

WHITE PAPER

# Nuclear Tax Credit Compliance:

PFE Supply Chain Exposure, Compliance Costs, and the Challenge of  
Building at Scale

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## Good Energy Collective

Good Energy Collective (GEC) is a nuclear policy and research organization focused on the practical implementation of nuclear energy at scale. This white paper is part of GEC's series on supply chain constraints and federal policy design for the nuclear buildout.

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Component-level data underlying this analysis is available to policymakers, developers, lenders, and project financiers on request. The model can be run against any proposed regulatory scenario to show compliance impact across the current pipeline.

# 1 Introduction

The §45Y production tax credit and §48E investment tax credit, created under the Inflation Reduction Act of 2022,<sup>1</sup> are the principal federal tax incentives for new nuclear construction. The One Big Beautiful Bill Act (OBBBA, Pub. L. 119-21, 2025) conditioned those credits on a new supply chain compliance test.<sup>2</sup> A nuclear project must demonstrate that the share of its direct manufactured-product costs traceable to Prohibited Foreign Entities (PFE) falls below a statutory threshold. The threshold ranges from a maximum of 60% PFE content for projects beginning construction in 2026 to a maximum of 40% for projects beginning construction in 2030 and after. The test is binary: at or above the threshold, the entire credit is forfeited. There is no partial credit.

This paper presents the results and methodology of Good Energy Collective's PFE Compliance Model: what the test costs across current pipeline scenarios, which components drive the compliance burden, and why the challenge differs fundamentally by reactor type and queue position.

The analysis yields two primary findings. For conventional light water reactors, specifically the AP1000, the only large reactor design completing US construction in the modern era, compliance is achievable for early-queue projects but deteriorates rapidly as the global reactor pipeline grows. The supply chains that enable compliance are finite and globally shared: allied heavy forgers, turbine-generator manufacturers, and transformer producers serve reactor builds across multiple designs and geographies. As the global reactor pipeline grows, AP1000 projects compete for forging and manufacturing capacity alongside EPR, APR1400, ABWR, and other reactor designs being planned and built on the same timelines as new US reactors. As concurrent builds multiply, that capacity exhausts, and later-queue projects face rising PFE exposure and steeper compliance costs.

For advanced reactor designs the problem is also structural. These reactors will face similar challenges but also have several components for which there are zero or limited commercial allied suppliers at scale today. Federal programs are actively building those supply chains, but until they come online, the compliance framework will face difficulty accommodating these advanced nuclear technologies.

The analysis is based on a component-level model covering 125 discrete manufactured products and components across both reactor types, enumerated from the GNCA code-of-accounts structure and the INL literature review of advanced reactor cost estimates.<sup>3</sup> These components cover approximately 34% to 44% of total project cost. Civil and structural work, craft and construction labor, engineering and design services, project management, contingency, and indirect costs are excluded from both the numerator and denominator of the MACR calculation, consistent with the narrow denominator approach under Notice 2026-15.<sup>4</sup> Full component-level detail, including GNCA account coverage, PFE exposure estimates, and cost shares, is documented in the accompanying Technical Appendices. Results use the two-layer trace methodology established by IRS Notice 2026-15: PFE exposure is traced to Manufactured Products and their direct Manufactured Product Components, consistent with the minimum depth that notice requires for clean energy facilities.

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<sup>1</sup>Inflation Reduction Act of 2022, Pub. L. 117-169, 136 Stat. 1818 (August 16, 2022). Created §30D Advanced Clean Vehicle Credit (first major FEOC restrictions in the Internal Revenue Code); §45Y Clean Electricity Production Credit; §48E Clean Electricity Investment Credit; and domestic content bonus provisions under §45Y(g)(11) and §48E(a)(5).

<sup>2</sup>One Big Beautiful Bill Act, Pub. L. 119-21 (2025), §§ 45Y, 48E, 7701(a)(51)-(52).

<sup>3</sup>Idaho National Laboratory, INL/RPT-23-72972, "Literature Review of Advanced Reactor Cost Estimates" (2023).

<sup>4</sup>IRS Notice 2026-15 (February 2026).

## 2 Context

### 2.1 The Federal Tax Credit Structure

The §45Y production tax credit and §48E investment tax credit are the principal federal financing mechanisms for new nuclear construction. For a large reactor project, the §48E ITC is foundational to the capital structure: it converts a substantial portion of project cost into a present-value cash benefit that makes the project financeable. At current cost levels the credit is not a marginal improvement, it is the condition under which a project attracts capital.

**Table 1. §48E Investment Tax Credit Rate Structure**

Credit component	Rate (% of TPC)	Per AP1000 (TPC ~\$7.4B)
Base §48E ITC (with prevailing wage and apprenticeship)	30%	~\$2,215M
+ Energy community bonus (qualifying site)	+ 10%	+ \$739M
+ Domestic content bonus (US-manufactured products)	+ 10%	+ \$739M
<b>Maximum combined rate</b>	<b>50%</b>	<b>~\$3,693M</b>
Without domestic content bonus (baseline used in this analysis)	40%	~\$2,954M

The domestic content bonus requires that a specified share of manufactured products be produced in the US.<sup>5</sup> Its achievability under current domestic manufacturing capacity is uncertain; \$2,954M (40% of TPC) is the baseline credit value used throughout this analysis.

### 2.2 The PFE Compliance Test

The OBBBA conditioned the §45Y and §48E credits on a new supply chain test: the Material Assistance Cost Ratio (MACR), defined in §7701(a)(52). The MACR is the ratio of non-PFE direct manufactured-product costs to total direct manufactured-product costs. A project passes when that ratio exceeds the applicable threshold. PFE countries are China, Russia, Iran, and North Korea, plus entities meeting the ownership, debt, or control thresholds in §7701(a)(51).

**Table 2. MACR Threshold Schedule (by beginning-of-construction year)**

Beginning of construction	Maximum PFE content allowed	Minimum non-PFE required
2026	60%	40%
2027	55%	45%
2028	50%	50%
2029	45%	55%
<b>2030 and after</b>	<b>40%</b>	<b>60%</b>

<sup>5</sup>OBBBA §45Y(g)(11), §48E(a)(5) (domestic content bonus). TPC (Total Project Cost): approximately \$7.4 billion per AP1000 unit; Good Energy Collective, PFE Compliance Model v2 (June 2026).

The threshold tightens annually through 2030, at which point it stabilizes at 40% maximum PFE content. Projects beginning construction today will place-in-service in the early 2030s, making the 40% ceiling the operative constraint for the current pipeline. The test is pass-or-fail: a project that exceeds the threshold by a single percentage point forfeits the credit in full.

IRS Notice 2026-15 established interim guidance on the three-step MACR calculation: identify Manufactured Products (MPs) and their Manufactured Product Components (MPCs); determine direct costs for each; and subtract costs attributable to PFE-produced MPs and MPCs. The 2023-2025 Safe Harbor Tables issued for the domestic content bonus identify MPs and MPCs for solar PV, onshore wind, battery energy storage, and hydropower.<sup>6</sup> Nuclear is not listed in any of those tables. Nuclear developers must apply the direct cost method using project-specific component and sourcing data.

### 2.3 The Two Reactor Bookends

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This analysis covers two reactor designs that bookend the compliance challenge facing the current US nuclear pipeline.

The AP1000 is the most commercially mature large reactor design in the US. Two units completed construction at the Vogtle site in Georgia in 2023 and 2024, the first US nuclear units to both begin and complete construction since the late 1970s.<sup>7</sup> The NRC Design Control Document is in its 19th revision.<sup>8</sup> A supply chain serving the global non-China AP1000 fleet already operates: Japan Steel Works (JSW), Doosan Enerbility, and Framatome forge reactor pressure vessels; GE Vernova builds turbine-generator sets; Urenco and Orano enrich LEU fuel. For the AP1000, compliance is a capacity and queue problem, the allied supply chain exists, but it is finite and globally shared.

