ADVANCE Act: A Practical Path Forward for Nuclear Innovation

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About the Author

Joshua A. Tolbert, Ph.D., P.E., is a seasoned engineer with four engineering degrees, including a doctorate in mechanical engineering. He has extensive experience in power generation, including coal, natural gas, biomass, and nuclear, as well as leadership roles such as CTO and VP of Engineering for a commercial developer of small-scale nuclear power plants. Dr. Tolbert has worked with nuclear regulators domestically and internationally, including the UK ONR, Poland's PAA, Argentina's ARN, Romania's CNCAN, and Turkey's NDK.

In the private sector, Dr. Tolbert has identified the major obstacles to nuclear power development, including regulatory, technical, and economic challenges. He has a deep commitment to participating in the revitalization of the nuclear industry by implementing practical solutions to these obstacles.

His technical expertise includes the full design of a small-scale pressurized water reactor (PWR), encompassing the primary loop, secondary loop, and auxiliary systems, all utilizing advanced modularization techniques to enhance constructability and reduce costs. This hands-on experience positions Dr. Tolbert to offer unique insights into the challenges and opportunities facing the nuclear industry today.

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Introduction

The ADVANCE Act of 2024 marks a pivotal moment for the U.S. nuclear sector—not because it introduces radical new mandates, but because it finally acknowledges a fundamental truth: the bottleneck in American nuclear development is no longer technological ambition, but regulatory and structural inertia. For decades, the industry has been trapped in a loop. New concepts are proposed, regulatory frameworks struggle to adapt, projects stall, and the cycle repeats. As a result, the United States continues to produce extraordinary engineering on paper and painfully little steel in the ground.

The Act attempts to break this pattern by modernizing regulation, strengthening public-private collaboration, and giving the Nuclear Regulatory Commission a clear directive to embrace risk-informed, performance-based licensing. Yet, laws cannot implement themselves. The question now is whether the industry can translate this moment into real, deployable capacity. That requires more than regulatory adjustments—it requires a coherent, shared technical pathway that developers, regulators, and policymakers can rally around.

This paper proposes precisely such a pathway: a Joint Generic Plant Design Project, built on proven technology, modernized safety analysis, and a forward-looking regulatory philosophy. It is an approach that blends the best of nuclear history with the needs of America's modern grid, creating a design that can anchor the industry's revival and give the ADVANCE Act a concrete vehicle through which to succeed.

A Generic Plant Design as the Missing Foundation

One of the most significant structural flaws in U.S. nuclear development has been the absence of a standardized, regulator-approved foundation. Unlike countries that built fleets around repeatable designs—France with its P4 and N4 reactors, South Korea with the OPR-1000 and APR-1400—the U.S. relied on bespoke, project-specific designs. This approach magnified licensing burden, increased technical uncertainty, and prevented supply chains from maturing.

The solution is not theoretical; it has been demonstrated globally: a generic, pre-approved design that defines core systems, safety methodologies, containment philosophy, and key component boundaries. Such a design does not eliminate innovation; it creates a platform for it. With a common baseline, developers can iterate responsibly, suppliers can invest confidently, and regulators can review consistently.

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The U.S. once had this capability. In the 1960s, smaller pressurized water reactors were built rapidly and economically. Adjusted for inflation, their overnight costs routinely fell between $1 million and $2 million per megawatt—numbers that would be unthinkable today. Those designs were not perfect, but they were robust, understandable, and grounded in reactor physics rather than regulatory overengineering.

A modernized version of those reactors—updated with contemporary materials, digital I&C, enhanced containment modeling, and a risk-informed safety case—could form the backbone of a generic U.S. reference plant suitable for deployment under the ADVANCE Act.

Modern Regulation and Modern Design Must Be Developed Together

A crucial opportunity within the ADVANCE Act is its alignment with the NRC's evolving Part 53 framework. Part 53 attempts to shift the U.S. from prescriptive, deterministic licensing toward an approach that evaluates actual risk and real-world performance. It encourages safety cases that focus on outcomes rather than box-checking, and it integrates probabilistic thinking more explicitly into the regulatory fabric.

