OF BENEFICIAL USE CASES

Because mobile reactors are dispatchable via truck, rail, barge and aircraft, they are well suited to provide safe, carbon-free, reliable, and scalable energy – wherever and for however long they are needed for the following services:

- supply electricity to micro-grids in populated and remote locations;
- power mining and drilling operations (e.g., in the Permian Basin), industrial centers, data centers, defense facilities, military bases, university campuses and lunar installations;
- generate process heat for industrial and utility applications;
- power propulsion in maritime and space applications;
- provide primary and backup power for life-saving applications in hospitals or in disaster-relief scenarios; and
- provide uninterruptable power supply as emergency backup power in the event of loss of offsite power for these and other applications.

II. OVERVIEW OF DEPLOYMENT MODEL

The rapid, high-volume deployment model is characterized by continuous (versus discrete) commercialization of a fleet of reactor units of the same or similar design, allowing for iterative design refinements. A regulatory approach and philosophy that enables safe, scalable deployment of one or more reactor units every week is of vital importance to not only the business model of small and mobile reactor enterprises, but to meet emission goals, satisfy energy demand, and provide baseload generation for increased grid stability. To achieve rapid, high-volume deployment that accommodates niche markets, fleet-wide developers envision a highly agile NRC licensing and oversight regime for a fleet of reactors rather than the conventional approach for discrete reactor units and plant sites. A license to provide electricity, power and/or process heat ***as a service*** should afford flexibility for the following:

1. Limited initial physics testing at the manufacturing facility
2. Transportation of reactor units with activated fuel
3. Deployment unconstrained by population density based on realistic hazards with very low risk
4. Series deployment to multiple sites over the lifetime of a reactor unit
5. Continuous NRC monitoring of performance indicator data for a flat annual fee
6. Incremental design changes as needed in response to data monitoring and operating experience
7. Limited oversight of the manufacturing facility for a flat annual fee that includes:
    a. Minimal baseline inspection of fuel storage, fuel handling, low-power physics testing, transportation, and control center operations;

b. Minimal baseline inspection of quality management program performance for reactor units on a sampling basis, informed by risk evaluations and measurable or calculable performance outcomes (i.e., performance indicators)
c. Reactive or supplemental inspections only if significant safety or performance issues warrant

This licensing and oversight strategy represents an extension of NRC policy and RIPB concepts currently applied to inspection and oversight regimes. Since 1999, that policy was intended to "appl[y]… to NRC rulemaking, licensing, inspection, assessment, enforcement, and other decision-making."[6] The Commission's vision in 1999 was to modernize NRC's regulatory operations through RIPB approaches. That modernization has yet to be fully realized. As such, this licensing strategy represents a radical departure from current regulatory practice – a practice that at times has blurred the line between the applicant's/licensee's ultimate responsibility for safe operations and the regulator's role to provide reasonable assurance of adequate protection of public health and safety.

To that end, the NRC has considered the low risk to public health and safety in licensing nuclear materials for portable application. For example, in 2012 a Risk Management Task Force, led by then Commissioner George Apostolakis, acknowledged the need for right-sized, PB regulation of portable nuclear technologies, informed by a functional containment consideration:

> *The licensing requirements for less hazardous uses, types, and amounts of radioactive materials can be and are correspondingly less prescriptive and reflect a less robust consideration of defense-in-depth. For example,* ***portable*** [emphasis added] *and fixed gauges use small radioactive sources that are* ***double encapsulated and contained within a relatively robust housing*** [emphasis added]. *The gauges can be used by individuals with a modicum of training that can be taken online.*[7]

The same RIPB considerations apply to the need for a licensing and oversight framework that accommodates rapid, fleet-wide reactor deployment.

The RIPB blueprint described herein integrates regulatory functions for continuity from licensing to right-sized performance monitoring of the fabrication, site preparation, assembly, fueling, testing, transportation, installation, and operation of a fleet of small and mobile reactors, including but not limited to microreactors. The integration of regulatory functions should yield efficient, effective and reliable licensing and oversight outcomes for this deployment model. Additionally, the PB features of this blueprint facilitate international harmonization of regulatory approaches to innovative new designs, thereby enlarging the marketplace for US technologies.

