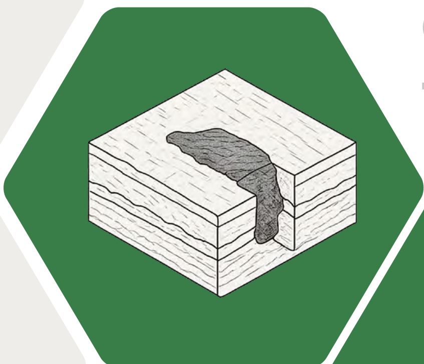
Uranium Investor Foundation Series

A structured set of guides that lay out the fundamental elements of the uranium industry and prepare readers for deeper market interpretation.



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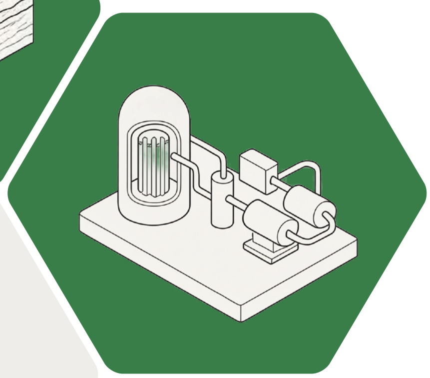
The Nature of Uranium



Guide II:
How Nuclear Power Uses Uranium

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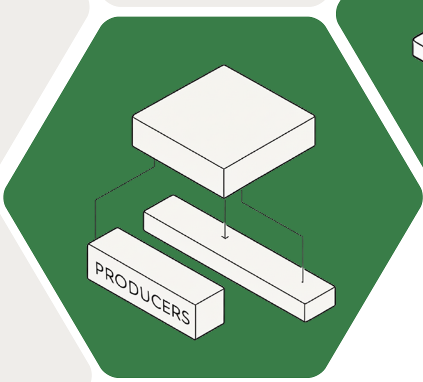

Guide IV:
The Structure of the Uranium Sector

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How to Read This Series

These guides are meant to be read as a sequence. Each one adds a layer of understanding that the next builds on, without repeating what came before. Together, they form a framework for thinking about uranium markets rather than a set of conclusions to be taken one at a time.

Each guide looks at a different structural aspect of the uranium sector. The series moves from the nature of uranium itself, to how reactors actually consume fuel, to why supply so often arrives later than expected, and finally to how the sector is organized and how material flows through it in practice.

No single guide is intended to stand on its own. The ideas are designed to connect, and some of their implications only become clear once the full structure is in place. Readers will get the most value by moving through the series in order, allowing each piece to inform the next.

These guides are not forecasts, price targets, or investment recommendations. Their purpose is to clarify constraints, sequencing, and incentives so that market data and commentary can be interpreted with better context.

The aim throughout is not to introduce more information, but to sharpen how existing information is read. By the end of the series, readers should have a clearer sense of how uranium markets actually behave, and why they often look calm on the surface even when underlying conditions are changing.

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GUIDE 2 — How Nuclear Power Uses Uranium

In nuclear energy, time itself becomes a fuel requirement— reactors consume uranium not by choice, but by design, creating a demand profile that moves with unwavering regularity.

1. What This Guide Covers

Nuclear power is the only major energy technology whose fuel use follows a strict, mechanical rhythm rather than economic discretion. This guide explains how uranium moves from mined material to reactor fuel, how the fuel cycle governs timing and throughput, and why reactor behaviour creates one of the most predictable sources of commodity demand anywhere in global energy.

The narrative begins with the upstream stages of the fuel cycle—conversion, enrichment, and fabrication— because these processes determine how much uranium reactors ultimately require and when it must be procured. It then moves through the characteristics of reactor operation, including reload scheduling, inventory requirements, and the structure of the global fleet. Together, these elements explain why uranium demand evolves gradually, why short-term variations are limited, and why the supply side of the market is far more volatile than the demand side.

Throughout the guide, the emphasis remains on the forces that shape annual uranium use and the timing of procurement decisions. The goal is to give investors a clear understanding of the mechanisms that govern demand and to show how these mechanisms influence market behaviour, contracting urgency, and long-term pricing dynamics.

2. Why This Matters for Investors

Uranium demand differs from most commodity markets in one critical respect: reactors do not adjust their consumption in response to price, economic cycles, or short-term market conditions. Fuel use is determined by reactor physics, regulatory requirements, and engineering schedules. Utilities operate within a system that forces them to procure uranium years before it is needed and maintain inventories that protect against supply interruption.

