

Why an Approved SMR Design Is the Easy Part

What actually decides when small modular reactors ship — a reactor engineer's read on the real commercialization risks

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A small modular reactor can pass every regulatory test and still sit unbuilt for years. Three things decide whether it ships — and none of them is the reactor.

EXECUTIVE SUMMARY

The order books and the headlines make small modular reactors look imminent. From an operator's vantage, the reactor design is largely the solved part of the problem. The binding constraints sit downstream of the physics — in licensing throughput, in high-assay low-enriched uranium (HALEU) fuel supply, and in qualified manufacturing capacity. A program can hold an approved design and still be years from operating megawatts if any one of these is unresolved. This paper sets out what has to be true for the current pipeline to become delivered power, and offers a short decision lens for anyone underwriting an SMR schedule.

1 The design is the solved part

In May 2025 the U.S. Nuclear Regulatory Commission issued a standard design approval for NuScale's uprated 77-MWe power module — a 462-MWe, six-module plant, and the company's second approved design after its 50-MWe design was certified in 2023. Several other developers are advancing through the regulator in parallel. The engineering of these reactors is maturing on a predictable path.

That is exactly why design maturity is the wrong place to look for schedule risk. An approved design is a license to proceed, not a built plant. The question a buyer or an investor should ask is not 'does the reactor work' — it is whether the three systems the reactor depends on can be delivered on the same timeline.

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2 Constraint one: licensing throughput

Design approval is a single step in a longer chain. Combined operating licenses, site-specific review, and the regulator's own bandwidth set the real cadence. The NRC's Part 53 framework — a risk-informed, technology-inclusive licensing pathway whose final rule took effect in 2026 — is meant to streamline advanced-reactor review, but it is new and largely untested at scale; today's first movers still

ride the established Part 50/52 path.

For a program, this means schedule risk lives in the review queue, not in the reactor. A realistic plan matches its licensing route to its design maturity and to how much novelty the regulator is being asked to absorb at once.

3 Constraint two: HALEU fuel

Most advanced and small modular designs call for HALEU — uranium enriched up to 19.75%, well above the ~5% of today's light-water fleet. Commercial HALEU supply barely exists. The U.S. Department of Energy is standing it up: it has allocated feedstock to advanced developers, delivered the first HALEU to a fuel fabricator at Oak Ridge in early 2026 — enough for a first microreactor core — and directed roughly \$2.7 billion toward strengthening the enriched-uranium supply chain.

The reason HALEU is structurally scarce is physical, not political. Enriching to 19.75% takes far more separative work than reactor-grade fuel — about 45 SWU per kilogram of product versus about 8 for 4.5% fuel (see figure). A design that needs HALEU is therefore tied to a fuel timeline it does not control.

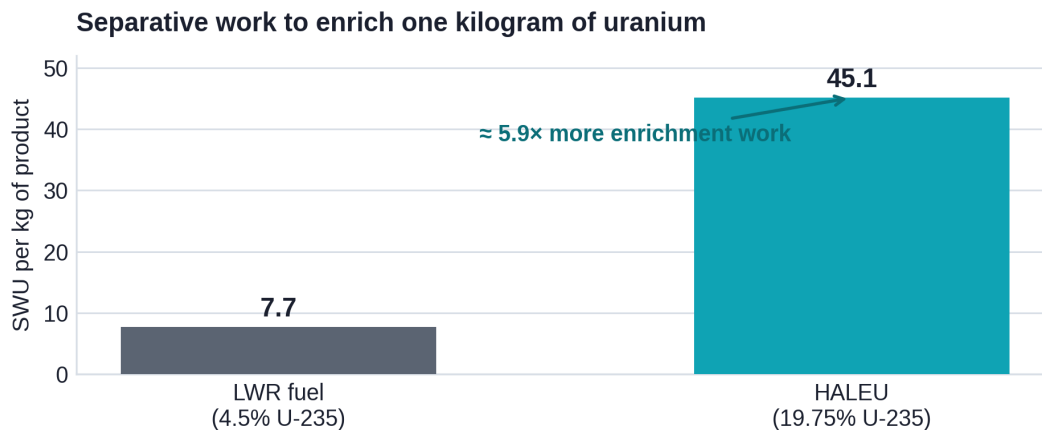


Figure 1 — Separative work (SWU) required per kilogram of product. HALEU at 19.75% demands roughly 5.9× the enrichment effort of 4.5% light-water fuel, which is why HALEU capacity cannot scale on the same curve as conventional enrichment. Separative-work calculation; assumes natural feed at 0.711% U-235 and 0.20% tails assay. The ~5.9× ratio holds across tails assumptions.

4 Constraint three: qualified manufacturing capacity

The scarce input in nuclear manufacturing is not press tonnage or raw steel — it is qualified capacity: the NQA-1-governed machining, welding, non-destructive examination, and records work that turns a forging into a component a regulator will accept. SMRs do not remove this constraint; by multiplying the number of units and suppliers, they multiply the number of qualified supply chains that must exist at once.

A fleet of small reactors competes for the same narrow base of qualified suppliers that a handful of large plants would have used. First-of-a-kind units feel this most, before any learning curve has had a chance to lower cost.

5 What has to be true

A program worth underwriting can show four things at once:

- ✓ A licensing path matched to design maturity — and to how much novelty the regulator must absorb at once.
- ✓ A secured fuel route — a named HALEU (or LEU) source and a delivery date that precedes fuel load, not a market that 'should' exist.
- ✓ Qualified-supplier commitments — not tonnage, but NQA-1-qualified machining, welding, NDE, and records capacity under contract.
- ✓ A realistic first-of-a-kind cost and learning curve — priced before the fleet economics are assumed.

6 The honest read

The technology is not the gating risk for SMRs. Timelines will be set by fuel availability, licensing throughput, and qualified manufacturing capacity — three constraints that move slowly and largely independently of how good the reactor is. A schedule that quietly assumes all three resolve on their own is the one to treat with caution. The developers who ship first will be the ones who treated fuel, licensing, and supplier qualification as the main project — not as paperwork around the reactor.

ABOUT THE AUTHOR

Elliot Marsh is a commercial reactor engineer and the author of NeutronRise, writing on reactor physics, fuel cycle, and nuclear manufacturing & quality. Every figure in NeutronRise work is verified against primary sources — NRC, DOE, IAEA, WNA, and NEI.

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