ESA

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Foreword

As we are finalizing the Euratom Supply Agency’s 2024 Annual Report the nuclear sector in Europe continues to face important challenges, but also sees new opportunities for development. During the year, the nuclear supply market continued to face supply uncertainties linked to the changing geopolitical environment. As the data presented in this report shows utilities and other market actors have made significant progress in their effort to diversify away from Russian supply. At the same time, the challenge remains to reduce and sustainably eliminate the remaining dependencies. This includes areas where market actors still rely on Russian technologies, and specific areas such as the dependencies in conversion services and for certain medical isotopes. On 6 May 2025 the European Commission has adopted a Roadmap towards ending Russian energy imports which provides a clear orientation in support of diversification and sets out a series of specific measures to be put forward to support phasing out dependencies.

Moreover, the pressure on Uranium supply is growing, again due to geopolitical developments, but also to potentially increased demand linked to the global expansion of nuclear markets.

At the same time, a number of countries across Europe are pushing forward plans to extend or expand nuclear power generation, including by using innovative designs such as Small and Advanced Modular Reactors.

In this complex situation, the Euratom Supply Agency continues to play its central role - ensuring the security of supply of nuclear materials - by using its legal prerogatives, by providing reliable market analysis and by working closely with partners in Member States and industry.

Building upon ESA’s analysis of the market situation, this report again contains a series of recommendations to provide orientation to market actors.

During the year, across its activities, the Agency continued to address the changing needs of market actors. Increasingly, ESA works with new partners who develop innovative nuclear technologies and will have to understand and implement the requirements of the Euratom framework. We expect to be faced with an increasing number of transactions, and to respond to additional requests to analyze and report on market developments in a more dynamic way.

In this situation of pressure, the Agency relies on the commitment and competence of its small and dedicated staff, working under continuously high work pressures.

I look forward to another challenging year as we work closely with our partners – representatives of Member States, supply chain actors, the Advisory Committee and colleagues at the Commission – towards achieving ESA's objectives in the changing security of supply landscape.

Michael Hübel
Director General

Contents

Foreword ... 3

Executive summary ... 8

Abbreviations ... 11

1. Nuclear fuel supply and demand in the EU ... 12

1.1. Fuel loaded ... 12

1.2. Future requirements ... 13

1.3. Supply of natural uranium ... 15

1.4. Special fissile material ... 25

1.5. Inventories ... 26

1.6. Future contractual coverage rate ... 27

2. Security of supply ... 30

2.1. Analysis of EU market ... 30

2.1.1. Inventories ... 31

2.1.2. Demand ... 32

2.1.3. Supply diversification ... 33

2.1.4. Prices ... 36

2.1.5. Medical radioisotopes ... 36

2.2. Future outlook ... 37

2.2.1. Contractual coverage ... 37

2.2.2. EU and global fuel cycle market ... 38

2.2.3. Enable nuclear expansion and developments ... 42

3. Overview of EU developments ... 44

3.1. Euratom ... 44

3.1.1. EU nuclear energy policy ... 44

3.1.2. Nuclear safety, radiation protection, radioactive waste management and nuclear decommissioning ... 45

3.1.3. Emergency preparedness and response ... 45

3.1.4. External dimension of nuclear energy policy ... 45

3.1.5. ITER and fusion energy ... 46

3.1.6. Euratom safeguards ... 46

3.1.7. European Commission research and innovation programmes ... 47

3.1.8. Activities of the European Commission’s Joint Research Centre ... 48

3.2. Country-specific developments....50
3.3. Non-power applications of nuclear technology: supply of medical radioisotopes....59
3.3.1. SAMIRA....59
3.3.2. Monitoring the supply of Mo-99 in the EU....59
3.3.3. Studies and research....60
3.3.4. New infrastructure developments....61
4. World market for nuclear fuels in 2024....64
4.1. Primary uranium supply....66
4.2. Secondary sources....67
4.3. Conversion....68
4.4. Enrichment....69
4.5. Fuel fabrication....72
4.6. Reprocessing and recycling....73
4.7. Storage and repository of nuclear spent fuel....74
5. Key achievements....75
5.1. Mission and governance....75
5.2. Principal activities....76
5.2.1. Contract management....76
5.2.2. Security and diversification of the nuclear fuel supply chain....77
5.2.3. Market monitoring and analysis....79
5.2.4. Supply of medical radioisotopes....80
5.2.5. Cooperation with stakeholders and partners....82
6. Management....83
6.1. Budgetary and financial management....84
6.2. Human resources....86
6.3. Information management and communication....86
6.4. Audit and discharge....87
6.5. Internal control and assurance....88
6.6. Improving effectiveness and efficiency....89
Annexes....90
Annex 1 EU-27 gross and net requirements (quantities in tU and tSW)....90
Annex 2 Fuel loaded into EU reactors and deliveries of fresh fuel under purchasing contracts....92
Annex 3 ESA average prices for natural uranium....94
Annex 4 Purchases of natural uranium by EU utilities, by origin, 2014-2023 (tU)....95

Annex 5 Use of plutonium in MOX in the EU and estimated natural uranium and separative work savings 96
Annex 6 EU nuclear utilities that contributed to this report 97
Annex 7 Uranium suppliers to EU utilities 98
Annex 8 Calculation method for ESA's average U_3O_8 prices 99
Annex 9 ECA audit report 2022 101
Annex 10 Declaration of assurance 109
Annex 11 Work Programme 2024 111
List of tables 116
List of figures 116

Executive summary

This report provides a comprehensive overview of the European Union's nuclear fuel market, highlighting key trends, challenges, and strategic developments in the context of evolving geopolitical tensions. Against the backdrop of the EU's efforts to diversify its energy sources and reduce dependence on Russian nuclear imports, the report examines the current state and future outlook of the nuclear fuel market, including consumption patterns, procurement strategies, and market dynamics, and outlines the agency's 2024 key activities and recommendations to maintain a stable and secure nuclear fuel supply.

Market analysis and recommendations

In 2024, the European nuclear fuel market displayed notable resilience in the face of sustained geopolitical instability and supply chain uncertainty. Nuclear energy maintained its strategic importance in the EU's energy landscape, contributing nearly 25% of electricity generation and consumption in the EU-27. Amid efforts to reinforce energy sovereignty and meet decarbonization goals, utilities loaded 1 761 tonnes of uranium into reactors, drawn from 12 120 tonnes of natural uranium. A growing share of this demand was met through the use of mixed oxide (MOX) fuel and reprocessed uranium, for savings equivalent to almost 5% of annual natural uranium requirements.

Uranium procurement by EU utilities remained strong, totalling 13 667 tonnes—about one-fifth of global demand—primarily secured through multi-year contracts. This procurement strategy reflected the importance of supply stability, although more than 40% of uranium imports still originated from CIS countries, notably Russia and Kazakhstan, despite ongoing diversification efforts. Imports from African producers declined. By the end of 2024, European utilities held close to 40 000 tonnes of uranium equivalent in inventories, providing a buffer sufficient for more than three reload cycles on average—an important measure of resilience in the face of supply disruption risks.

The report emphasizes that enhancing supply chain resilience through long-term contractual and political commitments, diversification, strategic stockpiling, and recycling is essential for long-term nuclear fuel security. Russia's ongoing war in Ukraine has intensified the urgency of reducing dependency on Russian nuclear supplies. While the EU has not taken any direct measures on Russian nuclear materials, the policy direction aims toward full phase-out. The REPowerEU Plan has accelerated diversification initiatives, expansion of European production capacities, and international collaboration, though these efforts continue to face logistical and regulatory challenges.

Risk management remains a central tool in the nuclear fuel security of supply. Regulatory authorities, the nuclear industry and utilities are encouraged to assess and mitigate vulnerabilities stemming from geopolitical risks, ownership of suppliers, and transportation routes. Strategic stockpiling is increasingly vital, with recommendations to maintain inventories sufficient for multiple reloads and to explore an EU-wide coordination mechanism.

Looking ahead, a slight decline in reactor fuel demand is projected through 2033, while domestic fuel sources—particularly MOX and reprocessed uranium—are expected to play a larger role. This trend supports the EU's ambitions to reinforce fuel autonomy. To safeguard fuel security, sourcing strategies must continue to prioritize supplier diversity, ideally involving at least one EU-based source.

In the field of medical radioisotopes, the EU's dependency on foreign supply chains remains a major vulnerability. The report recommends urgent diversification, establishment of domestic production capabilities, and preservation of nuclear medicine expertise, as exemplified by ongoing initiatives like the European Radioisotopes Valley (ERVI).

While short-term supply security appears stable, a noticeable drop in contractual coverage for uranium and fuel-cycle services is expected after 2028. This highlights the importance of concluding new long-term contracts and incentivising investment in conversion and enrichment capacity. France's George Besse II facility, if expanded, could cover domestic conversion needs, but significant capacity gaps remain in the Western market. Supplier due diligence and long-term contracting will be essential to close these gaps.

With nuclear energy regaining strategic relevance, EU Member States are encouraged to define clear national nuclear strategies, promote circular fuel practices, and ensure fuel diversification—especially for new nuclear reactors based on non-EU technologies. These steps are key to embedding nuclear energy within the EU's secure, sustainable, and low-carbon energy mix.

Market and nuclear policy developments in the EU and worldwide

The European Union made substantial policy advances in 2024 in its climate and energy strategy, particularly in implementing the REPowerEU initiative. The European Commission and the Euratom Supply Agency played key roles in supporting and monitoring diversified nuclear fuel sources of the utilities operating VVER, Russian-designed reactors. Additionally, the EU is looking into the dependency on Russian sources for non-power uses, such as medical radioisotopes and research reactor fuel, advancing the SAMIRA action plan to enhance resilience in these critical sectors.

The electricity market reform marked a major milestone in 2024. Revised rules explicitly recognized nuclear energy as essential to decarbonization. The changes facilitated the use of power purchase agreements (PPAs) and contracts for difference (CfDs) to support investment in nuclear projects, while urging Member States to eliminate legal and regulatory barriers to long-term contracting. This development creates a more stable investment framework for nuclear projects, including life extensions and new builds.

The Commission also launched the European Industrial Alliance on Small Modular Reactors (SMRs), aimed at accelerating the development and deployment of SMRs across Europe by the early 2030s.

Work continued on ensuring full implementation of the Euratom legal framework. The Commission adopted a new Recommendation on dose coefficients and published the third implementation report of the Radioactive Waste Directive. A pilot project for a joint European radioactive waste management approach was launched, while decommissioning assistance programs in Bulgaria, Lithuania, and Slovakia continued to mitigate long-term safety risks at former nuclear power sites.

In emergency preparedness, the European Commission ensured the ongoing operation of the ECURIE and EURDEP systems, and reinforced cooperation with Ukrainian authorities and the IAEA to handle potential nuclear or radiological emergencies. Internationally, the EU engaged with major organizations including the IAEA and OECD/NEA, and with partners such as the US, UK, Japan, Canada, Kazakhstan, and Australia to reinforce supply chain resilience and promote high standards of nuclear safety and security.

Monitoring of Ukraine's nuclear facilities remained a high priority, with particular attention to the Zaporizhzhia plant. The EU also finalized post-Fukushima stress tests for Türkiye's Akkuyu nuclear power plant and continued discussions with other non-EU countries. These efforts reflect the EU's role as both a regional and global standard-setter in nuclear safety and cooperation.

The EU, through Euratom, also continued its leadership role in the ITER fusion project. In 2024, ITER achieved its highest execution rate to date, with the EU supporting critical installations and addressing outstanding technological challenges. These steps marked substantial progress toward realizing fusion as a long-term carbon-free energy source.

Nuclear safeguards remained robust in 2024. Euratom safeguards covered 99.94% of over 539 000 tonnes of civil nuclear material in the EU, with physical verification and accountancy procedures ensuring no diversion from peaceful uses. A political agreement was reached on an updated Euratom safeguards regulation, further strengthening legal compliance and international credibility.

The Euratom research and training programme allocated €121 million to 21 projects focused on nuclear safety, waste management, and innovative technologies. Highlights included EU-CONVERSION and PreP-HALEU, which aimed at securing fuel supplies for research reactors and medical radioisotope production. The SAVE project supported fuel diversification for VVER reactors in Europe and Ukraine. Two new co-funded partnerships—EURAD-II and CONNECT-NM—were launched to address radioactive waste and develop advanced nuclear materials. These projects underpin the EU's commitment to research excellence and strategic autonomy in the nuclear field.

Key achievements and management in 2024

ESA successfully navigated complex external and internal challenges in 2024, demonstrating sound financial management, operational efficiency, and institutional resilience. The Agency simplified its budget structure, improving operational transparency and flexibility. It achieved a high budget execution rate of 99.53% for commitment appropriations, with effective internal budget transfers helping to respond to dynamic needs. Financial reports and accounts were submitted on time and received a positive audit outcome, underscoring sound financial governance.

To enhance internal operations and security, ESA finalized the NOEMI security plan, completed the development of a data reporting tool, and appointed a Local Information Security Officer (LISO) to strengthen cybersecurity. A comprehensive risk assessment was carried out, and internal controls were refined. A self-assessment confirmed the effectiveness of the internal control system, reinforcing ESA's commitment to good governance and risk mitigation.

Amid growing workload due to geopolitical instability and market complexities, ESA optimised the use of shared resources in collaboration with other European Commission departments and partner agencies. The Agency met its objectives despite resource pressures, maintaining its focus on nuclear fuel supply security and stakeholder engagement. While recruitment remained a challenge, ESA preserved a diverse and gender-balanced workforce, reinforcing its commitment to inclusivity and resilience.

In summary, ESA's performance in 2024 reflects its ability to adapt to evolving external conditions and to continue fulfilling its mandate in support of the EU's nuclear supply security, diversification strategy, and broader energy objectives.

Abbreviations

CIS	Commonwealth of Independent States
ESA	Euratom Supply Agency
Euratom	European Atomic Energy Community
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
NEA (OECD)	Nuclear Energy Agency (Organisation for Economic Co-operation and Development)
(US) DoE	United States Department of Energy
(US) NRC	United States Nuclear Regulatory Commission
DU	depleted uranium
EIA	environmental impact assessment
ERU	enriched reprocessed uranium
EUP	enriched uranium product
HALEU	high-assay low-enriched uranium
HEU	high-enriched uranium
lb	pound
LEU	low-enriched uranium
LTO	long-term operation
NatU	natural uranium
MOX	mixed oxide [fuel] (uranium mixed with plutonium oxide)
RET	re-enriched tails
RepU	reprocessed uranium
SWU	separative work unit
tHM	(metric) tonne of heavy metal
tSW	1 000 SWU
tU	(metric) tonne of uranium (1 000 kg)
U_3O_8	triuranium octoxide
DUF_6	depleted uranium hexafluoride
UF_6	uranium hexafluoride
BWR	boiling water reactor
EPR	evolutionary/European pressurised water reactor
LWR	light water reactor
NPP	nuclear power plant
PWR	pressurised water reactor
RBMK	light water graphite-moderated reactor (Russian design)
VVER	pressurised water reactor (Russian design)
kWh	kilowatt-hour
MWh	megawatt-hour (1 000 kWh)
GWh	gigawatt-hour (1 million kWh)
TWh	terawatt-hour (1 billion kWh)
MW/GW	megawatt/gigawatt
MWe/GWe	megawatt/gigawatt (electrical output)

1. Nuclear fuel supply and demand in the EU

This overview of nuclear fuel supply and demand in the EU is based on information provided by utilities companies or their procurement organisations in an annual survey covering:

- acquisition prices for natural uranium;
- the amounts of fuel loaded into reactors;
- estimates of future fuel requirements;
- quantities and origins of natural uranium, conversion services and separative work;
- future contracted deliveries; and
- inventory trends.

In 2024, net electricity generation from the 101 reactor units operating in the 27 EU countries (EU-27) reached 617.3 TWh, accounting for 23.71% of all electricity production in the EU-27[1]. The share of nuclear energy in electricity consumption amounted to 25.5%[2].

1.1. Fuel loaded

In 2024, 1 761 tU of fresh fuel was loaded into commercial reactors. It was produced using 12 120 tU of natural uranium and 11 tU of reprocessed uranium as feed, enriched with 9 166 tSW.

In 2024, 1 761 tU of fresh fuel was loaded into commercial reactors.

The fuel loaded into EU reactors had an average enrichment assay of 4.15%, with 81% falling between 3.54% and 4.76%. The average tails assay was 0.20%, with over 82% falling between 0.16% and 0.25%.

MOX (mixed oxide) fuel was used in several reactors in France and the Netherlands. MOX fuel loaded into nuclear power plants in the EU contained 6 934 kg plutonium in 2024, 45% more than in 2023. The use of MOX resulted in estimated savings of 605 tU, and 422 tSW, an increase of 42% and over 40% respectively since 2023 (see Annex 5). MOX fuel is produced by mixing plutonium recovered from spent fuel and depleted uranium obtained from the enrichment process. MOX fuel increases the availability of nuclear material, reduces the need for enrichment services and increases the security of supply.

1 Source: Net electricity generation by type of fuel (Eurostat) - aggregated monthly data extracted on 28 April 2025.

2 Source: Eurostat. Supply, transformation and consumption of electricity - monthly data.

The amount of natural uranium equivalent included in fuel loaded into reactors in 2024, including natural uranium feed, reprocessed uranium and savings from MOX fuel, totalled 12 736 tU.

The total amount of natural uranium equivalent included in fuel loaded into reactors in 2024 was 12 736 tU.

MOX fuel and reprocessed uranium can be considered as domestic secondary sources that reduce the requirements for natural uranium. In 2024, they are equivalent to 4.8% of the EU's annual natural uranium requirements. It is up to the Member States and their corresponding national policies to decide whether to consider the spent fuel as radioactive waste or as a valuable source of new material after reprocessing. According to European Commission data, 7 of the 27 EU countries have reprocessed or plan to reprocess spent fuel, and 2 have not ruled out doing so.

Table 1. Natural uranium equivalent included in fuel loaded by source in 2024

Source	Quantities (tU)	% of annual requirement
Uranium originating outside the EU-27 (1)	12 120	95.2
Indigenous sources (2)	616	4.8
Total annual requirements	12 736	100

(1) Includes any small quantities of natural uranium resulting from enrichment underfeeding, re-enriched tails, and uranium of EU origin.

(2) Includes reprocessed uranium, savings from the usage of MOX fuel.

1.2. Future requirements

EU utilities have estimated their gross reactor requirements for natural uranium and enrichment services for the next 20 years, factoring in possible changes to national policies or regulatory requirements that would result in the construction of new units (the estimates only include projects already granted a construction licence), lifetime extensions, early retirement of reactors, and phasing-out or decommissioning. Plans for future new builds including new technologies (e.g. SAMRs) are therefore not included in their estimated requirements.

Net requirements are calculated on the basis of gross reactor requirements, minus the savings obtained from planned uranium/plutonium recycling and inventory usage.

Natural uranium – average reactor requirements		
2025-2034	11 731 tU/year (gross)	9 238 tU/year (net)
2035-2044	8 931 tU/year (gross)	5 908 tU/year (net)

Enrichment services – average reactor requirements		
2025-2034	9 964 tSW/year (gross)	7 829 tSW/year (net)
2035-2044	7 470 tSW/year (gross)	4 659tSW/year (net)

Estimates of future reactor requirements for uranium and separative work (SW), based on data supplied by all EU utilities, are shown in Figure 1 (see Annex 1 for numerical values).

Figure 1. Reactor requirements for uranium and separative work in the EU (in tonnes NatU or SWU)

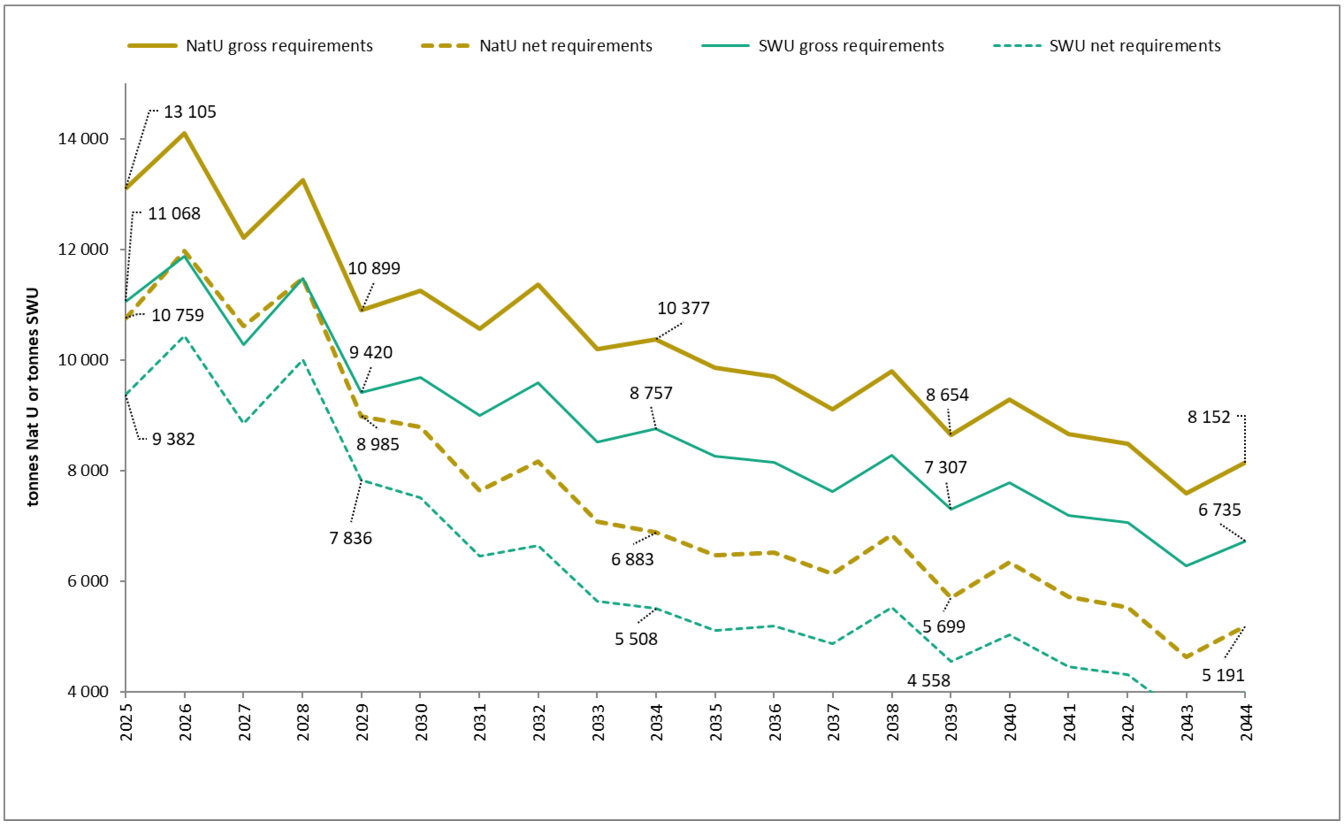
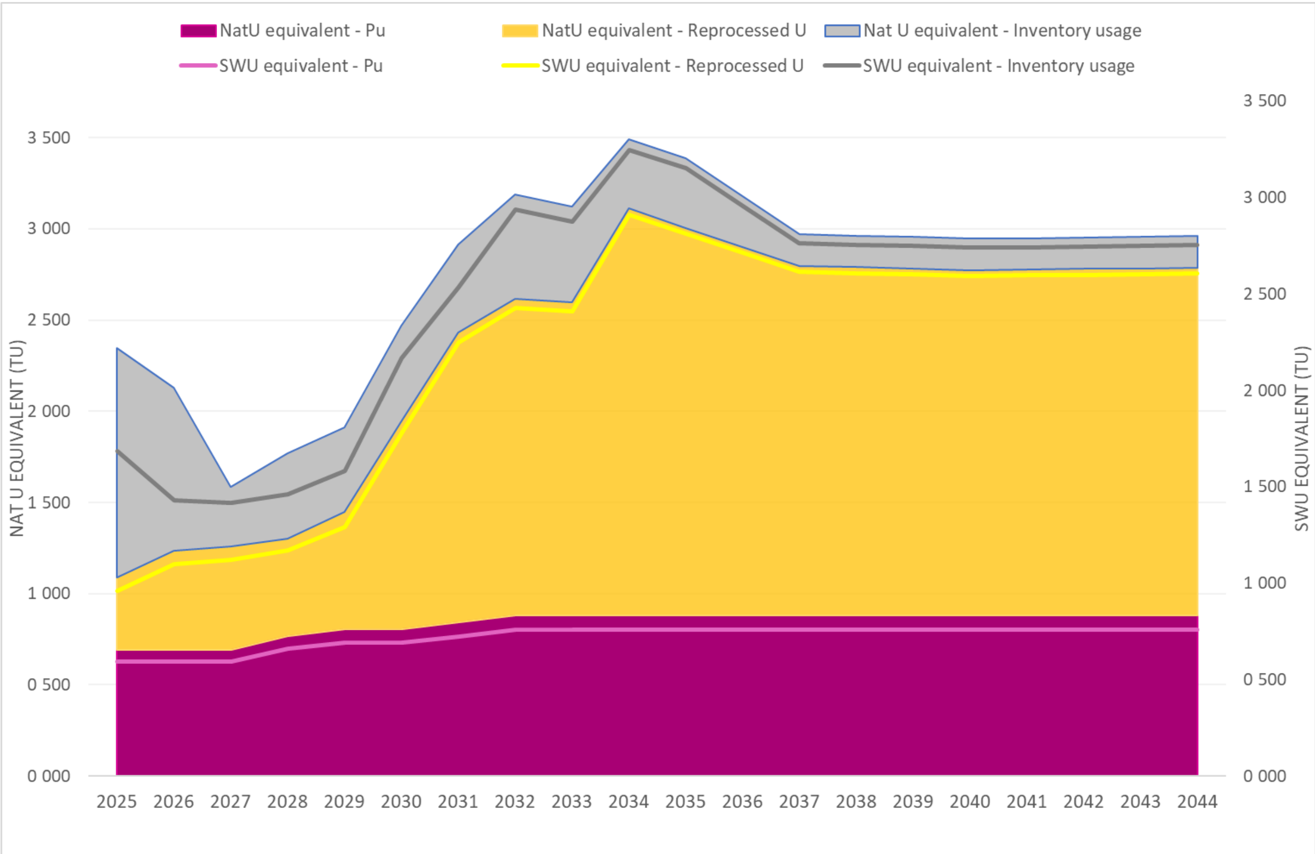


Figure 2. Estimated future use of secondary sources



1.3. Supply of natural uranium

Volume of deliveries

The volume of deliveries includes deliveries to EU utilities or their procurement organisations in 2024, excluding research reactors. Where stated, it also includes the natural uranium equivalent contained in enriched uranium purchases.