This creates a demand profile that is steady, durable, and resistant to external shocks. Even major global events rarely cause sudden changes in annual uranium requirements. Meanwhile, supply remains vulnerable to delays, operational issues, and geopolitical disruptions, making any shortfall more meaningful because demand does not slow down to compensate.

For investors, this structural mismatch has several important implications:

- **Demand remains stable even when markets are volatile.** Reactors continue to reload on schedule through price swings, recessions, and energy cycles.
- **Timing effects originate in the fuel cycle, not in consumption.** Procurement decisions shift when conversion, enrichment, or fabrication tighten, but annual uranium requirements remain largely unchanged.
- **Any supply disruption becomes disproportionately important.** Because consumption cannot pause, shortfalls accumulate over time rather than self-correct.

Understanding how nuclear power uses uranium is therefore essential for interpreting price signals, anticipating contracting cycles, and evaluating risk in the uranium sector.

3. How Uranium Enters the Fuel Cycle

A. From Ore to Yellowcake

The first step in the fuel cycle is the transformation of ore into U_3O_8, a stable and transportable uranium oxide. Mining and milling are the only stages directly exposed to geological uncertainty, infrastructure constraints, and operational variability. Grades can fluctuate, deposit types differ widely in complexity, and production may be interrupted by mechanical failures, reagent constraints, permitting delays, or labour challenges.

Once uranium is converted into U_3O_8, it becomes part of a standardized global material stream. At this point the behavior of the supply chain changes. The remaining stages—conversion, enrichment, and fabrication—are industrial processes with relatively stable throughput. Variation in the mining stage therefore creates a structural imbalance: supply is volatile, while the downstream system that consumes uranium remains steady and unyielding.

For Investors:

- Mining variability creates the majority of supply risk in the fuel cycle.
- Downstream processes cannot compensate for inadequate mine output.
- U_3O_8 inventories help manage timing but do not address long-term shortages.

B. Conversion to UF_6

Conversion transforms U_3O_8 into uranium hexafluoride (UF_6), the gaseous form required for enrichment. This process is highly specialized and performed by a limited number of facilities worldwide. Conversion plants operate with large-scale, continuous systems that require maintenance and regulatory oversight. Because capacity is concentrated, outages or planned maintenance can quickly tighten the market.

When conversion becomes constrained, utilities face delays in moving material into enrichment. This does not reduce their annual uranium needs; instead, it disrupts the timing of procurement and increases the importance of holding U_3O_8 or UF_6 inventory. A tight conversion market often leads utilities to contract further ahead to secure their required throughput.

For Investors:

- Conversion bottlenecks alter the timing of procurement, not the scale of demand.
- Persistent constraints increase reliance on upstream inventories.
- Tight conversion markets contribute to earlier and more aggressive contracting cycles.

C. Enrichment and the Tails Effect

Enrichment increases the proportion of U-235 from its natural concentration to levels suitable for reactor fuel. The efficiency of this process determines the tails assay, which reflects how much U-235 remains in the waste stream. A higher tails assay means the enriching plant extracts less fissile material from each tonne of natural uranium, requiring more U_3O_8 to achieve the same amount of enriched product. A lower tails assay means more U-235 is extracted, reducing natural uranium requirements.

Changes in tails assay can shift global uranium needs by several percent. These movements do not arise from reactor behaviour but from the capacity and economics of the enrichment industry. When enrichment capacity is abundant, enrichers tend to operate with low tails assays, effectively acting as a source of secondary supply through underfeeding. When capacity tightens, tails assays rise, eliminating underfeeding and increasing demand for natural uranium.

For Investors:

- Tails assay shifts can materially adjust annual uranium demand.
- Tight enrichment markets eliminate secondary supply and increase primary requirements.
- Tails behaviour often changes before mine supply does, influencing the contracting environment.

D. Fuel Fabrication

Fabrication converts enriched uranium into fuel assemblies that are engineered for specific reactor designs. These facilities operate on precise schedules because each assembly must meet strict regulatory and performance standards. Fabricators commit capacity years in advance, which means utilities must secure upstream material well before fabrication occurs.

Fabrication does not alter total uranium demand but plays a critical role in timing. Because there is limited flexibility in fabrication scheduling, any delay upstream can cascade into the reload date unless utilities maintain sufficient inventory.

For Investors:

- Fabrication timelines enforce long lead times on uranium procurement.
- The 12–24 month gap between mining output and reactor use shapes contracting urgency.
- Fabricators' forward booking policies push utilities toward earlier commitments.

