Insight

Improving Federal Review of Advanced Nuclear

EWELINA CZAPLA | MARCH 12, 2020

Executive Summary

- The deployment of civilian nuclear energy in the United States has faced challenges from long regulatory review times and difficulty obtaining financing.
- Because it is capable of meeting various energy generation needs without emitting carbon, advanced nuclear technology can be part of the innovative solutions needed to address climate change.
- Novel regulatory review pathways could help ensure the timely review of the various advanced nuclear technologies under research and development.

The Challenge: Reliable and Clean Energy

Reliable, affordable energy forms the backbone of any economy. Yet the challenge of climate change requires that our energy production also be increasingly "clean"—or emit as little carbon as possible. Nuclear power for decades has produced reliable electricity with few, if any, carbon emissions. Currently, nuclear power provides nearly 20 percent of total power in the United States and approximately 57 percent of non-fossil fuel energy.[1] By producing nuclear power, the United States avoids more than 175 million tons of carbon emissions per year that would have otherwise been released had coal generators produced the electricity.[2]

Despite its strengths, nuclear power is facing deployment challenges on two levels: economic challenges as demonstrated by operating reactors, and regulatory delays for innovative technology. First, current nuclear power plants are expensive to operate, making nuclear energy less competitive with other sources. Operations and maintenance (O&M) costs account for approximately 60 percent of reactors' total generating costs.[3] Simultaneously, the cost of natural gas has dropped precipitously with the shale-gas boom, making natural gas a much more attractive option for new power plants. As a result, power companies have dramatically slowed construction of new nuclear plants and are shuttering some existing plants. Eight facilities have closed in the last 6 years; five more are scheduled to be decommissioned by 2025. In the United States, a new commercial power nuclear reactor has not been placed in service for over 30 years.[4] And recent efforts to build new reactors in South Carolina and Georgia have faced difficulties.

Second, while advanced nuclear technology promises to alleviate many of the problems driving costs of older technology, the regulatory review of civilian nuclear technology stands in the way of its commercialization. In the decades following World War II, the United States rapidly commercialized the military's nuclear breakthroughs. Today's regulatory process was designed for the current set of pressure-water or boiling-water reactors, yet a new generation of advanced nuclear-energy technology is on the cusp of commercializing. [5]

Unlike the light-water reactors currently in use, advanced reactors rely on various cooling systems and modified fission and even fusion. While varied, these new reactor designs promise to offer benefits such as modular implementation, flexible power production, and inherently safe operations and passive cooling. This advanced nuclear technology is designed to be less costly to deploy and maintain as well as a better investment. As a result, it holds the promise of making nuclear energy attractive again.

Yet for this new technology to be commercialized successfully, policymakers must implement better regulatory policies and pathways. There is no question about the need for regulation—nuclear energy, if improperly implemented, can pose a clear threat to the health and safety of the public—but regulatory review tailored to advanced technology can better address the risks with novel implementation, allowing more clean and reliable energy production in the United States. In fact, the Nuclear Energy Innovation and Modernization Act (NEIMA), signed in January 2019, requires the Nuclear Regulatory Commission (NRC) to develop a licensing framework for advanced nuclear technologies.

The Opportunity: Advanced Technology

The small modular reactor (SMR) is likely the next novel design to be implemented in the United States. The NRC is currently reviewing a design developed by NuScale Power, which will be constructed at the Idaho National Laboratory for the Utah Associated Municipal Power as part of their Carbon Free Power Project. NuScale is one of only a few designs before the NRC in recent years, and while its design is novel, it relies on lightwater fission like the reactors in operation today, simplifying its review. In general, SMRs are about one-third the size of the reactors that are currently operating, and they have simple, compact designs that can be assembled in a factory and transported to the power plant site, reducing construction time.[6] Modular construction and the smaller footprint allows SMRs to come online faster, reducing the risks that delay construction and deter investment. Speedier deployment means less spent on interest and faster returns to investors, and the modular design provides the option of future expansion.