In 2024, demand for natural uranium in the EU accounted for approximately 20% of global uranium requirements. EU utilities purchased a total of 13 667 tU in 118 deliveries under multiannual and spot contracts.

As in previous years, supplies under multiannual contracts were the main source to meet demand in the EU. Deliveries of natural uranium to EU utilities under multiannual contracts accounted for 12 623 tU (of which 12 414 tU with reported prices). The remaining 1 044 tU was purchased under spot contracts.

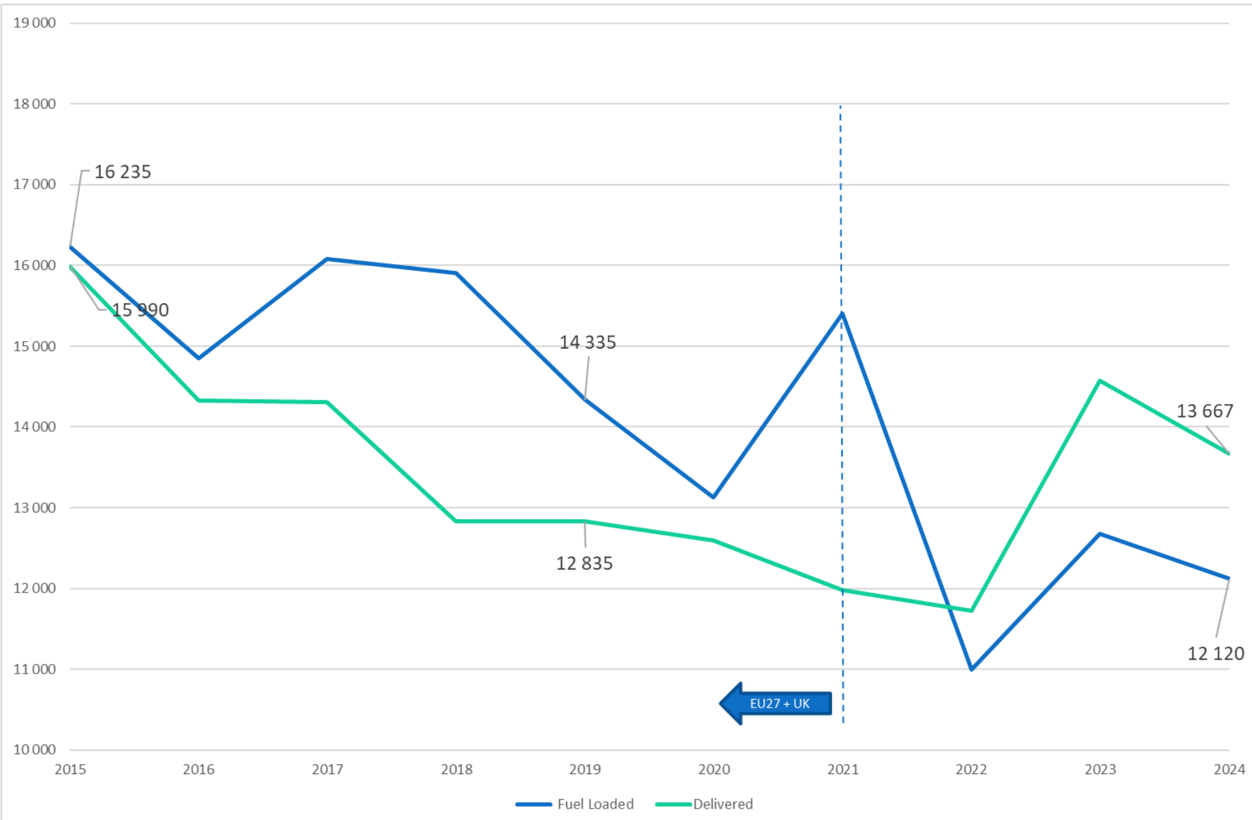
On average, the quantity of natural uranium delivered was 110 tU per delivery under multiannual contracts.

Demand for natural uranium in the EU accounted for approximately 20% of global uranium requirements.

Since the start of Russia's war of aggression against Ukraine, EU utilities have been stockpiling nuclear materials and fuel to mitigate the risk of disruption of supply chains. Therefore, in 2024, they continued loading less material into reactors than they bought. Figure 2 shows the quantities of natural uranium feed contained in fuel loaded into EU reactors and natural uranium delivered to utilities (see Annex 2 for the corresponding table for 1980-2024).

As in the previous year, in 2024 utilities bought more material than they loaded into reactors.

Figure 3. Natural uranium equivalent feed contained in fuel loaded into EU reactors and natural uranium equivalent delivered to utilities under purchasing contracts (tonnes NatU)



Average delivery prices

ESA's price calculation method converts the currency of the original contract prices, if stated differently, into euro per kg uranium (kgU) in the chemical form U3O8, using the average annual exchange rates published by the European Central Bank. The average prices are then calculated after weighting the prices paid by quantity delivered under each contract. Annex 3 lists the ESA historical prices and European Central Bank exchange rates. Annex 8 sets out the detailed price calculation methodology.

1. ESA spot U_3O_8 price: the weighted average U_3O_8 price paid by EU utilities for uranium delivered under spot contracts was calculated to be:	
EUR 132.32/kgU contained in U_3O_8	An 11% decrease from EUR 149.28/kgU in 2023
USD 55.09/lb U_3O_8	An 9% decrease from USD 60.46/lb U_3O_8 in 2023

The ESA U_3O_8 spot price reflects short-term price developments on the uranium market as it is calculated from contracts for either a single delivery or for several deliveries over a maximum 12-month period.

2. ESA multiannual U_3O_8 price: the weighted average U_3O_8 price paid by EU utilities for uranium delivered under multiannual contracts was calculated to be:	
EUR 142.26kgU contained in U_3O_8	A 23% increase from EUR 115.79kgU in 2023
USD 59.23/lb U_3O_8	A 23% increase from USD 48.16/lb U_3O_8 in 2023

3. ESA 'MAC-3' multiannual U_3O_8 price: the weighted average U_3O_8 price paid by EU utilities under multiannual contracts which were concluded or for which the pricing method was amended in the past 3 years and under which deliveries were made, was calculated to be:	
EUR 155.50/kgU contained in U_3O_8	A 50% increase from EUR 103.56/kgU in 2023
USD 64.74 /lb U_3O_8	A 50% increase from USD 41.95 /lb U_3O_8 in 2023

The ESA multiannual U_3O_8 price is not forward-looking. It is based on historical prices contracted under multiannual contracts, which are either fixed or calculated based on formulas indexing mainly uranium spot prices.

Figures 3a and 3b show the ESA average price of natural uranium since 2015. The data are presented in Annex 3.

Figure 3a. Average prices of natural uranium delivered under spot and multiannual contracts, 2015-2024 (EUR/kgU)

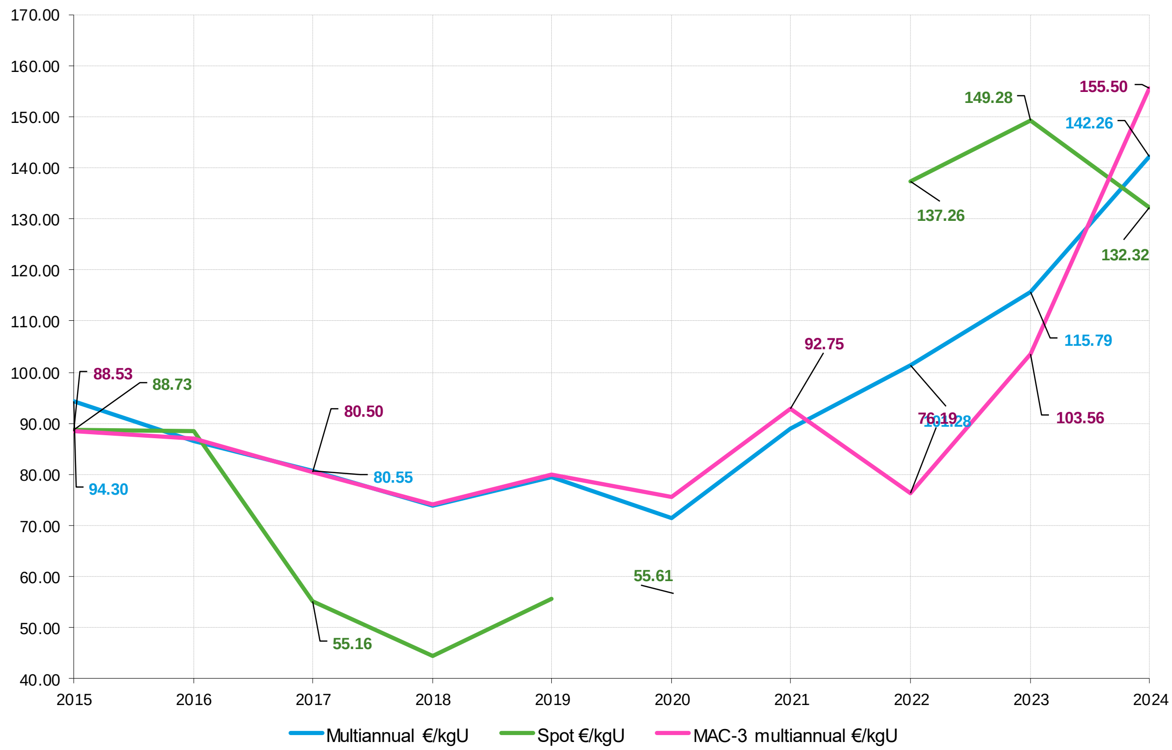
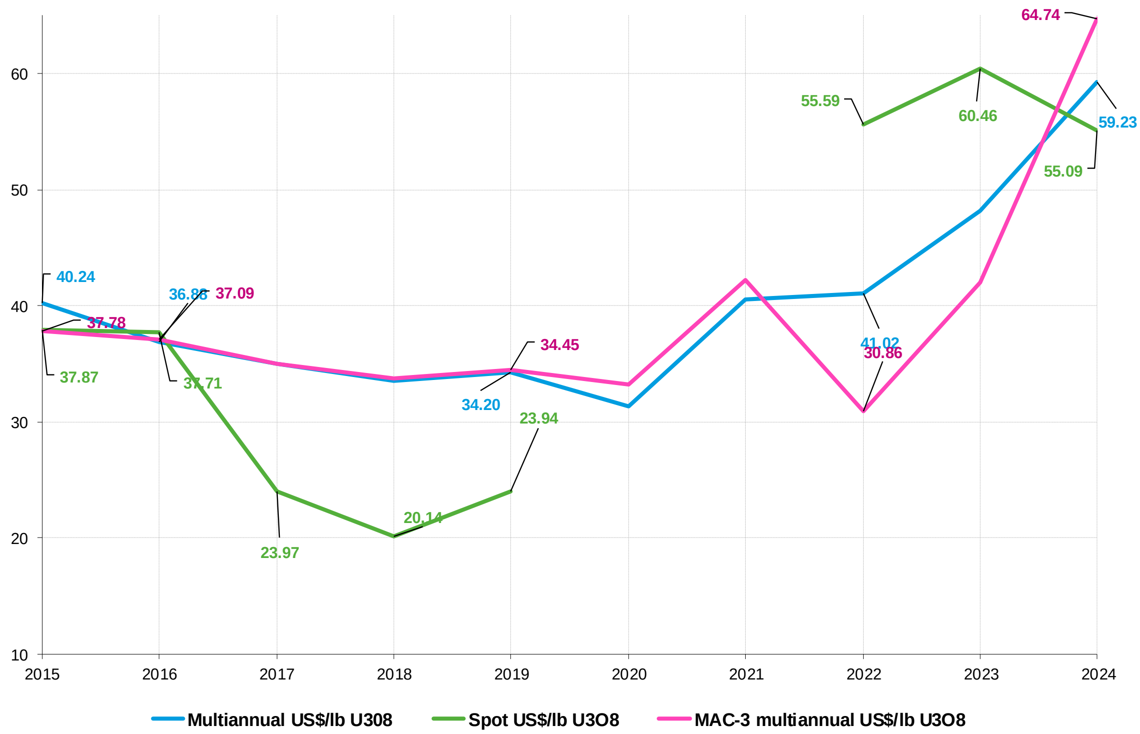


Figure 3b. Average price of natural uranium delivered under spot and multiannual contracts, 2015-2024 (USD/lb U3O8)



Origin of fuel supplies

In 2024, natural uranium supplies to the EU continued to come from diverse sources. The origins of natural uranium supplied to EU utilities remained similar to 2023, though there were some changes in market share.

Table 2. Origins of uranium delivered to EU utilities in 2024 (tU)

Origin	Quantity	**Share (%)**	**Change in quantities 2023/2024 (%)**
Canada	4 741	33.90%	-1.27%
Kazakhstan	3 391	24.25%	10.79%
Russia	2 185	15.63%	-36.08%
Australia	1 474	10.54%	296.32%
Niger	1 154	8.25%	-44.75%
China	644	4.61%	100.00%
Uzbekistan	249	1.78%	-8.04%
Namibia	146	1.04%	-73.41%
Malawi	3	0.02%	100.00%
EU	0		0
Re-enriched tails	0		0
Other [(1)]	0		0
Total	13 984	100	-4.08%

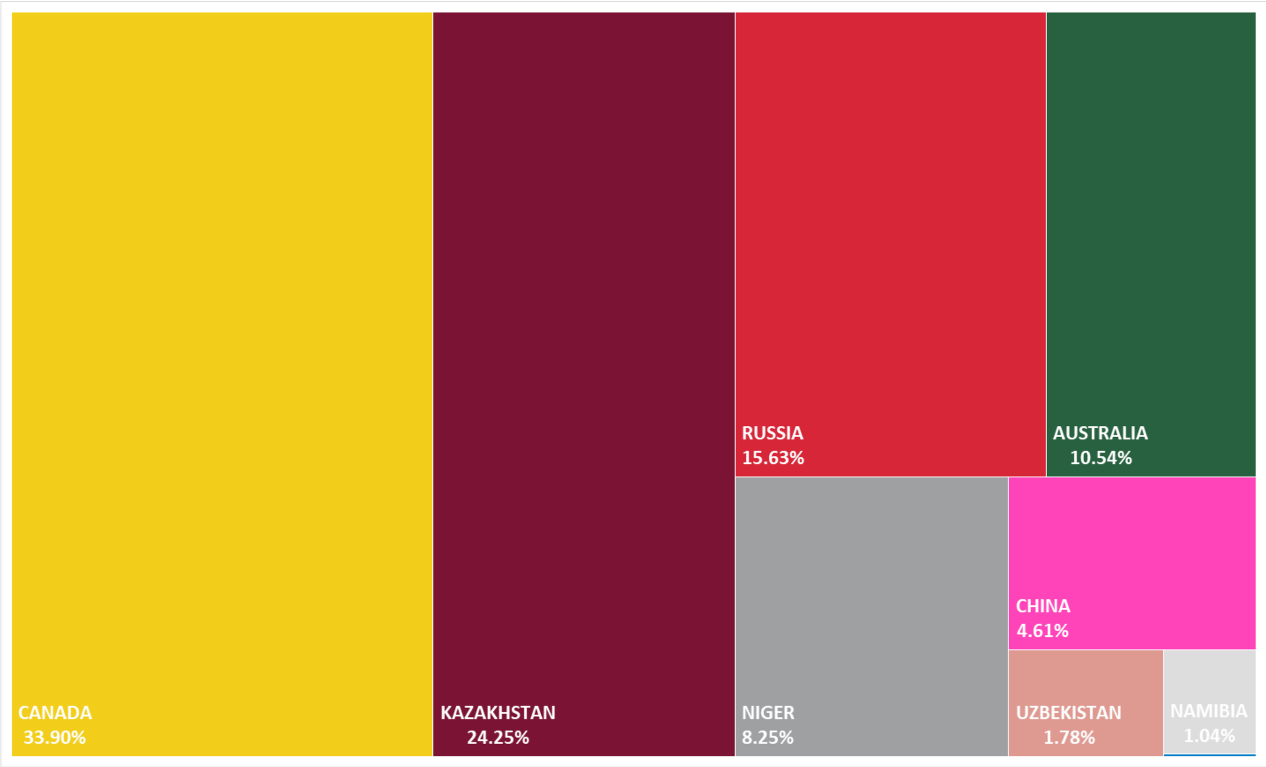
Due to rounding, the totals may not add up.

(1) Material saved through underfeeding, mixed origin and unknown

Four countries provided over 84% of all-natural uranium supplied to the EU in 2024, even though a slight reduction has been recorded.

Over 84% of natural uranium supplied to the EU came from four producing countries.

Figure 4. Origins of uranium delivered to EU utilities in 2024 (% share)



Natural uranium produced in Commonwealth of Independent States (CIS) countries accounted for 41.66% of all-natural uranium delivered to EU utilities. CIS deliveries amounted to 5 825 tU in 2024 against 6 750 tU the year before. Natural uranium originating in non-CIS countries amounted to 8 012 tU in 2024, an increase compared to the 7 828 tU imported in 2023.

Similar to the previous year, deliveries of uranium from Africa decreased sharply in 2024, reaching 1 303 tU compared to the 2 651 tU delivered in 2023.

Figure 5. Origins of uranium delivered to EU utilities in 2024 by geographical regions (tU)

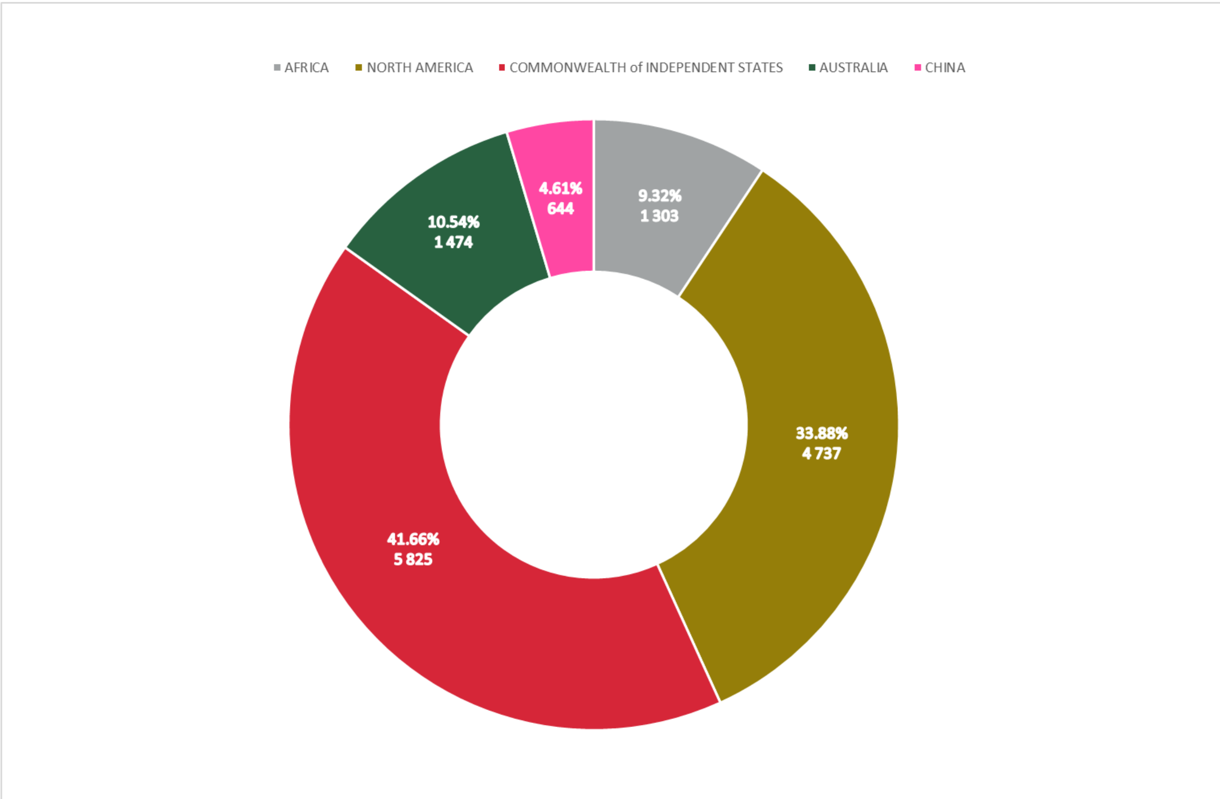
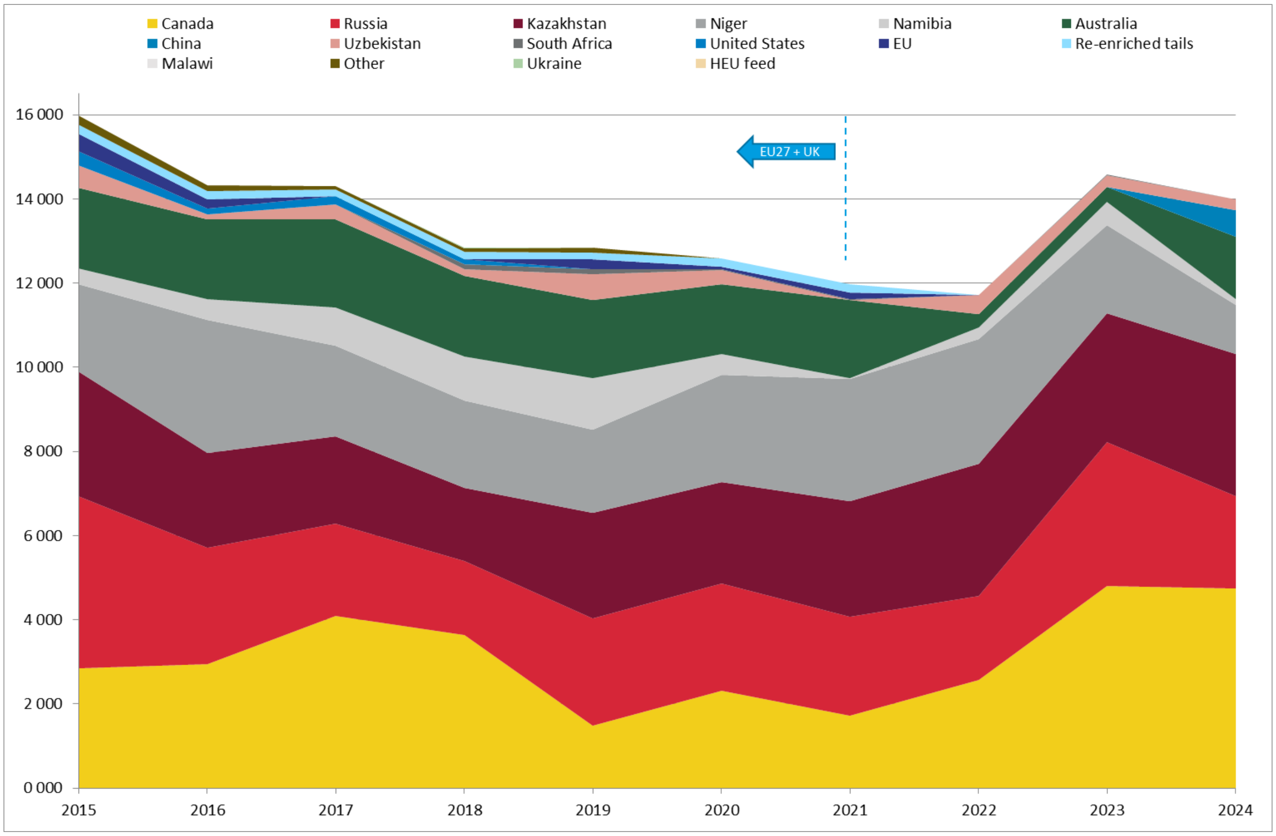


Figure 6. Purchases of natural uranium by EU utilities, by origin, 2015-2024 (tU)



Conversion services

Under separate conversion contracts, 7 729 tU were converted, accounting for 58% of all service deliveries to EU utilities. The remaining 42%, or 5 778 tU, were delivered under other types of contracts (purchases of natural UF6, EUP, bundled contracts for fuel assemblies).

