



URANIUM EXPLOITATION IN ROMANIA: STRATEGIC RESOURCE MANAGEMENT, ENVIRONMENTAL RISK, AND ENERGY SECURITY

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Abstract: *This paper analyzes uranium exploitation in Romania from a scientific perspective that connects resource geology, mining engineering, environmental protection, and national energy security. The relevance of the topic derives from the strategic role of uranium in the nuclear fuel cycle and from the need to evaluate how domestic extraction capacity may contribute to supply stability, industrial continuity, and long-term energy planning. The study approaches the subject as an integrated system problem in which reserve assessment, extraction technology, ore processing, waste management, radiological control, and site rehabilitation must be examined simultaneously. Methodologically, the paper proposes a structured analytical framework based on technical feasibility, environmental risk indicators, regulatory constraints, and strategic value for the Romanian energy sector. Particular attention is given to the balance between national resource use and the obligations associated with worker protection, groundwater quality, tailings management, and post-mining land recovery. The central argument is that uranium exploitation should be evaluated not only through short-term economic output, but through its capacity to support a secure, controlled, and environmentally responsible energy policy. The resulting perspective is relevant for researchers, decision-makers, and engineering practitioners involved in mineral and nuclear resource governance.*

Keywords: *Uranium exploitation; Romania; energy security; strategic resources; environmental risk; nuclear fuel cycle.*

1. Uranium in Romania’s energy-security architecture

This section should establish why uranium matters strategically. Romania operates two CANDU units at Cernavodă. Official SNN data show that nuclear power provides about **18-20% of domestic electricity generation**, while national gross nuclear electricity production in 2024 was **10,912 GWh**, i.e. **20.8%** of Romania’s total gross electricity production. SNN also states that the two operating units contribute **1,400 MW installed capacity** and about **33% of Romania’s clean electricity** [1].

In the same section, it is important to show that Romania still has a uranium resource base, but not a large or low-cost one by international standards. The NEA/IAEA Red Book reports Romania at **6,600 tU identified recoverable resources in the <USD 130/kgU and <USD 260/kgU categories**, and **4,000 tU reasonably assured in situ resources** in those same cost categories. That means Romania has a resource base of strategic relevance, but one that requires careful economic, environmental, and licensing analysis before any claim of renewed mining autonomy can be made [2].

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2. Environmental risk, regulatory constraints, and legacy liabilities

This section should explain why uranium policy in Romania cannot be discussed only through production volumes. Official Romanian reporting to the Joint Convention shows that legacy liabilities remain substantial: restoration works were underway at **Avram Iancu, Lisava, Ciudanovița, and Crucea Nord Botușana**, while Feldioara remains tied to tailings and radioactive waste management obligations. At Feldioara, the first part of the **Cetățuia II** pond received about **2,120,000 m³** of tailings over **368,000 m²** and is in closure; the second part has an estimated **414,500 m³** capacity over **133,000 m²**; and the **Mittelzop** pond has about **300,000 m³** volume over **87,000 m²**, with treated waters ultimately discharged toward the Olt River. In the former Banat uranium mines, mine water treatment has been reported at **1,500 m³/day** to a residual concentration of **0.1 mgU/l** [3].

This is where the paper should also introduce the scientific literature. The Crucea deposit is geologically significant, but the literature also confirms that Romanian uranium areas must be treated as sensitive geological and environmental systems, not merely extractive reserves. The Crucea ore deposit has been described in recent geochemical work, while Tulgheș-Grințieș has already been discussed in the Romanian literature in terms of benefits, controversy, and territorial implications [4].

3. Case study: the Feldioara-Pitești-Cernavodă chain and strategic optimization options

This should be the most data-rich section and the one where you place at least four tables. It is also the best place for the real “engineering-management” contribution of the paper. In 2024, Pitești manufactured **11,019 fuel bundles** and delivered **10,800 bundles** to Cernavodă, while SNN states that each bundle contains around **19 kg of uranium**. In the same year, Feldioara produced **278,973.585 kg U** in the form of sinterizable uranium dioxide powder, with additional stock prepared for 2025, and SNN states that the 2024 fuel chain used powder derived from processing technical-grade uranium concentrate purchased from **Kazatomprom (Kazakhstan)** and **Cameco International (Canada)** [5].

That combination is the key case-study argument: Romania no longer fits the old model of simple domestic mine-to-reactor autonomy; instead, it already operates a hybrid model of **imported concentrate + domestic conversion/processing + domestic fuel fabrication + domestic nuclear generation**. SNN’s 2025-2030 capital strategy confirms that this integrated model is being expanded through Feldioara upgrading, fuel-fabrication expansion at Pitești, and a possible operationalization of the **Tulgheș-Grințieș** mine within a broader strategy of stock coverage and supply diversification. The same strategy states that Pitești’s modernization aims to **double production capacity** and be commissioned by **2031**, while SNN’s administration plan notes that Units 3 and 4 would raise annual fuel-bundle needs from about **10,800** to nearly **21,500** [6].