The high-temperature gas reactor (HTGR) represents a different problem class. No HTGR has been built commercially in the United States. On the hardware side, nuclear-grade graphite at reactor specification, the reflector and moderator blocks that make up the core structure, has no allied supplier at commercial scale today. Allied processors exist (Toyo Tanso, SGL Carbon) but their combined capacity is constrained and insufficient to support more than a handful of concurrent builds. High-temperature metallic alloys required for the HTGR pressure boundary and heat exchanger components, including Alloy 617 and Haynes 230, have very limited allied manufacturing at nuclear qualification levels. Helium circulators operating at HTGR temperature ranges are specialty equipment with few qualified suppliers globally. For the HTGR, compliance is not a sourcing premium problem. The allied supply chain that would enable compliance does not yet exist at the scale required.

### 2.4 The Global Construction Context

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Sixty-two reactors are under construction globally as of December 2025, per the IAEA Power Reactor Information System.<sup>9</sup> Understanding who builds them and on whose supply chains they

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<sup>6</sup>IRS Notice 2023-38, 2023-33 IRB 296; IRS Notice 2024-41, 2024-26 IRB 1; IRS Notice 2025-08, 2025-8 IRB 829.

<sup>7</sup>Georgia Power / Georgia Public Service Commission, Vogtle Construction Monitoring Reports (VCM 1–45+), Docket No. 29849, 2013–2024. <https://psc.ga.gov/search/facts-docket/?docketId=29849>. Vogtle Unit 3 entered commercial operation April 2023; Unit 4 entered commercial operation June 2024. First US commercial nuclear units completed from a new construction start since 1978.

<sup>8</sup>NRC ADAMS, AP1000 Design Control Document Rev 19 (ML11171A425); X-energy Xe-100 Pre-Application Documents, NRC Docket No. 99902071. Full bibliography available on request.

<sup>9</sup>International Atomic Energy Agency, Power Reactor Information System (PRIS), Under Construction by Country, December 2025. <https://pris.iaea.org/>. Under Construction = first concrete poured; includes units where construction is currently suspended. World

draw is essential context for the AP1000 compliance analysis. A full enumeration of the global construction pipeline, with design type, country, and supply chain classification for each unit, is provided in Appendix B.

Twenty-eight are in China, built as CAP1000s and HPR1000s on predominantly domestic Chinese supply chains. Approximately 16 are Russian VVER designs under construction in Russia, Egypt, Türkiye, Bangladesh, and Iran, drawing primarily on Russian supply chains. A further six are Indian PHWRs on domestic Indian supply chains. These are significant numbers but they are not the constraint for a US AP1000 developer: they draw mainly on supply chains that are either PFE-origin or domestically captive. That said, the boundary is not absolute: Doosan Enerbility supplied reactor pressure vessels to the original AP1000 units at Sanmen and Haiyang in China,<sup>10</sup> and Siemens Energy supplied components to the Akkuyu project in Türkiye.<sup>11</sup> Allied and PFE-country supply chains are commercially interconnected, not cleanly separated.

Of the remaining units, the designs currently drawing on allied large-reactor supply chains are two EPRs at Hinkley Point C in the UK (Framatome) and two APR1400s in South Korea (Saeul 3 and 4, Doosan).<sup>12</sup> Two Japanese ABWRs and Brazil's Angra 3 are listed as under construction under IAEA's first-concrete definition but have suspended active work. No non-China AP1000 is under construction anywhere.

The AP1000 design family has 14 units under active construction, all in China and built as CAP1000s, China's localized variant of the AP1000.<sup>13</sup> Current CAP1000 construction draws primarily on domestic Chinese heavy-forging capacity. The commercial and supply relationships between allied and Chinese heavy-forging manufacturers are interconnected: early AP1000 construction at Sanmen and Haiyang drew on Doosan-supplied reactor pressure vessels. The degree to which ongoing CAP1000 builds draw on allied forging capacity cannot be fully determined from public information.

The non-China AP1000 pipeline is contracted but pre-construction. Firm contracted units include three in Poland, two in Bulgaria, and one in the Czech Republic, with construction start years in the early to mid-2030s.<sup>14</sup> A larger planned pipeline exists in Ukraine, the United States, and India at various stages of commitment. A new US project beginning procurement now would be drawing on allied forging and manufacturing capacity during the same 2028-2035 window in which this

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Nuclear Association, "Nuclear Power in the World Today" (2025), noting suspended construction at Ohma 1 and Shimane 3 (Japan) and Angra 3 (Brazil).

<sup>10</sup>World Nuclear Association, "Heavy Manufacturing of Power Plants" (op. cit.); World Nuclear News, "Vogtle reactor vessels pass final inspection," 2012 (documenting Doosan manufacture of AP1000 RPVs for Vogtle, Sanmen, and Haiyang); Framatome corporate documentation on Hinkley Point C reactor vessel delivery (December 2022 and November 2025).

<sup>11</sup>GRS (Gesellschaft für Anlagen- und Reaktorsicherheit). "Nuclear Energy Worldwide 2026." February 2026. <https://www.grs.de/en/news/nuclear-energy-worldwide-2026>. Documents Siemens Energy supply of components to Akkuyu Unit 1 and Turkish government announcement of delay attributed to Siemens Energy withholding key components (September 2024). See also World Nuclear News reporting on Akkuyu construction progress.

<sup>12</sup>World Nuclear Association, "Heavy Manufacturing of Power Plants," Information Library (accessed June 2026). <https://world-nuclear.org/information-library/nuclear-power-reactors/other/heavy-manufacturing-of-power-plants>. Documents JSW approximately 80% global market share for large forged nuclear components; combined allied capacity approximately 22 reactor pressure vessel-equivalent sets per year (JSW, Doosan Enerbility, Framatome); approximately four pressure vessels per press per year common throughput.

<sup>13</sup>Global Energy Monitor. Global Nuclear Power Tracker. June 2026. <https://globalenergymonitor.org/projects/global-nuclear-power-tracker/>. Documents 14 AP1000-derived CAP1000 units under active construction in China as of mid-2026; confirms no non-China AP1000 units under construction globally. See also World Nuclear Association, "Nuclear Power in China" (2025 edition).

<sup>14</sup>World Nuclear Association, "Plans for New Reactors Worldwide" (2025); "Nuclear Power in Poland" (2025); "Nuclear Power in Bulgaria" (2025).

European cohort enters construction. The model's N=8 scenario represents that forward concurrent demand, not a count of units presently under construction.

## **2.5 The FID Timing Problem**

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Nuclear projects take 7 to 10 years from final investment decision to commercial operation. The MACR is determined by actual procurement, which occurs after FID, over the first years of construction. A developer must therefore estimate their compliance position at FID, before the sourcing decisions that determine it have been made. Lenders need reasonable confidence that the project will pass the MACR test before they will commit capital, but that confidence must be established at the very moment when the compliance calculation cannot yet be completed. The AP1000's 1.6 percentage point margin at N=8 is not a comfortable buffer for a developer making a multi-billion dollar investment decision based on a forward estimate of a metric they cannot yet verify.

## **2.6 Legislative And Regulatory Uncertainty**

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The compliance framework for nuclear is still being developed. The OBBBA requires publication of nuclear-specific safe harbor tables by December 31, 2026. Until that guidance is in place, developers are working with an incomplete framework. This is a distinct challenge from the supply chain problems this paper documents: even a project with a well-characterized supply chain cannot finalize its compliance analysis until the rules governing that analysis are established.

## 3 Methods

### 3.1 Component Database

The model covers 125 manufactured components across the AP1000 and HTGR, organized in a relational database that links each component to its supply chain tier, cost share, PFE exposure calculation, and source documentation. Components were identified from public design documentation, regulatory filings, and engineering analyses.

**Table 3. Supply Chain Model Structure (five-level hierarchy)**

Level	Layer	Count	Primary sources
1	Raw inputs	26	USGS Mineral Commodity Summaries; IAEA Nuclear Fuel Cycle Information System; WNA fuel cycle reports
2	Materials	26	ASME/ASTM material specifications; ASM International Handbook; alloy composition databases
3	Components	125	AP1000 DCD Rev 19 (ML11171A425); HTGR pre-application documents; INL/RPT-23-72972; Vogtle regulatory filings; EPRI; ASME certificate database; UN Comtrade; full bibliography available on request
4	Assemblies	32	INL Generic Nuclear Cost Algorithm (GNCA) code-of-accounts structure
5	Plant MACR	1	Cost-weighted aggregation of component PFE fractions

### 3.2 PFE Estimation

PFE exposure for each component is estimated through a bottom-up methodology drawing on national production-share statistics from public sources.<sup>15</sup> At the raw input level, 26 elemental inputs carry a PFE share derived from country-level mining, refining, and processing production data from USGS, IAEA, and UN Comtrade. These propagate through material grades to manufactured components by cost weight.