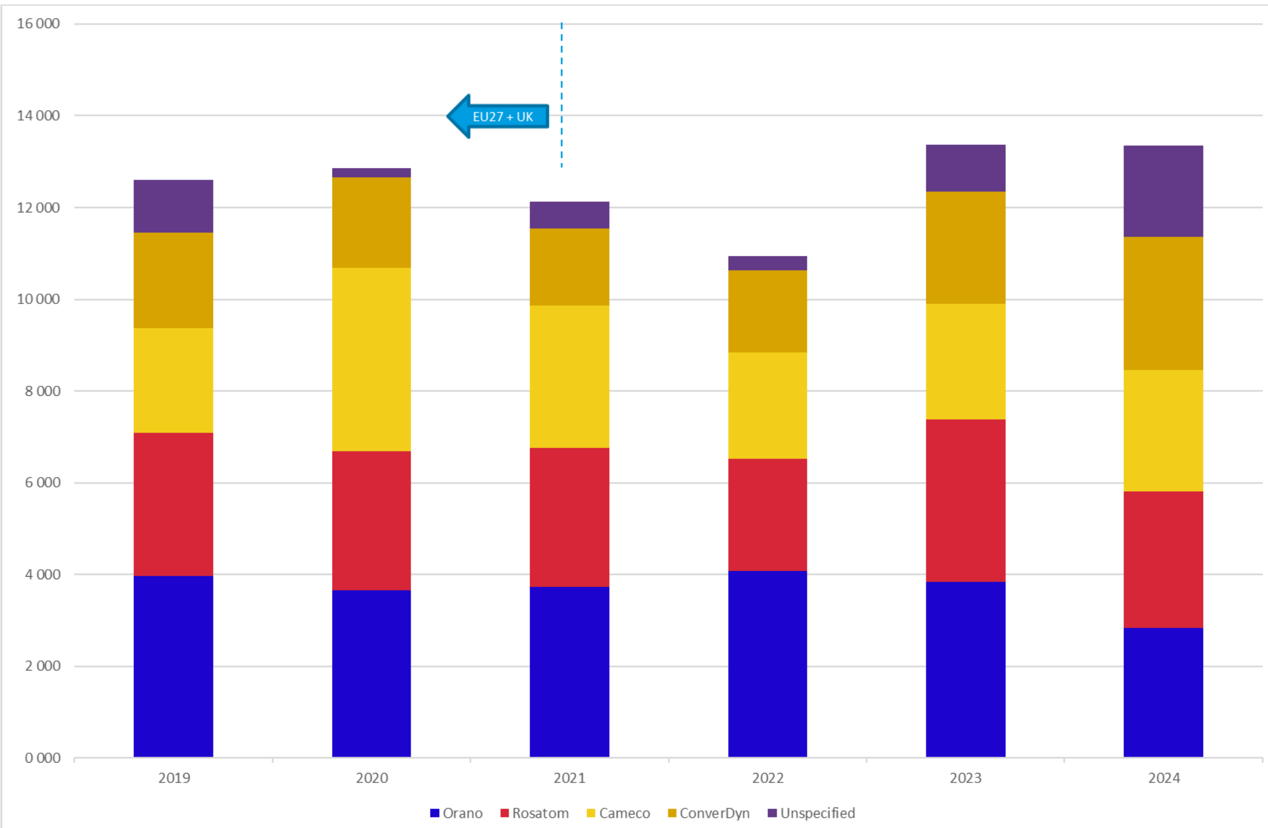
Conversion service deliveries to EU utilities were at the same level in 2024 as in 2023.

Table 3. Provision of conversion services to EU utilities

Converter	Quantity in 2024 (tU)	Share in 2024 (%)	Quantity in 2023 (tU)	Share in 2023 (%)	Change in quantities 2023/2024 (%)
Rosatom (Russia)	2 977	22.37	3 543	26.51	-15.97
ConverDyn (US)	2 898	21.78	2 448	18.32	18.39
Orano (EU)	2 840	21.34	3 834	28.69	-25.94
Cameco (Canada)	2 643	19.86	2 525	18.90	4.66
Unspecified	1 949	14.65	1 013	7.58	92.33
Total	**13 306**	**100**	**13 364**	**100**	**-0.43**

Due to rounding, the totals may not add up.

Figure 7. Supply of conversion services to EU utilities by provider, 2019-2024 (tU)



1.4. Special fissile material

Deliveries of low-enriched uranium

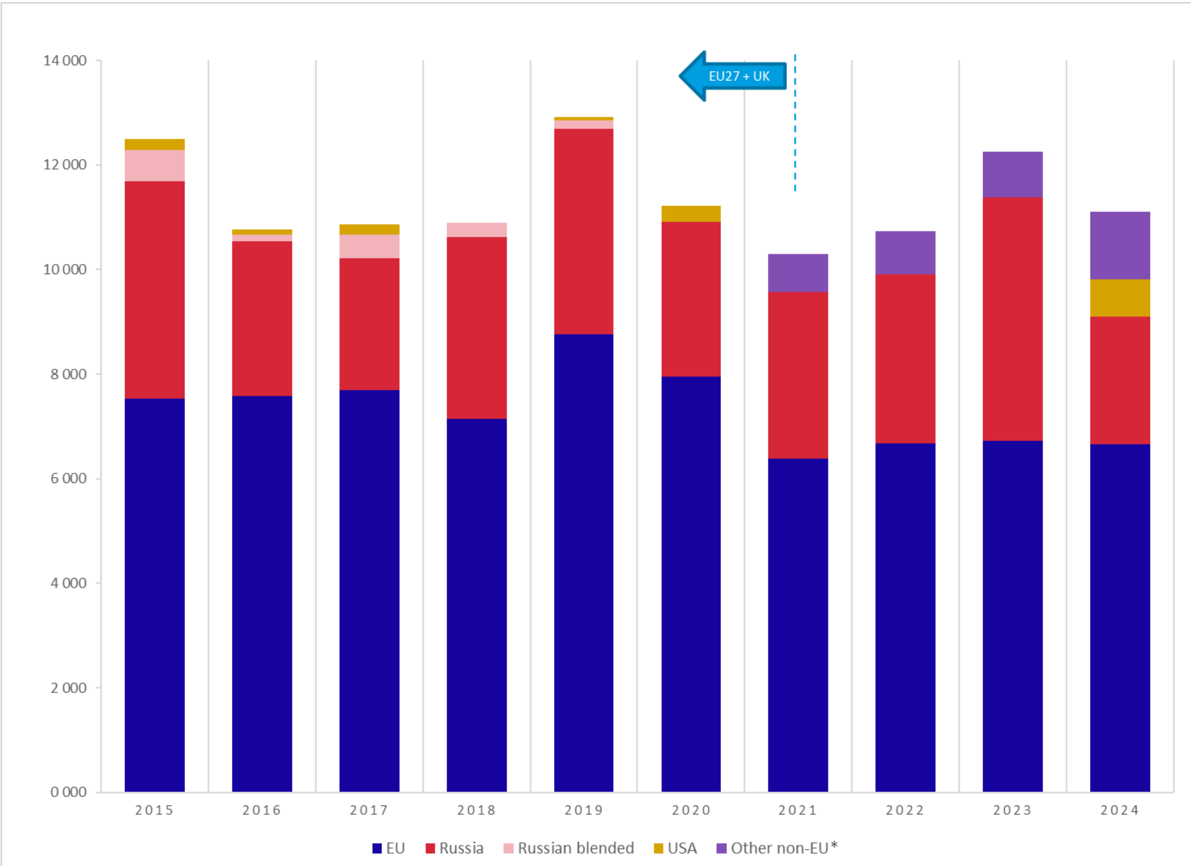
In 2024, enrichment service deliveries to EU utilities were 15% lower than in 2023, with nuclear power plant operators opting for an average enrichment assay of 4.19% and an average tails assay of 0.20%.

Enrichment service deliveries to EU utilities were 15% lower in 2024 than in 2023.

Table 4. Origin of enrichment services to EU utilities

Enrichment origin	EUP tU 2024	Uranium feed 2024 (tU)	Quantities in 2024 (tSW)	SW share in 2024 (%)	Quantities in 2023 (tSW)	SW share in 2023 (%)
EU	1 042	7 932	6 654	63.95	6 728	54.88
Russia	356	2 844	2 450	23.55	4 647	37.90
Other	182	1 423	600	12.50	885	7.22
TOTAL	1 580	12 199	10 405	100	12 260	100

Figure 8. Supply of enrichment to EU utilities by provider, 2015-2024 (tSW)

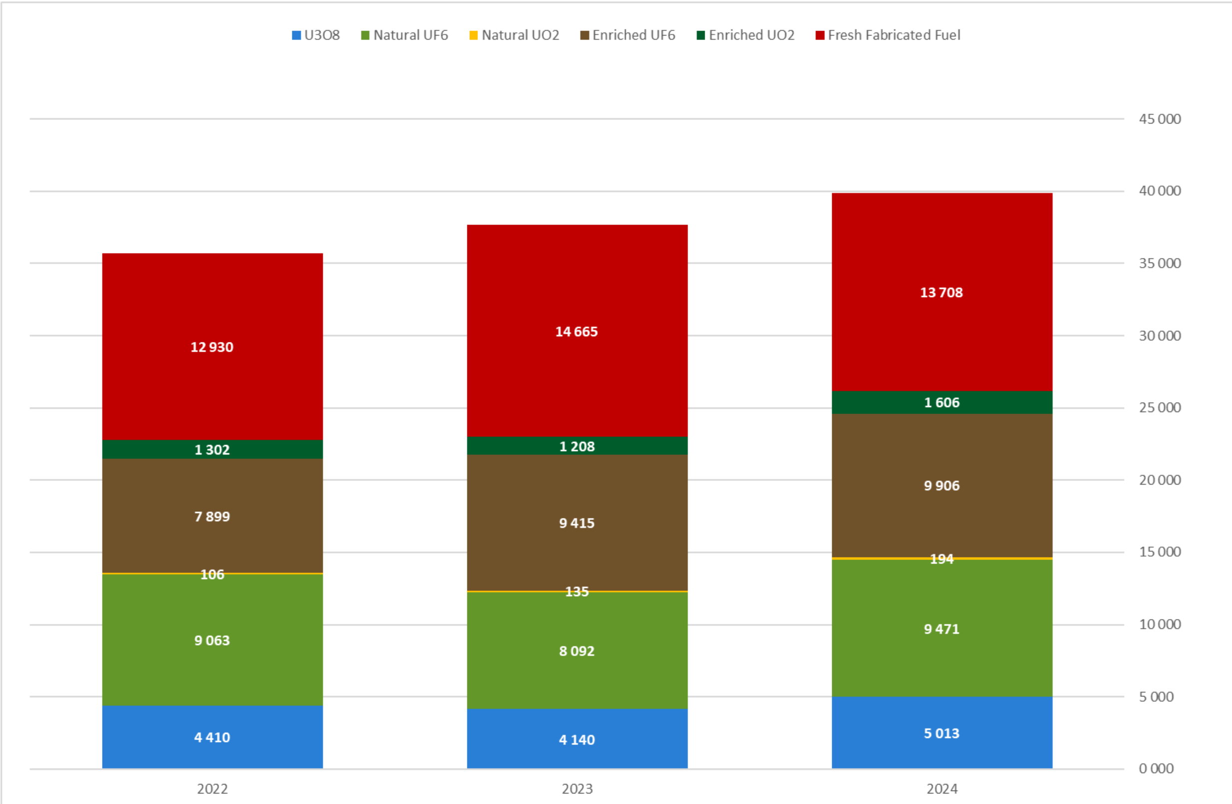


*Other non-EU, starting from 2021

1.5. Inventories

At the end of 2024, the natural uranium equivalent in inventories owned by EU utilities totalled 39 898 tU. The inventories comprised uranium at different stages of the nuclear fuel cycle (natural uranium, in-process for conversion, enrichment, fuel fabrication and fresh fuel), stored at EU or other nuclear facilities.

Figure 9. Total natural uranium equivalent inventories owned by EU utilities at the end of the year, by chemical form, 2022-2024 (in tonnes)



The changes in the aggregate natural uranium inventories do not necessarily reflect the difference between the total natural uranium equivalent loaded into reactors and uranium delivered to EU utilities, as the level of inventories is subject to movements of loaned material, sales of uranium to third parties and one-off national transfers of material.

Based on average annual EU gross uranium reactor requirements (11 731 tU per year), uranium inventories are sufficient to fuel the nuclear power reactors of EU utilities for more than three reloads on average. This average conceals a wide range, although all utilities keep a sufficient quantity of inventories for at least one reload.

Uranium inventories can fuel the nuclear power reactors of EU utilities for three reloads on average.

A further analysis of the inventories of EU utilities shows that most of these inventories are located in the EU. However, some are located outside the EU and a small fraction for future delivery is stored at unknown locations.

1.6. Future contractual coverage rate

The contractual coverage rate of EU utilities for a given year is calculated by dividing the maximum and minimum contracted deliveries in that year – under already-signed contracts – by the estimated future net reactor requirements of the utilities in the same year. The result is expressed as a percentage. Figures 9 and 10 show the maximum and minimum contractual coverage rate for natural uranium and for SWUs respectively, and Figure 11 shows the maximum and minimum contractual coverage rate for conversion services for EU utilities.

$$\text{Contractual coverage rate of year X} = 100 \text{ X } \frac{\text{Maximum/and minimum contracted deliveries in year X}}{\text{Net reactor requirements in year X}}$$

For net reactor requirements (the denominator), a distinction is made between demand for natural uranium and demand for enrichment services. Average net reactor requirements for 2025-2033 are estimated at 9 238 tU and 7 829 SW per year (see table in Annex 1). ESA assumes the same quantity of requirements for conversion services as for natural uranium. A distinction is drawn between demand for conversion services covered under separate conversion contracts and other contracts, which include deliveries of natural UF6, EUP or bundled contracts for fuel assemblies.

A quantitative analysis shows that EU utilities are well covered under existing contracts with EU and third-country suppliers for natural uranium, conversion and enrichment services. However, when looking at minimum contractual arrangements, the situation is different.

Figure 10. Coverage rate for natural uranium, 2025-2033 (%)

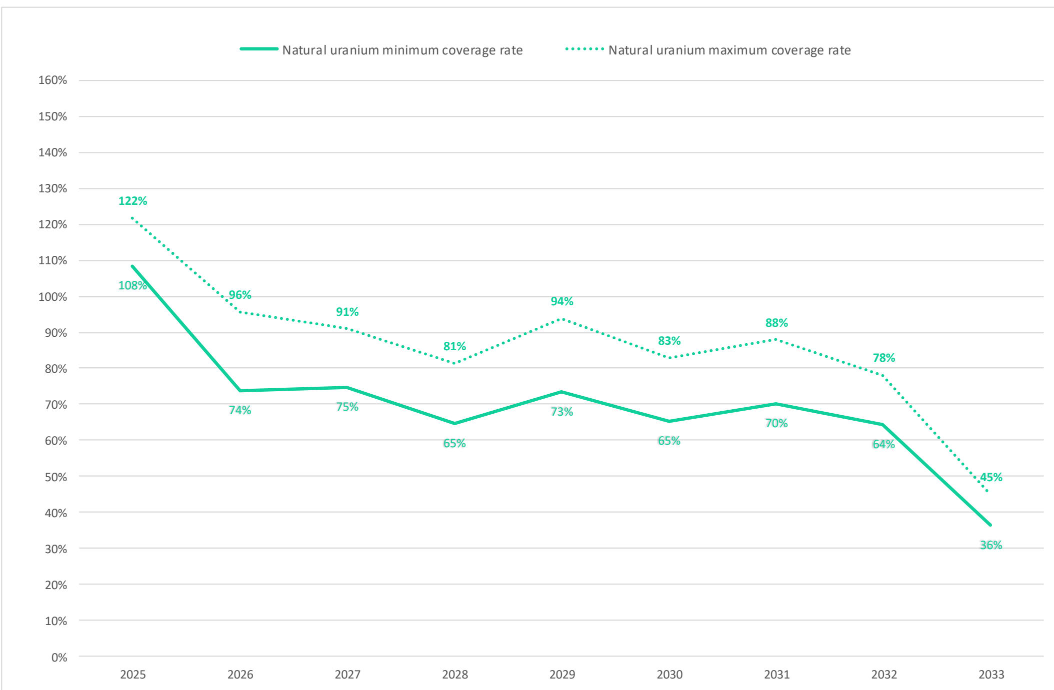


Figure 11. Coverage rate for conversion services, 2025-2033 (%)

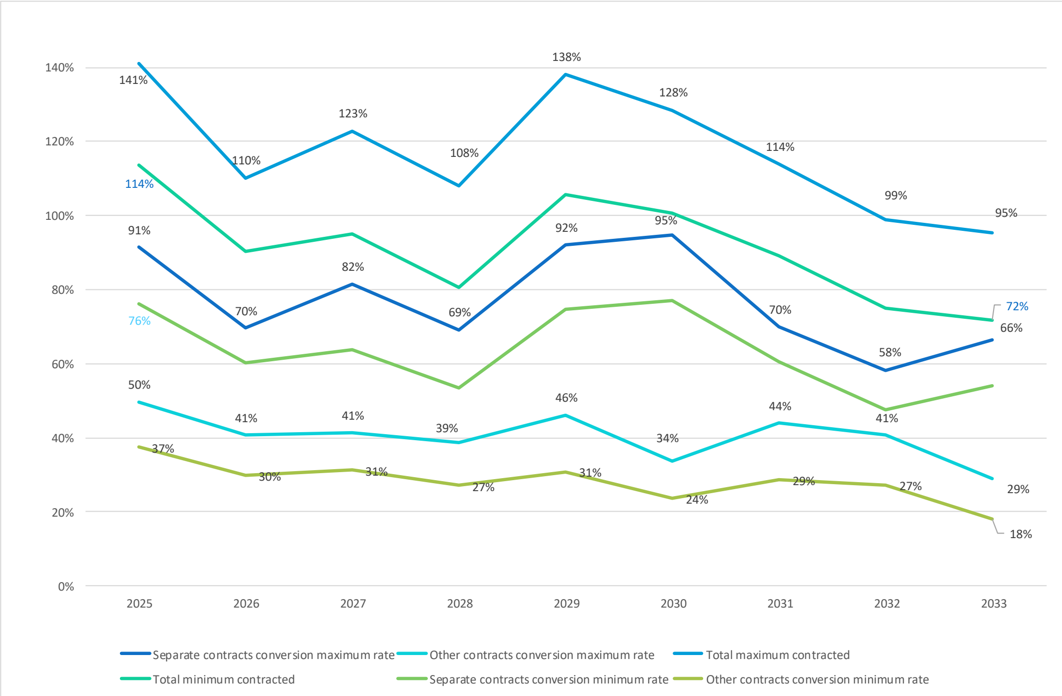
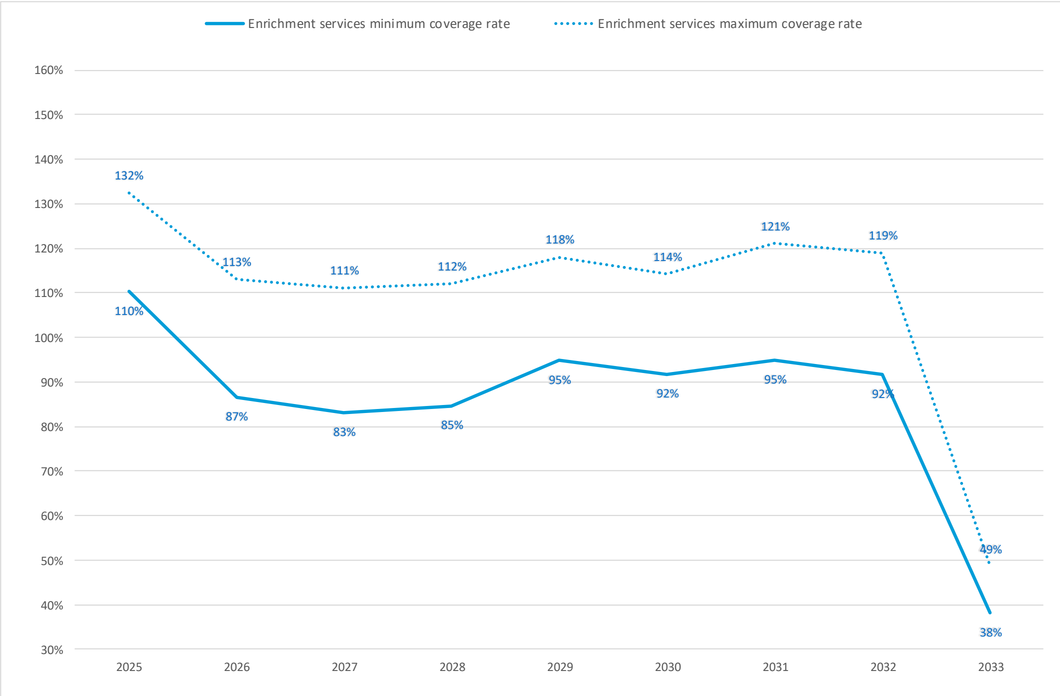


Figure 12. Coverage rate for enrichment services, 2025-2033 (%)



2. Security of supply

2.1. Analysis of EU market

The security of supply of nuclear materials and fuel is of paramount concern for the European Union (EU), given its substantial reliance on nuclear energy to meet electricity demands. Largely based on data provided by EU utilities presented in chapter 1 and information gathered from monitoring the EU nuclear fuel market, this chapter presents the Agency's analysis of market trends. Furthermore, it looks at the market developments, their impact on the security of supply and outlines a number of essential recommendations aiming at ensuring supply of nuclear materials and related services.

The EU's nuclear fuel supply chain is heavily dependent on imports of uranium, whereas other parts of the nuclear fuel cycle are more diversified, with enrichment, conversion and fuel fabrication capacities secured to a greater extent within the EU, even though external dependencies remain. Recent global events have underscored the vulnerabilities of the supply chain. Geopolitical tensions have had a significant impact on the security of supply of nuclear materials and services to EU users, with a substantial proportion of these supplies originating from countries with uncertain or unstable political environments. Most importantly, the Russian invasion of Ukraine has fundamentally changed the EU's security of supply environment for nuclear materials and services.

Preparedness at EU and Member State level
Euratom should consider taking forward policies and measures for crisis preparedness and management, similar to those developed for other sources of energy. Such policies and measures would ensure a coordinated response to supply chain disruptions and minimise their impact on EU utilities and users. This could include reserving EU industry capacity and essential services for EU users, building common strategic stocks, and considering how to best make use of the provisions of the Euratom Treaty for common purchase and distribution mechanisms. The approach should give due consideration to securing adequate amounts of material at different stages of the fuel cycle (e.g. natural uranium, converted uranium, enriched uranium products and fuel assemblies).

The EU has taken steps to enhance the security of its nuclear fuel supply chain. The RePowerEU action plan provides a framework to reduce the EU's energy dependency on Russia, in collaboration with like-minded countries. The European Commission, some Member States and EU industry have launched initiatives aimed at diversifying the EU's nuclear supplies and expanding production capacity. Over three years into the Russian aggression against Ukraine, the EU has increased its resilience and its level of strategic autonomy.

The EU and like-minded countries have also adopted far-reaching restrictive measures towards Russia in various areas, targeting organizations, individuals, and specific activities, as well as affecting transport and trade. The United States has enacted a ban on uranium imports from Russia, with waivers possible until the end of 2027. While nuclear fuel and services have been exempted from direct EU restrictions thus far, a complete phase-out of supplies from Russia remains a political and strategic objective[3].

Meanwhile, various challenges have emerged affecting transport routes, in particular nuclear fuel logistics. In addition, as a result of restrictive measures taken, including by third countries, completing financial transactions with certain countries has become more difficult. As in other energy sectors, the nuclear industry and power operators should take measures to guarantee regular and sufficient supplies, irrespective of the structure of the market.

3 On 6 May 2025, the Commission has adopted the REPowerEU roadmap, setting out a coordinated, secure and gradual phase out of Russian gas, oil and nuclear energy imports. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Roadmap towards ending Russian energy imports, COM(2025) 440.

Various measures are available to reduce the risk of interruptions in supply or to limit their effects.

These measures need to be underpinned by a robust risk-management framework, which identifies, assesses, monitors and mitigates potential risks to the supply chain.

Risk management
Energy regulators, safety regulators, grid operators and electricity holdings should factor nuclear supply risks into their risk assessment and preparedness. Nuclear utilities and fuel-cycle actors should implement a robust risk-management framework to minimise the risk of supply chain disruptions, ensure a stable and reliable supply of nuclear fuel, and support the continuous operation of nuclear power plants. They should specify the acceptable level of exposure with respect to high-risk profile partners or operations/transactions and be mindful of possible interrelationships across energy products and interdependencies of supply chains (e.g. risk of storage and transport, origin of components and source material for components and parts). The risk factors to be considered in relation to security of supply include: • changing Community and national decisions, regulatory frameworks; • legal and economic ownership of suppliers; • physical location and control of nuclear materials; • geographical origin of supplies, considering the potential risks associated with different regions; • risk profile of transactions or commercial partners and suppliers; • supply logistics. All market parties concerned should draw up and implement plans to mitigate identified risks. They should cooperate to strengthen mechanisms for data and information sharing on the evolution of factors affecting the supply of nuclear fuels and relevant products. The security of energy supply should be monitored at different levels: at EU/Euratom level, at national, industry and utility level. It should be a coordinated effort to include all viewpoints and interests. Market players should continue monitoring the market, taking into account origin and transit risks and carrying out contractual due diligence to manage their exposure to a changing market and avert security of supply vulnerabilities.

The polarization of markets with different forms of restrictive measures in place, but also the increased interest in nuclear energy, raise concerns that markets may further tighten and become more limited, posing challenges to the security of supply of nuclear materials and services.

2.1.1. Inventories

ESA has long recommended that EU utilities maintain sufficient strategic inventories and utilize market opportunities to increase their stocks, depending on their individual circumstances.

Recent Trends. Since 2022, the overall EU inventory level has been growing, in contrast to the previous years. As advised by the Agency, utilities have increased their stocks to manage the unstable market conditions as a consequence of Russia's aggression towards Ukraine. In 2024, the overall EU inventory level increased by 5.96% compared to 2023.