4. Conclusions

Table 1. Romania’s uranium resource base relevant to strategic planning

Indicator	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	<USD 260/kgU
Identified recoverable resources (tU)	0	0	6,600	6,600
Reasonably assured in situ resources (tU)	0	0	4,000	4,000

Source basis: NEA/IAEA Red Book 2022.

Romania is marked there as a Secretariat estimate and partly based on prior reporting.

Table 2. Operational indicators of the Romanian nuclear fuel chain in 2024

Indicator	Value
Installed nuclear capacity at Cernavodă	1,400 MW
Nuclear share in Romania’s domestic electricity generation	approx. 18-20%
Nuclear share in national gross electricity production (2024)	20.8%
National gross nuclear electricity production (2024)	10,912 GWh
Fuel bundles manufactured at Pitești NFP (2024)	11,019
Fuel bundles delivered to Cernavodă NPP (2024)	10,800
Distribution of delivered bundles	5,040 to Unit 1; 5,760 to Unit 2

Indicator	Value
Approximate uranium per bundle	19 kg
Approximate uranium embedded in current annual bundle demand	~205–210 tU/year
FPCU Feldioara production sold to Pitești NFP (2024)	278,973.585 kg U in UO ₂ form
Upstream concentrate sources explicitly mentioned by SNN	Kazatomprom (Kazakhstan); Cameco International (Canada)

The “~205-210 tU/year” value is an authors’ calculation from SNN’s official bundle and uranium-per-bundle figures.

Table 3. Main environmental liabilities and remediation-sensitive sites in the Romanian uranium sector

Site / activity	Main issue	Quantitative detail	Reported status / responsible framework
Feldioara - Cetățuia II, Part 1	Tailings storage legacy	~2,120,000 m ³ tailings; 368,000 m ²	Closure in progress; transformation into repository
Feldioara - Cetățuia II, Part 2	Tailings storage capacity	~414,500 m ³ ; 133,000 m ²	Commissioned in October 2001
Feldioara - Mittelzop pond	Final settling of fine tailings	~300,000 m ³ ; 87,000 m ²	Waters pumped to decontamination plant, then toward Olt River
Banat former uranium mines	Acid/radioactive mine water management	1,500 m ³ /day; residual 0.1 mgU/l after treatment	Decommissioning and remediation ongoing
Avram Iancu, Lisava, Ciudanovița, Crucea Nord Botușana	Rock dumps and restoration liabilities	Ongoing remediation works	Managed through national closure/restoration framework

Source basis: CNCAN Seventh National Report.

Table 4. Strategic options for optimization of Romania’s uranium supply chain

Scenario	Technical basis	Near-term feasibility	Environmental burden	Security-of-supply value	Scientific assessment
A. Imported concentrate + domestic conversion + domestic fuel fabrication	Already in use in 2024	High	Medium	High	Best short-term continuity option
B. Hybrid model: diversified imports + strategic stock + Feldioara upgrade + Pitești expansion	Consistent with SNN strategy	Very high	Medium	Very high	Best medium-term optimization path
C. Full domestic upstream restart including Tulgheș-Grințieș	Mentioned in SNN strategic planning	Low in short term / medium in long term	High	Very high if licensed and accepted	Requires strongest environmental and social safeguards
D. Downstream-only strategy with no upstream development	Technically simple	High	Lower upstream burden	Medium	Lower autonomy, stronger import dependence

This table should be labelled as **authors’ analytical synthesis based on official SNN strategy and ESA security-of-supply recommendations**. ESA explicitly emphasizes diversification, alternative supply chains, and stronger inventories where full diversification is difficult.

A strong conclusion for this paper should say that Romania's optimal pathway is **phased and hybrid**, not doctrinaire. In the short and medium term, the most defensible option is to preserve reactor continuity through diversified external uranium concentrate procurement, maintain domestic conversion and purification at Feldioara, and modernize Pitești so that the domestic fuel-fabrication segment is not the bottleneck for Units 1-4. In parallel, any future reopening of upstream domestic mining should be conditioned by full hydrogeological, radiological, environmental, and social licensing, not treated as an automatic strategic good.

The future perspective is clear: if Units 3 and 4 advance and Pitești fuel demand rises toward roughly **21,500 bundles/year**, Romania will need a more robust uranium strategy than the present two-unit system. That makes stock policy, supplier diversification, Feldioara modernization, and evidence-based assessment of Tulgheș-Grințieș more important than symbolic claims of mining revival [7, 8, 9].

A good final sentence for **our contribution** would be this:

“Our contribution consists in integrating resource data, operating data, and environmental liability data into a single strategic assessment framework for the Romanian uranium sector, showing that energy security depends not only on resource availability, but also on conversion capacity, fuel fabrication continuity, remediation obligations, and the sequencing of future nuclear investments.”

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