A Note to Congressional Staff on Advanced Reactor Technology & Funding Directions

Ernie Kee · 22 December 2020

About this document (background added November 2026)

In January 2019 the Nuclear Energy Innovation and Modernization Act (NEIMA) directed the Nuclear Regulatory Commission (NRC) to develop a technology-inclusive, risk-informed and performance-based licensing framework for advanced reactors. On 17 December 2020 the National Academies committee studying how to lay the foundation for new and advanced nuclear reactors in the United States held its first public meeting, a webinar in which congressional staff described House and Senate work on that legislation.[1]

Ernie Kee wrote this note to those staff members five days later. Its central idea is that regulation and research funding for advanced reactors should concentrate on containment, so that the production technology inside it can be built and maintained to ordinary commercial standards. An expanded version, co-authored with colleagues in the SoTeRiA laboratory at the University of Illinois, followed on 4 January 2021.

The note that follows is reproduced as written on 22 December 2020.

[1] National Academies of Sciences, Engineering, and Medicine, Committee on Laying the Foundation for New and Advanced Nuclear Reactors in the United States, first public committee meeting (virtual), 17 December 2020. The committee's public meetings are listed in Appendix J (pp. 234–235) of its final report, *Laying the Foundation for New and Advanced Nuclear Reactors in the United States* (Washington, DC: The National Academies Press, 2023), `https://doi.org/10.17226/26630`.

A Note to Congressional Staff on Advanced Reactor Technology & Funding Directions: *an engineer's perspective*

Ernie Kee, member of the public

Tuesday 22nd December, 2020

Thank you for your interesting comments in the recent National Academies webinar "New and Advanced Nuclear Reactors in the United States: Committee Meeting." It was really great to hear about Congressional actions on the Senate and House sides. My interest as public citizen in the new legislation, which I believe coincides with Congressional interest, is to create a pathway to where safe and commercially viable advanced reactors are built in the US. I believe our primary common interest is to offset, as much as possible, the risks associated with carbon-based energy on climate changes.

What follows is informed by personal experience in most of the nuclear power settings, US Navy nuclear operator (submarine service), fuel manufacture, national laboratory tests (LOFT program), and experience as Shift Technical Advisor, Unit Reactor Engineer, and Probabilistic Risk Analyst at a large commercial PWR power station. Such experience leads to a belief that commercial viability of nuclear power in the US, especially new build in deregulated electricity markets, will not be possible absent a new concept in regulatory perspective.[1] For example, the NRC has historically required a safety analysis report from each plant they license; these reports can run to approximately 10,000 pages and represent a short summary of the engineering analyses, all of the analyses are reviewed by NRC staff. This level of oversight and review creates enormous uncertainty in costs and schedules in existing and new build commercial reactor investments and is why nuclear power is either only marginally viable or no longer viable in some markets.

As you all pointed out in the webinar, Congress avoids interfering in the NRC's regulatory decisions, but Congress does have the ability to direct funds. In my opinion, it would make sense for Congress to direct funding that would demonstrate that containments for the different advanced designs will prevent radioactive material release. Engineers can create reliable reactor designs at reasonable price points, this is not a national challenge that

[1] Some early evidence of uncertainty leading investors away from advanced reactors is emerging: `https://www.reuters.com/article/us-usa-nuclearpower-nuscale/some-u-s-cities-turn-against-first-planned-small-scale-nuclear-plant-idUSKBN25T30E`. Website accessed 22 December 2020.

needs to be demonstrated. However, while it not a technical challenge to do so, engineers simply can not predict how long it will take to resolve regulatory questions generated from details contained in 10's of thousands of pages of documentation the Commission asks for. Limiting Commission and DOE focus on containment performance rather than production technology would create the basis for a new concept risk-informed concept whereby the production technology could be developed and administered under commercial standards, but containment of radioactive material is paramount and subject to strict controls, analysis, and documentation. By focusing on containment the Commission only needs review of a few additional critical technical specifications, beyond those for containment, that would ensure any radioactive material created is contained no matter what kind of accident causes failure of the process such as those pertaining to:

Prompt criticality Prompt criticality has the potential to produce an extremely high energy release, an unbounded hazard,

Maximum operating power level By keeping the reactor at, or below, the licensed power level ensures the hazard potential is bounded by the process stored energy plus the energy released from radioactive decay, and

Shutdown maintenance Reaching and maintaining reactor shutdown ensures the thermodynamic state can be known over time.

This Congressional (and Commission) focus would serve the national interest by ensuring only private funds already required by the Price Anderson Act (PA) would be used in accidents; preventing radioactive material release from containment would ensure there would be no need for the Commission to declare an Extraordinary Nuclear Event. Only private insurance funds as required by the PA would be the source for clean up and decommissioning of the plant. My hope is that Congress can figure out how to allow the Commission to regulate advanced nuclear reactor containments to be built in such a way that the fission (or less importantly, when feasible, fusion) process can completely fail, but any radioactive material from the failure is contained until it can be safely removed, for possibly a few years. In so doing, Congressional action would lead the way to creation of a regulatory structure agnostic to nuclear technologies, such as, high temperature gas, molten salt, liquid metal, light water, heavy water, and so forth, that could be built to commercial standards; the critical technology is what is important to the public and enforced by the Commission – that is, the ability to contain the hazard and thereby ensure adequate protection of the health and safety of the public.

However, containment of radioactive material following an accident is a relevant unresolved challenge facing the industry and the Commission that can be be overcome but the DOE must recognize the challenge in its funding priorities. It is important to understand that every US and overseas commercial nuclear accident since 1978 has resulted in radioactive material release and although the Three Mile Island accident released a relatively small

amount of material, only about 1/3 of the core was destroyed in that accident.[2] Congress should consider the containment challenge a national priority to lay the foundation for reduction in the advanced reactor regulatory structure and ensure commercially viable nuclear energy will be included in the energy mix to mitigate risk of climate change from carbon-based energy sources. Ex ante protection against radioactive release is essential: any reactor accident that allows radioactive release outside the containment will rightly cause public skepticism that adequate protection can be enforced.

Finally, Congressional action that would create highly effective containment technology is entirely consistent with the Nuclear Energy Innovation and Modernization Act interest in risk-informed and performance-based regulation. It focuses resources on the natioanl challenge facing the Commission and the DOE, and by this focus, lays the foundation for reduction of uncertainty with cost and schedule for new build. Risk analysis clearly shows that containment is the single most important element in preventing harm to the public. Performance of the containment, basically a set of independent passive defenses against release, can be much more easily be monitored and thereby facilitates performance-based regulation unlike the hurdles associated with monitoring performance of the nuclear process.

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[2] There may have have been as many as two more in the USSR with Gen 2 reactor designs according to Ha-Duong and Journé in their article "Calculating nuclear accident probabilities from empirical frequencies."

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