In 2024 the overall EU inventory level increased by 5.96 %.

Ensuring adequate inventories
Utilities should maintain adequate inventories of nuclear materials in the EU and other low-risk locations to cover future requirements and should use market opportunities to increase stocks. Fuel supply chain actors should also maintain inventories to avoid disruptions in the nuclear fuel supply chain. In building inventories, due care must be paid to determining the appropriate chemical-physical specifications and amounts, given the lead times in the fuel cycle steps. Stock should include fresh fuel in quantities that can respond to supply chain delays or interruptions. National reserves or inventories of utilities dependent on non-EU design and supplier should also include a number of reloads to tide them over until alternative fuel is available in the event of the fuel supply definitive interruptions. While some EU Member States already have stockpiling requirements in place, Euratom would benefit from a coordinated approach to strategic stockpiling for emergency situations. Member States, producers and users are invited to take a coordinated approach, considering the financing and technical efforts involved.

Fuel and Enriched Uranium. Although EU fresh fuel stocks decreased by 6.5% during 2024, the total amount of enriched uranium in all chemical and physical forms (fuel, UO2, UF6) remained identical to the situation at the end of the previous year. Notably, more than 60% of the inventory is held in the form of enriched uranium or fresh fuel.

Natural Uranium. The EU's natural uranium inventory has seen a significant increase, with a total growth of 18.7% in 2024 compared to the previous year. This expansion is driven by uncertainty in the uranium supply market, fuelled by diverse geopolitical events. As a result, the EU utilities have strategically increased their holdings of natural uranium in various chemical forms, including U3O8, UO2 and UF6, to ensure a stable supply and mitigate potential future risks. Specifically, U3O8 stocks have risen by 21.1%, while converted uranium (UF6) inventories have grown by 17.0%, driven by concerns over the uncertain availability of open-market conversion capacity.

Utilities Profile. All utilities have nuclear material in their inventory to cover between one and more than three reloads each, with the vast majority covered for more than two reloads. The sufficiency of the inventory level for a particular utility depends on its profile and risk factors. At least 94% of the nuclear materials as well as the entirety of the Fresh Fabricated Fuel held by the utilities are located within the EU territories.

The ESA considers that most utilities' inventories remained at a healthy level during 2024.

2.1.2. Demand

In 2024, the amount of fuel loaded into commercial reactors remained stable compared to the previous year.

Fuel loaded. In 2024, the total amount of fuel loaded into commercial reactors remained stable (1 761 tU), compared to the previous year. The total amount of natural uranium contained in the fuel loaded into reactors in 2024 was 12 120 tU.

Deliveries. EU utilities received 13 667 tU of uranium in 2024, purchasing almost 13% more material than they loaded into reactors.

Estimates of future reactor requirements for uranium and enrichment services indicate a decrease of around 5% in gross requirements and 8% in net requirements over the next decade. Moreover, domestic sources of supply, such as MOX fuel and reprocessed uranium, have increased by 28% (135 tU) compared to 2023 and are expected to continue growing and to stabilize between 2 800 and 3 000 tU after 2034.

2.1.3. Supply diversification

Bundling supplies and/or relying on a single supplier at any stage of the nuclear fuel cycle hamper market functioning and transparency, lead to excessive dependence and make a utility vulnerable to adverse events.

> Diversification is key to securing future deliveries and to minimising dependence on individual suppliers. Security of supply should preferably encompass:
>
> - at least two different suppliers from friendly jurisdictions , whenever possible at least one EU-based;
> - different suppliers at each stage of the fuel cycle, considering legal and economic ownership;
> - diverse geographical origin of the supplies and physical location of the nuclear materials;
> - creating alternative routes and modes of transport to minimise reliance on single transport routes or modes.
>
> The Commission, ESA and national authorities should continue to jointly monitor the implementation of nuclear supplies diversification plans. The focus should be on the VVER reactor fuel and on taking action to eliminate any risks or threats to the timely completion of these plans, while fully respecting the nuclear safety framework.

The long-term security of supply relies on diversifying sources for utilities, preventing over-reliance on a single non-EU design or supplier, and maintaining the competitiveness of EU industry throughout the fuel cycle. ESA has consistently advised utilities to secure their current and future needs by concluding multi-year contracts with a range of suppliers. The analysis shows a significantly changed supply landscape compared to 2023, driven in part by the REPowerEU initiative and diversification efforts more generally, which have reduced supplies from Russia and CIS countries. However, ongoing VVER fuel stockpiling efforts and the needs for reprocessing-related services, may introduce fluctuations in supply levels over the next few years.

Uranium

Origin. The entirety of fresh uranium demand in the EU is covered by imports from third countries and is therefore subject to geopolitical developments and related trade policy implications.

The origins of natural uranium deliveries to EU utilities remain diversified. The top four supplier countries in 2024 were Canada, Kazakhstan, Australia, and Russia, which differed from the 2023 ranking[4]. The top four countries now account for 84% of total supplies, while the top five countries account for more than 92%. Supplies from Russia and Niger were partially replaced by imports from Australia and to a minor extent from Kazakhstan and China. As a result, the origin of supplies is more widespread than in previous years. This increased diversification reduces dependence on a single region or supplier.

> Given the absence of EU domestic uranium mining, the regional concentration of uranium origin and that a number of utilities have a single non-EU supplier, the Agency stresses the need to source supplies from diverse jurisdictions and geographical origins.

4 In 2023, the top four supplier were Canada, Russia, Kazakhstan and Niger.

Deliveries are more widespread than in previous years. In 2024, five big producing countries supplied more than 92% of the natural uranium delivered to the EU, while in previous years supplies were concentrated in only four supplier countries.

The concentration of supply from the CIS countries has decreased to less than 41.7% in 2024, down from 46.3% the year before, 13.71% less by weight. At the same time imports from the rest of the world increased by almost 2.35% compared with the previous year.

This reduction is largely due to a significant decrease in supplies from Russia, which accounted for 15.6% of total uranium deliveries to EU utilities in 2024, a decrease of 36.1% from the previous year. Deliveries from Africa amount to 9.3%, also down by 50.84% compared to 2023. If deliveries from Niger are excluded supplies from Africa account only for 1% of total supplies.

Utility Procurement Practices. In line with ESA's recommendation, 92% of natural uranium deliveries to the EU in 2024 were made under multi-year contracts, while 8% were purchased through spot contracts. Only a small number of utilities still rely on a single supplier for their natural uranium needs, which may increase their vulnerability to supply disruptions. ESA's recommendations to diversify supply sources and conclude multi-year contracts with multiple suppliers remain essential for ensuring long-term security of supply.

Conversion

Origin. In 2024, the EU uranium conversion market saw a relatively stable quantitative supplies. Russia (Rosatom) was the largest supplier despite a 16% decrease in supply compared to 2023, Rosatom provided 2,977 tU, accounting for 22.4% of the total market share. Converdyn (United States) continued to increase its EU market share, providing 18.4% more conversion services than in the previous year.

There has been a significant increase in conversion services provided from the US.

The services provided from within the EU, by Orano followed closely, with 2,840 tU, representing 21.3% of the market share, although this marked a 25.9% decrease from 2023.

However, the analysis of uranium conversion trends is complicated by a significant portion of services reported with unspecified origin, which accounted for 14.6% (1,949 tU) of the total market, a 92.3% increase from 2023.

Utility Procurement Practices. The proportion of conversion services provided as part of bundled contracts, which include purchases of natural UF6, EUP, and fresh fuel fabrication, accounted for 58% of all service deliveries to the EU. This represents a 9.6% increase from 2023, indicating a growing trend towards bundled contracts among the utilities which is not in line with ESA recommendations.

Enrichment

In 2024, EU enrichers increased their share to 63.9% with 6 654 tSWU (from 54.9% in 2023 with 6 728 tSWU), even though the total quantity of separative work provided to EU utilities decreased by 15.1%. The enrichment services provided by suppliers outside the EU decreased considerably by 44.9% year on year. Among them, Russian enrichment accounted for 23.55% of the total (37.9% in 2023) thus supplying 47.3 % less enrichment services than the previous year.

In 2024, the share of uranium enrichment provided by suppliers outside the EU decreased by 44.9% compared to 2023.

On average, utilities opted for a 4.19% enrichment assay, marginally lower than in 2022 (4.26%). The contracted tails assay remained almost identical and amounted to 0.20%.

Fuel

Most EU utilities have access to at least two alternative fuel fabricators. In contrast to the situation elsewhere in the EU, dependence on a single design and supplier of fuel for the Russian-designed water-water energy reactors (VVER) remains a significant vulnerability for the security of supply.

The utilities and research reactor operators that depend on a single non-EU supplier design for fuel assemblies, components and spare parts should continue developing and implementing actions that cover all aspects of the diversification process.

Special attention should continue to be given to accelerating the market introduction of alternative fuel designs. In parallel it is essential to start developing alternative solutions for fuel designs and components, based on European intellectual property rights and a European supply chain.

Cooperation between industry and operators, involving regulators as appropriate, is vital to reduce the time to design and market alternative VVER nuclear fuel, further improving the security of supply, and giving due priority to nuclear safety.

Supply Security in the EU. The situation has progressively evolved. In addition to granting EUR 10 million to the APIS[5] project in 2023, the European Commission has awarded a similar grant to the SAVE[6] project, led by the French company Framatome in 2024. The SAVE project aims to enhance VVER nuclear fuel supply security in Europe and Ukraine by developing a reliable and safe sovereign fuel design. Countries operating VVER reactors have made progress in diversifying their fuel supplies and - with the exception of Hungary - adopted alternative designs from different suppliers. The Agency notes the efforts by operators and producers to design, license and create fabrication capacity for alternative fuel design for VVER reactors.

Recent Developments. Notable progress has been made in the use of alternative fuel designs for VVER reactors. On the VVER-1000[7] side, in April 2024, the Bulgarian Agency for Nuclear Regulation (ANR) issued a permit to Unit 5 of the Bulgaria's Kozloduy nuclear power station to start using Westinghouse-made nuclear fuel RWFA for VVER-1000. On 29 May 2024, the Westinghouse fuel was loaded.

Similarly, on the VVER-440[8] segment, the first batch of Westinghouse Electric Company NOVA nuclear fuel has been loaded into Fortum's Loviisa Nuclear Power Plant during its annual outage in August 2024.

In 2024, alternative fuel has started to be loaded in Russian designed VVER-440 and VVER-1000 units.

Preparatory Work and Risk Assessment. In the other plants, preparatory work to use alternative fuel is on-going. In the meantime, utilities have increased their fuel stocks to fill the gap until alternative fuel is available and licensed.

For power plants using other fuel designs, the short-term risk of dependency from Russia appears less significant, to the extent that deliveries from other sources have covered most of the needs, both in materials and enrichment services.

5 'Accelerated Program for Implementation of secure VVER fuel Supply' (APIS)) to carry out the necessary safety analyses and tests and put in place procedures needed to license alternative non-Russian fuel design for VVER reactors in the EU and Ukraine

6 'Safe and Alternative VVER European Fuel'

7 VVER-1000 units are operational in Bulgaria and Czechia.

8 VVER-440 units are operational in Czechia, Finland, Hungary and Slovakia.

2.1.4. Prices

The ESA multiannual price increased last year by 32% and accounted for EUR142.26 per kgU and MAC-3 price increased by 50% and accounted for EUR155.50 per kgU. ESA spot price index was 11% down as compared with 2023, amounting to EUR132.32 per kgU. At the same time, price indices of uranium originating in CIS countries were 25%, 26% and 24% lower than the price for uranium of non-CIS origin.

On the global market, the average spot price of UxC natural uranium was 27% up and amounted to USD 84.77 per lb U_3O_8. The UxC average long-term natural uranium price was 26% up and amounted to USD 77.83 per lb U_3O_8.

Compared to late 2023, the average price of conversion services was USD 67.50 /KgU in the EU and USD 67.67 /KgU in North America. This is 39% above the previous year average price. Long-term prices also rose in 2024. Compared to 2023, the UxC long term average price of conversion rose by 24% to reach almost 39.54 USD per KgU in the EU and by 25% (39.71 USD per kgU) in North America.

The UxC spot average price of enrichment rose to USD 172.67 / kg SWU, a 20% increase year to year. The UxC long term average price of enrichment rose to USD 160.08 per kgSWU, a 10% increase.

2.1.5. Medical radioisotopes

ESA highlights ongoing foreign dependencies within the medical radioisotope supply chain, posing potential risks to the EU's leadership in producing medical radioisotopes and advancing nuclear medicine products and procedures. A key factor for a secure supply of medical radioisotopes is having nuclear materials for irradiation targets and research reactor fuel readily available. Presently, HALEU is not manufactured in the EU and must be imported from the US or Russia, with US supplies expected to last until 2035-2040 based on current estimation.

Advance an alternative fuel for research reactors
Research reactor operators reliant on non-EU suppliers or fuel designs should advance their diversification strategies. Efforts should be made to develop EU fuel design and domestic production capacities, which could be based on the Euratom coordinated research projects [9].

HALEU's significance has risen due to its role in fuelling advanced reactors. In response, the US Department of Energy (DoE) is working on various methods to produce HALEU through its HALEU Availability Program, which received backing from the 2020 Energy Act and the 2022 Inflation Reduction Act, allocating USD 700 million in support. In 2024, the US DoE selected several companies for enrichment and deconversion services to establish a domestic HALEU supply and announced an additional USD 80 million for innovations in HALEU production processes. The UK also plans to invest GBP 300 million in a HALEU initiative, including a GBP 196 million award to URENCO for a Capenhurst uranium enrichment facility capable of producing 10 tonnes of HALEU annually by 2031.

To secure HALEU for medical isotopes in the EU, the options proposed by the Agency's working group10 in its 2022 report remain viable. The ESA is participating in the European Commission's efforts to explore metallic HALEU supplies within the European Radioisotopes Valley Initiative (ERVI) under the SAMIRA action plan. Additionally, the Euratom research project 'Preparatory phase for a European production capability to secure a supply of HALEU fuel',(11) launched in 2024, aims to stimulate collaboration among stakeholders to achieve the necessary maturity for EU HALEU production capabilities. Despite retaining the technical expertise for uranium metallization, this process has been inactive on an industrial scale in the EU for over a decade.

9 Euratom research and training programme (europa.eu).

10 'Securing the European Supply of 19.75% Enriched Uranium Fuel: PROPOSED OPTIONS', Euratom Supply Agency, May 2022.

11 EU Funding & Tenders. Call for Proposal 'Preparatory phase for a European production capability to secure a supply of high-assay low-enriched uranium (HALEU) fuel', HORIZON-EURATOM-2023-NRT-01-11.

Address HALEU vulnerability
Clear political actions are essential at the EU and Member State levels to mitigate HALEU supply risks. Efforts must focus on achieving EU self-sufficiency through all possible avenues, including the ERVI initiative under SAMIRA. Consideration should be given to fostering EU production by capitalizing on EU industry and technology, particularly in preserving metallization knowledge. Efforts should be continued to develop transport packaging solutions and have them licensed across relevant markets.

Another concern is the EU's **reliance on Russia for enriching stable isotopes** critical for developing new medical radioisotopes, which are essential for creating new cancer treatments. Enhancing the EU's enrichment capacity for source materials and stable isotopes requires significant investments and addressing the lack of domestic electromagnetic or suitable enrichment facilities. Building infrastructure for recycling costly enriched materials could reduce waste and enhance competitiveness, needing new dedicated installations.

It is crucial to maintain and expand EU capabilities for stable isotope enrichment via centrifugation—potentially combined with other methods—and bolster cyclotron-based radionuclide production.

Enhance the security of supply of source materials and stable isotopes
The EU, Member States, and industry should address security of supply and reduce foreign dependencies by: • diversifying supply sources. • recycling/reusing enriched materials. • building EU capacity for source materials and stable isotopes enrichment.

Finally, **establishing a system to monitor supply and generate long-term forecasts** is vital for maintaining an uninterrupted flow of medical radioisotopes. This system should encompass a diverse range of radioisotopes and production techniques, drawing on the experience of the European Observatory on the Supply of Medical Radioisotopes, which tracks Molybdenum-99/Technetium-99m supply. Such a system would provide decision-makers and stakeholders with the necessary facts and insights to guide strategy, inform policy development, and support investment decisions within the supply chain.

Develop a forecast and monitoring system
The EU, Member States, industry, and nuclear medicine stakeholders should join forces to develop a forecast and monitoring system to oversee the security of supply for essential medical radioisotopes.

2.2. Future outlook

2.2.1. Contractual coverage

Uranium. Under existing contracts, the supply of natural uranium is largely secured until 2027. From 2028 until 2031, the coverage oscillates between 80% and 90% of requirements and then drops to 45% in 2033, which is the last year of analysis. The uranium minimum contractual coverage rate follows a similar pattern, going down to 38% in 2033.

Conversion. A quantitative analysis of conversion services shows that EU utilities' net reactor requirements are well covered under existing contracts. The maximum contractual coverage rate is above 100% until 2033. The minimum contracted supply of conversion services is around or above 100% until 2031. It then drops to the range between 80-90% in 2032 and 2033.

Enrichment services under maximum contractual coverage rate are above 100%, well secured until 2032. Then the rate drops to 49% in 2033. The minimum contracted supply of enrichment services is oscillating between 110% in 2025 and 80-90% in the next years to drop to 38% in 2033.

Utilities should consider concluding multiannual contracts to cover most of their requirements for uranium and services. Long-term contracts add stability and predictability for the nuclear industry and electricity production. They help give a clear understanding of future demand and can foster industry investment in production capacity.

To cover residual short-term requirements, lacking reliable supplies in this timeframe, utilities are recommended to consider concluding short-term or spot contracts, mindful of the potential risks. It is essential to conduct thorough due diligence to ascertain the economic and mining origins, and availability, of the materials in question. This approach enables early detection of vulnerabilities in the supply chain, allows for a more accurate assessment of risks associated with potentially unreliable sources, and facilitates the mitigation of those risks.

2.2.2. EU and global fuel cycle market

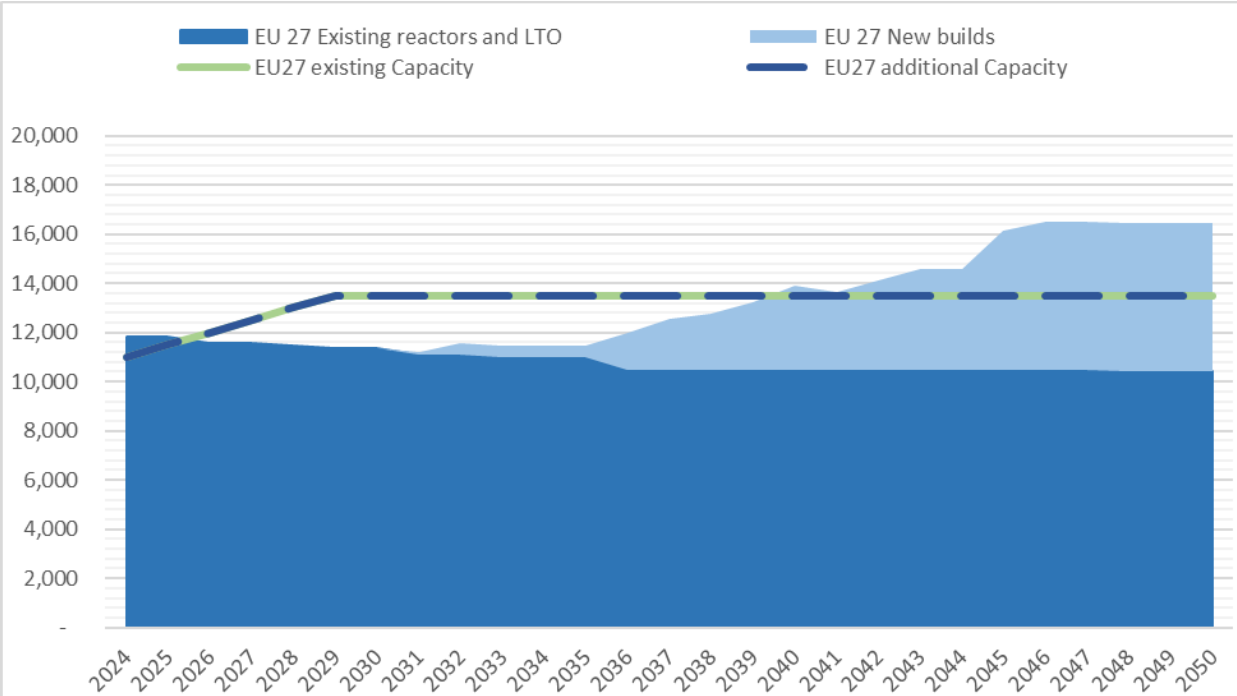
In this section ESA evaluates future demand and supply scenarios for conversion and enrichment and identifies the gap between the two given the demand growth scenarios will realise. EU demand is based on future electricity generation capacity projections of DG ENER and Member States' National Energy and Climate Plans (NECPs). The demand for conversion and enrichment services in the Western geopolitical region and the rest of the world is sourced from the reference scenario in the World Nuclear Association's 2023 Nuclear Fuel Report, 'Global Scenarios for Demand and Supply Availability 2023-2040'." Future capacity of enrichment and conversion plants in Western geopolitical region is sourced from press releases, company's annual reports, ESA estimates and feedback from industry. The projected future demand is depending on the progress related to new builds.

It is important to underline, that commercial commitments undertaken by the EU producers with customers outside the EU, are not known by ESA and they reduce the capacity available to the benefit of the EU utilities.

Conversion market

European Union. The current capacity of the only conversion plant in the EU, located in France, is estimated to be 11 000 tU per year which is slightly below the needs of the EU nuclear reactor fleet. The capacity is expected to be sufficient by 2026 and to exceed EU needs starting that year, provided Orano ramps up its capacity from the current operating level to 13 500 tU by 2029.

EU 27 demand for conversion services vs capacity projections



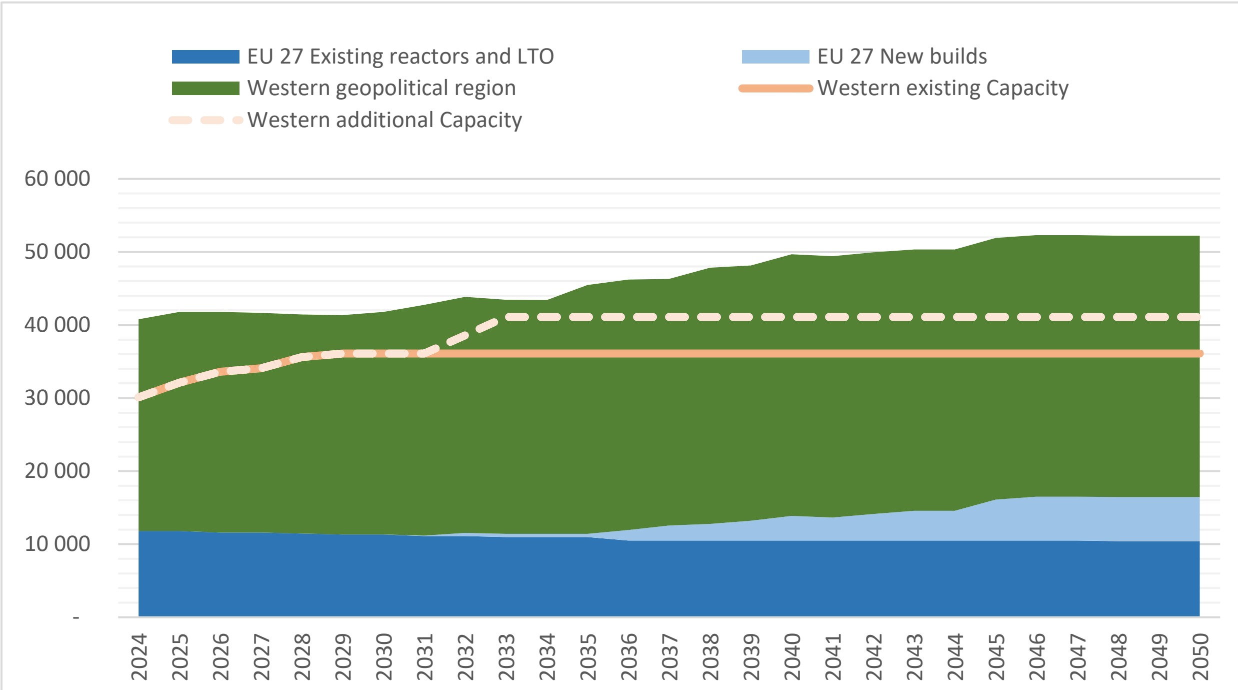
Westerngeopolitical region[12]. The current capacity of conversion plants located in Western geopolitical region accounts for approx. 31 100 tU per year and is insufficient to supply the nuclear reactor fleet in these countries. The gap exceeds 10 000 tU and slightly decreases to more than 5 000 tU per year by 2029. However, the gap is projected to widen again due to planned long-term operation programmes (LTOs) and new reactors being connected to the grid.

These shortfalls can be mitigated by secondary sources, particularly UF6 inventories. Nevertheless, in the long run, there is insufficient capacity to convert enough uranium to meet the reactor needs . Inventories held by EU utilities—primarily in the form of already converted uranium (UF6), enriched UF6, and fresh fuel—can sustain EU reactors for approximately two years.

The remaining needs are currently satisfied by other suppliers and by secondary sources. It is important to underline that, given the limited inventories, other secondary sources like reprocessing and MOX fuel are insufficient to cover the gap in the event of a sudden supply interruption.