For components where the supplier landscape is geographically narrow and well-documented, including enrichment services, TRISO fabrication, structural graphite, and specialty materials, estimates draw directly on known supplier geography and publicly available capacity data. For components with broader supplier populations, production-share statistics at the raw material tier provide the analytical foundation. Firm-level procurement data is not fully publicly available across the supply chain; this is the inherent constraint on any public-data analysis of this kind.

### 3.3 Cost Allocation

Component cost shares are derived from the INL Generic Nuclear Cost Algorithm (GNCA), INL/RPT-23-72972 (2023). The GNCA provides a standardized code-of-accounts cost breakdown structure for nuclear power plants, dividing total project cost across 32 equipment account categories. Cost shares are expressed as fractions of total direct costs of manufactured products, the MACR denominator.

<sup>15</sup>U.S. Geological Survey, Mineral Commodity Summaries (2024); International Atomic Energy Agency, Nuclear Fuel Cycle Information System (2024).

### 3.4 The Dispatch Model

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The model runs in six analytical stages:

- **Develop Database.** 125 components organized with cost shares, PFE estimates, and supply chain traceability.
- **Estimate PFE.** Bottom-up from raw input production shares through material grades to component level.
- **Allocate Costs.** INL GNCA cost shares assigned to each component.
- **Dispatch Model.** For a given project, compliance actions are dispatched cheapest-first by cost-effectiveness (dollars per point of MACR reduced) until the plant clears the applicable threshold.
- **Build Queue.** The dispatch is run sequentially for  $N = 1$  to 30 concurrent builds. As earlier-queue projects consume allied capacity, later entrants face higher PFE exposure and rising compliance costs.
- **Calculate MACR.** Cost-weighted aggregation to plant level under narrow denominator (equipment procurement costs only). Tested against the applicable threshold by beginning-of-construction year.

### 3.5 Two-Layer Trace

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All results in this paper are reported on what we term the two-layer trace. In this framework, PFE exposure is traced from the Manufactured Product (MP) level, the major equipment items and systems in the plant, down to their direct Manufactured Product Components (MPCs), the sub-components and material inputs that constitute each MP. The trace stops at the MPC level. It does not descend further to sub-components of MPCs or to raw material origin.

This two-layer structure reflects the minimum tracing depth established by IRS Notice 2026-15 for clean energy facilities and represents the compliance methodology nuclear developers must satisfy under the MACR framework. Nuclear is not covered by the 2023-2025 Safe Harbor Tables and must apply the direct cost method; this model simulates that calculation at the MP and MPC level. A full sub-tier trace extending to raw material origin was also built and is available on request; it provides a conservative upper bound on PFE exposure but is not the basis for results reported here.

### 3.6 Limitations

#### Data Scope

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This analysis draws on public regulatory filings, government databases, published industry data, and primary research. Some cost and sourcing information is not available at the firm level: vendor pricing, procurement contract terms, and fuel cycle contract terms are proprietary and not publicly disclosed. PFE exposure estimates reflect production-share data and published capacity information rather than firm-level procurement records. Supply chain capacity figures and global queue estimates are derived from public statements and industry data rather than confirmed order backlog data. Compliance costs in this paper represent documentation, qualification, and re-sourcing burden; purchase price premiums for allied over PFE-origin components are not included and may be substantial. The true economic burden of compliance exceeds what this model shows.

## **Regulatory Methodology**

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Results reflect a reasonable interpretation of the Notice 2026-15 framework applied to nuclear. Several definitional questions remain open: the scope of the denominator, the depth of required sub-tier tracing, and how fuel-cycle inputs for advanced reactor designs are classified. The nuclear-specific safe harbor tables required by December 31, 2026 will resolve these questions. Results should not be read as a legal determination of any project's MACR under the final rules.

## **What This Model Does Not Show**

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This model does not estimate purchase price premiums for allied versus PFE-origin components, the schedule cost of supplier qualification, or the compounding effects of managing multiple compliance actions simultaneously. These represent real economic burdens that a public-data model cannot quantify. The compliance costs reported here are a floor.

## 4 Findings

Five findings emerge from running the model across the current AP1000 and HTGR pipeline scenarios. Before presenting them, this section maps the supply chain risk terrain: which component categories carry the highest PFE exposure, what drives that exposure, and whether it is addressable through procurement choices or requires supply chain creation. Table 4 provides an illustrative subset of 13 components and categories. Full component-level data is available on request and will be presented in the appendix.

### 4.0 Supply Chain Risk Profile: Illustrative Component Subset

PFE risk in the nuclear supply chain falls into three distinct categories that require different responses. Understanding which category a component belongs to is the first analytical step for any compliance program.

**Table 4. Illustrative PFE Risk Profile, Selected Components and Categories (two-layer trace; AP1000 figures at N=1 unless noted; full component database available on request)**

Component / Category	Reactor	PFE Exposure	Risk Category	Primary Driver
<b>Category A: Structural barriers, allied supply does not exist at commercial scale</b>				
HALEU enrichment (19.75% U-235)	HTGR	~90%	Structural gap	No commercial allied enricher. Centrus Picketon: ~900 kg/yr vs. ~1,750 kg/yr per module annual requirement.
TRISO fuel pebbles	HTGR	~56%	Structural gap	No commercial allied pebble fabrication facility operational. X-energy TRISO-X (Oak Ridge, TN) under NRC licensing and active construction.
Nuclear-grade graphite (HTGR specification)	HTGR	~80% feedstock	Structural gap	~79% of global graphite feedstock is Chinese-controlled. Allied processors (Toyo Tanso, SGL Carbon) capped at ~4 reactor-equivalents/yr.
SiC coating (TRISO pebble shell)	HTGR	~45%	Structural gap	Limited non-PFE SiC chemical vapor deposition capacity at TRISO specification and volume.
Lithium-7 (coolant chemistry)	AP1000	~95%	Structural gap	Only China and Russia produce Li-7 at commercial scale. Domestic production capability is years and ~\$10-12M from operation. [19]
<b>Category B: Capacity-constrained, allied supply exists but is finite and globally shared</b>				
Reactor pressure vessel (RPV) and internals forgings	AP1000	0% at N=1 → ~35% at N=8	Queue-dependent	JSW + Doosan Enerbility + Framatome: ~22 large nuclear-grade forgings/yr globally. Near capacity at N=8 across all non-China builds.
Steam generator forgings and channel heads	AP1000	0% at N=1 → ~30% at N=8	Queue-dependent	Same allied forging pool. Each AP1000 requires two steam generators; four SG channel heads per plant.
Turbine-generator sets (1,117 MWe class)	AP1000	0% at N=1 → rising	Queue-dependent	GE Vernova is the dominant allied supplier for large nuclear turbine-generators. Alternative allied capacity is limited.
<b>Category C: Elevated sub-tier or material exposure, addressable through CGD, re-sourcing, or qualification</b>				
Large power transformers (≥ 345 kV)	AP1000	~25-35%	Elevated	Chinese manufacturers hold significant global market share. US capacity is constrained; qualification of new allied

Component / Category	Reactor	PFE Exposure	Risk Category	Primary Driver
				sources requires CGD and long lead times.
Grain-oriented electrical steel (GOES)	Both	~30-40%	Elevated	China accounts for approximately 30% of global GOES production. Japan and South Korea are primary allied alternatives but at premium pricing.
I&C / PLC / DCS systems (sub-tier)	Both	~45-60% (sub-tier)	Elevated (sub-tier)	More than 60% of global backend semiconductor ATP capacity is in China and Taiwan. [20] Electronics appear compliant at the box level but carry sub-tier PFE through IC packaging and board-level assembly.
Zirconium alloy cladding and structural tube	AP1000	~15-25%	Manageable	Kazakhstan is the primary Zr producer but allied fabricators (Framatome, Global Zirconium, ATF) produce finished cladding. Sourcing premium required; re-qualification manageable.