III. NEW CONCEPTS, TERMS AND DEFINITIONS

According to NRC staff's proposed 10 CFR Part 53, Subpart H[8], the NRC historically has interpreted fuel loading to mark commencement of reactor operation. Upon this interpretation the NRC proposes to require two independent, physical mechanisms to prevent criticality of a

[6] Staff Requirements - SECY-98-144 - White Paper on Risk-Informed and Performance-Based Regulation (https://www.nrc.gov/docs/ML0037/ML003753601.pdf), Item 8, definition of "RIPB Approach."
[7] "A Proposed Risk Management Regulatory Framework," A report to NRC Chairman Gregory B. Jaczko, April 2012. (https://www.nrc.gov/docs/ML1210/ML12109A277.pdf, p. 100)
[8] Subpart H – Licenses, Certifications and Approvals DRAFT Section 53.1480 – Combined license supporting testing of manufactured reactors, December 2024 (https://www.nrc.gov/docs/ML2434/ML24344A037.pdf)

fueled manufactured reactor except during testing at the manufacturing facility and commercial operations at a permanent deployment site. As such, the staff equates low power physics testing to "reactor operation," creating a host of conundrums despite acknowledging the low risk relative to operation for energy generation:

> *… the NRC recognizes that operation of a manufactured reactor with the reactor only generating fission reactions sufficient to gather data on the performance of the fuel or other SSCs would present reduced risk compared to operations for energy production because of the smaller inventory of fission products and resulting limited levels of radioactivity and heat generated by radioactive decay.*[9]

Criticality is not inherently unsafe. In fact, reactors are designed to go critical. As such, the regulatory focus should be on ***uncontrolled or inadvertent*** criticality for this diverse class of reactors.

Moreover, the staff contemplates only "subsequent transport to its final place of operation at a commercial nuclear facility that will operate the manufactured reactor pursuant to a combined license (COL)."[10] These conventional interpretations, based on regulatory approval milestones for large light-water reactors, do not countenance the modern licensing framework needed to enable rapid, high-volume, series deployment of fueled, tested, activated and operating mobile reactors. The proposed regulatory approach imposes undue design constraints with attendant costs and regulatory burdens to demonstrate a near absolute level of assurance that criticality will be prevented even though criticality is not inherently unsafe.

The rapid, high-volume and mobile reactor deployment model is premised upon concepts prepared and presented to NRC by the Nuclear Energy Institute (NEI) in July 2024:

> *In order to achieve the rapid high-volume deployment of advanced reactors to meet the potential demand from these markets and applications, the following business case requirements are of particular focus:*
>
> 1. *Deployment in less than 180 days (6 months) from the time that the site is identified to the time that operations and energy production begins; and*
> 2. *Regulatory costs are less than 1% of the total costs, as measured by total up-front capital costs, and annual on-going operations and maintenance (O&M) costs.*[11]

On December 9, 2024, the NRC issued its response to NEI:

> *The NRC staff agrees with the high-level concepts outlined in your letter and the staff has not identified any fundamental gaps with the NRC's ongoing and planned activities that would deter implementation of the planned business models associated with microreactor deployment. Furthermore, the staff supports the NEI position that the strategies and guidance being developed to support microreactor deployment may be applied in a graded manner to other advanced reactor designs.*[12]

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[9] Ibid, p. 4
[10] Ibid, p. 1
[11] NEI Concept Paper, "Regulation of Rapid High-Volume Deployable Reactors in Remote Applications" (https://www.nrc.gov/docs/ML2415/ML24152A325.pdf)
[12] https://www.nrc.gov/docs/ML2431/ML24317A174.pdf, p. 1

In its response, the NRC staff claimed that they had been engaged in "optimizing the regulatory framework for microreactors"[13], including the Part 53 rulemaking and various policy documents, since 2020. Although the NEI concept paper introduced new deployment models (e.g., mobile reactors), NRC's draft Part 53 rule and policy papers offer no pathway for NRC to license them. The proposed Subpart H, released in December 2024, makes some provisions for loading fuel into microreactors, conducting low-power physics testing at the manufacturing facility, and transporting the reactor to its "final" place of operation. However, it imposes undue regulatory burdens (e.g., requires two separate and independent physical mechanisms to prevent criticality) and offers no provisions for mobile reactors.