12 This includes the EU Member States, Switzerland, UK, Japan, Ukraine, South Korea, Australia, Canada and USA.

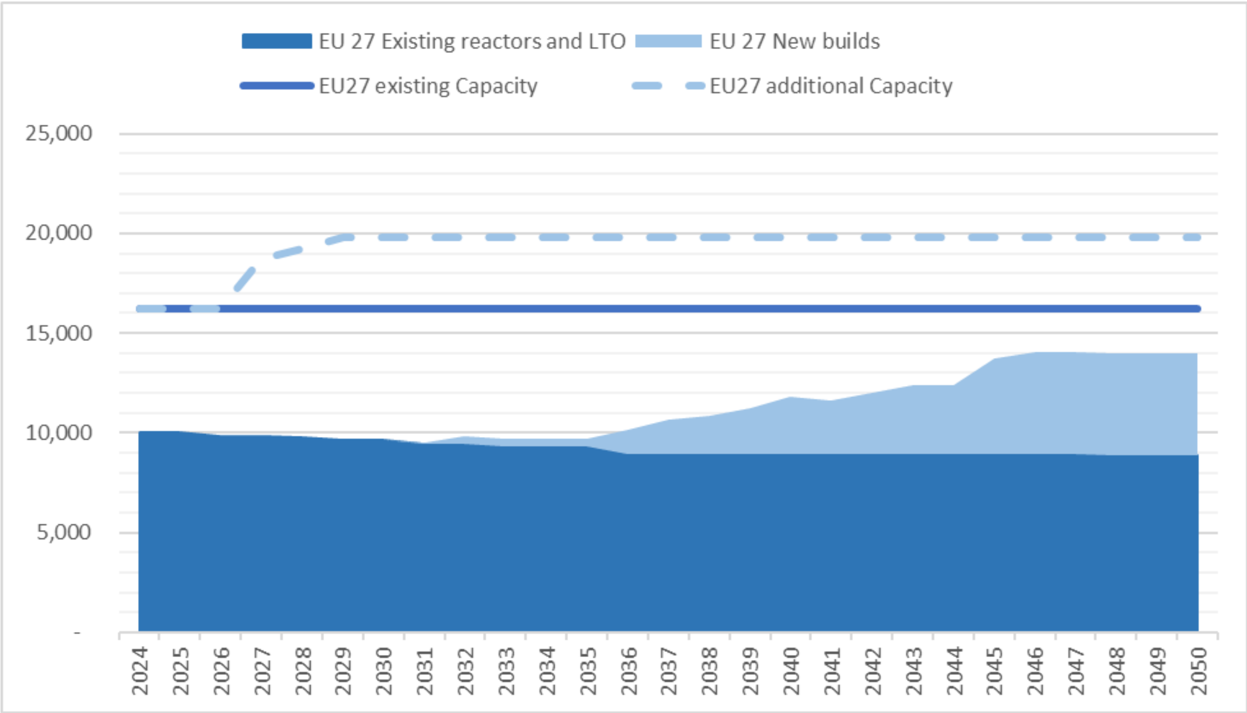
Western geopolitical region demand for conversion services vs capacity projections



Enrichment market

European Union. The EU based enrichment plants' aggregated capacity is sufficient for the EU to be self-dependent. The combined capacity accounts for 16 200 tSWU per year in plants located in France, the Netherlands and Germany. With the additional capacity becoming available anticipated increased demand could also be satisfied.

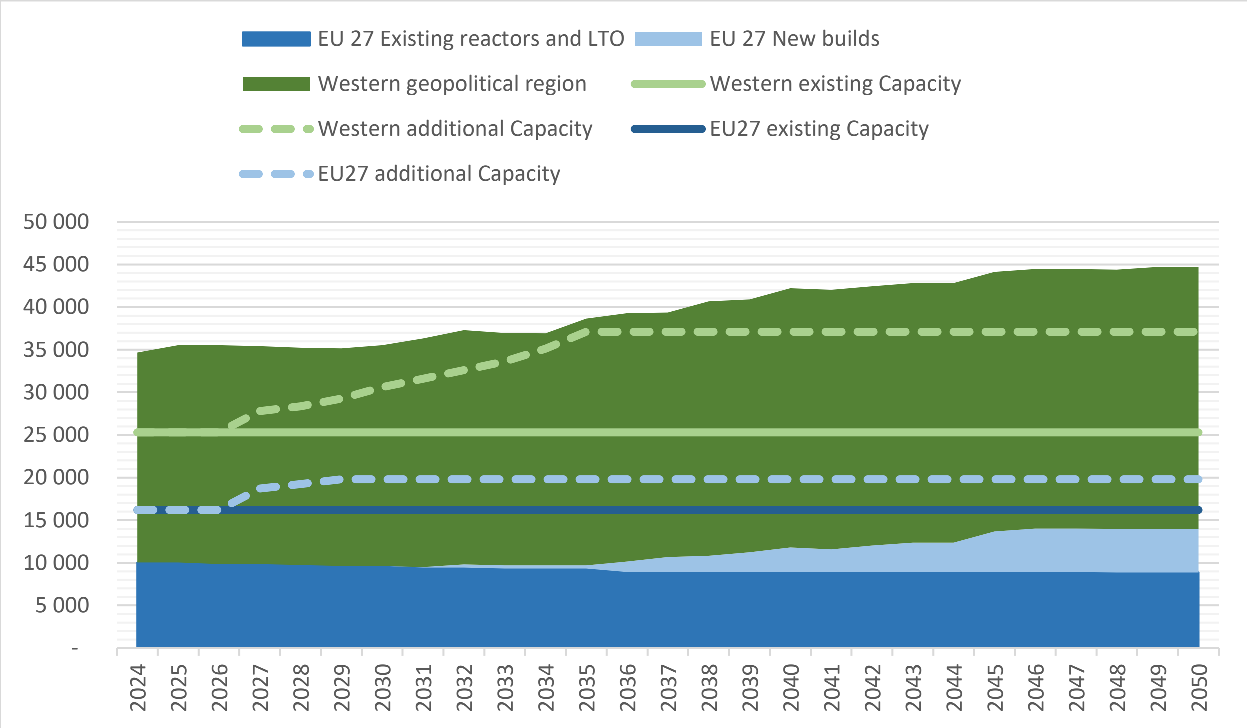
EU 27 demand for enrichment services vs capacity projections



Western geopolitical region. The current capacity of enrichment plants located in the Western geopolitical region accounts for 25 300 tSWU per year and is insufficient to supply the nuclear reactor fleet in these countries. The missing capacity exceeds 9 000 tSWU per year and decreases after 2027 when new centrifuge cascade units in France, Germany, Netherlands, UK and the US will be installed, However, even taking into account certain new technologies which are still under development and validation, the overall capacity will not be sufficient to satisfy Western needs. The gap gradually drops to 500 tSWU per year in 2037 and is estimated to rise when new reactors will come online in the mid-2030s. The gap will remain at more than 2 000 tU per year from 2040 on. Given the fact that there may be additional demand for HALEU related to SMRs and SAMRs and that there may be additional needs of research reactors the gap may rise even further.

Similarly to the conversion services market in a short-term part of the shortfalls can be mitigated by secondary sources, particularly inventories of enriched material. Nevertheless, in the long run, new capacity is needed. Currently the remaining needs are satisfied by other suppliers and by secondary sources. It is important to underline that, given the limited inventories, other secondary sources like reprocessing and MOX fuel are insufficient to cover the gap in the event of a sudden supply interruption.

Western geopolitical region demand for enrichment services vs capacity projections



Based on a clear government strategy, long-term commitments by the utilities are required to trigger investments that can enable increased conversion and enrichment capacity in the EU and like-minded countries. Supply contracts concluded for a period longer than 10 years are possible with additional authorisations.

In addition, political commitment is needed to trigger industry investment, particularly in enrichment and conversion capacities.

Furthermore, action is needed to boost capacity in certain fuel-cycle technology for reprocessing, uranium and plutonium recycling, or to tackle dependence.

At the same time, open market industry should bear in mind that excessively high prices could incentivise users to explore other supply options, defer the signing of long-term contracts or optimise the size of their inventories.

2.2.3. Enable nuclear expansion and developments

Building upon the increased focus on energy security, as evidenced by the COP28 nuclear declaration and the Heads of State-level nuclear summit in Brussels on 21 March 2024, there is a renewed global interest in nuclear energy as a low-carbon and fossil-free source.

Indeed, there is a growing interest in nuclear energy also in the EU, including among Member States that previously did not utilize this energy source or had taken nuclear phase-out decisions. Interested Euratom Member States see nuclear energy as playing a crucial role in transitioning to a decarbonized economy and ensuring electricity supply security for countries both within the European Union and worldwide that opt for this energy source. Nuclear energy can be complementary to renewable sources in a decarbonized energy mix to some extent, helping these countries to achieve their climate objectives and to strengthen energy security and the need to reduce dependence on fossil fuel imports.

Several EU Member States have put forward initiatives to extend the operations of their nuclear power plants, to expand their capacity or to build new power plants. The growing interest in nuclear energy is also fuelled by emerging technologies, such as small and advanced modular reactors (SAMRs), where there is significant progress in research and development and which in the future could play a role in integrated energy systems.

However, the scope, time and specific technologies that will be deployed remain uncertain. Further efforts are needed by interested Member States to develop reliable supply chains to meet the growing demand for nuclear and new nuclear technologies, to achieve climate goals while maintaining energy sovereignty.

A clear strategy needed

In alignment with national objectives for energy security and energy mix choices, Member States that opt for nuclear energy generation should foster a stable environment that enables utilities and industry to make informed strategic and operational decisions. To achieve this, they should clearly specify:

- national objectives: setting explicit national nuclear energy goals and targets in the energy mix;
- technology and fleet development: providing a clear roadmap for the long-term operation, new builds, and development of new nuclear technologies, including investments and deployment strategies;
- supply security: specifying the conditions that nuclear utilities must meet to ensure a reliable and secure supply of energy.

This clarity will enable the nuclear industry to make informed decisions, driving investment, innovation and growth in the sector.

While the nuclear market expands, alongside the required development of the fuel cycle and services, it will become increasingly crucial to reduce to the extent possible uranium imports and demand for services, as well as to promote a circular nuclear economy.

Increase indigenous sources of supply

Member States and market actors should:

- Consider prospecting for and exploiting mineral deposits domestically or in friendly jurisdictions, in a sustainable manner.
- Investigate the benefits and challenges of closing the nuclear fuel cycle, which may boost resource efficiency and reduce waste generation.
- Pursue a diversified range of solutions to enable the production and use of alternative and recycled uranium and plutonium products. This includes investing in EU-based technologies such as reprocessing, uranium and plutonium recycling, re-enrichment including of depleted material (e.g. tails), and their application in advanced reactors, including fast-breeder reactors and new generation reactors.

Particular attention should be paid when building new nuclear power plants using non-EU designs.

To ensure that these plants are not dependent exclusively on a single non-EU supplier of nuclear fuel, any such investment must be conditional on being able to diversify the fuel design.

3. Overview of EU developments

3.1. Euratom

3.1.1. EU nuclear energy policy

The European Commission develops and supports the implementation of energy policies that include the contribution of nuclear power to the long-term decarbonisation and security of supply of the EU (European Union) energy system in a safe, efficient and secure way. In 2024 the European Commission continued its work to promote and support the safe use of nuclear energy for peaceful purposes in Member States that choose to use it, with an emphasis on continually improving nuclear safety, and radiation protection.

In this context, the Commission's activities in 2024 continued in line with the REPowerEU Plan[13], adopted in May 2022 following Russia's war of aggression against Ukraine, which aims to reduce European dependence on Russian fossil fuels and energy imports by 2027. Achieving this objective demands a coordinated effort involving all relevant open market countries and industrial actors, as well as a multiannual plan to either ramp up existing capacity or build new capacity before phasing out Russian supplies. In 2024, the European Commission, alongside the Euratom Supply Agency (ESA), provided further support to nuclear fuel supply diversification, engaging in discussions with both domestic nuclear fuel cycle producers and users and other international partners. These efforts have supported the conclusion of contracts, aimed at diversifying nuclear fuel supply, for 4 out of 5[14] of the European utilities currently operating Russian-designed[15] VVERs[16].

The Commission's activities in 2024 continued in line with the REPowerEU Plan, adopted in May 2022, which aims to reduce European dependence on Russian fossil fuels and energy imports by 2027.

The Commission also kept up its assessment of dependence on Russia in non-power uses of radiation, such as the production of medical radioisotopes for cancer treatment, or the provision of fuel for research reactors. The Commission continued to implement the SAMIRA action plan in its three priority areas: the security of supply of medical radioisotopes, the quality and safety of ionising radiation in medicine, and innovation and technological development in this field (see also below, under 3.3.1).

In the context of the implementation of Chapter 4 of the Euratom Treaty, several investments in nuclear projects (Articles 41-44 of the Euratom Treaty) were notified to the European Commission, which adopted Points of View on the new nuclear investment plans scheduled in the Member States.

In June 2024, the EU revised its electricity market rules from 2019, explicitly recognising nuclear energy as a key element in achieving its decarbonisation aims17. The use of power purchase agreements (PPAs) and contracts for difference (CfDs) are permitted for the support of nuclear projects. The EU also encouraged Member States to remove barriers to PPAs, thereby facilitating long-term investment stability for sustainable and low-carbon energy, including

13 Repower EU

14 In addition to deliveries of fuel directly from Russia, the fifth member state has also contracted supply of nuclear fuel to be produced in the EU with Framatome in the frame of their joint venture with TVEL (Rosatom).

15 ESA Annual Report 2023, ISBN 978-92-68-19320-4

16 VVER translate from Russian as water-water power reactors.

17 Directive (EU) 2024/1711 of the European Parliament and of the Council of 13 June 2024 amending Directives (EU) 2018/2001 and (EU) 2019/944 as regards improving the Union's electricity market design

nuclear power.

In February 2024, the European Commission launched the European Industrial Alliance on Small Modular Reactors (SMRs)[18], which aims to facilitate and accelerate the development, demonstration, and deployment of SMRs[19] in Europe by the early 2030s.

The European Nuclear Safety Regulators Group (ENSREG) organised the seventh European Nuclear Safety Conference in June 2024, in cooperation with the Commission. The conference focused on responding to the growing interest in nuclear energy and gathered approximately 200 stakeholders. Among other topics, nuclear safety regulators discussed the significant issue of licensing of alternative fuels for VVER reactors in the EU.

In February 2024, the European Commission launched the European Industrial Alliance on Small Modular Reactors (SMRs).

The 17th edition of the European Nuclear Energy Forum (ENEF) took place in Prague on 30 September-1 October 2024[20]. The two-day event, co-organised by the Commission and Czechia (as the host country), provides a unique platform for broad and transparent discussions about the potential, opportunities, risks, and challenges associated with nuclear energy, including its place within the strategic framework of EU energy, climate and industrial policy. More than 270 representatives from various EU and global stakeholders participated in the forum's discussions on the role of nuclear energy in the context of the EU's overall targets, key enablers underpinning the nuclear development, and the benefits and challenges of SMRs.

3.1.2. Nuclear safety, radiation protection, radioactive waste management and nuclear decommissioning

In 2024, the European Commission's continued its work to ensure that the Euratom legal framework on nuclear safety, radioactive waste management and radiation protection was correctly and effectively transposed and implemented in Euratom Member States. In addition, a new Commission Recommendation was adopted on the use of dose coefficients for the estimation of radiation exposure for occupationally exposed workers. The third report of the Commission to the European Parliament and Council on the implementation of the Radioactive Waste Directive was published in May 2024[21]. In 2024, the Commission started the implementation of the European Parliament's Pilot Project on a joint European approach towards radioactive waste.

Furthermore, the Nuclear Decommissioning Assistance Programmes (NDAP)[22] continued in 2024 to reduce nuclear and radiation safety risks for the reactors being shut down in Bulgaria, Lithuania and Slovakia.

3.1.3. Emergency preparedness and response

In the field of nuclear-emergency preparedness and response (EP&R), the Commission ensured the continuous operation of both: (i) the European Community Urgent Radiological Information Exchange (ECURIE) system for the exchange of urgent information in the event of a radiological emergency; and (ii) the European Radiological Data Exchange Platform (EURDEP) system for the exchange of radiation-monitoring data. The Commission continued to cooperate closely with the EP&R competent authorities of Ukraine and agreed with the IAEA Practical Arrangements on cooperation in responding to nuclear and radiological incidents and emergencies.

3.1.4. External dimension of nuclear energy policy

The European Commission represents the European Atomic Energy Community (Euratom) in the international field. In 2024, the Commission continued to engage with and actively promote the highest levels of nuclear safety and safeguards internationally. The Commission remained actively engaged in strengthening global nuclear safety and safeguards through close collaboration with international organisations such as the International Atomic Energy Agency (IAEA) and the OECD's Nuclear Energy Agency (NEA), as well as with non-EU countries, including those neighbouring

18 Small modular reactors (europa.eu)

19 European Industrial Alliance on SMRs

20 16th European Nuclear Energy Forum

21 REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT on progress of implementation of Council Directive 2011/70/EURATOM and an inventory of radioactive waste and spent fuel present in the Community's territory and the future prospects THIRD REPORT Register of Commission Documents - COM(2024)197

22 Nuclear Decommissioning Assistance Programme (NDAP)

the EU.

In March 2024, the Prime Minister of Belgium, Mr Alexander De Croo, and the IAEA Director General, Mr Rafael Mariano Grossi, co-chaired a Nuclear Energy Summit in Brussels. The European Commission President Ms Ursula Von der Leyen and Commissioner for Energy Ms Kadri Simson attended and were joined by heads of state and government from 32 countries to discuss the role of nuclear energy in achieving net-zero goals and security of supply.

In September 2024, Euratom represented by the European Commission participated in the 68th regular session of the IAEA General Conference, met with many international partners and stakeholders and organised several important side events, including on challenges to nuclear safety during armed conflicts, on knowledge sharing on waste management and decommissioning as well as on the European Industrial Alliance on SMRs.

In response to the Russian war of aggression in Ukraine, the Commission continued in 2024 to closely monitor the situation in Ukraine's nuclear facilities, particularly in Zaporizhzhia nuclear power plant (NPP). The EU advocates for the unconditional, immediate, and complete withdrawal of Russia's forces and military equipment from the Zaporizhzhia NPP and the entire territory of Ukraine[23]. The European Commission continued to financially support nuclear safety in Ukraine and the IAEA activities in Ukraine.

The post-Fukushima nuclear safety assessment ('stress test') of the Akkuyu NPP (Türkiye), organised by the Commission and the European Nuclear Safety Regulators Group (ENSREG)[24], was completed in 2024.Contacts with other non-EU countries on possible stress tests are ongoing.

The Commission continued its dialogue on diversification efforts for security of supply in the nuclear industry with other countries, such as Australia, Canada, Japan, Kazakhstan, the US and the United Kingdom.

3.1.5. ITER and fusion energy

Euratom, represented by the European Commission, is the main contributor to the international fusion research project known as ITER. ITER is an experimental reactor under construction in France, aiming at proving the scientific and technological feasibility of nuclear fusion as a large-scale and carbon-free source of energy. ITER will be the first 'power plant sized' fusion device in the world, designed to test several essential systems and resolve outstanding scientific, engineering and technical challenges for future fusion power plants.

Throughout 2024, the Commission supervised the construction of ITER[25], which achieved an execution rate surpassing all previous years. The Commission supported the development of fusion energy more broadly to address remaining technological gaps through installations complementing ITER[26].

3.1.6. Euratom safeguards

Euratom safeguards is the legal and technical term that covers all elements of the nuclear material supervision system under the exclusive competence of the Euratom Community, established by the Euratom Treaty and operated by the European Commission on behalf of the Community. The Directorate-General for Energy is the service within the Commission responsible for Euratom safeguards.

Euratom safeguards are implemented through verification activities ensuring that, in the EU, civil nuclear materials are not diverted from their intended peaceful use. For international suppliers of nuclear material to the EU, Euratom safeguards offer a guarantee that nuclear materials are being managed appropriately and used peacefully in the EU.

In 2024, 99.94% of the more than 539 000 tonnes of civil nuclear material in the EU were subject to both accountancy and on-site physical verifications. The Commission continued to work in close cooperation with the IAEA under the framework of the two multilateral safeguards agreements and their respective additional protocol and on the implementation of the 'safeguards by design' concept, integrating relevant safeguards considerations early in the design phases, before starting the construction or modification of a nuclear installation.

23 EU Statement on nuclear safety, security and safeguards in Ukraine at the IAEA Special Board of Governors on 12 December 2024 | EEAS

24 ENSREG

25 ITER - the way to new energy

26 Fusion energy and ITER

As a result of applying Euratom safeguards under the Euratom Treaty, no evidence was found suggesting that nuclear materials were diverted from their intended uses in the EU. The safeguards obligations assumed by the Euratom Community under multilateral safeguards agreements concluded with the IAEA and bilateral agreements with non-EU countries were complied with.

Finally, the Commission proposal for a Council Decision approving a Commission Regulation (Euratom) on the application of Euratom safeguards (COM/2023/793) was negotiated in the Council of the EU, and the political agreement on the draft text of the new Regulation was reached in June 2024.

As a result of applying Euratom safeguards under the Euratom Treaty, no evidence was found suggesting that nuclear materials were diverted from their intended uses in the EU.

3.1.7. European Commission research and innovation programmes

In 2024, the actions led by the Commission under the Euratom research and training programme played a key role in advancing European expertise in nuclear research and innovation. The programme supported Member States in upholding the highest safety standards for both existing and future nuclear installations – critical for countries incorporating nuclear energy into their energy mix. Additionally, Euratom-funded research benefits the EU public through wider applications of ionising radiation, particularly in nuclear medicine.

Following the 2023-2025 Euratom call for proposals, the Commission awarded funding to 21 projects in 2024, allocating EUR 121 million to research in nuclear safety, waste management, radiation protection, non-power applications of nuclear technologies, and developing nuclear data for European modelling and simulation tools.

Two European co-funded partnerships were launched in 2024: on radioactive waste management (EURAD-II, EUR 20 million EU contribution) and on nuclear materials (CONNECT-NM, EUR 20 million EU contribution). These partnerships are the result of long-term efforts by the research community, stakeholders and Member States, working towards a shared research agenda to tackle key challenges in safe radioactive waste management and the development of innovative materials.

Euratom plays an important role in supporting the conversion of research reactors and the development of high-assay low-enriched uranium (HALEU) fuels. Launched in 2024, the EU-CONVERSION and PreP-HALEU projects aim to ensure a secure supply of safe low-enriched uranium fuels for European research reactors, essential for the production of medical radioisotopes (see also below, under 3.3.3).

Following the 2023-2025 Euratom call for proposals, the Commission awarded funding to 21 projects in 2024, allocating EUR 121 million to research in nuclear safety, waste management, radiation protection, non-power applications of nuclear technologies, and developing nuclear data for European modelling and simulation tools.

In 2024, the Commission launched the European Industrial Alliance on Small Modular Reactors, a strategic initiative to facilitate the demonstration and deployment of Europe's first SMR projects by the early 2030s. The Euratom research and training programme is providing EUR 15 million in funding for the research project on design advancement, construction and operation of SMRs including passive safety systems, fostering a coherent regulatory framework and enhancing SMR safety standards across Europe.

Furthermore, the Euratom research and training programme launched the SAVE project to ensure nuclear fuel diversification and to bolster the security of nuclear fuel supply in Europe and Ukraine for the Soviet-designed nuclear power plants known as VVER reactors.

In the field of radiation protection, the European Partnership for radiation protection research PIANOFORTE launched the second call[27] with the objective of enhancing knowledge base and fostering innovation within this domain.

In fusion research, the Fusion Expert Group was established to assist the Commission by providing strategic recommendations for implementing the fusion part of the 2021-2025 Programme and ITER activities 2021-2027. Comprising representatives from Member States and observers from EUROfusion and F4E, the group aims to build

27 https://pianoforte-partnership.eu/calls/open-call-2024

consensus on key pathways for fusion development and support the Commission in shaping the future EU fusion strategy.

In addition, the Commission awarded the SOFT Innovation Prize, recognising and showcasing innovation and rewarding excellence in fusion research.

Following an amendment to the Euratom research and training work programme 2023-2025, the Commission launched two coordination and support actions (CSAs) in 2024: one to prepare for a public-private partnership on fusion energy and another to establish a European nuclear skills initiative.

Published in November 2024, the ex-post evaluation of the Euratom research and training programme 2014-2020[28] examined its rationale, implementation, and achievements. It also assessed the programme's long-term impacts and sustainability to guide the design of future Euratom programmes.

3.1.8. Activities of the European Commission's Joint Research Centre

The new Joint Research Centre (JRC) Work Programme 2025-2027 continues to be organised in portfolios, addressing the political priorities of the European Commission.

There are three fully nuclear portfolios dedicated to:

- Nuclear Safety – Technology research and skills
- Research on Safety, Security and Safeguards of Small Modular Reactor and innovative systems
- Research and support implementation of nuclear safeguards

There a further six mixed portfolios, in which other JRC nuclear activities are integrated with other non-nuclear research areas. In particular, the portfolio 'Blueprints towards a strong European Health Union' is dedicated to health and incorporates projects with nuclear medical applications.

The medical applications of nuclear science remain a highly relevant topic amongst EU Member States, subject to a high level of consensus regardless of their view on nuclear power, as proven by the adoption of Council Conclusions on the security of supply of radioisotopes for medical use[29] (approved under the Belgian Presidency). These Conclusions acknowledge that JRC activities are fundamental to supporting research and facilitating innovation for the benefit of Member States on topics related to medical radioisotopes and other medical radiological technologies as well as to promote the innovation of new technical methods for medical radioisotope production.