Category A components cannot be brought into compliance through procurement choices regardless of price. They require supply chain creation, building or scaling allied enrichment, fabrication, or processing capacity that does not yet exist. Category B components are compliant today but will become non-compliant as the pipeline grows beyond the allied capacity ceiling. Category C components are addressable but at cost: commercial-grade dedication, source qualification, or sourcing premiums are required. The compliance cost estimates in this paper are primarily a function of Category B and C components. Category A components produce unclosable gaps.

**Finding 1. AP1000 compliance is achievable early but erodes sharply as the global queue fills**

A single AP1000 project built today carries 0% PFE exposure under the two-layer analysis with allied sourcing. The compliance challenge is not the reactor design. It is what happens when more projects join the queue.

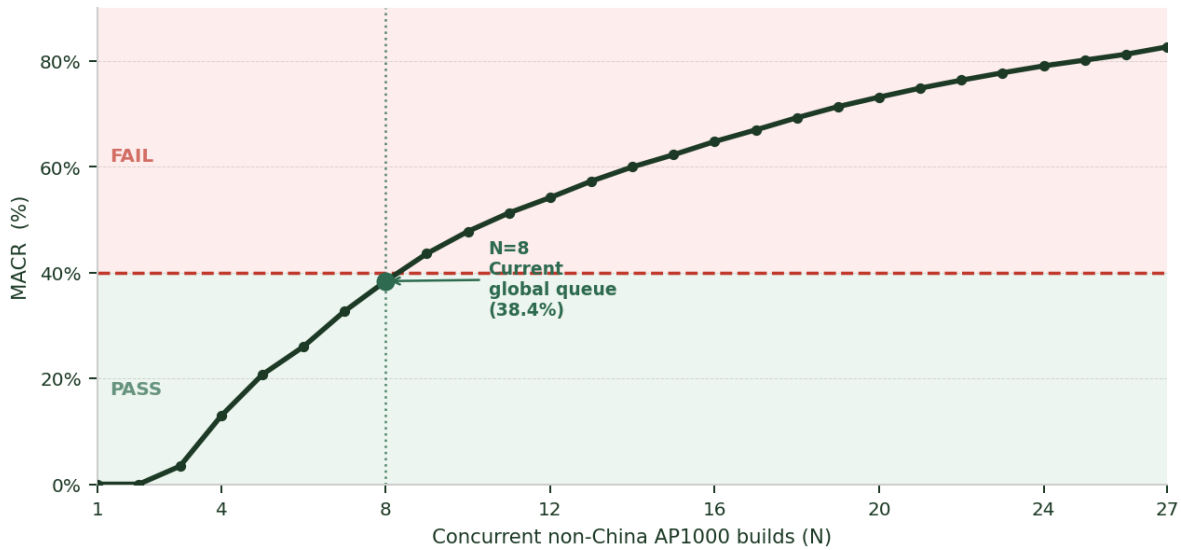
Allied manufacturing capacity for the AP1000 is global and shared. Japan Steel Works (JSW), Doosan Enerbility, and Framatome are the principal allied suppliers of large nuclear-grade forgings: reactor pressure vessels, steam generator channel heads, and pressurizer components. Their combined capacity of approximately 22 large nuclear-grade forgings per year also serves non-AP1000 programs globally, including the EPR builds in the UK and APR1400 builds in South Korea. As the contracted non-China AP1000 wave, Poland, Bulgaria, Czech Republic, and prospective US units, enters construction in the 2028-2035 window, that capacity will be simultaneously committed to multiple concurrent builds. The model’s N=8 scenario represents forward concurrent demand within that window.

At N=8 concurrent builds, the MACR under the narrow denominator reaches 38.4%, 1.6 percentage points from the 2030+ threshold of 40%.<sup>16</sup> A single additional project crosses the threshold entirely. Figure 1 shows the continuous escalation from N=1 to N=27.

Figure 1. AP1000 MACR escalation by concurrent non-China AP1000 build count (two-layer trace, narrow denominator; N=8 represents forward concurrent demand in 2028-2035 procurement window)

<sup>16</sup>Good Energy Collective, PFE Compliance Model v2 (June 2026). All MACR outputs, scenario results, and compliance cost estimates derive from this model. Data available on request.

Figure 1. AP1000 MACR escalates with the global build queue  
Two-layer trace, narrow denominator (Notice 2026-15 basis)



The escalation is not linear. It accelerates between N=3 and N=9 as allied forging capacity exhausts, then flattens as the incremental demand each new project places on PFE-share capacity diminishes. The inflection point, where the curve steepens, coincides with the depletion of the three principal allied forging facilities.

Table 5. AP1000 MACR and Compliance Cost by Global Pipeline Scenario (narrow denominator; N = concurrent non-China AP1000 builds globally; higher scenarios illustrative)

Scenario	AP1000 MACR	Status vs. 2030+ threshold	Compliance cost (N-th project, per plant)	Cost as % of ITC (40%)
First-mover baseline (N=1)	0.0%	<b>PASS (40 pts margin)</b>	\$37M	1.3%
<b>Contracted European cohort + one US start (N=8), forward concurrency in 2028-2035 procurement window</b>	<b>38.4%</b>	<b>PASS (1.6 pts margin)</b>	<b>\$338M</b>	<b>11.4%</b>
US growth scenario (N=17), illustrative	67.0%	<b>FAIL (-27 pts)</b>	\$632M	21.4%
Expanded buildout (N=27), illustrative	82.7%	<b>FAIL (-42.7 pts)</b>	\$955M	32.3%

Compliance costs in Table 5 are per plant for the N-th project, not a fleet total. The first project pays \$37M in qualification and sourcing burden. The eighth pays \$338M, 11.4% of the \$2,954M ITC value at the 40% rate. These are floor estimates: they exclude purchase price premiums paid for allied over PFE-origin components and capital investment required where allied capacity must be built from scratch.

At N=17 and N=27 the MACR threshold is breached regardless of compliance spending. No amount of documentation or re-sourcing brings those projects below 40% because the required allied capacity does not exist at those demand levels. The compliance cost figures for those scenarios represent the transaction floor on a failing project, money spent before the project forfeits the credit entirely.

Figure 2. AP1000 MACR by pipeline scenario: component breakdown (stacked bar by major supply category; two-layer trace, narrow denominator)

