The United States Nuclear Fuel Supply Chain

By Dr. Jeff Kleck

The U.S. nuclear fuel supply chain starts with **mining** and then moves through five core steps: **conversion** of Uranium Oxide (U_3O_8)→Uranium Hexafluoride(UF_6), **enrichment** to Low Enriched Uranium (formally U-235 < 20% per the NRC, but typically referring to 3-5% U-235) (LEU) or High-Assay Low Enriched Uranium (5–20% U-235 per the NRC) (HALEU), **deconversion** of UF_6 → oxide or metal, **fuel fabrication** (rods, assemblies, pebbles, or specialty forms), and **irradiation/use**. The current landscape is shaped by moving away from Russian supply following a 2024 import ban, the emergence of domestic HALEU capacity for advanced reactors, new "fuel lines" for Tri-structural Isotropic (TRISO) and metallic fuels that SMRs and microreactors will need in the late-2020s and 2030s, and the shift from LEU to LEU+ fuels in Lightwater Reactors (LWRs).

The Nuclear Fuel Supply Chain

1. Ore Supply
   uranium delivered to U.S. reactors by country:

Country of Origin	Relative Amount	U_3O_8 Equivalent (MLbs)
Canada	33%	18.6
Kazakhstan	22%	12.4
Australia	15%	8.6
Uzbekistan	8%	4.5
United States	8%	4.3
Namibia	4%	2.2
Russia	4%	2.0
Other	6%	3.3

2. Conversion ($U_3O_8 \rightarrow UF_6$)

Honeywell/ConverDyn	$U_3O_8 \rightarrow UF_6$	Only licensed U.S. converter

3. Enrichment

Urenco USA	LEU & LEU+	Licensed to produce LEU enriched to 5% and LEU+ (5-10% U-235) enriched to 10%
Centrus	HALEU	Licensed to produce HALEU enriched to 19.75%
Louisiana Energy Services	HALEU	Licensed to produce HALEU enriched to 5.5%

4. Deconversion ($UF_6 \rightarrow$ Uranium Dioxide (UO_2), Uranium Mononitride (UN), or metal)

Framatome + TerraPower	HALEU metallization pilot ($UO_2 \rightarrow$ metal)	Pilot line under development for Natrium metal fuel.
DOE Deconversion IDIQs	HALEU (oxide & metal)	10-year contracts to BWXT, Centrus, Framatome, GE Vernova, Orano, Westinghouse.

5. Fuel fabrication

TRISO fuel: BWXT is the only commercial producer of TRISO in the U.S. (e.g., for DoD's Project Pele) and has installed equipment for uranium nitride TRISO; X-energy's TRISO-X commercial facility in Tennessee targets mid-decade operations; Standard Nuclear (formed from USNC's bankruptcy) and Framatome have launched a TRISO JV.

BWXT	TRISO (UCO & UN) particles and pebbles	Fueling Project Pele; installed equipment for TRISO (UN) line.
X-energy / TRISO-X	Commercial TRISO pebbles	May 2026 target date
Standard Nuclear – Framatome JV	Commercial TRISO	2027 target date pending licensing.

Metallic fuel: Global Nuclear Fuel—Americas (GNF-A) and TerraPower are siting the Natrium Fuel Facility in Wilmington, NC; Oklo plans a metal fuel line at INL and a Tennessee fuel center.

TerraPower + GNF-A	Natrium metal fuel fab	Facility planned
Oklo	Metal Uranium Zirconium (UZr) fuel (Aurora)	INL fuel line design approved conceptually by DOE; TN fuel center announced.

Light Water Reactor (LWR) oxide fuel (UO_2): Westinghouse (Columbia, SC); Framatome (Richland, WA); Global Nuclear Fuel—Americas (Wilmington, NC).