The JRC estimates that number of patients eligible for radioligand therapies will increase threefold in the next decade. This proves once more the fundamental role of radio isotopes in theranostics (both for diagnosis and therapy) and the importance of the EU health system to be prepared for what is awaiting.

All reports from recent stakeholder consultations have been published and are accessible at these direct links:

- Translating radiotheranostic cancer research into clinical practice in Europe[30]
- Competences for medical applications of nuclear science[31]
- Research and Innovation for Sustainable Medical Radionuclide Supply in the European Union[32].

The JRC took part in several events dedicated to nuclear science and technology and involving major players in the international scenario. During the latest General Conference of IAEA, the JRC and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) had their first co-organised event about 'Improving knowledge on the levels and effects of ionising radiation through synergies between Euratom and UNSCEAR' while during the IAEA Ministerial Conference on Nuclear Science, Technology and Applications and the Technical Cooperation Programme, the JRC had a side event showcasing the exemplary collaboration between the JRC and the Steve Biko Academic Hospital in Pretoria, South Africa, on nuclear medical applications, specifically in 'Advancing Targeted Alpha Therapy'.

28 COM(2024) 549 final

29 https://data.consilium.europa.eu/doc/document/ST-9912-2024-INIT/en/pdf

30 https://publications.jrc.ec.europa.eu/repository/handle/JRC134480

31 https://publications.jrc.ec.europa.eu/repository/handle/JRC137512

32 https://publications.jrc.ec.europa.eu/repository/handle/JRC137214

Furthermore, JRC was co-organiser of the ‘2nd International Workshop on Medical Radioisotopes Supply’ along with the NEA, and the US Department of Energy. JRC also took part on the side event of the EU-IAEA Cooperation for Global Nuclear Security during the 2024 International Conference on Nuclear Security.

Since 2003 the JRC has worked to explore new approaches in research and development, particularly in nuclear-based power sources and materials for space applications. During 2024, JRC has continued researching in americium-241 (Am-241), to support the development of a European radioisotope heat and power systems for future space missions.

The JRC contributes to improve nuclear safety, security and safeguards with sustaining efforts in harmonisation and standardisation. In 2024, JRC delivered:

- 105 new peer-review scientific publications
- 10 additional reference materials
- 3 contributions to international standards
- 10 technical systems.

The JRC delivered 37 specialised training courses to over 900 beneficiaries from EU Member States and Ukraine, on

- nuclear safety
- radiation protection
- radioactive waste management
- decommissioning
- nuclear data measurements
- monitoring of environmental radiation
- nuclear security
- nuclear safeguards.

Training courses delivered through EUSECTRA[33] strengthened the capacities of over 350 nuclear inspectors and front-line officers. In addition, providing open access to 11 JRC’s nuclear research infrastructures located in Karlsruhe (DE), Geel (BE) and Petten (NL) has continued playing a key role in stimulating research, sharing expertise and enhancing skills. In 2024, it enabled 59 researchers, to conduct experimental research in JRC’s world-class laboratories.

The JRC contributes to improve nuclear safety, security and safeguards with sustaining efforts in harmonisation and standardisation.

In 2024, the JRC offered its expertise in support to 13 policy items related to nuclear fission, including to Commission obligations under Articles 41, 37, 35, 31 of the Euratom Treaty Directives, and instruments such as INSC and FPI.

In 2024, the JRC was set to further enhance its scientific and technical support to nuclear safeguards, driving innovation in technologies, methodologies, and standards to strengthen the effectiveness and efficiency of safeguards across the nuclear fuel cycle. Building on its established expertise, the JRC continued to play a key role in supporting Euratom safeguards and the IAEA, with a focus on transferring its research and development results into operational practice. The JRC’s on-site laboratory (LSS) at the Orano reprocessing plant in La Hague (France) will remain at the forefront of analytical capabilities, conducting a high volume of analyses to underpin safeguards activities. Moreover, the JRC expanded its training programme for safeguards inspectors (Euratom and IAEA nuclear inspectors) with the provision of 12 training courses, aiming to equip a new generation of experts with the skills and knowledge needed to tackle emerging challenges in nuclear safeguards. Through its ongoing support to the IAEA under the EC Support Programme with more than 40 active tasks, the JRC also contributed to strengthening global nuclear safeguards, promoting a culture of safety, security, and cooperation.

During 2024, the JRC has continued supporting the European Commission regarding nuclear and radiological threats consequence of the Russian war of aggression to Ukraine, including monitoring environmental radiation, and assessing the impact of trade-restrictive measures. International cooperation continues to be a pillar in all the domains in which the JRC operates.

33 About EUSECTRA - European Commission

3.2. Country-specific developments

During 2024, 101 commercial nuclear power reactors were operating in 12 EU Member States. French Flamanville-3 reactor was connected to the grid in December. One reactor was under commissioning in Slovakia (Mochovce-4), which began cold testing in December. The total net capacity at the end of 2024 was 98 320 MWe.

Table 5. Nuclear power reactors in the EU-27 in 2024

Country	Reactors in operation (under construction)	Net capacity (MWe) (under construction)
Belgium	5	3 908
Bulgaria	2	2 006
Czechia	6	4 212
Finland	5	4 369
France (*)	57	63 000
Hungary	4	1 916
Netherlands	1	482
Romania	2	1 300
Slovakia (**)	5 (1)	2 308 (471)
Slovenia (***)	1	688
Spain	7	7 123
Sweden	6	7 008
Total EU-27	**101 (1)**	**98 320 (471)**

(*) Flamanville-3 first grid connection took place on 21 December 2024.

(**) Mochovce-4 began cold testing in December 2024.

(***) The Croatian power company HEP owns a 50% stake in the Krško NPP in Slovenia.

Austria

The construction and operation of nuclear power installations in the country is prohibited by the Federal Constitutional Act for a Non-nuclear Austria.

Belgium

In February, after receiving approval from the European Commission, Belgium's Nuclear Research Centre (SCK-CEN) and the Centre for Metallurgical Research (CRM) signed a research partnership to develop an advanced smelter for metal resulting from the dismantling of nuclear power plants (NPPs).

In March, Belgian engineering company Tractebel, together with its subsidiary RED, published a white paper on potentials of small modular reactors (SMRs) to supply energy to data centres while providing a positive employment impact in the area.

Also in March, Belgium's Chamber of Representatives approved the legislation allowing the extended operation until around 2035 of the Tihange-3 and Doel-4 NPPs.

In June, results of a survey showed that 70% of the country's population support longer lifetime extensions – 20 years instead of the currently agreed 10 – and 84% were in favour of building SMRs

It was reported in June that the country's nuclear power plant operator ENGIE Electrabel had announced the cessation of use of Russian uranium to fuel Doel-4 and Tihange-3 NPPs, and subsequent contracts with western suppliers to ensure the operation of the reactors. Conversion and enrichment services from Russian companies have also been halted.

In July, the European Commission opened an in-depth investigation to examine whether Belgium's plans to grant public support for the lifetime extensions of Doel-4 and Tihange-3 NPPs were in line with EU State aid rules. The plan is to form a partnership with ENGIE, creating a 50-50 venture between the Belgian State and ENGIE's subsidiary Electrabel, with financial arrangements.

Bulgaria

In 2024, Bulgaria made significant progress in its nuclear energy programme by strengthening international partnerships, advancing new reactor projects, and making progress in fresh nuclear fuel diversification. On 12 February 2024, Bulgaria and the United States signed an intergovernmental agreement on cooperation on the project for the construction of nuclear capacity at the Kozloduy NPP site and the country's civil nuclear programme. The agreement was ratified by the 49th National Assembly on 22 March 2024.

In November, Westinghouse Electric Company, Hyundai Engineering & Construction Co., and Kozloduy NPP New-Build EAD signed an engineering services contract for the construction of two reactors utilising AP1000 technology, planned for construction on the Kozloduy site. In addition, Bulgaria strengthened its international cooperation in the energy sector by signing a Memorandum of Understanding with South Korea in September.

In line with European and international regulations, Bulgaria's nuclear sector continues to develop within an established legal framework. In 2024, no legislative changes falling under the competence of the Euratom Supply Agency were made. The operating licences for Units 5 and 6 of the Kozloduy NPP were amended to become open-ended and will be subject to periodic safety reviews in accordance with the requirements of the legal framework. At the request of the Bulgarian government, a peer-review mission was conducted by the IAEA in November to assess the national regulatory framework for nuclear and radiation safety, the safe management of radioactive waste, and transport safety. An IAEA OSART (Operational Safety Review Team) Mission took place at the Kozloduy NPP from 18 November to 5 December 2024. As part of the mission, an independent review of the level of safety in the operation of the nuclear units was carried out based on IAEA standards.

Simultaneously, Bulgaria continued its efforts to diversify its fresh nuclear fuel supply in line with ESA policy by successful loading Unit 5 at the Kozloduy NPP with 43 alternative fuel assemblies from Westinghouse. In December, Kozloduy NPP EAD signed a contract with Westinghouse to conduct safety analyses for the licensing of a new nuclear fuel assembly design, which is compatible with the fuel currently used in Unit 6 of the plant.

Croatia

In 2024 Croatia continued the preparations for the disposal of low and intermediate-level radioactive waste from the Krško NPP. In parallel the country is developing a centralised storage for the institutional radioactive waste. Croatia has also expressed interest in developing a second reactor at the Krško site, and both supports the development of SMR technology is starting to explore the possibilities of including it in their future nuclear capability.

Czechia

After launching a tender process by ČEZ, a.s. in 2022, for an EPC (engineering, procurement, and construction) contract for a new nuclear unit or units in Czechia, the KHNP company was selected as the preferred bidder. In July the Czech Government issued a security request to prepare EPC contracts for two new nuclear units at the Dukovany site and with an option for two new nuclear units at Temelín site. Negotiations with KHNP to finalise the EPC contract have started and are expected to close in first half of 2025. Commercial operation of the first new unit at the Dukovany site is expected in 2038, the additional units following according to the planned schedule. This strategic project will ensure the energy security and self-sufficiency of Czechia for several decades to come.

In parallel ČEZ continued in 2024 safely increase production from existing six nuclear reactors which by 2030 will reach more than 32 TWh and achieve a useful life of 60 years. Moreover, ČEZ and Rolls-Royce SMR agreed to enter to strategic partnership to enable the development and construction of SMRs in Czechia. The two companies will work collaboratively on plans for the deployment of up to 3 GW in Czechia.

Denmark

Although the Danish parliament passed a resolution to forbid building nuclear power plants in the country in 1985 and research into nuclear power is limited, the Technical University of Denmark (Danmarks Tekniske Universitet, DTU) has maintained several research environments working with nuclear physics and technologies. In January, the DTU announce that it had established a new interdisciplinary centre to strengthen collaboration between the relevant research environment and to ensure that the country will continue to have skills in the field.

In July, Copenhagen Atomics signed a collaboration agreement to conduct the first critical experiment on thorium molten salt reactors in Europe with Swiss Paul Scherrer Institute (PSI). The experiment will take place at PSI's facilities using Copenhagen Atomic's 'Onion Core' reactor design and is scheduled for 2026-2027.

In November, Copenhagen Atomics signed a cooperation agreement with US-based DeepGeo, to better understand the fuel needs of company's thorium molten salt reactor.

Estonia

Significant developments occurred in Estonia in 2024 regarding the potential adoption of nuclear energy, driven by the findings of the inter-ministerial Nuclear Energy Working Group established in April 2021. The group was tasked with assessing the feasibility of implementing SMRs in Estonia beyond 2030. By the end of 2023, they submitted a comprehensive report indicating that, with timely planning, adequate funding, political support, and public approval, nuclear energy could effectively contribute to the country's climate goals, ensure stable electricity generation, and bolster economic growth.

In June, in response to the report, the Estonian Parliament officially endorsed preparations to use of nuclear energy and agreed to establish the necessary legal framework. The Ministry of Climate subsequently renewed the Nuclear Energy Working Group's mandate, directing efforts towards the integration of an independent regulatory authority, the drafting of the Nuclear Energy and Safety Act, and enhancing academic collaboration. Additionally, the planning process for site selection will commence in 2025, marking a pivotal step towards the future of nuclear energy in Estonia.

Finland

In 2024 nuclear energy production increased to 31.8 TWh of electricity, which is about 39.1% of Finnish electricity production, due to the first complete year of Olkiluoto 3 operation, including the first annual outage in March 2024.

Construction of the world's first final repository for spent fuel, Onkalo, is being finalised at the Olkiluoto site. The first operating licence application has been submitted for a government decision, due in the next few years, and the commissioning process for Onkalo has entered the trial run, consisting of a full-scale final disposal test with final equipment under actual conditions, but without the actual spent fuel.

In the beginning of 2024 Teollisuuden Voima Oyj initiated an environmental impact assessment process to study possibilities of continuing the operation of the Olkiluoto 1 and 2 NPP units until 2048 or 2058. The options studied in the EIA included the possible upgrade of thermal power by 10% from 2500 MW to 2750 MW.

In August, the first batch of Westinghouse nuclear fuel was loaded into Fortum's Loviisa NPP during its annual outage. The loading of the new fuel guarantees a reliable Western alternative for fuel deliveries to the Loviisa power plant.

The FiR1 research reactor, which operated for over 50 years at VTT's premises in Otaniemi and was used for a wide range of research and healthcare purposes, was dismantled. Finland's first nuclear decommissioning project covered the whole decommissioning work: planning, preparatory measures, dismantling of the reactor and radioactive waste management.

In the summer Terrafame started recovering uranium at its Sotkamo site. Production enables the natural uranium found in the ore to be extracted as a by-product. The recovered uranium will be transported abroad for further processing.

Using this recovery process, Finland is the only EU Member State that produces uranium. The recovery plant is estimated to operate at full capacity by 2026, when the uranium output will reach about 200 tonnes per year.

Finnish nuclear energy legislation is being reformed to take into account the changed operating environment, the development of technology, changes in the energy market and the renewal of other national and international regulation. New legislation is planned to come into force from the beginning of 2028.

France

In February, President Macron chaired a new Nuclear Policy Council (CPN), following that held in June 2023. The role of the CPN is to set out and implement the main orientations of French nuclear policy, and it decided to confirm the strategy for the reprocessing, reuse of used fuels and new prospects for the complete closure of the fuel cycle through the end of the century. This policy decision led to launch a sustainability/resilience programme extending the life of the La Hague reprocessing & Melox recycling plants beyond 2040, as well as studies for the renewal of the recycling platform at La Hague with a new MOX fuel fabrication facility around 2040 and a new used fuel reprocessing facility by 2045-2050.

On 21 May, a law on the organisation of the governance of nuclear safety and radiation protection was passed to meet the challenge of reviving the nuclear industry. It aims to bring together the work of the Nuclear Safety Authority (ASN) and the Institute for Radiological Protection and Nuclear Safety (IRSN) in a new independent administrative authority, the Nuclear Safety and Radiation Protection Authority (ASNR), on 1 January 2025.

In November and December, the government submitted for consultation the multi-year energy programming (PPE) for the 2025-2030 and 2031-2035 periods, which focus on accelerating the deployment of renewable energies, continued operation of the current nuclear reactors beyond 60 years, and then beyond 70 years, and a new-build programme of 6 EPR2 nuclear reactors with Final Investment Decision expected from EDF (Électricité de France) no later than 2026. Additional analysis will be conducted to consider a further 13 GW of new nuclear capacity equivalent to that of 8 EPR2 reactors.

A programme under the France 2030 investment plan launched three calls for projects (AAP) to new concepts of innovative nuclear reactors, including fission and fusion. The goal is to create a new ecosystem of nuclear start-ups, focusing on technologies for non-electric applications, recycling radioactive materials, and improving safety. Eleven companies received a total of 128 million euro in support. They will also get technical support from the French Alternative Energies and Atomic Energy Commission (CEA) with oversight from the Ministries of Energy, Industry, Research, and Defence.

In February, Cruas-2 restarted with enriched reprocessed uranium, marking the first use of enriched reprocessed uranium in a French reactor since the use of RepU was put on hold in 2013.

In May and June, EDF successfully issued a total of EUR 6.8 billion of green bonds to finance investments in the lifetime extensions of the existing French nuclear reactors, aligned with the European taxonomy.

On 21 December the Flamanville 3 reactor was connected to the national grid, following loading of the reactor in May 2024 and authorisation by the ASN to launch divergence operations in August. Following this initial coupling, in line with the startup operations, the phases of testing and of connection and disconnection to the grid will continue for several months, under the supervision of the ASNR, until the reactor reaches 100% power.

Nuclear production reached 361.7 TWh in 2024, the best performance of the French nuclear fleet since 2019 when the two reactors of Fessenheim were still in operation. Nuclear production increased by 41.3 TWh compared to 2023 and 82.7 TWh compared to 2022. This strong industrial performance, and a high level of hydraulicity, translate into 96% carbon-free electricity generated in France in 2024 and 80 TWh of clean electricity exported to neighbouring countries. Subsequently, EDF increased its nuclear production targets to 350 to 370 TWh for years 2025, 2026 and 2027.

On 10 October 2024, Orano laid the foundation stone of the extension of its Georges Besse 2 enrichment plant at its Tricastin site. The deteriorated situation in Niger affected Orano mining operations in the country. Following the signature by Orano in October 2023 of the Protocol for the development and operation of the Zuuvch Ovoo uranium mine in Mongolia, the investment agreement was validated by the Mongolian government in December.

On 17 October, Orano inaugurated the TN Eagle Factory in Cherbourg dedicated to the innovative production of modular casks for the transport & dry storage of used fuel.

In 2024, production of UO_2 powder has started at Orano Malvési site for MOX production.

Germany

The efforts towards conversion from HEU to LEU fuel progressed as scheduled at the FRM II research reactor in Munich. As significant milestone, a contract with Framatome was signed for the pre-industrialisation of fuel manufacturing, with a goal to submit the request for the conversion licence to the licensing body by the end of 2025 to start the conversion in the early 2030s.

The radioactive waste from the reprocessing of spent fuel elements from German NPPs in France has been re-transferred to Germany as agreed. The last four casks containing high active waste (HAW) from the reprocessing plant in La Hague arrived at the storage facility on the site Philippsburg in Germany on 20 November. The re-transfer of the last 14 containers of radioactive waste to be shipped to Germany from the reprocessing plant in Sellafield, United Kingdom, is on track, and is expected to be completed in 2026.

The site selection procedure for a deep geological repository for HAW continues. In 2024, additional regions were labelled as being of low or zero suitability. Currently 44% of German territory is still included in the procedure. The formation of the Gorleben salt dome, in which an exploration mine had been constructed in the 1990s, was excluded in 2020 already; the backfilling of this mine has started in the end of 2024.

Hungary

In April, a new oversight concept was introduced by an amended and a new Hungarian Atomic Energy Authority (HAEA) regulation. The amendments focused primarily on implementing rules for this new oversight concept for the construction of new nuclear units (2 VVER-1200 units at Paks II site), which enable a more efficient application of the regulatory supervision that is more in line with the graded approach principle and adapted to the life cycle of the installation. The rules of the new regulation cover the register of independent inspection bodies that may be involved in inspections and their accreditation requirements.

The new oversight concept aims to strengthen the effectiveness of regulatory supervision, to continuously improve the level of nuclear safety, to systematically apply the graded approach principle to regulatory supervision, to optimise licensing at the component level by strengthening licensing at the facility level, to focus on the control of the licensee's management system, internal processes, safety culture, the application of licensee responsibility and to create the possibility of third party involvement in the performance of inspections.

In August the first equipment, the core catcher arrived at the Paks 2 site. Production was constantly monitored by Hungarian experts and HAEA representatives.

In September, following the completion of soil stabilisation work in Unit 5, excavation to design level began, to depths of up to 23 metres in some places, while consolidation work on Unit 6 is still ongoing. To monitor the extensive construction work on site, HAEA conducts regular weekly inspections at the site.

Among the site preparation activities, slurry walls and soil stabilisation are subject to the occupancy permit process required by HAEA in its construction permits.

In November, the HAEA decided to lift the hold point in the construction licence for two new VVER-1200 units at the Paks 2 site. A hold point is a phase or operation in the construction process that requires HAEA approval before moving forward. The HAEA had set the submission of an updated safety report as a hold point because the original permit application from June 2020 reflected the planning status from late 2019. When reviewing the updated safety report submitted in 2022, the HAEA consulted with an external expert and had several discussions with the company Paks II. Zrt. The company then submitted the revised report in several parts.

The HAEA established that Paks II fulfilled the tasks related to the lifting of the hold point and therefore decided to lift it, enabling Paks II to start the additional establishment activities according to the permits related to the specific activities, after fulfilling the obligations and conditions included in them. The next significant milestone of the construction is the first concrete pouring, which is the beginning of the concreting works of the nuclear island.

In October, Framatome and the MVM Paks NPP company signed an agreement to supply fuel to the Paks NPP from 2027. Framatome, in cooperation with the Russian TVEL, will produce fuel as a joint venture Together with Slovak, Czech and Finnish operators, Paks NPP supports Framatome's own VVER fuel design as well.

Italy

In 2024, the National Platform for Sustainable Nuclear Energy (PNNS) – launched by the Ministry of the Environment and Energy Security in 2023 – continued its work exploring the potential reintroduction of nuclear energy to Italy through advanced and sustainable technologies. The platform focused on key thematic areas, including nuclear fission and fusion technologies, safety and regulation, waste management, training, and social acceptability. Its findings will contribute to evaluating a potential national strategy for sustainable nuclear energy to support Italy's energy transition and decarbonisation objectives.

As part of Italy's commitment to strengthening nuclear safeguards, the National LOF (Location Outside Facility) was officially established in 2024 under agreements between the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN) and Euratom. Initially comprising 40 holders across 53 sites, the National LOF expanded to 62 sites by the end of the year. Within this framework, ISIN ensures compliance with the obligations outlined in Regulation 302/2005/EURATOM on behalf of the participating operators.

Italy advanced in the decommissioning of its former nuclear facilities. The state-owned company, Società Gestione Impianti Nucleari SpA (SOGIN), successfully completed the first phase of decommissioning the reactor vessel of the Garigliano NPP. Additionally, dismantling operations commenced on the six steam generators of the Latina (MAGNOX) NPP.

Significant steps were taken in 2024 to address the management of spent nuclear fuel. Based on a previous intergovernmental agreement signed between Italy and France in 2006, negotiations resumed in 2024 for the shipment of the remaining 13 tHM of spent fuel to France for reprocessing, along with the return of vitrified waste to Italy.

Consolidating its position in advanced nuclear research and development, Italy played an active role in European initiatives aimed at fostering innovation in nuclear technologies.

Lithuania

On 27 June, the updated national energy independence strategy was adopted by the Seimas (Lithuania Parliament). The document aims to make Lithuania a fully energy independent country by 2050 that produces energy for its own needs and exports it. The updated national energy independence strategy set the goal of analysing the possibility of using the IV generation small modular reactor in Lithuania after 2038. The results of this assessment will determine the decision taken on development of nuclear energy in Lithuania after 2030 by the Seimas.

In July, Ignalina NPP signed a contract with a Swedish-Spanish consortium comprising Westinghouse Electric Sweden AB and Westinghouse Electric Spain, S.A.U., for the dismantling of the drum-separators of Unit 1 and Unit 2 of Ignalina NPP. The value of the contract is 32.4 million euro and set to take place in six years.

In October, the State Nuclear Energy Safety Inspectorate (VATESI) issued a licence to Ignalina NPP for decommissioning activities at the plant's power units and older radioactive waste management facilities.

On 23 April, the Ignalina NPP signed a public procurement contract with the company UAB Panevėžio statybos trestas for the construction of the Low and Medium Level Radioactive Waste Repository for Short-lived Waste, including the related works. The contractor is obliged to finish the entirety of the works within a period of 4.5 years. The value of the contract is more than EUR 156 million.

On 15 March, in Vilnius, the Ignalina NPP held the first public consultation for local representatives on the site selection process for a deep geological repository for radioactive waste in Lithuania. Representatives from 42 municipalities participated in the public consultation. This is the first in a planned series of such consultations with the public to ensure an open discussion among stakeholders and their participation in the decision-making process on the siting of the deep geological repository in the country.

Netherlands

In 2024, the Dutch government increased its ambitions on nuclear power: the Borssele NPP will remain operational after 2033, and the parties intend to build four new NPPs (instead of two) including the possibility of multiple small reactors. The parties also earmarked an additional EUR 9.5 billion (above the EUR 5 billion set aside in 2021) for this development.

The government presented a programme to investigate the potential of SMRs and, where possible, to accelerate their rollout.

The Dutch nuclear industry and several education institutes signed an agreement to promote nuclear technology industry skills at the vocational education level to support the government’s Human Capital programme aimed at training sufficient personnel for the growing nuclear sector.

In September the government decided that decision-making on the final disposal of radioactive waste will be brought forward, thereby abandoning the previous policy of deciding on the final disposal of radioactive waste in 2100. The aim is to develop a new participatory step-by-step approach including a timeline by end of 2027. The nuclear waste processing and storage company, COVRA, presented its Masterplan 2050 and became the formal owner of the Dodewaard NPP (out of operation since 1997) which will be decommissioned by 2045. The new MOG (multifunctional storage facility) building at COVRA for legacy and decommissioning waste is currently under construction.

The Technical University Delft finished the multi-year OYSTER refurbishment programme of the Hoger Onderwijs research reactor with the final milestone, implementation of a cold neutron source, achieved in 2024.

The EU approved the financing by the Dutch government of the new PALLAS reactor and realisation of the reactor at the Petten site is progressing. From 1 January 2025, NRG PALLAS will operate as one legal entity and will be converted into a state-owned company in 2025. The government presented a roadmap for the development of radio pharmaceuticals in the Netherlands. The medical technology company SHINE, with the University of Groningen, received a EUR 10.5 million grant to establish a supply chain for Terbium isotopes.