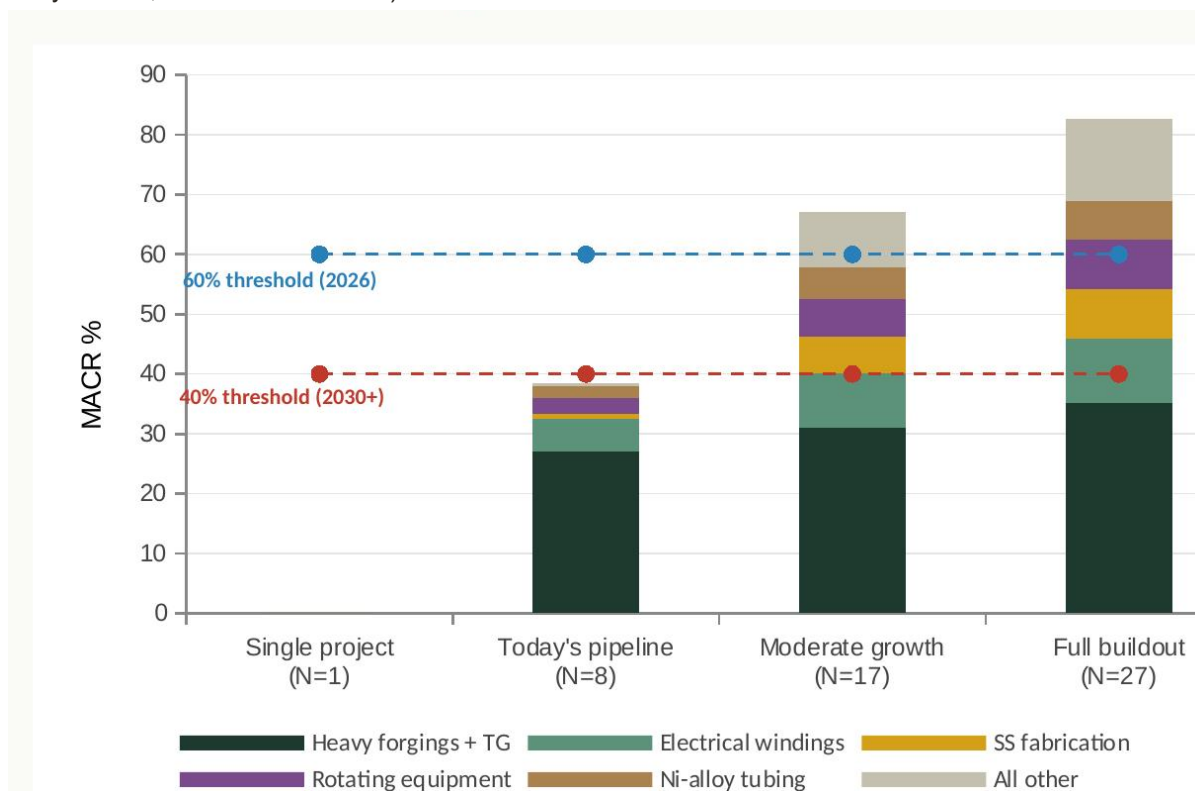


Figure 2 shows what drives the escalation. Heavy forgings and turbine-generators (the dominant dark bar) are the principal driver because they require the largest allied-capacity allocation per plant and because global allied throughput in both categories is concentrated among three or four manufacturers. As N rises, those manufacturers' annual output is allocated to earlier-queue projects, and the blended PFE fraction for heavy forgings rises as market-share capacity includes PFE-controlled manufacturers.

## Finding 2. HTGR compliance is structurally constrained, spending alone cannot close the gap

The HTGR result is qualitatively different from the AP1000. For the AP1000, compliance cost is the premium of switching to allied suppliers when allied capacity is tighter than demand. For the HTGR, the supply chains for several components central to the design have no commercial allied supplier at scale today. There is no premium that resolves that gap.

### The Structural Baseline

A single HTGR project already carries 14.3% PFE exposure before any capacity constraint applies. That baseline reflects the concentration of HTGR-specific materials and components in PFE supply chains, a function of the reactor's design requirements rather than procurement choices.

The hardware dimensions of that concentration are specific. Nuclear-grade graphite at reactor specification, the material used for core reflector and moderator blocks, has approximately 80% of its feedstock production under Chinese control. Allied processors capable of producing graphite at

HTGR specification, primarily Toyo Tanso and SGL Carbon, have combined annual output of approximately four reactor-equivalents. High-temperature metallic alloys required for the HTGR pressure boundary and heat exchanger components, including Alloy 617 and Haynes 230, have very limited allied manufacturing at nuclear qualification levels. Helium circulators operating at HTGR temperature and pressure conditions are specialty equipment with few qualified suppliers globally. These are not components where an allied alternative exists and simply costs more. In several cases, no commercially qualified allied alternative exists.

The AP1000 starts at 0% PFE under the two-layer trace because its principal hardware components have qualified allied OEM manufacturers in operation. The HTGR starts at 14.3% because the equivalent allied manufacturing infrastructure for several of its hardware categories does not exist at commercial scale.

### Capacity Constraints And Threshold Breach

As concurrent HTGR builds increase, capacity constraints on graphite processing and other HTGR-specific components accelerate the escalation beyond the structural baseline. The threshold is crossed at five concurrent builds.

**Table 6. HTGR MACR by Concurrent Build Count (two-layer trace, narrow denominator)**

Concurrent HTGR builds	HTGR MACR	Status vs. 2030+ threshold (40%)
N=1	14.3%	<b>PASS (25.7 pts margin)</b>
N=4	39.9%	<b>PASS (0.1 pts margin)</b>
<b>N=5 , threshold crossed</b>	<b>46.0%</b>	<b>FAIL (-6 pts)</b>
N=8	55.2%	<b>FAIL (-15.2 pts)</b>

Figure 3. HTGR MACR by build count: structural baseline and capacity-constrained exposure (two-layer trace, narrow denominator)

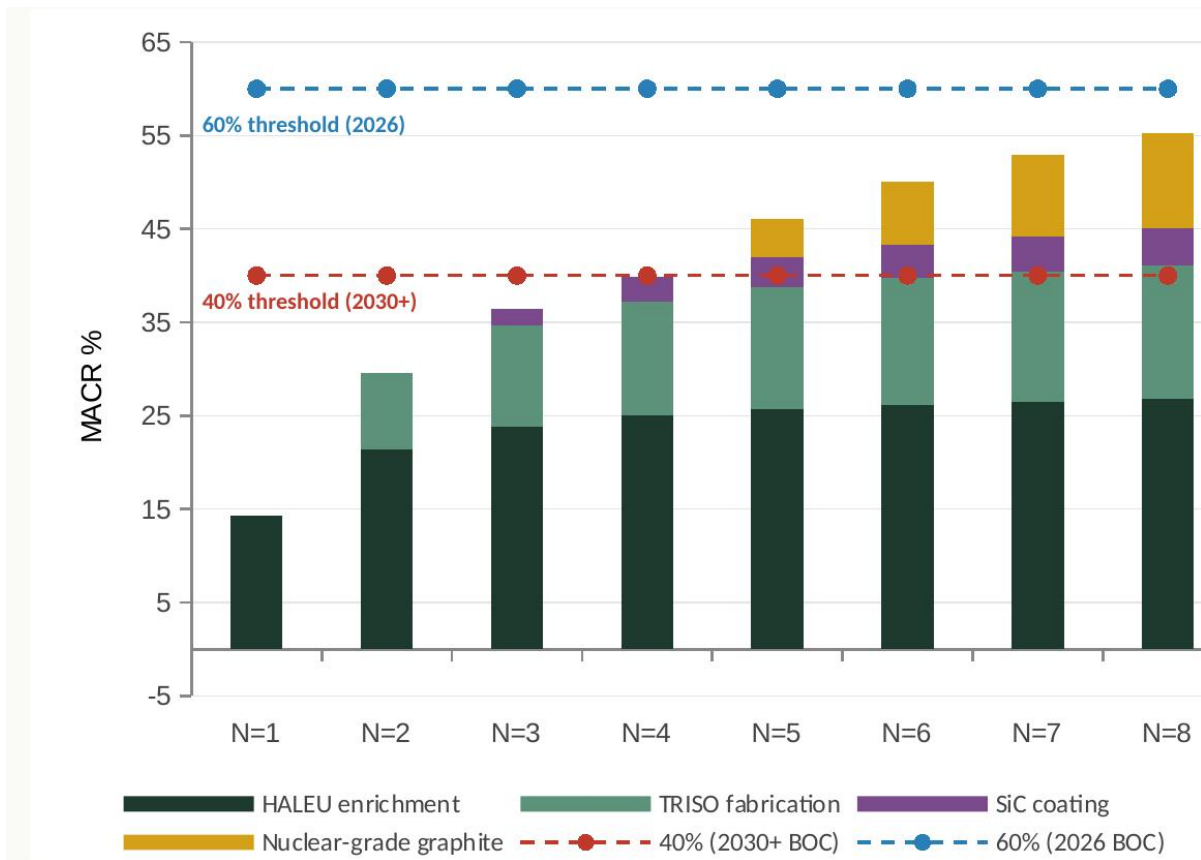
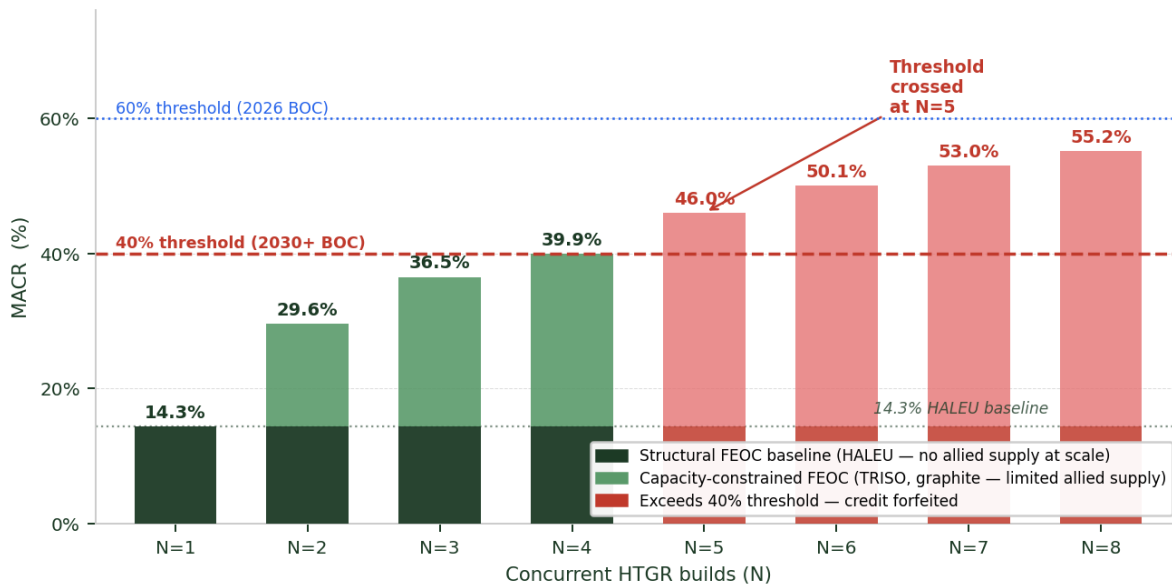


