

MVP: A Product Development Approach to Nuclear Industry Revitalization



Joshua A. Tolbert, Ph.D., P.E.

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.

Introduction

The nuclear industry often finds itself stuck between ambition and execution. For decades, reactor developers have pursued groundbreaking innovations — new fuel forms, novel coolants, advanced materials, exotic geometries — all in the hope of unlocking a future where nuclear power is cheaper, faster to build, and easier to regulate. But what the industry has repeatedly failed to deliver is something far more important: a plant that actually gets built.

This failure is not for lack of engineering talent or regulatory intelligence. It is the consequence of a development philosophy that chases “breakthrough reactors” while neglecting the underlying barriers that make nuclear deployment slow, expensive, and unpredictable. In modern technology terms, nuclear has been trying to leap directly to a fully featured V1.0 product without ever producing a credible Minimum Viable Product (MVP).

This paper argues that nuclear power must adopt a product development mindset grounded in practical deliverability. The MVP for a nuclear plant is not an experimental reactor or a futuristic concept. It is a modernized version of what we already know works — a right-sized, standardized, clean-sheet Pressurized Water Reactor built using contemporary fabrication methods, risk-informed design, and streamlined regulation.

In short: if the nuclear industry wants credibility, it needs to ship something.

The Nuclear MVP: Returning to What Works

Small- and mid-sized PWRs from the 1960s and early 1970s were not merely successful — they formed the backbone of the U.S. nuclear fleet and were built with speed and cost discipline unmatched by modern standards. Adjusted for inflation, these units routinely achieved overnight costs in the \$1–\$2 million per megawatt range and construction timelines under five years.

Those reactors were not perfect by contemporary engineering expectations. But they were safe, reliable, and economically viable — attributes far more important than speculative breakthroughs that may never be commercialized. The MVP approach does not seek to recreate these designs verbatim. Instead, it proposes to modernize them with:

1. digital instrumentation and control
2. improved materials and analytical techniques
3. modular construction philosophies
4. refined containment modeling

5. and risk-informed safety classification

The result is a reactor that is not experimental, but contemporary; not overly ambitious, but achievable; not a science project, but a product.

Why the Industry Needs an MVP

The concept of a Minimum Viable Product comes from the startup and product design world. It describes the simplest version of a product that delivers value, demonstrates feasibility, and provides a foundation for iteration. The nuclear sector lacks this foundation. Despite over a decade of R&D, very few advanced reactors have been licensed, and almost none have been deployed.

Without an MVP reactor:

1. supply chains cannot stabilize
2. construction methods cannot mature
3. regulators cannot refine risk-informed licensing
4. investors cannot quantify risk
5. operators cannot develop fleet experience
6. and the public cannot reconnect with nuclear as a viable resource

Instead, every project is a first-of-a-kind (FOAK) effort — and FOAK is the most expensive way to build anything.

The MVP approach breaks this cycle by giving the industry a shared reference point: a reactor that can be built now, at scale, with predictable cost and regulatory outcomes.

Containment as the Anchor of a Buildable Design

One of the most meaningful design decisions in the MVP framework is the emphasis on robust containment. Containment is the ultimate safety boundary in nuclear plants, but its secondary value in modern design is equally important: a strong containment structure allows upstream systems to be designed with pragmatism rather than perfection.

This design philosophy simplifies PRA, reduces accident complexity, and provides a clear pathway for component classification. Rather than driving every subsystem toward extreme reliability (and thus extreme cost), a robust containment allows for:

1. realistic accident modeling
2. rational redundancy decisions
3. better integration of conventional, industrial-grade components

4. and simplified safety case arguments

This approach is not only technically sound — it aligns with the regulatory direction of the NRC’s emerging Part 53 framework, which seeks to evaluate safety outcomes rather than prescriptive system requirements.

Sizing Matters: Choosing the Right Reactor Scale

The MVP plant must be sized for constructability and speed. Historically, the move to ever-larger reactors (4,000 MWth units and beyond) was a defensive economic response to regulatory escalation. But the consequences were predictable: greater thermal power led to larger components, larger containments, and longer construction timelines.

Small and mid-sized reactors offer the opposite:

1. simpler logistics
2. more repeatable manufacturing
3. faster construction
4. reduced seismic and structural demands
5. and a more stable supply chain

A right-sized MVP — on the order of 500–2,000 MWth — balances these advantages while retaining the power density and physics maturity of light-water technology.

Practical Engineering Over Speculative Innovation

The nuclear MVP does not reject innovation — it prioritizes practical innovation. It invites modern engineering where modern engineering adds value:

1. computational fluid dynamics for thermal-hydraulic optimization
2. probabilistic risk assessment for system classification
3. modern welding, fabrication, and non-destructive examination techniques
4. AI-enhanced monitoring and predictive maintenance
5. digital twins for construction planning

But it rejects innovation for innovation’s sake. It does not chase materials that have never been mass-produced or fuels with uncertain supply chains or coolant systems with no commercial operating experience.

It focuses on what is feasible, licensable, and buildable.

The Path to Deployment

With an MVP plant, nuclear development finally gains a runway. The first unit provides:

1. the design reference
2. the supply chain template
3. the regulatory precedent
4. the construction playbook
5. the cost and schedule data
6. and the operational experience

Each subsequent unit becomes cheaper and faster, just as it did for the U.S. in the 1960s and for South Korea in the 1990s and 2000s.

This is how industries scale — through iteration, not through perpetual reinvention.

The MVP becomes the platform on which future innovations can be tested, integrated, and, when successful, deployed at scale. Without this foundation, every new reactor concept remains trapped in FOAK purgatory.

Conclusion

The nuclear industry has long been trying to leap to the future without ever building the present. It has pursued breakthroughs rather than buildability, novelty rather than practicality, and ambition rather than iteration. An MVP reactor resets the development cycle by providing a design that can be built now, with today's supply chain, under a risk-informed regulatory regime, and with predictable outcomes.

This approach does not limit innovation — it enables it. It creates a platform on which better designs, fuels, and systems can be layered. But most importantly, it delivers what nuclear needs most: proof that we can build a reactor on time, on budget, and repeatedly.

Nuclear does not need a revolution to begin its revival.
It needs an MVP.