While some regulatory developments are encouraging, they do not achieve the licensing framework necessary to enable a rapid, high-volume, fleet-wide approach to deploying small and mobile reactors. For NRC to satisfy NEIMA and the ADVANCE Act, and for the regulated community to effectively convey the licensing strategy for current and emerging deployment models with a high degree of fidelity, new interpretations and additional terminology are necessary. These terms and definitions may be conceptually novel to the NRC, but they are not new to nuclear reactor applications. For example, the US has experience with portable reactors for military installations, floating reactors for energy production, and maritime propulsion. Federal partners at the National Aeronautics and Space Administration are actively pursuing apace nuclear propulsion[14] and lunar power generation[15].

To improve communication and foster common understanding, new terms and deployment concepts are defined below:

Activated fuel is fuel that has achieved criticality for the purposes of physics testing or generating heat in operational mode and therefore emits radiation that may require shielding. Activated fuel has been subjected to activation, defined by NRC as "the process of making a radioisotope by bombarding a stable element with neutrons or protons."[16]

Continuous deployment involves the simultaneous fabrication, testing and maintenance of multiple reactor units in various stages of manufacture, transportation, operation, refueling, and decommissioning.

High-volume deployment involves production of hundreds to thousands of reactor units with rates measured in number of products per weeks or months "(rather than years as is the case for large light-water reactors and other advanced reactors)."[17]

Mobile reactor is a reactor that is not stationary, may require assembly at a deployment site, and can operate[18] in motion (e.g., contains activated fuel and can be used for nuclear propulsion).

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[13] Ibid, p. 1

[14] https://www.nasa.gov/space-technology-mission-directorate/tdm/space-nuclear-propulsion/#:~:text=Nuclear%20thermal%20propulsion%20provides%20high,harness%20solar%20power%20becomes%20impractical

[15] https://www.nasa.gov/centers-and-facilities/glenn/nasas-fission-surface-power-project-energizes-lunar-exploration/

[16] https://www.nrc.gov/reading-rm/basic-ref/glossary/activation.html

[17] NEI Concept Paper, "Regulation of Rapid High-Volume Deployable Reactors in Remote Applications" (https://www.nrc.gov/docs/ML2415/ML24152A325.pdf), Executive Summary

[18] The term "operate" as used here applies the NRC's traditional definition of "reactor operation" in that fuel is loaded. However, a preferred alternative is for NRC to define "reactor operation" in a more practical sense that corresponds to the intentional removal of design features that preclude criticality.

Series deployment involves the redeployment of a mobile reactor to one or more different sites after initial site service is no longer needed.

Stationary reactor is sited in a fixed location for its operational lifetime.

Transportable reactor is a portable reactor that is fully contained, does not operate[19] while moving, and is designed for temporary installation at multiple sites in quick succession.[20]

IV. CONCEPTUAL STRATEGY FOR AN RIPB APPROACH TO REGULATION

The NRC first defined the attributes of an RIPB approach in a 1999 staff requirements memorandum (SRM) for SECY-98-144 (commonly referred to as the White Paper)[21]. The SRM directed the NRC staff to develop and apply RIPB concepts to regulatory decision-making, including rulemaking, licensing, inspection, assessment, and enforcement. NEIMA and the ADVANCE Act reinforce this direction and serve as reminders that the NRC must modernize.

In 2019 the NRC launched the Part 53 rulemaking in response to NEIMA. The staff issued its Draft Part 53 rule for formal comment on October 31, 2024, and solicits specific comments on how Section 208 of the ADVANCE Act can be satisfied under Part 53. This brief concept paper offers an RIPB alternative to Part 53 and the proposed Subpart H that accommodates diverse small and mobile reactor deployment models. The alternative could replace Subpart H or be added to Part 53 under a separate subpart that is fully RIPB and, as such, would accommodate the mobile reactor licensing strategy described herein. Specifically, an integrated licensing and oversight framework would emphasize safety performance using risk insights as intended by 1999 Commission policy[22], NEIMA, and the ADVANCE Act.