Figure 4. HTGR MACR escalation showing structural baseline (HALEU-driven floor and capacity-constrained additions)

Figure 2. HTGR MACR: structural baseline plus capacity constraints  
Two-layer trace, narrow denominator (Notice 2026-15 basis)



Three hardware categories drive the structural PFE exposure for the HTGR:

**Nuclear-grade graphite at reactor specification (~80% PFE feedstock).** The HTGR core consists of graphite reflector and moderator blocks that must meet reactor-grade purity and dimensional tolerances not required in commercial graphite applications. Approximately 80% of global graphite feedstock production is Chinese-controlled.<sup>17</sup> Non-PFE processors capable of producing graphite at HTGR specification are primarily Toyo Tanso (Japan) and SGL Carbon (Germany), with limited combined annual output. Allied graphite processing capacity is the binding constraint on concurrent HTGR builds: the MACR threshold is crossed at five concurrent builds as this capacity ceiling is reached.

**High-temperature metallic alloys (~moderate PFE).** The HTGR pressure boundary and heat exchanger components require specialty alloys qualified for operation above 700°C, primarily Alloy 617 and Haynes 230. Allied manufacturing of these alloys at nuclear qualification levels is very limited. Few suppliers globally have demonstrated production of these materials to ASME nuclear code requirements at the quantities an HTGR construction program would require.

**Helium circulators (~moderate PFE).** The primary and secondary helium circulators are the principal rotating equipment in an HTGR and operate under conditions of temperature, pressure, and gas chemistry that have no direct commercial analogue. Qualified allied suppliers of helium circulators at HTGR specification are few, and production lead times are long.

Beyond these hardware categories, additional supply chain constraints exist in the fuel cycle, but the fuel cycle is not the basis of the model results reported here. The hardware categories above are sufficient to produce the MACR escalation shown in Table 6.

Other advanced reactor designs face comparable or greater structural compliance challenges. Molten salt reactors, sodium fast reactors, and other advanced designs dependent on specialty materials or novel fuel forms carry similar PFE concentration profiles, compounded in some cases by additional specialty material requirements that have no commercial allied supply at any scale. The HTGR findings should be read as representative of a broader class of advanced reactor compliance challenges, not as a design-specific outlier.

### **Finding 3. AP1000 compliance costs are substantial and rise with queue position**

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Compliance cost for an AP1000 project is not a fixed property of the design. It is a function of where that project sits in the global build queue. This distinction matters because the queue is not hypothetical. As established in Section 2.4, the contracted European AP1000 pipeline, three units in Poland, two in Bulgaria, and one in the Czech Republic, is expected to enter construction and active procurement in the same 2028-2035 window as any new US reactor beginning development today. A US project entering procurement now does not enter at N=1. It enters at approximately N=8, the forward concurrent demand on allied manufacturing capacity when the European cohort is included. That is the baseline scenario, not a stress test.

Table 7 presents compliance costs across four queue scenarios for the AP1000. The first-mover scenario (N=1) represents a project that enters the allied supply chain before the European cohort begins procurement. The N=8 scenario represents the current contracted pipeline reality. The N=17 and N=27 scenarios are illustrative of a larger US buildout under the executive order targets, and are

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<sup>17</sup>U.S. Geological Survey, Minerals Yearbook, Volume III: Area Reports: International, China (2020–2021), published 2023. <https://pubs.usgs.gov/myb/vol3/2023/myb3-2023-china.pdf>. Natural graphite: China accounted for approximately 79% of world production in 2021. See also USGS Mineral Commodity Summaries (annual) for current graphite production data.

provided to show the trajectory of cost escalation across the full range of plausible pipeline outcomes.

**Table 7. AP1000 Compliance Cost by Queue Scenario (per-plant cost for the N-th project; narrow denominator; N = concurrent non-China AP1000 builds globally)**

Scenario	N	AP1000 MACR	Status vs. 2030+ threshold	Compliance cost (N-th project)	Cost as % of ITC (40%)
First-mover baseline	1	0.0%	<b>PASS (40 pts margin)</b>	\$37M	1.3%
<b>Current forward concurrency (contracted European cohort + one US start)</b>	<b>8</b>	<b>38.4%</b>	<b>PASS (1.6 pts margin)</b>	<b>\$338M</b>	<b>11.4%</b>
US growth scenario (illustrative)	17	67.0%	<b>FAIL (-27 pts)</b>	\$632M	21.4%
Expanded buildout (illustrative)	27	82.7%	<b>FAIL (-42.7 pts)</b>	\$955M	32.3%

The compliance cost at N=8, \$338M per project, representing 11.4% of the \$2,954M ITC value, is not a marginal overhead. It is a material project cost that must be incorporated into financing models, developer budgets, and policy evaluations of credit effectiveness. A developer treating compliance as an administrative formality will find that the actual program, with its supplier audits, qualification engineering, commercial grade dedication work, potential re-sourcing, and component redesign, carries a price tag that is visible in the project economics. And \$338M is itself a floor estimate: it excludes the purchase price premium for allied over PFE-origin components, the schedule costs of supplier qualification, and the compounding burden of managing multiple compliance actions simultaneously.

The mechanism connecting queue position to compliance cost is the finite capacity of the allied manufacturing pool. The three principal capacity-constrained categories for the AP1000 are heavy nuclear-grade forgings (reactor pressure vessels, steam generator heads, and primary circuit components), large turbine-generator sets, and high-voltage power transformers. Each of these is produced by a small number of qualified allied manufacturers. Japan Steel Works, Doosan Enerbility, and Framatome together produce approximately 22 RPV-equivalent forging sets per year. GE Vernova and Mitsubishi are the primary allied turbine-generator suppliers for AP1000-class plants. The large transformer supply chain has few qualified nuclear-grade producers globally.

At N=1, a project can secure allied capacity across all three categories at standard cost and lead time. The allied pool has slack. As N increases and the contracted European projects begin procurement, slack disappears. A project entering at N=8 competes for the same forging slots, turbine delivery windows, and transformer production schedules that the Polish, Bulgarian, and Czech projects have already begun to claim. Where allied capacity is available, it comes at higher cost and longer lead time. Where it is fully subscribed, the compliance action that depended on it, re-sourcing from a PFE-origin manufacturer to a specific allied OEM, becomes unavailable or requires the developer to establish a new qualification on a non-preferred supplier, which itself carries engineering cost and schedule risk.

This is why compliance cost at N=8 is nine times higher than at N=1, not two or three times higher. It is not that the documentation overhead increases nine-fold. It is that the sourcing and qualification actions available to a first-mover, secure a slot at JSW, qualify Doosan as an alternative, source

turbine components from GE Vernova on standard terms, are progressively more expensive and in some cases unavailable by the time an eighth project enters procurement. The dispatch model in Section 3.5 captures this: compliance actions are ordered by cost-effectiveness and dispatched cheapest-first. As the cheapest actions become unavailable due to capacity exhaustion, the model dispatches progressively more expensive alternatives. The resulting cost curve reflects the depletion of low-cost options as the queue fills.