The expansion of production capacity at Urenco Nederland with 0.8 million SWU is ongoing.

Thorizon MSR (molten salt reactor) received a grant of EUR 10 million from the French government, is endorsed by the EU SMR Alliance and a collaboration with two other Dutch companies for further development is established. Both French and Dutch nuclear authorities will collaborate on the review of the MSR design.

Poland

Three nuclear project streams were under consideration in Poland in 2024.

Government agencies implemented the Polish Nuclear Power Programme (PPEJ) to build 6-9 GWe of installed nuclear power capacity based on large, proven water-pressure reactors (PWR). These assumptions were also confirmed in the adopted document on 'Polish Energy Policy until 2040' (PEP2040). The Cabinet resolution of 2 November 2022 stated that the first nuclear power plant in Poland under the PPEJ will be built based on American AP1000 reactor technology.

Preparations and geological work at the Lubiatowo-Kopalino site of the future NPP have been underway since May. The purpose of the in-depth geological research is to detail the exploration of the geological, engineering and hydrogeological conditions of the area. The results of the research will be used to design the NPP facility, in particular the main buildings.

On 18 August, two bills amending the special nuclear act and certain other acts were added to the Cabinet's list of legislative and programme works to provide financing for the NPP construction project, and to improve the efficiency of the construction process of nuclear facilities in Poland. They were subsequently adopted in January 2025.

On 28 August, Polskie Elektrownie Jądrowe (PEJ) submitted an application to the province of Pomerania for a permit to start preparatory work for the construction of the NPP.

On 18 December, the European Commission issued a decision opening an extended procedure for granting State aid to the Lubiatowo-Kopalin NPP.

The French EDF and the Korean KHNP have also expressed interest in participating in the PPEJ in relation to the second NPP, in addition to Westinghouse. These players all maintain their interest in the implementation of the project to build a second power plant.

For the construction of a third NPP outside the PPEJ programme, on 24 November 2023, the Minister of Climate and Environment issued a decision in principle at the request of PGE PAK Energia Jądrowa for construction of a NPP comprising two APR1400 units in cooperation with the Korean company KHNP in the Konin area. This is a project that is not included in the PPEJ and is a business initiative by those involved, which has been granted initial support from the government.

Other nuclear projects in Poland involve private sector expressions of interest in SMRs, with various companies signing agreements with foreign nuclear vendors. Several projects have received 'decisions in principle' expressing general approval from the government for the capacity of the proposed NPP, reactor technology and the municipality envisaged to host the investment.

Among them there were a plan of the KGHM company to deploy two SMRs in Greater Poland region (NuScale as the preferred technology), a ŚGP Industria project to construct two reactors in the Rolls-Royce SMR technology in vicinity of Kielce and a Orlen Synthos Green Energy (OSGE) programme for the construction of 24 SMRs at six locations based on GE Hitachi Nuclear Energy's BWRX-300 design.

In 2024, OSGE's plans advance on three locations: Stawy Monowskie, Włocławek and Ostrołęka, for which the procedure for environmental impact assessment is ongoing. KGHM's plans have been put on hold by the company's new management.

Poland has been developing a geological repository to manage spent fuel and radioactive waste, in line with the goals set out in the PEP2040. Studies on potential sites for deep geological disposal began in 2014. The selection and evaluation of the site for a deep geological repository are closely tied to decisions on the proposed Polish Underground Research Laboratory (PURL).

In November, the Polish Minister of Industry Marzena Czarnecka and the Japanese Deputy Minister of Economy, Trade and Industry of Japan Shinji Takeuchi signed a memorandum on cooperation in the nuclear sector in Warsaw, confirming their interest in bilateral cooperation between the countries in developing nuclear energy as a technology to meet the goals of energy transformation and improve energy security.

Romania

In June, Romania's national nuclear energy company SN Nuclearelectrica S.A. (SNN) and Canadian Nuclear Partners S.A. signed a long-term Framework Agreement to provide project management organisation services for the preparation and implementation of the Cernavodă Nuclear Power Plant Unit 1 refurbishment project in Romania.

On 19 December, SNN and the international consortium of four companies – Candu Energy Inc. (an AtkinsRéalis company), Ansaldo Nucleare, the Canadian Commercial Corporation, and KHNP – ceremonially signed the engineering, procurement, and construction (EPC) contract for the Cernavodă NPP Unit 1 refurbishment.

In February, Nuclearelectrica signed a Memorandum of Understanding with SACE and Ansaldo Nucleare on the development and financing of the refurbishment of Cernavodă NPP Unit 1 and Cernavodă NPP Units 3 and 4.

In July, the European Commission issued a positive opinion on the Cernavodă project Units 3 and 4, managed by the project company Energonuclear and owned by SNN. The engineering, procurement, and construction management (EPCM) contract was signed in November.

In July, SNN and RoPower Nuclear, the project company from Doicești, Romania, announced the signing of the Front-End Engineering and Design Phase 2 (FEED 2) contract. In addition, Feldioara Uranium Concentrate Processing Plant (FPCU Feldioara), which produces uranium dioxide, intends to develop its process for UF6 conversion.

SNN and Framatome announced the successful outcome of the feasibility study assessing the possibility of producing the medical isotope Lutetium-177 (Lu-177) at the Cernavodă NPP in country.

Slovakia

In November, the Slovak government approved the plan to build a new nuclear reactor with an installed capacity of up to 1 700 MW in Jaslovské Bohunice with the commercial operation expected in 2040. There are also plans to build the first SMR by 2035-2037, with two to four SMRs in total to be built later.

Radioactive waste from abroad can be processed in the country again as the lawmakers lifted the 2021 ban. In Slovakia, large-scale industrial processing of radioactive waste is handled solely by the Nuclear Decommissioning Company, which processes waste from Czechia, Germany and Italy through incineration after winning international public tenders.

As part of the work to decommission the V1 NPP in Jaslovské Bohunice, the key ‘Dismantling of Reactor Coolant System Large Components’ project finished operations and the dismantling of the F&D facilities. A total of 4 300 tonnes of processed contaminated metallic materials (including reactor pressure vessel, main circulation pumps or steam generators…) could be freely released, representing 99%, only 51 tonnes required management as radioactive waste.

Unit 4 of the Mochovce nuclear power plant launched the second phase of inactive tests in the commissioning process. In early December, Slovenské elektrárne, a.s. began a cold hydraulic test of Unit 4, as an important step toward bringing the power plant into operation and the first comprehensive test in which the reactor systems operated together with auxiliary systems.

In July, in line with ESA’s diversification policy Slovenské elektrárne and Framatome signed an agreement on the fuel supply for VVER 440 reactors (following a contract in 2023 with Westinghouse to supply nuclear fuel for VVER 440 units), to diversify nuclear fuel supplies for Slovakia’s NPPs. The first deliveries are expected in 2027.

In 2024, Slovakia was selected for the Project NEXT, a US initiative for further exploration of the possibilities of implementing SMR technology (deeper development of the analysis from Project Phoenix).

Slovenia

In autumn 2024, the spatial planning process was triggered for the JEK2 nuclear power plant, to be located next to the existing Krško NPP. The nationwide referendum to be held in Slovenia in November 2024 about proposed new nuclear power unit has been called off. The state-owned investor will continue with spatial planning procedures and another referendum will be most likely called again in 2027 before the FID (Final Investment Decision) is taken.

Construction work began for the repository for the permanent disposal of low and intermediate-level radioactive waste (LILW). It will be a near-surface facility located next to the existing Krško NPP, with a disposal unit in the form of a silo.

Slovenia’s National Assembly approved the Resolution on the Long-term Peaceful Use of Nuclear Energy, setting a framework for the future use of nuclear energy in the country.

The updated National Energy and Climate Plan was adopted by the government, setting ambitious targets for 2030 to reduce greenhouse gas (GHG) emissions, increase energy independence and accelerate the transition to clean energy sources. Nuclear power is seen as one of two possible scenarios for long-term sustainable energy future and energy security.

Spain

In September the final update of the national energy and climate plans was submitted, and the country continues on that basis, phasing out its nuclear fleet with the following decommissioning programme: Almaraz 1 in 2027, Almaraz 2 in 2028, Asco 1 and Cofrentes in 2030, Asco 2 in 2032, and Vandellós II y Trillo in 2035.

Sweden

In 2024, the Swedish government was working intensively to create conditions for investment in new nuclear power in the country. Several public inquiries are ongoing in several important areas such as risk sharing, financing, as well as the possibility for authorities to evaluate new nuclear power technology before a formal application for construction. The results of public inquiries are being analysed, and government is expected to draft a proposition during 2025.

The Swedish Radiation Safety Authority (SSM) approved the renewed safety report from Swedish Nuclear Fuel and Waste Management Co (SKB) for the interim storage of used nuclear fuel in Oskarshamn. This means that the expanded storage capacity (from 8 000 tonnes up to 11 000 tonnes) can be put into operation.

SSM approved the safety report from SKB for an expanded final repository for low and medium level radioactive waste in Forsmark. SSM has also decided to grant the European Spallation Source (ESS) permission to begin trial operation of the entire accelerator.

3.3. Non-power applications of nuclear technology: supply of medical radioisotopes

Medical radioisotopes are crucial in diagnosing and treating serious illnesses like cancer, cardiovascular diseases, and neurological disorders. Globally, over 10 000 hospitals use about 100 nuclear medicine procedures, resulting in nearly 49 million annual interventions. In the EU more than 1 500 facilities treat around 10 million patients yearly. Nuclear medicine plays a vital role in cancer treatment, with 60% of its procedures focusing on oncology. The use of radioisotopes in this field is rapidly advancing, with significant market growth expected for innovative radiopharmaceuticals.

Nuclear research reactors are the main source of radioisotopes, although technologies like cyclotrons and accelerators are also widely used. Radioisotope production in research reactors involves complex, specialised supply chains across countries, requiring precise delivery operations. Technetium-99m (Tc-99m) is the most widely used radioisotope, used in 80% of diagnostic procedures. Its production starts with uranium target irradiation in research reactors to produce Molybdenum-99 (Mo-99), which is then processed into Tc-99m generators to be delivered to hospitals. Any supply-chain disruptions could severely affect patients.

Globally, over 10 000 hospitals use about 100 nuclear medicine procedures, resulting in nearly 49 million annual interventions. In the EU more than 1 500 facilities treat around 10 million patients yearly.

The EU is a key player in nuclear medicine, hosting a robust supply-chain network. It includes uranium fuel and targets manufacturing in France, research reactors in Belgium, Czechia, the Netherlands and Poland, and processing facilities in Belgium and the Netherlands. The EU has over 60% of the global Mo-99/Tc-99m market share, contributing significantly to advancements in the field.

For more on the supply-chain security of medical radioisotopes, see Chapter 2.1.

3.3.1. SAMIRA

In 2024, the European Commission continued to implement the SAMIRA action plan[34] in its three priority areas: the security of supply of medical radioisotopes, the quality and safety of ionising radiation in medicine and the innovation and technological development in this field. An ongoing feasibility study on the European radioisotopes valley initiative (ERVI)', expected to conclude in 2025, analysed various actions to strengthen the radioisotopes supply chain, such as investment needs in new production infrastructures or the monitoring of supply, which could build on the European Observatory on the Supply of Medical Radioisotopes. On the quality and safety of medical applications, a Commission Recommendation on clinical audits[35] (2024/1112/Euratom) was adopted and several studies and activities continued to be undertaken in cooperation with the experts' group. The EU-JUST-CT study on improving justification of computed tomography was concluded and published[36]. In the research and innovation field, the publication of *A European research roadmap*[37] on medical applications marked a significant milestone, and support for research and innovation continues to be provided through different Commission programmes.

In 2024, the European Commission continued to implement the SAMIRA action plan.

3.3.2. Monitoring the supply of Mo-99 in the EU

The European Observatory on the Supply of Medical Radioisotopes (please see Chapter 5.2.4), jointly chaired by the Euratom Supply Agency and the industry association of nuclear medicine – Nuclear Medicine Europe (NMEU), closely monitors the supply of the most vital diagnostic medical radioisotope: Mo-99/Tc-99m in the EU. The NMEU's Security of Working Group ensures effective coordination of reactor maintenance schedules to avoid disruptions in the supply of Mo-99/Tc99m. The Emergency Response Team (ERT), set up under the Observatory's umbrella and created within the NMEU's Security of Working Group and composed of representatives of research reactors, Mo-99 processors and Mo-99/Tc-99m generator manufacturers identifies potential shortages of Mo-99 and draws up mitigation action plans involving all stakeholders.

34 SAMIRA Action Plan

35 Commission Recommendation (Euratom) 2024/1112 of 18 April 2024 on clinical audits of medical radiological practices carried out pursuant to Council Directive 2013/59/Euratom

36 European co-ordinated action on improving justification of computed tomography - Publications Office of the EU

37 Medical applications of ionising radiation for better patients' lives

In 2024, several significant events, which had negative impacts on supply, occurred. One of these events was the delayed restart of the high-flux reactor (HFR) in the Netherlands (March - April) caused by a deviation in the cooling system found during the reactor startup procedure.

Between July and September, the ERT dealt with the negative consequences of extended scheduled maintenance of the OPAL reactor in Australia. The additional restart delay was due to the highly complex operation of replacing the Cold Neutron Source (CNS), with the technically complex part of reconnecting the CNS pipework to the reactor.

Between September and November, the ERT was activated to deal with the severe supply crisis, which had a significant impact on the supply security. The ERT dealt with the consequences of the delayed restart of the HFR reactor, caused by deformation in one of the pipes in the reactor primary system.

The Observatory played a pivotal role in managing these supply-disruption challenges. The Joint Communication Team, set up within the Observatory, disseminated the updates received from the ERT to various stakeholder groups, including European Commission departments, the EU Health Security Committee, the Council of the European Union (Atomic Questions Group), the European Medicines Agency, the European Association of Nuclear Medicine, the OECD/NEA and the IAEA.

3.3.3. Studies and research

PRISMAP

The key objective of the PRISMAP[38] project (2021-2025) is to unify key infrastructures to set up a common entry point for biomedical researchers and physicians. PRISMAP provides a sustainable supply of high-purity-grade research radionuclides for medicine, thus speeding up the introduction of new medical radioisotopes. The PRISMAP network groups together 23 European academic institutions and research centres. PRISMAP unites key European, national, and regional production infrastructures known for their expertise in producing and distributing non-conventional radionuclides. This network enables the supply of research radionuclides with new purity levels for medical research. It also includes research centres and hospitals skilled in translational research, vital for advancing medical radionuclide studies. PRISMAP offers services or hosts users lacking licences, infrastructure, or expertise. Research projects can be pursued across Europe or within PRISMAP hubs. As the PRISMAP community expands, new research centres and facilities can join, sharing resources and expertise to ensure a sustainable supply of novel radionuclides.

In 2024, following the PRISMAP call for scientific user projects, 22 eligible proposals were received, 14 of which have been selected for funding. The PRISMAP offers topical schools to provide advanced training in topics where the scientific community can benefit. The focus of that training is to draw attention to the state of the art, while also giving participants hands-on opportunities. In 2024, the PRISMAP offered two schools: the PRISMAP school on Radionuclide Production in Leuven (Belgium) in the spring and the PRISMAP school on Medical Imaging in Riga (Latvia) in the autumn.

SECURE

In 2024, work continued on the ‘Strengthening the European Chain of sUpply for next-generation medical RadionuclidEs’ (SECURE)[39] project, which began in 2022. The SECURE consortium, led by Poland’s National Centre for Nuclear Research, aims to efficiently utilise existing resources for new radionuclides, focusing on alpha emitters and beta-emitting theranostic radionuclides. Developing alternative production technologies for these therapeutic radionuclides demands multidisciplinary expertise. The consortium selected key radioisotopes important for nuclear medicine and tackled challenges to ensure their future availability by removing production barriers and providing guidance for their clinical potential and safe use. New project milestones related to the research and development of new targets and irradiation protocols for the production of radionuclides used for therapy (both alpha and beta-emitters) were reached in 2024, and new deliverables were provided paving the way for further developments.

38 The European medical isotope programme: Production of high purity isotopes by mass separation

39 Strengthening the European Chain of sUpply for next_generation medical RadionuclidEs, ENEN2 - Secure Project

Conversion of high-performance research reactors

Building on the outcome of the Heracles-CP[40] and LEU-FOREvER[41] projects, the EU-Qualify[42] project continued in 2024. Coordinated by the Belgian Nuclear Research Centre (SCK-CEN) and involving five partners, the project focused on the qualification of three particular types of fuels: (i) the dispersed U-Mo fuels; (ii) the monolithic U-Mo fuels; and (iii) the high-loaded dispersed U3Si2 fuels. This qualification was accomplished through: (i) fabrication and concurrent qualification of pilot manufacturing equipment and processes; (ii) irradiation under representative irradiation conditions; (iii) post-irradiation examinations; and (iv) modelling of the in-pile behaviour to support LEU conversion safety analyses.

The 2023-2025 Euratom research and training work programme, published in 2023, included a research call (with an EU contribution of EUR 7 million) allowing for a continuation of the work initiated by the three projects[43] above. Within this framework, in 2024 a new project called 'Supplying the European Research Reactors with Safe Low-Enriched Uranium Fuels for Their Conversion and Long-Term Operation to Secure the Supply of Medical Radioisotopes (EU-CONVERSION)'[44] started. The proposed actions within EU-CONVERSION project, coordinated by the Technical University of Munich, include the consolidation of generic fuel qualification data together with two reactor-representative irradiation tests for high-performance research reactor conversions, the demonstration of sustainable and efficient European supply chains for advanced HALEU research reactor fuels for research reactors, as well as the establishment of modern computational methods for nuclear safety analysis and fuel performance modelling.

Future supply of HALEU

High-assay low-enriched uranium metal (HALEU) is vital for research reactors and for producing medical radioisotopes. It is also a prerequisite for the development of advanced nuclear reactors like SMRs. The preparatory phase project for a European production capability to secure a supply of HALEU fuel (PreP-HALEU) was launched in 2024. The PreP-HALEU project[45] (with an EU contribution of EUR 1 million), coordinated by the French Alternative Energies and Atomic Energy Commission, aims to build this capacity. It unites enrichment companies, fuel manufacturers, research organisations, and medical radioisotope producers to generate crucial technical, economic, and regulatory information. Through this collaborative effort, the PreP-HALEU intends to:

- generate substantial technical, economic, and regulatory information to support the decision-making process
- foster alignment among the countries and parties involved in establishing an EU HALEU capability as a shared asset.

Under the PreP-HALEU, the quantitative requirements for HALEU metal will be updated, and working groups will delve into enrichment, metallisation, and transportation considerations. The integration of these elementary bricks will be extensively discussed to create a coherent project dynamic and consistently consolidate results into an executive summary, a key input for the decision-making phase.

3.3.4. New infrastructure developments

Jules Horowitz material test reactor

In 2024, the Jules Horowitz Reactor (JHR) project in France met major milestones pertaining to the following activities:

- Design: positive reviews of the detailed design of MADISON (Multi-rod Adaptable Device for Irradiation of LWR Fuel Samples Operating in Normal conditions) and ADELINE (Advanced Device for Experimenting up to the Limits of the Nuclear fuel Element) experimental loops.
- Manufacturing: completion of the stainless-steel casing of the reactor pools, the supply of the lifting units for the hot cells.

40 Towards the Conversation of High-Performance Research Reactors in Europe

41 Low_Enriched Uranium Fuels fOR REsEarch Reactors

42 'European QUalification Approach for Low_Enriched Fuel Systems for secure production supply of medical isotopes.

43 EU Funding & Tenders Portal (europa.eu)

44 Supplying the European Research Reactors with Safe Low-Enriched Uranium Fuels for Their Conversion and Long-Term Operation to Secure the Supply of Medical Radioisotopes (EU-CONVERSION)

45 Preparatory Phase for a European Production Capability To Secure A Supply Of Haleu FueL (Prep-HALEU)

- Assembly: electromechanical erection activities expanded across most levels of the buildings, the assembly achievement of the cooling systems building ground level.
- Test: implementation in TOTEM (cold test facility) of two mock-ups: a hot cell and the MADISON out of pile experimental loop.

According to the Atomic Energy Commission (CEA), in 2029, the JHR reactor will enter a commissioning phase with a first criticality scheduled in 2032.

PALLAS

In July 2024, the European Commission approved, under EU State aid rules, a EUR 2 billion Dutch measure to support the PALLAS project aimed at producing medical radioisotopes for cancer diagnosis and treatment. The new reactor is envisioned to start operating in the early 2030s. The nuclear health centre will process the medical isotopes produced by the reactor into radiochemicals. Under the measure, the aid will take the form of loans and equity for a total amount of approximately EUR 2 billion to a newly established company ('NewCo') that will build and operate the reactor and the nuclear health centre. NewCo will result from the merger of the PALLAS Foundation set up by the Netherlands in 2013 to manage the preparatory phase of the project, and the Nuclear Research and Consultancy Group that operates the existing HFR.

At the end of 2024, progress on the PALLAS construction pit has been marked by a series of works following drilling of 380 foundation piles into the ground. 4 000 cubic metres of concrete were poured underwater to create the pit's foundation floor. With foundation piles in place and the concrete floor hardened, the basic foundation of the construction pit had been established. Subsequent works at the bottom of the pit included cleaning of the pit, inspecting the piles, placing rebars, pouring concrete to reinforce the piles and construct the bearing slab, the foundation floor of the reactor building, which is the final step in completing the foundation for the reactor building.

Myrrha

In June 2024, a groundbreaking ceremony was held at the Minerva particle accelerator construction site in Mol, Belgium, marking the start of the first of three phases of the development of the Myrrha accelerator-driven research reactor. Myrrha (Multipurpose Hybrid Research Reactor for High-tech Applications) will be a sub-critical assembly relying on accelerated protons producing neutrons in the target to achieve periods of criticality in a low-enriched uranium core. The project should be fully operational from 2038.

It is intended to replace Belgium's BR-2 research reactor and will be used in a range of research functions including demonstrating the concept of transmutation of long-lived radionuclides in nuclear waste, as well as producing radioisotopes for medicine. It will be producing a new generation of medical radioisotopes that emit alpha particles. The Myrrha project forms part of the European Strategy Forum on Research Infrastructures and is one of three new research reactors forming the cornerstones of the European Research Area of Experimental Reactors, alongside the Jules Horowitz Reactor at Cadarache in France and the PALLAS reactor at Petten in the Netherlands.

Lutetium-177

In May 2024, Curium announced that it had signed a long-term agreement to extend its current partnership with NRG PALLAS for new irradiation services in Petten, Netherlands to produce non-carrier added lutetium-177 (Lu-177). By accessing capacity at Petten HFR for Lu-177, Curium will be able to serve patient demand throughout most of the year at high capacity and importantly will address the growing need for Lu-177 products. Curium's Lu-177 production facility and NRG's HFR reactor are both located on the Energy & Health Campus in Petten. In support of its Lu-177 product platform to expand the delivery of this medical isotope, Curium has installed several Lu-177 production lines at its facilities in Petten, which started production in early 2024.

In June, Curium signed a long-term partnership with the Institut Laue-Langevin (ILL) for irradiation services at their high-flux nuclear reactor in Grenoble, France, to produce non-carrier added Lu-177. The agreement follows Curium's announcement last month to extend its irradiation partnership with NRG PALLAS in the Netherlands.

In September, Curium officially opened a new facility in Petten to produce non-carrier added Lu-177. Using in-licensed technology from the Türkiye-based Eczacıbaşı-Monrol, the facility will initially include two production lines (with ability to scale via further lines as needed in the future) to supply Curium's proprietary Lu-177 product pipeline, as well as external pharmaceutical and hospital customers.

In October 2024, Framatome and SN Nuclearelectrica SA announced the successful outcome of a feasibility study that assessed the possibility of producing medical isotope Lu-177 at the Cernavodă NPP in Romania. The two companies launched the project, covering detailed engineering, procurement, installation and the commissioning of the irradiation system at Unit 2 of the Cernavodă NPP. The launch of a full-scale commercial irradiation service for medical isotopes is targeted for 2028. The feasibility study was initiated in November 2023, based on Framatome's isotope production technology. The study demonstrated that by adapting Framatome's technology to Unit 2 of the Cernavodă NPP, the reactor would be able to irradiate Ytterbium-176 (Yb-176) at the market technical standard required to produce Lutetium-based radiopharmaceuticals.

Actinium-225

In June 2024, Eckert & Ziegler Radiopharma GmbH (Eckert & Ziegler), in collaboration with the Nuclear Physics Institute of the Czech Academy of Sciences (Ústav jaderné fyziky, UJF), announced the grand opening of an Actinium-225 (Ac-225) production facility, which marked the culmination of a longstanding partnership between Eckert & Ziegler and UJF. The facility successfully started Ac-225 production in December. In parallel with production, Eckert & Ziegler started the validation process to produce GMP-grade Ac-225. It is expected to become available in the first half of 2025. The production facility employs cyclotron-based methods to generate Ac-225 from Radium-226 (Ra-226).

In September 2024, PanTera, the Belgian radioisotope producer, announced that it has completed a EUR 93 million oversubscribed Series A fundraise, with additional equity and debt funding bringing the total amount raised to EUR 134 million. Alongside this, IBA (Ion Beam Applications S.A.), and SFPIM, a Belgian sovereign fund, will convert EUR 7.2 million convertible loans into equity, further strengthening PanTera's balance sheet. The oversubscribed round is the largest Series A round to date in the life sciences sector in Belgium. In parallel, the company will receive an additional in-kind contribution from SCK-CEN to expand its business opportunities. PanTera was founded in 2022 with the primary goal of enabling large-scale production of Ac-225. The funds raised will be used primarily to support the construction of a state-of-the art production facility in Belgium. The Company's unique, patented photo-nuclear 'gamma' production process transforms Ra-226 into Ra-225, which in turn decays into Ac-225. Alongside its effort to develop commercial-scale production of Ac-225, PanTera is already providing early Ac-225 supply through an alternative production method.