Globally, uranium mined on one continent is routinely converted, enriched, fabricated, and then shipped again before ever reaching a reactor, reflecting a fuel cycle that is industrially rigid but geographically fragmented.

4. How Reactors Consume Uranium

A. Reload Cycles

Reactors operate on reload schedules that are set by engineering requirements rather than market conditions. Most reactors replace roughly one-third of their core every 12 to 24 months. These cycles are planned years ahead, regulated closely, and implemented regardless of uranium price movements or broader energy market trends.

Once commitments are made, utilities have little flexibility to defer fuel. Reactors cannot switch to alternative fuels or reduce consumption in response to price. This rigidity means annual uranium demand is driven more by physical plant behaviour than by economic factors.

For Investors:

- Uranium is a mandatory input that reactors consume on fixed schedules.
- Reload cycles anchor demand even during price volatility or economic slowdowns.
- Annual consumption varies little unless fleet size changes.

B. Baseline Consumption

Global uranium consumption depends primarily on the number of reactors operating and the reload cycles they follow. On a consolidated basis, annual demand tends to fall within a narrow range, with limited year-to-year variation. Minor fluctuations arise from maintenance schedules, unplanned outages, or operational shifts, but these do not meaningfully change global totals.

The stability of baseline demand is a function of the technology itself. Reactors maintain consistent output, operate at high-capacity factors, and require fuel regardless of market conditions. These characteristics make uranium one of the most predictable long-term commodity demand streams.

For Investors:

- Consumption remains stable across economic cycles.
- Demand growth or decline emerges slowly, driven by fleet changes rather than behaviour changes.
- Predictability allows for clearer long-term modelling than in most resource sectors.

C. Minimum Operating Inventories

Utilities maintain inventories throughout the fuel cycle to ensure continuous operation. These inventories include fabricated fuel ready for insertion, enriched uranium in process, UF_6 awaiting enrichment, and U_3O_8 held for security or regulatory reasons. Inventory policies vary by region, but most utilities maintain a buffer that spans several reload cycles.

These inventories create short-term flexibility but do not change long-term demand. They can cushion temporary supply disruptions or delays in the midstream, yet a persistent imbalance between supply and consumption will eventually draw down inventories and expose market tightness.

Most commercial reactors replace roughly one-third of their fuel core at fixed intervals, meaning uranium must be procured years in advance regardless of price or market conditions.

For Investors:

- Inventories influence procurement timing, but not annual uranium needs.
- Drawdowns signal emerging supply stress.
- Low inventory mobility is an early indicator of contracting pressure.

5. Fleet Behaviour and Global Uranium Demand

A. Operating vs Operable Fleet

The distinction between operating and operable reactors is important for interpreting demand. Operating reactors consume fuel; operable reactors are those that could operate but are currently offline due to maintenance, regulatory review, refurbishment, or strategic decisions. Only the operating fleet directly determines uranium consumption.

Because the operable fleet can restart or retire over long-time horizons, its impact on demand unfolds gradually. Restart decisions can add demand quickly, but even in these cases, the overall global effect remains manageable due to the size of the fleet and the long visibility of regulatory processes.

For Investors:
- Demand is driven by reactors that are actively generating power.
- Restarts and retirements influence demand steadily rather than abruptly.
- The operable fleet provides optionality but not immediate pressure on supply.

B. New Builds

New reactors entering service require an initial core load significantly larger than a standard reload. This makes commissioning years important drivers of short-term demand. Initial core loads are determined during the design stage and procured well in advance of reactor start-up, often years before electricity generation begins.

The presence of new builds in the pipeline therefore influences procurement activity early. Construction milestones are tied to long-term planning, enabling clear visibility into when first-core fuel will be required.

For Investors:
- New builds create demand surges associated with initial fuel loads.
- Procurement for new reactors begins well before they enter service.
- Construction programmes signal multi-year increases in uranium requirements.

C. Uprates and Efficiency Adjustments

Reactor uprates increase electrical output but do not fundamentally change uranium requirements. While operational efficiency may improve on a per-megawatt-hour basis, reload volumes remain largely determined by core geometry and fuel management strategies. As a result, uprates have minimal impact on aggregate uranium demand.

For Investors:
- Uprates do not materially reduce uranium use.
- Any impact tends to be neutral or slightly positive for demand forecasts.
- Demand remains tied to physical reload needs rather than efficiency gains.

D. Life Extensions

Life extension decisions preserve reactor operation for additional decades and therefore extend uranium demand far into the future. Because many reactors were initially licensed for shorter operational lives, extensions represent a major source of long-term stability in the demand outlook.