## What Each Cost Category Represents

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Documentation, audit, and tracing is the fixed compliance overhead that every project pays regardless of sourcing decisions or queue position. It covers the engineering hours required to establish and maintain origin records for each in-scope component, structured by safety class: nuclear safety-related components require more intensive tracing and documentation than balance-of-plant equipment. It includes first-tier supplier audits at qualified OEMs and selected second-tier supplier audits for components where PFE content sits below the first-tier manufacturer (notably electronics, instrumentation, and control components where semiconductor and rare earth content carries significant PFE exposure at the sub-component level). This cost is relatively stable across queue positions because it reflects the compliance program architecture, not the difficulty of finding allied supply.

Sourcing, commercial grade dedication, and redesign covers the project-level cost of switching from a PFE-origin supplier to an allied alternative. Where an allied OEM exists and is available, this cost covers the engineering and testing required to qualify that OEM through commercial grade dedication: writing the qualification plan, testing to the applicable code and standard, witnessing production, and documenting the dedication. For components where no drop-in allied alternative exists, it covers the engineering analysis, redesign, and re-qualification required to use a substitute component or material. This category is the primary driver of cost escalation with queue position. As allied capacity tightens and availability narrows, CGD programs must target less-preferred suppliers, accept longer qualification timelines, or pursue redesign solutions that were not the first choice. Each of these paths costs more than the standard CGD of a preferred, available allied OEM.

Supply chain development is zero for the AP1000 at all queue positions. The allied manufacturing infrastructure for AP1000 major components exists. The compliance challenge for the AP1000 is managing within an existing supply chain that is under pressure, not building a new one. This is the fundamental difference between the AP1000 and the HTGR, and it is why the cost structures diverge so sharply.

Program overhead covers the project management, legal, and administrative costs of running a compliance program: tracking component traceability records through engineering, procurement, and construction; maintaining documentation for Treasury audit; managing supplier qualification records; and coordinating the compliance program with the broader EPC timeline.

### **The N=8 scenario is not conservative**

A US project beginning procurement today does not enter at N=1. It enters behind the contracted European AP1000 cohort (Poland, Bulgaria, Czech Republic) whose procurement timelines overlap with the 2028-2035 window for any new US reactor. It also enters a forging and manufacturing market already serving Korean APR1400s, UK EPRs, and Japanese ABWRs drawing on the same allied capacity pool. The \$338M compliance cost at N=8 is not a tail risk. It is the expected cost for a

project entering procurement under current market conditions. A first-mover advantage, and its associated \$37M compliance cost, is available only to a project that secures allied supplier commitments before the European pipeline claims that capacity. That window is narrowing.

#### **Finding 4. HTGR compliance cost is dominated by supply chain infrastructure, not procurement overhead**

The HTGR compliance finding is structurally different from the AP1000. For the AP1000, the compliance problem is one of capacity and cost: the allied supply chain exists, and the question is whether a project can secure access to it at reasonable cost before the queue fills. For the HTGR, the compliance problem is one of supply chain existence: for several principal hardware categories, the allied manufacturing infrastructure that would enable compliance is not present at commercial scale today. This distinction has direct implications for what compliance investment can and cannot accomplish.

A developer facing high AP1000 compliance costs at N=8 has recourse: earlier procurement, deposits to hold forging slots, aggressive CGD programs, and redesign to reduce PFE exposure in specific components. These are expensive actions, but they are executable. A developer facing HTGR structural supply chain gaps does not have equivalent recourse. Spending more on procurement does not create allied manufacturing capacity that does not exist. The constraint is industrial, not financial.

Table 8 presents the first-mover HTGR compliance cost breakdown. The total of \$240M at N=1 already exceeds the \$338M AP1000 cost at N=8 in structural character, if not yet in absolute magnitude, because \$193M of it, 80% of the total, represents capital investment in industrial infrastructure rather than procurement overhead.

**Table 8. HTGR Compliance Cost: First-Mover Breakdown (per-plant, N=1 baseline; Xe-100 four-pack, 320 MWe; ITC at 40% of TPC as reference)**

Cost category	Cost	Notes
Documentation, audit, and tracing	\$13.5M	Lower than AP1000 because HTGR compliance problem is concentrated in fewer, larger component categories rather than distributed across 108 components
Sourcing, commercial grade dedication, and redesign	\$31.3M	Higher than AP1000 because CGD burden on HTGR-specific hardware is substantially greater than on conventional LWR mechanical equipment; fewer established qualified sources
Supply chain development (allied capacity creation)	\$193.0M	Capital investment required to establish allied manufacturing capacity for HTGR-specific hardware categories that does not currently exist at commercial scale. This is industrial infrastructure investment, not a procurement cost.
Program overhead	\$2.5M	
<b>Total compliance cost</b>	<b>\$240.3M</b>	
ITC (40%) value (reference)	\$1,266M	Based on TPC of approximately \$3.2B for Xe-100 four-pack
Compliance as % of ITC (40%)	19.0%	First-mover, N=1; HTGR threshold also breached at N=5 from capacity constraints

The \$193M supply chain development cost warrants specific examination because it is unlike the other three categories. Documentation cost is an administrative burden. Sourcing and CGD cost is a qualification burden. Both are forms of compliance overhead, costs that arise from the requirement to demonstrate compliance. Supply chain development cost is different in kind: it is the estimated capital required to bring allied manufacturing capacity for HTGR-specific hardware components into existence at commercial scale. It is a prerequisite to compliance, not a cost of demonstrating it. A developer who does not make this investment cannot comply, regardless of the sophistication of their procurement program or the resources dedicated to documentation and qualification.

The hardware categories that drive this cost are described in Finding 2. Nuclear-grade graphite at reactor specification is the largest single contributor: establishing and qualifying a new processing line for HTGR-specification graphite at allied facilities requires capital investment in equipment and process development that is not replicable through procurement contracts with existing suppliers at their current scale. High-temperature metallic alloys and helium circulators at HTGR specification add further investment requirements, each requiring qualification programs at nuclear code standards for equipment that has no direct commercial analogue in the allied industrial base.

The practical consequence is that the HTGR compliance cost structure does not respond to the same policy instruments as the AP1000. For the AP1000, early procurement, slot reservations, and qualification investment reduce compliance costs and preserve optionality. For the HTGR, individual developer action is insufficient to close the gap. The \$193M per first-mover project is a floor: it reflects what a single project would need to invest assuming no shared infrastructure. Fleet-scale deployment would reduce the per-project cost as infrastructure is amortized across multiple projects, but that requires coordinated investment at a scale no single developer would undertake unilaterally for a technology that cannot yet confirm it will pass the compliance test.

At 19% of the \$1,266M ITC value at the first-mover baseline, HTGR compliance cost is already significant before any queue effects apply. Unlike the AP1000, where MACR and compliance cost are both functions of N, the HTGR faces a structural cost regardless of queue length. The MACR also escalates with concurrent builds: the threshold of 40% is breached at five concurrent HTGR builds, as documented in Finding 2 and Table 6. At that point, the compliance framework cannot be satisfied regardless of compliance spending. The combination of high first-mover cost and low threshold breach point defines the compliance challenge for the HTGR: it is not a problem that scales away with deployment, and it is not a problem that resolves with sufficient spending. It is a problem that requires allied industrial capacity to exist before it can be addressed.

## 5 Conclusions

### 5.1 Two Categories Of Compliance Challenge

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The findings of this analysis identify two structurally distinct categories of PFE compliance challenge for the nuclear sector. Understanding the distinction between them is prerequisite to understanding what the compliance framework can and cannot accomplish.

The first category is a capacity and queue challenge. For the AP1000, the allied supply chain exists: qualified manufacturers produce reactor pressure vessels, steam generators, turbine-generators, and transformers at nuclear specification, and non-PFE sources supply LEU enrichment at commercial scale. The compliance challenge is securing access to those manufacturers at reasonable cost before the global queue fills. At N=1, that access is available and compliance is manageable. At N=8, which is the forward concurrency level a new US project faces given the contracted European pipeline, compliance costs reach \$338M per project, representing 11.4% of the ITC value, before any MACR threshold violation occurs. The constraint is not the existence of allied supply, but its capacity relative to global demand. This is a problem that responds to policy interventions: early procurement, slot reservations, investment in allied capacity expansion, and transitional provisions that reflect the time required to close capacity gaps.

