



Fuel at Paks NPP, Hungary

Quarterly Uranium Market Report

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4th Quarter 2023

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Uranium Prices Analysis

During the second half of 2023, ESA processed 104 transactions, including contracts, amendments and notifications on the frontend activities. Between July and December, European utilities concluded 4 new spot natural uranium supply contracts (including purchases, sales, exchanges and loans) and 3 new long term contracts.

Table 1. ESA Quarterly Spot Prices

Quarter	ESA Spot ¹ EUR/kgU	ESA Spot USD/lb U ₃ O ₈	ESA Spot All Users ² EUR/kgU	ESA All Users USD/lb U ₃ O ₈
2022 Q4	-	-	-	-
2023 Q1	124.59	51.42	-	-
2023 Q2	-	-	-	-
2023 Q3	142.85	59.80	-	-
2023 Q4			-	-

Table 2. Number of contracts processed by ESA

Quarter	Number of spot natural uranium contracts concluded by EU utilities ³	Number of spot natural uranium contracts concluded by All parties ⁴	Total number of contracts processed by ESA
2022 Q4	2	2	55
2023 Q1	5	5	62
2023 Q2	3	3	58
2023 Q3	3	3	57
2023 Q4	1	1	47

¹ ESA Quarterly Spot Uranium Price is a simple average of natural uranium prices. It accounts for one transaction only or multiple transactions executed during the quarter and one of the parties is EU utility. It is calculated, only if, at least three transactions with reported prices were executed.

² ESA All Users Quarterly Spot Uranium Price is a simple average of natural uranium prices. It accounts for one transaction only or multiple transactions executed during the quarter and one of the parties is EU utility or other user (intermediary, producer)

³ including purchases, sales, exchanges and loans

⁴ including contracts, amendments and notifications on the front-end activities

Update on VVER fuel developments

There are currently over 30 reactors of VVER-440 and VVER-1000 design operating in the EU and in Ukraine. For years, Westinghouse has been dedicated to developing fuel for VVER reactors and successfully supplying Ukraine with the necessary fuel during the last decade. Additionally, the company has entered into contracts with various EU utilities that operate diverse VVER reactors. In September, the company announced the delivery of its inaugural reload batch of VVER-440 fuel assemblies to the Rivne-2 unit of Energoatom, Ukraine's state-owned nuclear utility. Energoatom had already implemented a nuclear fuel diversification project for VVER-1000 reactors and it is now the sole power generation company operating VVER reactors with alternative fuel. This development marks the end of the Russian monopoly in the VVER nuclear fuel market segment, not only benefiting Ukraine but also extending the possibilities for the entire region to achieve genuine nuclear energy independence.

Westinghouse is currently the only European producer of VVER-440 and VVER-1000 fuel. Currently, 15 VVER-440 reactors and four VVER-1000 reactors are operating in the EU countries. The European Union supports the design development and licensing activities through the APIS (short for Accelerated Program for Implementation of secure VVER fuel Supply) project, which aims to create security of supply of nuclear fuel for the Russian-designed VVER pressurized water reactors operating in the EU and Ukraine. The APIS project brings together a total of 12 EU and Ukrainian partners and is part of the EU's Horizon Europe program for research and innovation, with a contribution of 10 million euros from the Euratom Work Programme 2023-2025. The APIS consortium creates strong cooperation between countries with experience in the adaptation of fuel types and countries just starting their journey toward nuclear fuel diversification.

VVER-440 fuel update: Westinghouse closed out the design of the improved VVER-440 fuel assembly, including improvements such as an increased number of grids, use of Westinghouse standard ZIRLO®, LowTin ZIRLO™ and Optimized ZIRLO™ materials, and Additive Manufacturing for certain components. Following the successful licensing of NOVA E-5 and NOVCC fuel assemblies for operation at Rivne Nuclear Power Plant unit 2, the fuel assemblies from Westinghouse were loaded into the reactor. After a flawless start-up, the unit operates at 100% of its power and reload supplies are planned to both Rivne units in 2024. To further meet its VVER customers' requirements for increased margins at uprated power and follower operation, Westinghouse is conducting a development program to enhance its VVER-440 fuel design that is denoted NOVA E-6 for the fixed fuel assembly, and NOVCD for the follower fuel assembly. The final design review is planned for the first quarter of 2024.

Earlier this year Westinghouse signed an agreement with CEZ (Czechia) to supply VVER-440 fuel assemblies at the Dukovany Power Plants. The fuel supply diversification is one of the key steps to further strengthen the Czech Republic's energy security. Westinghouse will deliver the first batch of VVER-440 fuel assemblies to the Dukovany NPP at the end of this year.

Fortum (Finland) is pursuing mechanical operating experiences with the new fuel type, after a test assembly manufactured by Westinghouse was loaded into the Loviisa-2 reactor in 2023. The licensing process ongoing, reviewing the licensing and manufacturing documentation of the first new fuel deliveries is expected to be ready in 2024.

Based on fuel supply contract concluded in August 2023 between Slovenske elektrarne and Westinghouse Sweden AB, activities leading to licensing nuclear fuel are ongoing. The first fuel supplies, which are the subject of the agreement, are expected approximately one year after getting an approval for its use in compliance with the applicable legal regulations in the Slovak Republic. Currently work on licensing requirements, development of design and supporting documentation for nuclear fuel is in process, connected with powerplant data exchange and clarification for compatibility analysis and calculation of core design for homogeneous cycles. Slovenske elektrarne expect to finish the licensing process by 2026-2027.

VVER-1000 fuel update: Although Westinghouse's VVER-1000 design has long been an established, standard product, there is further development in progress. With the Next Generation VVER-1000 design, Westinghouse expects to achieve a 20-30% grid pressure drop reduction while keeping the grid strength at least at the level of the current design. 3D printing of test components has been used extensively in the project, significantly reducing the cycle time for testing different design concepts. Six cores in Ukraine are currently fully loaded with Westinghouse's VVER-1000 fuel. Fuel licensing is ongoing for the Czech's Temelin NPP and for remaining four Ukrainian VVER-1000 units. Bulgaria's Kozloduy unit 5 has been granted permission for a phased transition to the use of Westinghouse fuel, that will be delivered in time to be loaded during a planned outage scheduled in May. The deliveries for Temelin NPP will follow a few months after the Dukovany deliveries, based on the refuelling schedules.

Cooperation: Mutual cooperation and transparent communication between all stakeholders is essential to meet the commitment to ensure nuclear fuel diversification in the shortest possible time. The VVER Fuel Forum 2024, on 13-14 February also served to fulfil these conditions. The forum, hosted by Slovenské elektrárne in cooperation with Westinghouse saw the participation of Energoatom, Fortum, ČEZ, Kozloduy NPP, MVM Paks, and Slovenské elektrárne, a.s. The event provided the opportunity to share experience, approaches, best practises and challenges with VVER-440 and VVER 1000 fuel deployment in operating reactors. This cooperation will be helpful for safety operation of mixed cores on VVER-440 and VVER-1000.

Detailed reviews included information on strategy and process of fuel implementation, new fuel designs, upgrade of the production plant, supplies and NPPs operation.

Future perspectives: The efforts to diversify Russian-design nuclear fuel supply have reached a crucial stage of transition. Real progress has been made towards achieving genuine fuel diversification, and concrete results are now within reach. In line with the REPowerEU action plan and ESA recommendations, further work is taking place on developing a long-term solution through a program that will create an alternative fuel design based on European intellectual property rights and establish a European supply chain. This will ensure increased resilience and sovereignty of EU nuclear power production.



Mochovce panorama©Slovenské elektrárne