These decisions are often supported by maintenance investments, regulatory approvals, and long-term energy planning. Once implemented, they ensure continued fuel consumption at predictable intervals. When reactors receive life extensions, utilities effectively lock in decades of future uranium demand without changing annual consumption patterns.

For Investors:
- Life extensions add multi-decade visibility to demand.
- They contribute more to long-term demand than new builds over comparable timelines.
- Fleet longevity is one of the most important structural supports for uranium consumption.

6. Small Modular Reactors (SMRs)

SMRs use uranium in ways that mirror large-scale reactors but introduce new patterns in timing and fleet growth. Their most immediate effect comes from first-core requirements. Although each SMR is smaller, its initial fuel load is disproportionately large relative to its operating capacity, making early deployments meaningful for short-term demand.

SMRs are also designed for serial production, with standardized components and fuel characteristics. This creates opportunities for centralized procurement and longer-term contracting strategies. Once in operation, SMRs follow consistent reload schedules similar to traditional reactors, contributing steady annual demand.

While SMRs will take time to scale, their design and deployment model align well with the features that make nuclear demand predictable: fixed cycles, long visibility, and mandatory fuel requirements.

Although individual SMRs are smaller than conventional reactors, their initial core loads are disproportionately large relative to ongoing reload requirements, creating front-loaded uranium demand.

For Investors:
- SMRs add new first-core demand as deployment scales.
- Their standardized design supports long-term procurement strategies.
- Once operational, SMRs reinforce uranium's stable demand profile.

7. Why Uranium Demand Is Predictable

Nuclear power's demand stability emerges from three structural features. First, reactors have no alternative fuel; they rely entirely on uranium to sustain a chain reaction. Second, the long lead times required for enrichment and fabrication force utilities to plan their fuel needs years in advance, smoothing the impact of short-term market shifts. Third, changes in fleet size occur slowly, as reactor construction, refurbishment, and retirement follow timelines spanning many years.

Together, these characteristics create a demand environment with limited volatility. Even significant events rarely cause abrupt changes in consumption. Instead, the global fleet adjusts gradually, with long-term decisions providing visibility into future requirements.

Unlike fossil fuel generators, nuclear reactors cannot reduce fuel use in response to price or demand shocks, making uranium consumption one of the least elastic commodity demand streams.

For Investors:
- Demand evolves at a measured pace tied to physical infrastructure.
- Fuel-cycle planning dampens volatility and increases contracting visibility.
- Stable demand places greater significance on supply-side constraints.

8. Investment Implications of the Fuel Cycle

The structure of the fuel cycle creates several important implications for the uranium market. Because demand is stable, market tightness arises primarily from supply shortfalls, inventory depletion, or constraints in conversion and enrichment. These stresses do not reduce consumption; they simply change when utilities must act to secure future supply.

The predictability of demand also makes supply disruptions more impactful. When production falls short, the deficit accumulates over time rather than prompting an adjustment in consumption. This dynamic forces utilities to increase contracting, draw down inventories, or shift procurement earlier, all of which contribute to upward pressure on prices.

Finally, the introduction of SMRs reinforces these patterns by adding new demand streams that follow the same disciplined reload cycles as traditional reactors. Their deployment contributes additional visibility and strengthens the structural features already present in the nuclear fleet.

For Investors:

- Demand consistency makes supply shortages more visible and more consequential.
- Timing shifts in procurement often signal tightening before prices move.
- Structural demand paired with variable supply creates favourable long-term investment conditions.

When supply falters, utilities do not consume less uranium; they contract earlier, draw down inventories, or accept higher prices to protect reactor continuity.

9. Understanding Demand Sets the Stage for Understanding Supply

This guide has shown that uranium demand is anchored by the steady behaviour of the global reactor fleet. Reactors reload on fixed schedules, plan years ahead, and consume fuel regardless of market conditions. This stability means the uranium market is shaped far more by the performance of supply than by fluctuations in consumption.

When demand is predictable and inflexible, any disruption in mining, conversion, or enrichment accumulates rather than corrects itself. Tightness emerges not from sudden demand growth but from supply failing to arrive when expected.

Guide 3 builds on this by examining why uranium supply so often falls short of planned timelines.

It outlines the real-world frictions—long preparation cycles, regulatory hurdles, operational setbacks, and the difficulty of restarts—that consistently delay new or returning production.

With demand now understood, the next guide turns to the side of the market where variability truly resides.