Westinghouse	UO_2 (PWR & BWR)	U.S. LWR fuel site; LEU+ lead tests at Vogtle.
Framatome	UO_2 (PWR & BWR)	U.S. manufacturing + code approvals for higher-enrichment transport/methods.
GNF-A	UO_2 (BWR) fuel	U.S. division of GE-Hitachi Joint Venture

Table Notes and Clarifications:

Light Water Reactors (LWR) include both Boiling Water Reactors (BWR) and Pressurized Water Reactors (PWR).

References and Data Sources:

EIA Uranium Marketing, 2024; NRC Uranium Conversion, 2025; NRC LEU, 2025; NRC HALEU, 2025; DOE Deconversion, 2025; NRC Fuel Fabrication, 2025; Oklo, 2025

Who (MMR/SMR) Uses What Fuel

U.S. Companies (current)	Model	Fuel Type (A-Z)	Enrichment	Reactor Type	Output (MWe)
Antares Nuclear	R1 Microreactor	TRISO	HALEU	HPM	0.2
BWXT	BANR	TRISO	HALEU	HTBR	50
Kairos Power	KP-FHR	TRISO	HALEU ~19.75%	FHR	150
Radiant Nuclear	Kaleidos	TRISO	HALEU <19.75%	HTGR	1
Valar Atomics	Numenor	TRISO	HALEU	HTGR	25
Westinghouse	eVinci	TRISO	HALEU 19.75%	HTHPR	5
X-Energy	Xe-100	TRISO	HALEU	HTGR	80
General Atomics	EM^2	UC	HALEU	HTGR	265
Natura Resources	MSR-100	UF_4	HALEU	MSR	100
Terrestrial Energy	IMSR	UF_4	LEU <5%	IMSR	195
Aalo Atomics	Aalo-1	UO_2	LEU ~5%	STR	50
Deep Fission	DBR	UO_2	LEU <4.95%	PWR	15
GE Hitachi	BWRX-300	UO_2	LEU ~3-5%	BWR	300
Holtec International	SMR-300	UO_2	LEU	PWR	300
Last Energy	PWR-20	UO_2	LEU <4.95%	LWR	20
NuScale	NPM-4	UO_2	LEU <4.95%	LWR	308
ARC Clean Technology	ARC-100	UZr	HALEU ~13%	SFR	100
Oklo	Aurora Powerhouse	UZr	HALEU	HPM	15

Table Notes and Clarifications:

Most of the conventional Generation 3 reactors that compose the U.S.'s 94 unit fleet use UO_2 fuel. enrichment level annotated when disclosed.

Acronyms and Definitions:
See paper Small Modular Reactors: Redefining the Future of Decentralized Energy in the United States

The Commercial Landscape for TRISO and Uranium Oxide

TRISO Fuel

- BWXT – Currently the only producer of commercial TRISO fuel.

- X-energy have claimed that they are expecting a fully licensed and constructed plant and commercially approved TRISO fuel by May 2026.

- The Standard Nuclear & Framatome Joint Venture has claimed they will have commercial TRISO production sometime in 2027 pending regulatory approval.

- 30-40 pounds (depending on enrichment level and methods) of U_3O_8 equivalent for 1 pound of HALEU fuel.

LWR Oxide (UO_2) Fuel & Enhancements

- Westinghouse, Framatome, and Global Nuclear Fuel-Americas are the current producers of commercial UO_2 fuel for the lightwater reactors that make up the bulk of America's 94 unit conventional nuclear fleet.

- Global Nuclear Fuel-Americas is licensed to enrich their fuel up to 8% LEU+ but has not completed the changes necessary to start producing yet. When they do so, they can produce the new standard of Accident Tolerant Fuel (ATF) for LWRs which allows a higher degree of reactor safety and performance

- Both Westinghouse and Framatome are pursuing the ability to produce LEU+ ATF . Westinghouse is looking to be able to enrich up to 8% and Framatome up to 6.5%

- 10 pounds of U_3O_8 equivalent for 1 pound of LEU (4%) fuel.