PERFORMANCE-BASED CONCEPTS

Some developers propose to demonstrate the safety case for their reactor designs to NRC under an RIPB regulatory framework. Although that framework is under development, neither the draft rule nor proposed Subpart H considers the fleet-wide mobile reactor deployment model described herein. As such, this conceptual licensing strategy illustrates the need for a regulatory approach that is correspondingly technology inclusive.

In short, the desired technology-inclusive framework includes three high-level performance objectives consistent with the NRC's RIPB Reactor Oversight Process (ROP), which remains one of NRC's few working examples of a PB approach to regulation[23]:

1. Reactor safety
2. Radiation safety
3. Safeguards (physical and/or cyber security)

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[19] Ibid.

[20] SECY-24-0008 defines transportable reactor as "factory-fabricated micro-reactor designs that are 'self-contained' in that they would incorporate the reactor, shielding, and balance of plant in one or several transportable containers and require minimal site preparation or construction activities at the deployment site." This definition does not account for series deployment or transportation back to the manufacturing facility for refueling, testing, maintenance or decommissioning.

[21] Staff Requirements - SECY-98-144 - White Paper on Risk-Informed and Performance-Based Regulation (https://www.nrc.gov/docs/ML0037/ML003753601.pdf).

[22] Ibid.

[23] https://www.nrc.gov/about-nrc/regulatory/risk-informed/concept/performance.html

Lower-tiered performance objectives in a structured objectives hierarchy may not be necessary depending on the design of the reactor, source terms, and any associated safety systems and security features.

Some developers plan to test their technologies at the Demonstration of Microreactor Experiments test bed at Idaho National Laboratory. Data collected during testing can be used to inform the selection of measurable or calculable performance indicators and objective performance criteria for NRC to assess a license holder's safety and security performance. While some reactor developers will have the capability to continuously monitor a wide range of parameters (e.g., temperature, flow, pressure, component status, radiation, etc.), a small subset of those data will be of regulatory interest as indicators of safety and security performance.

RISK-INFORMED CONCEPTS

Many developers are considering a wide range of tools and options for risk evaluation that may not meet current industry standards for the development of PRAs, but still provide adequate methods for risk evaluation.[24] Developers and applicants should have the flexibility to apply risk insights from alternative risk evaluation tools and methods.[25] For example, a failure modes and effects analysis (FMEA) may be more practical for first-of-a-kind (FOAK) demonstrations and deployments. The FMEA could inform the selection of safety parameters that warrant continuous monitoring. While many parameters will be of interest to the developer for non-safety reasons (e.g., efficiency, reliability, customer preferences, etc.), only safety parameters would be monitored by NRC. Once a sufficient body of operating experience and data are gathered, a PRA ***may*** be of value; however, for some developers, PRA offers limited to no utility for licensing a fleet of small and mobile reactors and should be treated as a tool for voluntary use, not prescribed by regulation as the only means for evaluating risk.

V. LICENSING OBJECTIVES

To achieve the fleet-wide mobile reactor deployment model, some developers anticipate a licensing approach along traditional licensing pathways for the FOAK license(s). Subsequent licensure could occur utilizing a materials license for possession of nuclear materials, a manufacturing license (or another design-centered license), and a fleet-wide service provider license under Part 53 for subsequent Nth-of-a-kind (NOAK) deployments.

POSSESSION LICENSE

To obtain, store and handle fresh and used reactor fuel, conduct reactor testing and commence operation, developers could apply for a license under 10 CFR Part 70 and other

[24] SRM-SECY-98-144 acknowledges that PRA is not the only method for evaluating risk: "PRA ***and other risk assessment methods*** [emphasis added] (also described in the PRA Policy Statement) considers risk (i.e., all three questions) in a more coherent, explicit, and quantitative manner. Risk assessment methodology examines systems and their interactions in a [*sic*] integrated, comprehensive manner."
[25] In her voting record for SRM-SECY-23-0021, Commissioner Caputo made reference to "risk evaluation" in lieu of PRA, noting that NEIMA mandates a technology-inclusive framework for "a spectrum that runs the gamut from large systems with complexity similar to that of currently operating light-water reactors for which a PRA may be appropriate, to small, simple microreactors for which a PRA may not be. … The staff's proposal for an alternative evaluation for risk insights (AERI) or ***some other form of risk evaluation*** [emphasis added] could provide a more appropriate tool for licensing and regulating simple microreactors, for example, or even some moderately sized reactors." (See https://www.nrc.gov/docs/ML2319/ML23199A289.pdf.)