The second category is a structural challenge. For the HTGR and other advanced reactor designs, the allied manufacturing infrastructure for several principal hardware categories does not exist at commercial scale today. This is not a capacity constraint in the sense of too much demand relative to available supply. It is an absence of qualified allied supply at any scale. No level of compliance spending, no early procurement decision, and no CGD program can resolve a supply chain that has not yet been built. The hardware categories implicated include nuclear-grade graphite at reactor specification, high-temperature metallic alloys qualified for HTGR operating conditions, and helium circulators at the pressure and temperature range the design requires. The compliance challenge here responds to a different set of interventions: industrial policy to establish the manufacturing base, and regulatory provisions that provide a transitional pathway while that base is under construction.

### 5.2 The Framework Mismatch

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The PFE compliance rules applied to nuclear under the OBBBA have their origins in clean energy supply chain legislation primarily designed for other technologies. The Inflation Reduction Act of 2022 introduced the first major prohibited foreign entity restrictions in the tax code through the electric vehicle battery credit under §30D, targeting Chinese battery cell and critical mineral supply chains. The same legislation created §45Y and §48E as technology-neutral clean energy credits with domestic content bonus provisions calibrated primarily around solar PV, onshore wind, battery storage, and offshore wind. The guidance implementing those provisions, IRS Notices 2023-38, 2024-41, and 2025-08, issued Safe Harbor Tables covering manufactured products and MPCs for solar PV, onshore wind, battery energy storage, and hydropower. Nuclear was not in those tables because, at the time the IRA was enacted and the guidance was issued, nuclear was not the primary target of the domestic content framework.

The OBBBA extended PFE restrictions to §45Y and §48E through the MACR test, applying to all qualified facilities including nuclear. The statutory structure, the MP/MPC tracing framework, the two-

layer methodology, and the threshold schedule derive directly from the existing clean energy supply chain framework. They were not designed around the specific characteristics of nuclear supply chains. The result is a framework calibrated for technologies with fundamentally different supply chain profiles: solar panels with well-characterized Chinese silicon wafer content, wind turbines with identifiable nacelle and tower suppliers, battery storage with relatively compact bill of materials and established domestic and allied manufacturing. For these technologies, the MP/MPC framework is tractable, the supplier populations are well-defined, and allied alternatives are commercially available.

Nuclear supply chains have characteristics that differ materially from the technologies the existing framework accommodates. They are more globally concentrated: a small number of qualified allied manufacturers supply critical long-lead components for every non-PFE large reactor project in the world, and there is no equivalent of adding a new solar panel factory to relieve capacity pressure. They are more capital-intensive to develop: the barrier to entry for a new allied heavy forger is measured in years and hundreds of millions of dollars. The component scope is substantially larger: 125 or more manufactured products and MPCs per reactor design, each requiring origin tracing, versus a handful of principal components for a solar or wind project. And for several advanced reactor designs, key hardware categories are in early stages of commercial development with no established allied supply base at any scale.

Nuclear is not listed in the 2023-2025 Safe Harbor Tables and cannot use the safe harbor methodology. A nuclear developer must apply the direct cost method, a project-by-project, component-by-component analysis with no regulatory shortcut, against a compliance framework whose definitional questions, denominator scope, tracing depth, and component classification, remain unresolved until the nuclear-specific safe harbor tables required by December 31, 2026 are issued.

The result is a framework mismatch. The MACR test applies a compliance structure calibrated for established manufacturing sectors to a technology that is simultaneously rebuilding its domestic and allied industrial base. For the AP1000, the allied supply chain exists but is under capacity pressure from a global pipeline that includes non-AP1000 designs drawing on the same forging and manufacturing pool. For the HTGR and comparable advanced designs, several hardware supply chains do not yet exist at commercial scale. In neither case does the current framework provide the regulatory certainty that enables projects to proceed to final investment decision.

The nuclear-specific safe harbor tables required by December 31, 2026 are the mechanism through which Treasury can address this mismatch. Those tables will need to grapple with characteristics that did not arise in the solar, wind, and battery guidance: the narrow supplier pool for high-specification components, the long procurement lead times that require early compliance determination, the distinction between supply chains under capacity pressure and those that do not yet exist, and the treatment of hardware categories whose allied qualification is actively underway but not yet complete.

### **5.3 Implications For The US Nuclear Pipeline**

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The analysis identifies a clear direction of travel under the current framework, and it is not favorable for the US nuclear pipeline.

For the AP1000, compliance costs are already substantial. N=8 is not a future scenario. It is the baseline scenario for any US project beginning procurement today, derived from the six contracted

European AP1000 units whose procurement timelines overlap with the 2028-2035 window for any new US reactor. A first-mover advantage with its \$37M compliance cost exists only for a project that secures allied supplier commitments before the European cohort does. That window is closing. The \$338M compliance burden at N=8 is a material project cost that must be incorporated into financing models and developer economics. It does not by itself make the project uneconomic -- the ITC value at \$2,954M dwarfs it -- but it is a real cost that reduces the net benefit of the credit, requires active management beginning at FID or earlier, and escalates further as the pipeline grows.

The compliance margin at N=8 is also narrow. The AP1000 MACR of 38.4% against the 2030+ threshold of 40% leaves 1.6 percentage points of headroom. This is not a comfortable buffer for a developer making a multi-billion dollar investment decision. A project that enters procurement at N=8 or N=9 -- the difference being a single additional concurrent build anywhere in the global AP1000 pipeline -- faces a different outcome entirely. The threshold crossing is not gradual; it is binary, and the consequence is the forfeiture of the entire ITC value. Lenders and investors will need confidence that the project will pass the MACR test, and that confidence cannot be fully established before the December 2026 safe harbor tables clarify the regulatory methodology.

For the HTGR and comparable advanced reactor designs, the direction of travel is more constrained. The MACR threshold is breached at five concurrent builds, a pipeline scale that could be reached before the allied hardware supply chains required for compliance are operational. At that point, compliance spending cannot close the gap, and the credit is inaccessible to the technology class regardless of what developers invest in procurement or qualification.

This has broader implications. The federal policy objective is to build a fleet, not a single project. A framework that is manageable for first movers but breaks down at the pipeline scale required to meet stated targets is not aligned with that objective. The findings suggest that the compliance framework will become more constraining as the nuclear pipeline grows, precisely when it needs to be most supportive.

## **5.4 The Purpose Of This Analysis**

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This analysis does not advance specific policy recommendations. Its purpose is to document the structure, scale, and mechanism of the PFE compliance challenge for nuclear electric-generating facilities with the analytical precision required to support informed regulatory development.

The component-level model underlying this analysis is designed to answer quantitative questions about specific regulatory scenarios: how does MACR change under a broad versus narrow denominator? What is the compliance cost impact of including or excluding specific component categories? How do different N values affect the compliance position of a project entering the contracted European AP1000 pipeline? These questions can be answered from the model, and GEC is prepared to run specific scenarios in support of Treasury's development of the nuclear-specific safe harbor tables.

What the analysis does show, without ambiguity, is that the compliance challenge for nuclear is real, is already material at current pipeline scales, and differs in character between established reactor designs with capacity-constrained supply chains and advanced reactor designs with supply chains that have not yet been established. The nuclear-specific safe harbor tables required by December 31, 2026 represent the mechanism for addressing these characteristics. The development of those tables is, from the perspective of the US nuclear pipeline, one of the most consequential regulatory actions of the next eighteen months.

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References 1–17 correspond to footnote citations in the text in order of first appearance. References 18 and above are additional sources that informed the model and analysis.

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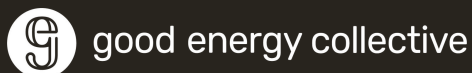
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Component-level data underlying this analysis is available to policymakers, developers, lenders, and project financiers on request. The model can be run against any proposed regulatory scenario to show compliance impact across the current pipeline.

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