However, regulatory frameworks are not validated by rulemaking—they are validated by application. A Joint Generic Plant Design Project gives the NRC an ideal testbed for refining Part 53 in real time. Instead of waiting for dozens of separate advanced reactor applicants, the NRC could work closely with DOE, industry, and ASME to develop a unified safety methodology that is both rigorous and practical.

In doing so, regulators would gain clarity, developers would gain predictability, and the country would gain a licensing model capable of scaling beyond single bespoke projects. This synergy between regulation and design is the essence of what the ADVANCE Act envisions but cannot impose on its own.

Rebalancing the Supply Chain Through Risk-Informed Design

Another core advantage of a generic design is the opportunity to rationalize the nuclear supply chain. Much of today's cost escalation stems from an assumption—never fully justified—that components throughout the plant must meet nuclear-specific certification standards, even when their failure would have no meaningful influence on public risk.

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Historically, U.S. nuclear plants were built largely with conventional components, and their safety cases rested on robust physical containment rather than the unrealistically perfect reliability of every mechanical subsystem. Over time, this balance shifted. Regulation increasingly emphasized accident prevention at the component level (core damage frequency), while maintaining stringent containment expectations. The result was a dual burden: invest heavily in preventing core damage, but also build massive, expensive containments in case prevention failed.

A modernized reference plant creates an opportunity to restore balance. By using probabilistic risk assessment to classify systems based on their actual contribution to safety, designers can apply ASME Section III requirements where they are truly justified—while integrating high-reliability industrial components elsewhere. This approach reduces cost, broadens supplier participation, and shortens lead times without compromising safety.

It is a shift toward engineering judgment over regulatory reflex, and it is crucial for restoring nuclear to an economically viable position.

A Unified Path from Design to Deployment

If the generic plant design is successfully developed and approved, it becomes much more than a paper exercise. It becomes a deployment platform. Developers could adopt the design as-is or modify specific elements while retaining the pre-approved safety basis. Utilities could plan projects with vastly reduced uncertainty. Vendors could align their product lines with standardized specifications. Investors could model risk with far greater confidence.

Critically, this approach builds momentum rather than dissipating it. The first plant constructed under the generic design would not be an isolated achievement—it would be the first unit of a fleet, with repeatability built in from day one.

This differs fundamentally from the one-off megaproject model that characterized the late 20th century and continues to plague nuclear construction today.

Why This Approach Fulfills the ADVANCE Act's Intent

The ADVANCE Act seeks to modernize regulation, encourage innovation, strengthen supply chains, and accelerate deployment. A coordinated generic plant design accomplishes all of this simultaneously.

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It modernizes licensing by becoming the first practical, full-cycle application of Part 53.
It encourages innovation by giving designers a stable platform from which to iterate.
It strengthens supply chains by defining the boundaries between nuclear-grade and industrial-grade components.
It accelerates deployment by resolving the most persistent source of delay: uncertainty.

Perhaps most importantly, it offers the U.S. a credible path to reclaiming leadership in nuclear construction at a time when global energy demand—driven heavily by AI, cloud computing, and industrial reshoring—is accelerating faster than new capacity is being built.

Conclusion

The ADVANCE Act provides the authority and direction needed to reform U.S. nuclear regulation, but authority without execution will not change outcomes. To translate the Act's promise into deployed reactors, the U.S. must create a coherent technical foundation that aligns design, regulation, supply chains, and industry incentives.

A Joint Generic Plant Design Project offers that foundation. By drawing on proven reactor designs, modern analytical tools, and a risk-informed regulatory philosophy, it creates a practical, buildable, and repeatable pathway for nuclear deployment—one that is both realistic in the near term and scalable in the long term.

If implemented with discipline, this approach can finally break the cycle of nuclear stagnation and allow the United States to build reactors again at the pace required for its economic and technological future.

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