Energy Demand

- The U.S. will have an estimated 115 GW of additional electrical demand by 2030. As mentioned in previous papers, expansion of electrical capacity is not yet at pace with demand. In 2024, the LWR nuclear fleet consumed 0.5 million pounds of U_3O_8 equivalent per GW-year of electrical power produced.
- Around 59 million pounds per year of U_3O_8 equivalent processed into conventional UO_2 for LWRs and or TRISO for advanced reactors could meet all of this additional demand. Only 55.9 million pounds U_3O_8 equivalent were delivered to reactors in 2024, meaning there would need to be a doubling of U_3O_8 equivalent being delivered to reactors to meet this additional demand. Nuclear alone cannot feasibly scale to meet all anticipated short term demand.

References and Data Sources:

X-Energy, 2025; Standard Nuclear & Framatome JV, 2025; TerraPower and Global Nuclear Fuel-Americas, 2025; Westinghouse. 2025; Framatome, 2025; EIA, Uranium Marketing, 2024; EIA, Electricity Generating Capacity, 2024; DOE, Evaluating the Reliability and Security of the United States Electric Grid, 2025

Conclusion:
The post-mining U.S. fuel chain is in the midst of its largest structural change in decades. First-of-a-kind projects (Natrium, Xe-100, microreactors) and DOE programs (HALEU allocations, deconversion IDIQs, fuel-line pilots) are catalyzing domestic capacities across enrichment, deconversion, and fabrication. The next three years are decisive: TRISO lines must move from pilot to ton-scale, metal fuel supply chains must be demonstrated end-to-end, and LEU+ must be proven at scale in today's fleet. If these pieces align, Nuclear energy will be able to accommodate the growing energy demands of the grid both on the utility and microgrid scale.

Citations:

- EIA Uranium Marketing, 2024
- NRC Uranium Conversion, 2025
- NRC LEU, 2025
- NRC HALEU, 2025
- DOE Deconversion, 2025
- NRC Fuel Fabrication, 2025
- Oklo, 2025
- X-Energy, 2025
- Standard Nuclear & Framatone JV, 2025
- TerraPower and Global Nuclear Fuel- Americas, 2025
- Westinghouse, 2025
- Framatome, 2025
- EIA Electricity Generation Capacity, 2024
- DOE Evaluating the Reliability and Security of the United States Electric Grid, 2025

The Author:
Dr. Jeff Kleck, an Adjunct Professor at the Stanford University School of Medicine, boasts a distinguished career marked by technology leadership and commercial tech venture creation. The current Chairman of the Open Power & Energy Network (OPEN), Dr. Kleck brings extensive expertise across technology, academia, government, and industry. Dr. Kleck concurrently serves as a Senior Advisor to the United States Government.

Contributors:
Erik Nelson, Engineering Intern, Open Power & Energy Network
Kate Pfeiffer, Director of Federal Policy and Strategy, Open Power & Energy Network
Matt Lungren, Health and Technology Advisor, Open Power & Energy Network
Steve Young, Engineering Fellow, Open Power & Energy Network
William McGrouther, Engineering Fellow, Open Power & Energy Network

Peer Reviewer:
Dr. Jared Dunnmon, a Non-resident Fellow at the Columbia Center on Global Energy Policy, boasts a distinguished career marked by leadership in technological advancements and strategic initiatives. A former University of Oxford Rhodes Scholar, Dr. Dunnmon brings a wealth of expertise spanning Artificial Intelligence, Economics, Computing Science, Mechanical Engineering, and Power and Energy Technologies.

Dr. Ryan Weed, a physicist and experimental test pilot, has a distinguished career defined by advancements in aerospace innovation and nuclear propulsion technologies. A three-time NASA Innovative Advanced Concepts Fellow, Dr. Weed founded Positron Dynamics. He previously served at the Defense Innovation Unit (DIU). Dr. Weed holds a Ph.D. in Physics from The Australian National University and a B.S. in Applied Physics from Columbia University.