applicable materials-related licensing options. Licensing strategies may differ as a function of business models, and the NRC should ensure that flexibility is optimized in the frameworks under development in response to NEIMA and the ADVANCE Act.

DESIGN-CENTERED LICENSE

Some developers are designing reactors for integration into power conversion systems. Others are designing self-contained units comprising a reactor and balance of plant equipment capable of deployment and operation without any further assembly. Many developers plan to load fuel and conduct low power physics testing of each reactor unit prior to shipment. To support a fleet-wide service provider licensing approach under Part 53, developers may choose to anchor design acceptability in a manufacturing license, a standard design approval, or a design certification, driving design standardization for the fleet of reactor units.

Embedding the service provider licensing concept within 10 CFR Part 53 will establish a pathway for NOAK deployments. The NRC staff also could embed the concept in the manufacturing license provisions of 10 CFR 52, Subpart F, to facilitate FOAK deployments. For ease of transitioning from FOAK to NOAK deployment, the NRC should provide an option for efficient transference to a service provider license under Part 53, Subpart X[26], "Service Provider Licenses."

SERVICE PROVIDER LICENSE FOR SERIES DEPLOYMENT

Some mobile reactor units will be transported to sites identified by the customer and installed for permanent use. Others may be used temporarily and redeployed at another site. In both cases, self-contained reactor units would be installed on a concrete pad poured to the developer's specifications for product warranty. Once it is installed, it is connected to the local distribution network (or process heating system) and operated for as long as the service is needed or until refueling. It is inefficient, cost prohibitive and unduly time consuming to repeat the Part 50 or Part 52 licensing process for each and every reactor deployment. As such, the conventional approach to licensing (a multi-year process involving a safety review and an environmental review followed by administrative hearings) is not viable.

To its credit, the NRC is considering and implementing more efficient environmental review options. However, it's preliminary Subpart H[27] assumes permanent deployment at a single site rather than mobile operation or series deployment at multiple sites. This will not fully support all rapid, high-volume deployment models. To mitigate regulatory uncertainty and enterprise risk to small and mobile reactor companies and customers, another licensing and oversight pathway must be forged.

NEIMA mandates a modern, RIPB and technology-inclusive licensing framework for innovative designs. The ADVANCE Act reinforces this mandate and includes a mission alignment provision. On January 24, 2025, the Commission approved the following mission statement:

> *The NRC protects public health and safety and advances the nation's common defense and security by enabling the safe and secure use and deployment of civilian nuclear energy technologies and radioactive materials through efficient*

[26] The "X" is intended to represent a subpart placeholder.
[27] December 2024 - NRC Staff White Paper - Draft Part 53 Subpart H, Licenses, Certifications and Approvals DRAFT Section 53.1480 – Combined license supporting testing of manufactured reactors (https://www.nrc.gov/docs/ML2434/ML24344A037.pdf)

and reliable licensing, oversight, and regulation for the benefit of society and the environment.[28]

This mission can be met by following precedent recently established when the Commission approved a service provider license under 10 CFR Part 40[29]. The small and mobile reactor developer community would be better served by a licensing pathway that would entail a service provider license under 10 CFR Part 53, Subpart X[30]. There are clear parallels between licensing an emergent nuclear technology for remediating hazardous waste at thousands of uranium mines, and licensing emerging small and microreactor technologies for providing electricity and process heat at potentially thousands of sites under a service provider license. Both types of emergent technologies stand to benefit society and the environment. Presently, the creative NRC precedent of licensing a service is the most progressive pathway to meet statutory requirements in NEIMA and the ADVANCE Act.