Other advanced reactor concepts currently in development fall into three broad categories: advanced water-cooled reactors that improve upon existing water-based fission technology; non-water-cooled reactors that rely on liquid metal or molten salt; and fusion reactors that rely on a different process than fission reactors altogether.[7] Like SMRs, some of these technologies may be standardized and factory produced, but until concepts are tested and demonstrated it is difficult to determine capital cost.

Advanced designs will likely occupy a smaller geographic footprint than existing facilities, but they also will have a wider range in capacity, between 15 megawatt electrical (MWe) and 1,500 MWe. The upper end of this range means that reactors could power industrial facilities—which often need a dedicated energy source—rather than just produce power for broader markets. In addition, some advanced reactor designs allow for flexible energy production. While some advanced technology could operate in a baseload capacity like current nuclear facilities—meaning they are always operating to provide energy—others may respond to demand on the grid and produce power only when needed. This variable capacity of nuclear power is particularly valuable as a counterbalance to the cyclical generation of renewable sources such as wind and solar. In general, the modularity and flexibility could provide greater versatility to meet the many needs for emissions-free energy.

Regulation of Nuclear Energy

The development and commercialization of advanced nuclear technology is currently subject to the same regulatory challenges nuclear developers have faced for decades. Like traditional nuclear, advanced technologies face a long regulatory-review timeline, as well as negative public sentiment and resulting siting issues over safety and public-health concerns. The expense and length of the regulatory and permitting process require large upfront capital investment and make it difficult to obtain adequate financing. In addition, innovative nuclear technology requires an additional regulatory step, as the innovator must convince the NRC that the new design itself, apart from any specific implementation of it, is safe and effective—setting up an additional regulatory barrier to advanced nuclear technology.

The NRC licenses several aspects of new nuclear technology separately, such as the design certifications of new reactor designs, the operation of nuclear plants, and their siting. In addition, the NRC offers combined licensing of siting and construction of new reactors and the operation of nuclear power facilities. The independent review processes are intended to provide developers with the flexibility to pursue approvals piecemeal.

Those companies seeking to commercialize new designs must receive design certification from the NRC before committing to a commercial application. The review of the new design allows NRC to gain an understanding of the concept prior to commercialization to identify risks and formulate a regulatory standard for the technology, should it be commercially developed. Design certifications can be the most time-consuming and costly licensing stage.[8]

Following design certification, developers can pursue approval to construct and operate a new facility by submitting a combined license (COL) application. This process includes the preparation of an Environmental Assessment (EA) or Environmental Impact Statement (EIS), which the National Environmental Policy Act (NEPA) requires of federal agencies undertaking a major action. The environmental review can prove very time consuming, so much so that NEPA's implementation is currently undergoing modifications to reduce review time to less than 2 years.

The NRC offers early site permitting for those developers who have not yet filed a COL application or construction permit. This early permit allows a developer to complete a review of the site independently of the plant design they intend to construct. The process involves a NEPA review and is valid for with the option to renew for an additional 10 to 20 years.

The NRC's current permitting programs were designed with traditional light-water reactors in mind. These reviews come at a high cost in both time and money, as indicated in the table below. For example, the average time to complete a COL for seven projects was over 88,000 hours. These costs delay the implementation of advanced nuclear technologyestimates that it will take over 20 years and $1.4 billion to bring one of their plants into operation despite the fact that their design is a small modular light-water design rather than a novel system.

Table 1. New Reactor Business Line Fee Estimates[9]

	Staff Hours			Contractor Costs ($)			Total Costs ($)		
Licensing Action	Low	High LoE	Average	Low LoE	High LoE	Average	Low LoE	High LoE	Average
License amendments (130 total)	6	1,124	204*	n/a	n/a	n/a	1,632	302,560	55,633*
Combined Licenses (7 sites total)	44,269	178,160	88,812	2.76M	8.88M	4.87M	$21.6M	54.2M	29.9M**
Early Site Permits (5 sites total)	14,626	64,940	31,800	1.87M	5.11M	3.04M	5.2M	14.4M	9.0M

Design Certifications (5 total)	108,000	257,104	173,473	Information not available	Information not available	Information not available	14.1M	68.2M	34.6M

* This average does not include LAR 12-002 for Vogtle, which was an outlier at 10 times the average cost in hours (2,191 hours) and total cost ($598,698)
** The STP COLA was an outlier in total hours and costs. If STP is removed from the equation, the average total cost is $25.2M.