A service provider license also represents the clearest pathway to accommodating the rapid, high-volume deployment model described in the July 2024 NEI concept paper. An RIPB approach to a service provider license also includes provisions for NRC performance monitoring and oversight to verify safe fleet-wide operations throughout the life cycle of each reactor unit (see Section VI, Oversight Strategy). As such, and within the authority granted to NRC under the AEA, the NRC staff should explore options for issuing a service provider license to manufacture, fuel, test, transport, operate, maintain and decommission a fleet of small and mobile reactors (including microreactors).

The alternative approach described herein may involve Commission policy matters. The staff should present options for the Commission to consider how best to incorporate a service provider licensing option into the draft Part 53 rule as well as existing regulations and licensing frameworks (e.g., Part 52, Subpart F). If the NRC staff identifies legislative constraints to pursuing this licensing and oversight pathway, it should flag them for Congressional review and, possibly, new or amended legislation.

SAFETY REVIEW FOR A SERVICE PROVIDER LICENSE UNDER PARTS 52 AND 53

Initial Design Approval with Flexibility for Continuous Product Innovation: The safety review will involve a standard design that can be approved once and subject to a design control process (DCP)[31], governed by facility procedures. The DCP would afford flexibility for continuous design innovation and product enhancement without the need to request a license amendment. The NRC would authorize mobile reactor developers to iterate their designs based on operating experience, technological advances and customer needs provided the license holder can demonstrate that adequate safety margin is maintained.[32] The license holder would document its review of design iteration against criteria in the DCP procedure. The DCP procedure and review documentation would be subject to NRC inspection on a risk-informed sampling basis.

ENVIRONMENTAL REVIEW FOR A SERVICE PROVIDER LICENSE

Limited Site Preparation: Conventional regulatory practice and preparation of environmental impact statements and assessments (EISs and EAs) is disproportionate to the licensing action for small and mobile reactors. For some designs, the site is theoretically a shipping vessel, spacecraft

[28] See SRM-SECY-24-0083 (https://www.nrc.gov/docs/ML2502/ML25024A040.pdf)
[29] See SRM-SECY-23-0055 (https://www.nrc.gov/docs/ML2426/ML24269A245.pdf)
[30] The “X” is intended to represent a subpart placeholder.
[31] The DCP would be similar to the provisions of § 50.59.
[32] Reduced safety margins for structures, systems and components would be permissible as long as aggregate safety margin for the reactor unit remains acceptable.

or industrial facility. Self-contained reactor units can be installed on a concrete pad with minimal site preparation. The license holder, end user or a third party could install the pad in accordance with the developer's specifications. Many designs involve minimal environmental interface (e.g., no environmental effluents from a reactor unit). Small environmental impacts could be dispositioned efficiently through generic EAs and/or categorical exclusions[33].

VI. OVERSIGHT STRATEGY

Reactor developers, applicants and licensees are responsible for demonstrating the safe manufacture, transportation, installation and operation of reactors. The regulator's role is to establish guard rails for verifying safety and safeguards. In support of this, developers can work with the NRC staff to identify critical safety parameters for continuous monitoring by the license holder and NRC during all phases of the reactor life cycle. This approach streamlines the oversight process by minimizing reliance on resource-intensive inspection and obviating the administrative burden of collecting and reporting performance indicator data to the NRC.

Continuous Performance Monitoring: Continuous oversight capability can be customized to flag only safety-significant operational transients or conditions for the regulator. An elegant advantage of performance indicators is that they facilitate seamless transition of oversight from initial fuel loading to physics testing to transportation to installation and operation. This integrated approach to oversight of fleet-scale deployment reduces the need for NRC staff training and knowledge transfer throughout each phase of the reactor life cycle. The focus remains on safety and security performance throughout all phases of deployment, including transportation for refueling and decommissioning.

Efficient Use of Inspection Resources: Consistent with the ROP, oversight under a service provider license would encompass the cross-cutting areas of human performance, safety conscious work environment, and problem identification and resolution. However, the risk profiles and source terms of small reactors are expected to be significantly lower than those of currently operating reactors. Additionally, reasonable assurance of adequate protection will be efficiently and effectively verifiable through performance monitoring with limited need for inspection. Hence, cross-cutting areas do not warrant the assignment of an aspect for developing cross-cutting issues[34], a subjective and inefficient regulatory practice[35] instituted after poor safety culture contributed to a degraded condition at the Davis-Besse nuclear plant in 2002[36].