Those developers not yet ready to engage with the NRC's various permitting options may engage in pre-application review with the agency, which a handful of advanced nuclear developers have done. These companies include several molten salt reactor developers—TerraPower, LLC, Terrestrial Energy USA Ltd., and Kairos Power, LLC—helium-cooled fast reactor developer General Atomics, and Westinghouse Electric Company, which has developed a micro-reactor. And each of their designs is unlike the light-water reactors that the NRC has reviewed for decades.

In an effort to address these companies' desire to commercialize their designs, the NRC staff have been educated on the various new technologies under development. While the developers report progress on their designs to the NRC, the staff are considering novel approaches to their review. Together they are beginning to address the development of the framework required under NEIMA.

Learning from Pharmaceutical Review

The NRC is obligated to establish its new regulatory framework for advanced nuclear plants by the end of 2027 under NEIMA, in keeping with innovation in the industry. The multiple review pathways that the Food and Drug Administration (FDA) has created are potentially a useful example for the NRC.

The regulatory situation currently facing advanced nuclear technology parallels many of the challenges that the pharmaceutical industry has faced. Advanced reactors rely on novel technology that is implemented and operates differently, much like new drugs. In addition, there is a pressing need for its implementation as an emissions-free power producer, similar to the diseases that new drugs often address. And just as the FDA created new pathways for needed drugs, advanced nuclear technology is ripe for new review pathways that allow for expedited review based on the potential that nuclear energy holds for ameliorating carbon emissions.

The FDA's Center for Drug Evaluation and Research conducts pharmaceutical review using several pathways to expedite development and regulatory review. These pathways include fast track, breakthrough therapy, priority review, and accelerated approval. Different criteria qualify different drugs for each pathway. For example, the breakthrough-therapy pathway is for the review of drugs that provide an unmet need for a serious or life-threatening disease. Accelerated approval allows the FDA to review and approve a new drug for a particular use case while continuing to review that same drug for other use cases in order to meet a need that current treatments don't provide.

Just as the FDA has prioritized fighting diseases and alleviating suffering, the NRC could similarly prioritize the development of clean and stable energy sources. Expedited pathways could speed the commercialization of beneficial technology.

The Potential Shape of New Pathways

In the case of advanced nuclear, pathway criteria can be based on a technology's ability to meet specific challenges facing nuclear energy currently. Some hypothetical needs include:

- reducing O&M expenses at existing nuclear facilities;
- filling gaps in power production caused by renewables; and
- reducing emissions at industrial facilities.

In order to prevent early retirement or improve the economics of existing plants, technology that improves operations at light-water reactors can be the subject of a pathway. Advanced nuclear technologies that are flexible and respond to fluctuations in renewable capacity, such as modular reactors, can be the subject of another pathway, while microreactors that can serve as generators for industrial facilities currently relying on dirtier energy sources could be yet another. Such expedited pathways would allow issues in energy production to be addressed sooner than later as the threat of climate change grows more urgent.

[1] https://www.eia.gov/totalenergy/data/monthly/pdf/sec2_13.pdf

[2] https://www.scientificamerican.com/article/next-generation-nuclear/

[3] https://www.nei.org/resources/reports-briefs/nuclear-costs-in-context

[4] https://www.eia.gov/todayinenergy/detail.php?id=31192

[5] https://www.energy.gov/sites/prod/files/The%20History%20of%20Nuclear%20Energy_0.pdf

[6] https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants-types-of-reactors.php

[7] https://crsreports.congress.gov/product/pdf/R/R45706

[8] https://www.nrc.gov/reactors/new-reactors/new-licensing-files/nro-fee-transformation-data.pdf

[9] https://www.nrc.gov/reactors/new-reactors/new-licensing-files/nro-fee-transformation-data.pdf