Manufacturing Oversight: An RIPB approach to NRC inspection of the manufacturing and "hot cell" facilities would reward positive safety outcomes. The level of inspection would be informed by measurable or calculable safety performance against transparent, objective performance criteria. Sustained positive performance would result in minimum levels of inspection. Conversely, poor performance that erodes confidence in safety margin could result in increased inspection and oversight, including reactive inspections, supplemental inspections, and enforcement action if conditions for traditional enforcement[37] are met.

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[33] See existing categorical exclusions in § 51.22(c)(13), § 51.22(c)(14)(x) and § 51.22(c)(14)(xvi).
[34] See NRC Inspection Manual Chapter 310 (https://www.nrc.gov/docs/ML1901/ML19011A360.pdf)
[35] The NRC is assessing the cross-cutting issues program for modification and improvement under Section 507, "Improving Oversight and Inspection Programs," of the Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act of 2024.
[36] https://www.nrc.gov/docs/ML0925/ML092540336.pdf
[37] With implementation of the Reactor Oversight Process in 2000, the NRC shifted its focus to safety performance (versus compliance) and, by Commission policy, reserves traditional enforcement for

Construction Oversight: The approach to construction oversight as proposed by NRC's Advanced Reactor Construction Oversight Process (ARCOP) relies on inspection to enforce compliance with prescriptive requirements in the licensing basis. This conventional approach was applied for construction of AP-1000 reactors at the VC Summer and Vogtle sites. However, the ARCOP is not sufficiently PB or agile to accommodate a rapid, high-volume deployment model involving continuous manufacturing and transportation of assembled reactor units for installation, hook-up and operation. Inspection of these activities would be inefficient and time consuming. The proposed ARCOP would significantly impede delivery of products and services. Therefore, the efficient use of design-specific performance indicators would demonstrate reactor safety, radiation safety and safeguards as an RIPB alternative to NRC inspection.

Operations Oversight: Safety parameters can be monitored continuously by NRC to verify safe performance throughout the life cycle of a reactor unit, from testing to transportation to operations. In exchange for this modern, efficient RIPB approach to oversight (with optimized use of performance indicators and minimal baseline inspection), the license holder would pay a nominal annual fee for regulatory oversight services.

NRC Reporting Requirements: The draft Part 53 rule includes reporting requirements[38] that appear to be largely copied from existing requirements for large light-water reactors under Part 50. As such, they are not RIPB. Additionally, functional containment is provided by the ceramic coating of TRISO fuel, the fuel of choice for many advanced reactor developers. Small reactor units can be equipped with one or more sensors to detect radiation and alert operators to an upset condition for troubleshooting and resolution. In light of continuous performance monitoring capability and a DCP that is subject to NRC inspection, extensive reporting requirements are not justified.

VII. SUMMARY

This concept brief introduces a transformational, integrated approach to RIPB licensing and oversight of small and mobile reactors on a fleet-wide basis for series deployment. The conceptual approach aligns with a modern, RIPB regulatory framework that is technology-inclusive, as mandated by NEIMA and reinforced by the ADVANCE Act.

In response to the NRC's specific solicitation of comments on how Section 208 of the ADVANCE Act can be satisfied under Part 53, this brief offers a conceptual alternative licensing and oversight framework for microreactors and other small reactors (including mobile reactors) that integrates seamlessly with other phases of the reactor life cycle. The RIPB concepts herein should be further developed with external stakeholders and included in Part 53 to accommodate a rapid, high-volume deployment model for fleets of small and mobile reactors.

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performance issues that undermine the regulatory process, involve willful violations of requirements, or result in actual safety consequences. (https://www.nrc.gov/docs/ML1621/ML16214A274.pdf, p. 8)

[38] See § 53.1630, "Immediate notification requirements for operating commercial nuclear plants;" § 53.1640, "Licensee event report system;" and § 53.1645, "Reports of radiation exposure to members of the public."