Gallium-68

In August 2024, Eckert & Ziegler received approval from the European Commission for its Germanium-68/Gallium-68 (Ge-68/Ga-68) radionuclide generator GalliaPharm. The generator was first launched in 2014 and is now approved in 17 European countries and many other key international markets. With the EC approval, an additional 14 countries in the European Economic Area (EEA) will gain access to GalliaPharm, once national approval procedures have been completed. Consequently, it will soon be the first generator for the production of Gallium-68 commercially available in the entire EEA.

Lead-212

In February 2024, Orano Med, a subsidiary of the Orano Group, laid the foundation stone for its Alpha Therapy Laboratory (ATLab) in Onnaing, in France. This will be Europe's first industrial-scale pharmaceutical facility dedicated to the production of Lead-212 (Pb-212) based radioligand therapies. Targeted Alpha Therapy with Pb-212 combines the natural ability of biological molecules to target cancer cells with the short-range cell-killing capabilities of Pb-212 generated alpha emissions. ATLab, with over 3 000 m² of floor space, will represent an investment of EUR 29 million. It will focus on the production of Pb-212 therapies developed by Orano Med and their distribution in Europe. In June, Orano Med inaugurated the similar facility in Brownsburg near Indianapolis, Indiana, in the United States. ATLab Indianapolis is the world's first industrial-scale pharmaceutical facility dedicated to the production of lead-212-based radioligand therapies.

In November 2024, Orano Med celebrated in Bessines-sur-Gartempe in Haute-Vienne, in France, the groundbreaking for its ATEF (Advanced Thorium Extraction Facility) plant. This facility is the world's first industrial plant dedicated to the production of Thorium-228 (Th-228), a precursor of Pb-212, for radioligand therapies. ATEF's construction will industrialise the production process for Th-228, under development for over 10 years by the Laboratoire Maurice Tubiana (LMT). With over 7 000 m² of floor space, the ATEF facility, scheduled for commissioning in 2027, will increase the LMT's current production capacity tenfold. The project represents a total investment of approximately EUR 250 million.

Astatine-211

In October 2024, IBA announced that the European Commission has approved the financing of the Accelerate.EU project launching on 1 October 2024. Within the project, IBA will facilitate the development of a production network to enable better access to targeted alpha therapy across the EU through the development of a new alpha-machine cyclotron as an in-kind contribution. IBA will also work in close collaboration with the Jules Bordet Institute to manage the project. The Accelerate.EU project, a EUR 16 million initiative, was officially launched with the goal of establishing resilient and strategic European autonomy in alpha therapies. This five-year project aims to enhance patient access to cancer treatments by creating a complete value chain for the production and clinical application of the alpha-emitting isotope Astatine-211 (At-211). The project has secured EUR 8 million in funding from the European Commission under the Innovative Health Initiative (IHI), matched by an equivalent in-kind contribution from industry partners. This collaboration brings together 17 leading European institutions and companies across 9 countries, blending academic expertise with industrial innovation. The project will focus on developing and testing new therapeutic agents, ensuring a robust and sustainable infrastructure for At-211 production and treatment.

4. World market for nuclear fuels in 2024

This chapter presents the main developments in the world's nuclear fuel market during 2024. According to the International Atomic Energy Agency (IAEA)[46], there were 417 operating reactors at the end of the year, able to generate 377 GWe of net electrical capacity. At the same time, 62 reactors were under construction with a potential net capacity of 64.4 GWe, 28 of which were in China. A total of 7 reactors were connected to the grid during the year, 1 in France, 3 in China, 1 in UAE, 1 in India and 1 in the USA, accounting for a net capacity of 8.3 GWe.

The nuclear fuel market continued to grow, driven by increased global interest in nuclear power for energy security and decarbonisation. The IAEA, in its Report on Climate Change and Nuclear Power[47], asserted a need for significant investment to expand nuclear power capacity by 2050.

In 2024, the nuclear fuel market continued to grow, driven by increased global interest in nuclear power. After the role of nuclear energy was recognised at the UN Climate Change Conference (COP28) and the Atoms4NetZero initiative, world leaders gathered in Brussels at the first-ever Nuclear Energy Summit[48] (March 2024) to highlight the role of nuclear energy in addressing the global challenges of reducing the use of fossil fuels, enhancing energy security and boosting economic development.

At the same time, geopolitical instability, notably as a result of Russia's war of aggression against Ukraine, but also due to tensions in certain regions where uranium is mined, has had a major impact on the nuclear fuel market and supply chain, underpinning calls for strengthening resilience and security of supply.

In terms of global security of supply, the Sapporo 5 initiative (Canada, France, Japan, United Kingdom and the United States), continued its efforts to reduce reliance on Russian nuclear supplies. A joint statement was released in September 2024, calling for like-minded nations to join the commitment to secure a reliable nuclear fuel supply chain.

46 https://pris.iaea.org/pris/ (last access, March 2025)

47 New IAEA Report on Climate Change and Nuclear Power Focuses on Financing | IAEA

48 Declaration on Nuclear Energy

Geopolitical instability is leading to strengthening resilience and security of supply. The United States, for its part, passed a law [49] in May banning the import of unirradiated low-enriched uranium from Russia. Until the end of 2027, waivers may be issued if no alternative viable sources are available to continue the operation of a reactor. In response, Russia announced similar restrictions on enriched uranium exports to the USA.

During the year, uranium prices fluctuated significantly due to factors such as supply concerns from the main producers, the above-mentioned geopolitical risks and the possible imbalance between supply and demand triggered by the coming energy transition.

Average uranium spot prices in 2024 continued to rise compared to the average value for 2023, increasing by 36% to USD 84.77 per pound of U_3O_8. However, after reaching a peak in February 2024, the spot price of uranium subsequently decreased during the year, to USD 71.75 in late December, down by 28% compared to December 2024 [50].

Similarly, the average spot prices of conversion services amounted to USD 67.50 per kgU, a 64% increase compared with the average for 2023. The 2024 evolution of month-end prices followed a straight increasing trend and was up 73% from January to the end of the year. The same variations have been identified in the EU market as in the North American market [51].

Average enrichment spot prices in 2024 of USD 164.7 showed an increase of 20% per kgSWU compared to the average values for 2023. The upward trend was rising by 17% over the year without fluctuations, reaching USD 190 per kgSWU at the end of December [52].

Long-term prices in the uranium market rose slightly in 2024, by 10% compared to 2023, reaching USD 77.83 per pound of U3O8 on a yearly average. The long-term conversion price, having averaged USD 30 per kgU in 2023, increased to USD 40 per kgU in 2024: a 32% change.

Enrichment average long-term prices, in the same way, followed an upward trend to USD 160 per kgSWU, equal to 9% more than 2023 [53]. The average price increase during the year was still linear, amounting to an 11% change.

As in recent years the market faces pressure on prices due to increasing demand and uncertain supply situations. This is causing operators to restart mothballed facilities, and extend the capacity of existing ones, for uranium mining as well as conversion and enrichment.

In 2024, the interest in small modular reactor (SMR) development recorded worldwide continued to increase. New commitments, progress inconcepts and investments make the development and possible future deployment of these kinds of reactors more tangible in the years to come. In Europe the European Commission has launched an Industrial Alliance dedicated to SMRs, aiming to facilitate the development of SMRs in Europe by the early 2030s.

At the same time, the lifetime of several existing power plants all over the world has been extended, driven by economic factors and emissions reduction targets. Some examples include the political decisions in Belgium to extend the lifetime of two nuclear power plants, the Turkey Point Nuclear Generating Station (USA), where the operations were extended for up to 80 years, Takahama-3 and 4 (Japan), extended for up to 60 years, and Heysham 2 and Torness (UK), cleared for operation until 2030. Japan restarted two more reactors in 2024. Late in the year, it also announced that it intended to remove its policy to reduce the nuclear share of energy production from the national energy plan.The IAEA has set up the International Network on Life Management of Nuclear Power Plants (LMINPP Network), a new tool to support countries facing operational life extensions.

49 Prohibiting Russian Uranium Imports Act. On 13 May 2024, the bill became law. The ban terminates in December 2040, and any waiver determined must terminate by January 2028.

50 UxC month-end prices.

51 UxC month-end prices.

52 UxC month-end prices.

53 UxC month-end prices.

4.1. Primary uranium supply

In 2024, the world uranium market continued to cope with the consequences of various geopolitical events, including the political instability in key uranium-producing regions, such as Niger. Nigerien authorities took operational control of the SOMAIR company that manages the Arlit mines in the late 2024, after having withdrawn Imouraren SA's (Orano) licence to exploit the Imouraren deposit, and GoviEx Uranium's (Canada) mining rights for the Madouela project earlier this year. On the other hand, Global Atomic is developing the Dasa uranium mine and has received expressions of support from Niger's government.

In this context, several companies decided to make new investments and increase uranium mining, also by restarting existing sites. In the African region there are new projects for uranium mining also in Mauritania and Uganda.

Several companies decided to invest and increase uranium mining.

The rise in uranium prices, triggered by growing interest in nuclear energy, led industries to resume mining projects suspended in previous years. In the second quarter of 2024, Paladin Energy restarted commercial production from the Langer Heinrich uranium mine. Australia-based Lotus Resources Ltd is working to reopen the Kayelekera uranium mine in Malawi; its target is to start production next year. Brazilian fuel cycle company Indústrias Nucleares do Brasil has announced it is to resume uranium exploration in the country after a 40-year suspension.

In the USA, Uranium Energy Corp announced the restart of Christensen Ranch in-situ leach operations in Wyoming to produce uranium. Iso Energy company announced its strategic decision to reopen its producing mine and to start up production at Alta Mesa (Texas), with a joint venture between enCore Energy and Boss Energy. The country increased its efforts to produce uranium directly from mining. It is worth noting that the USA tripled domestic production of uranium concentrate (U3O8) in the third quarter of 2024, compared to the whole of 2023. However, the US production remained marginal at a global stage as illustrated in Table 8.

Canada has stated that the Midwest Main deposit in Saskatchewan has the characteristics for an in-situ leach operation and that production in McClean Lake is to restart using the surface access borehole resource extraction mining (SABRE) method.

Noteworthy events also include developments in Australia, where Rio Tinto managed the rehabilitation of the former Ranger uranium mine in the Northern Territory. Boss Energy Limited's Honeymoon in-situ leach project in South Australia reached a major milestone in a commissioning process that will see production ramp up to 2.45 million pounds of U3O8 (942 tU) per year.

In this context, the total production of uranium worldwide reached in 2024 the amount of 71 214 tons, 10.6% more than in 2023, when it was 64 410 tons. The increase stemmed mainly from the rump-up of Cameco's majority-owned Cigar Lake and McArthur River projects in Canada.

Table 8. Natural uranium production in 2024 (compared to 2023, in tonnes of uranium)

Region/country	Production 2024	Share in 2024 (%)	Production 2023	Share in 2023 (%)	Change 2023/2024 (%)
Kazakhstan	27 442	38.5%	24 902	38.7%	10.2%
Canada	16 874	23.7%	12 973	20.1%	30.1%
Namibia	8 664	12.2%	8 255	12.8%	4.9%
Australia	5 443	7.6%	5 534	8.6%	-1.6%

Uzbekistan	**4 717**	**6.6%**	**-**	**-**	**-**
Russia	**3 084**	**4.3%**	**3 175**	**4.9%**	**-2.9%**
China	**1 905**	**2.7%**	**1 905**	**3.0%**	**0.0%**
Niger	**1 134**	**1.6%**	**1 315**	**2.0%**	**-13.8%**
Others	**1 036**	**1.5%**	**-**	**-**	**-**
Ukraine	**340**	**0.5%**	**-**	**-**	**-**
United States	**306**	**0.4%**	**023**	**0.0%**	**1250.0%**
South Africa	**268**	**0.4%**	**237**	**0.4%**	**12.7%**
Total	**71 214**	**100.0%**	**64 410**	**100.0%**	**10.6%**

Source: Data from the UxC weekly news specialised publications (totals may not add up because of rounding). 2023 data not all available at the date of publication of the report. Note: (*) estimation.

Japan, which last year announced funds for mining projects, still faces the challenge of reducing its dependence on Russia and China for raw materials.

Finnish mining company Terrafame has begun recovering natural uranium as a by-product of zinc and nickel production at its Sotkamo mine in Talvivaara, and Kazakhstan's national atomic company received approval from the Ministry of Energy for a pilot to produce a total of 701 tU from the Inkai 3 deposit over four years.

4.2. Secondary sources

In 2024, as has happened very often in the past, the uranium required did not only come from primary production but also from inventory drawdowns and secondary sources, which can include commercial or government-held inventories. In the case of uranium, such secondary sources may – depending on economic factors – also include depleted uranium upgrades, or natural uranium saved by uranium enrichers by means of underfeeding.

Forecasting such imbalances remains challenging, as reliable global data on secondary and other sources of uranium are not readily available. However, most analysts anticipate a faster depletion of secondary sources towards the end of the current decade. This may be compounded by the rising trend in enrichment demand and separative work unit (SWU) prices, which are expected to reduce the scope for underfeeding, and by the physical uranium holdings in the hands of private trusts such as Sprott Physical Uranium Trust (SPUT), Yellow Cake plc, Zuri-invest and ANU Energy.

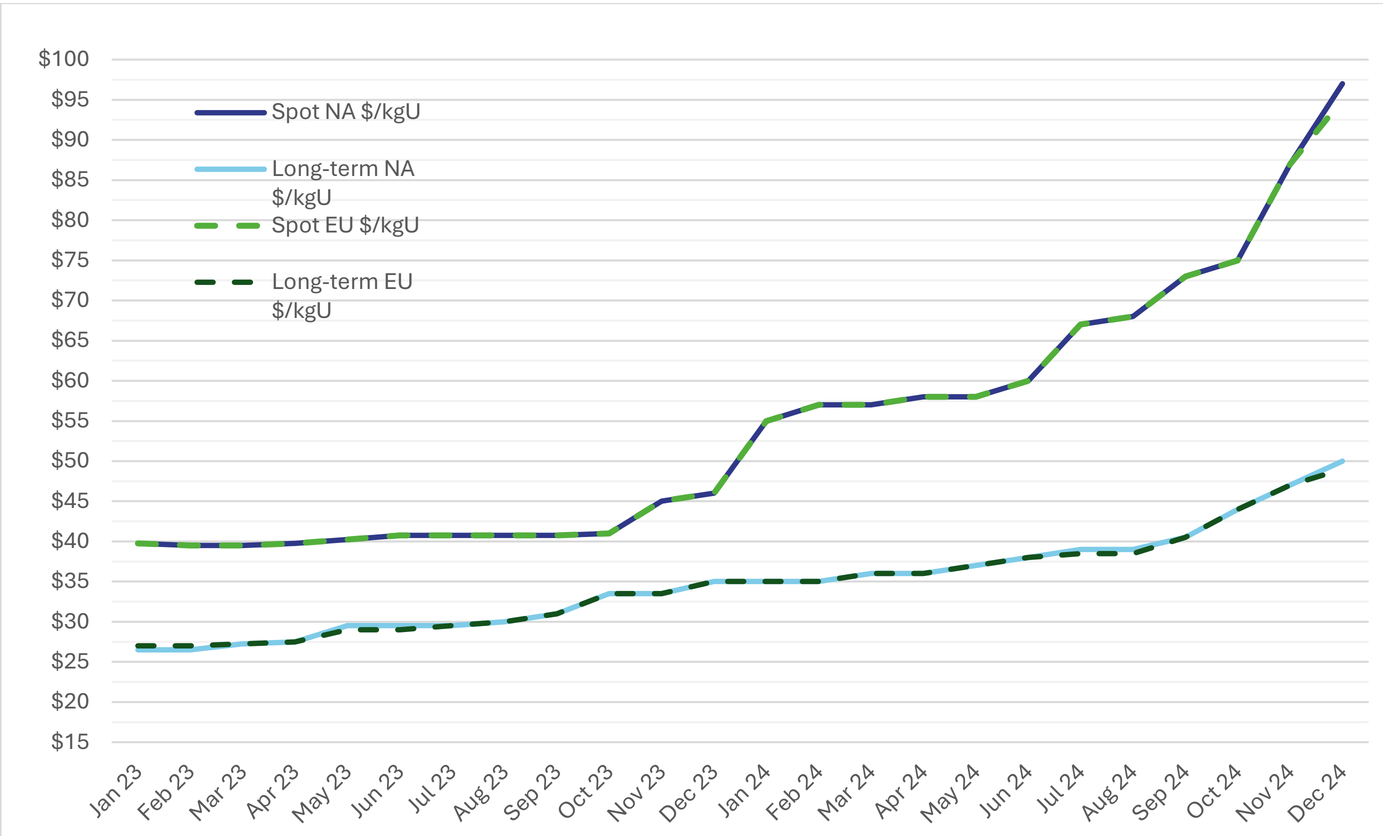
On the other hand, these stockpiles tend to be maintained at a reasonably high level, for security reasons, by utilities and governments.

Moreover, such trends could, over time, be offset by increased use of recycled uranium and plutonium as mixed oxide (MOX) fuel, if accompanied by the development of appropriate fuel cycle capabilities. While depleted uranium may sometimes be perceived as waste for geological disposal, it is best described as a strategic resource readily useable in oxide form to manufacture MOX fuel. Furthermore, developments in laser enrichment could allow cost-effective re-enrichment of high-assay tails to form a secondary source of natural uranium and further challenge assumptions regarding secondary sources as we head into the next decade.

4.3. Conversion

The uranium conversion market segment is still affected by the restricted number of operating facilities worldwide. It has experienced a significant surge in prices in 2024 as compared with the recent past.

Figure 13. Uranium conversion price trends (in USD)



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This trend reflects tightened market conditions aggravated by geopolitical tensions, notably the decision of Western countries to reduce their reliance on the Russian supply capacity. In the same way, the expected expansion of nuclear energy resulted in increasing demand from worldwide suppliers. This surge in prices could incentivise conversion services suppliers to increase their capacity at existing facilities and to invest in building new plants to meet the growing demand.

Expansion of existing capacity of production (e.g. in the US, France and Canada) or construction of new capacities (e.g. in the UK) could help ease market pressures, but any new investments are likely to be effective only in the longer term. For this reason, the conversion market is vulnerable to possible supply shocks.

Table 7. Commercial UF6 conversion facilities

Company	Licensed capacity in 2023 (tU)	Share of global capacity
Orano* (France)	15 000	24%
CNNC** (China)	15 000	24%
Rosatom (Russia)	12 500	20%
Cameco (Canada)	12 500	20%
ConverDyn*** (United States)	7 000	11%
Total nameplate capacity	62 000	100%

Totals may not add up because of rounding. Source www.world-nuclear.org

* Approximate capacity installed 10 500 tU

** Information on China's conversion capacity is uncertain

*** Activity restarted in 2023

The only conversion plant in the US, Metropolis Works plant, with a nominal capacity of 17 600 mtU as UF6, was restarted in 2023, but it is producing at a lower level. The option to increase capacity to 10 000 tU by 2028 is still being considered.

In 2024, Westinghouse was still working on the project to bring uranium conversion capability back to the Springfields site, for converting both reprocessed uranium and naturally enriched uranium, by the end of the decade, and it plans to make the final investment by 2025.

EDF is aiming at having a new reprocessed uranium plant built in Western Europe in order to convert the French reprocessed uranium derived from spent fuel treated at the La Hague reprocessing plant and stored as U3O8 in France. Discussions are ongoing with various fuel suppliers who have expressed an interest in building and operating a facility. Other utilities might also be interested in converting their stock of reprocessed uranium at that plant.

4.4. Enrichment

Being proliferation-sensitive, enrichment technology is available only to a limited number of governments, who entrust it to an even smaller number of commercial operators. The rise in prices and increasing demand drives western enrichers to invest or continue to invest in expanding their production capacity. Countries and governments are helping to facilitate this expansion, as they are aiming to develop a reliable domestic supply chain in the nuclear fuel cycle. The supply of enrichment services is part of this effort.

As reported by Urenco in its annual report, 2024 not only saw a continued upward trend in SWU market prices, in line with recent years, but also saw countries showing a growing commitment to nuclear energy to reach their decarbonisation targets and to ensure independence and security.

In particular, the company noted that, for the first time, the need to power data centres with low carbon electricity shifted the choice towards nuclear energy, together with the development of new advanced technology.

Figure 14. Monthly spot and long-term SWU prices (in USD)

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Urenco, in its programme to extend and refurbish enrichment capacity at the company's facilities, reached tangible milestones in 2024. Among these, the following can be mentioned: the first new centrifuge was deployed at the US plant, aiming to expand capacity by 15%, i.e. an additional 700 000 SWU per year; construction started on a centrifuge hall in the Netherlands; it was announced that new capacity would be installed at the German site with more modern centrifuge technology; and the refurbishment of centrifuges was completed at the UK site.

Likewise, Orano in France laid the foundation stone of its ambitious plan to expand capacity by 30% at its Georges Besse 2 plant, priced at EUR 1.7 billion and adding some 2.5 million SWU from 2028. The company also applied for a licence to produce uranium enriched at higher assays. Moreover, Orano took a step forward in its intention to build a new enrichment facility in Tennessee after having selected Oak Ridge as its preferred site. The initiative takes advantage of the Nuclear Energy Fund from the government of Tennessee.

After banning imports of enriched uranium from Russia, the US also unlocked USD 2.72 billion in federal funding to allow domestic uranium supplies and the construction of new enrichment capacity. Global Laser Enrichment plans to build a laser enrichment facility in Kentucky, while Centrus Energy is restarting its facility in Tennessee and plans to expand the Piketon site in Ohio.

Enriching recycled uranium is part of the commitment from countries and enrichers to increase capacity and develop the domestic market segment. While Russia had long been the sole supplier of enrichment services for recycled uranium, Urenco's facility in the Netherlands now also provides this service. Two modules of Orano's facility in France could also enrich reprocessed uranium; it is, however, a limited capacity for the French reactor fleet.

In 2024, interest in SMRs and advanced modular reactors (AMRs) with their new fuel technology and design has increased further. Similarly, interest in higher assays of low-enriched uranium fuel (LEU+, HALEU), so far not used in commercial nuclear fleets, is growing. In late 2024, the United States Nuclear Regulatory Commission (US NRC) approved a licence amendment to increase uranium enrichment levels by up to 10% at the Urenco facility in New Mexico.

Higher assays are essential for future users of smaller reactors unable to rely on uranium-plutonium mixed fuels. The United States Department of Energy (US DOE) estimates domestic demand for high-assay low-enriched uranium (HALEU) can reach 50 metric tonnes yearly by 2035.

A considerable part of the HALEU enrichment segment consists of non-power applications, such as process heat production by new advanced reactors, and to a limited extent medical isotope production.

However, HALEU stocks are limited. Developments in 2024 continue to drive change in the structure of the uranium enrichment industry. A secure and resilient supply of HALEU is essential to unleash the benefits of AMR technologies on our path to Net Zero. To support this the UK Department for Energy Security & Net Zero announced up to £300 million to establish domestic HALEU capability to support AMR and research reactors in the UK and overseas. This will include HALEU enrichment and development of deconversion, as well as transport capabilities and relevant regulatory guidelines. Within this programme, in May 2024, it awarded Urenco the first tranche of the funding to deliver first-of-a-kind HALEU enrichment capability on a commercial scale, with a target of carrying out first operations in 2031. The plant, sited at the Capenhurst site, will provide capacity to produce up to 10 tonnes of higher assays LEU (LEU+ and HALEU). In July, the UK Department for Energy Security & Net Zero launched the HALEU deconversion competition for grant funding to support the development of a HALEU deconversion facility. In December, the government awarded funding to Nuclear Transport Solution to lead the development of transport capabilities for the future use of HALEU.

In October 2024, the US DOE awarded contracts amounting to a total of USD 800 million to six companies for deconversion services that include the design, licensing and construction of production facilities and the production of oxide and metal HALEU product.

Table 8. Operating commercial uranium enrichment facilities, with approximate 2022 capacity

Company	Operational capacity 2022 (tSW)	Share of global capacity
Rosatom (Russia)	27 100	44%
Urenco (UK/Germany/Netherlands/United States)	17 900	29%
Orano (France)	7 500	12%
CNNC (China)	8 900	14%
Others * (INB, JNFL)	100	0%
Total nameplate capacity	61 500	100%

Totals may not add up because of rounding.

Source: www.world-nuclear.org, WNA Nuclear Fuel Report

* INB, Brazil; JNFL, Japan

4.5. Fuel fabrication

Unlike conversion or enrichment services, which mostly involve the chemical and physical transformation of uranium oxide, fuel fabrication is a rigorous manufacturing service that requires preparing fuel assemblies to the exact design and technical specifications of the customer reactor unit. While some degree of competition is theoretically possible, vendor consolidation over the years has led to a high degree of concentration.

In some subsegments, such as fuel with hexagonal geometry, fuel using mixed oxides and fuel using reprocessed or blended uranium, competition is even more restricted. Nevertheless, pushed by the interest in reducing dependence on Russia and the commitment to develop domestic fuel cycle supply chains, this segment is also undergoing marked changes.

The main trends in 2024 for the fabrication segment are, in a nutshell, the commitment of fuel manufacturers to upgrade their plants considering the coming growing demand; the water-water energetic reactor (VVER) market in Eastern Europe shifting into alternative suppliers; the increasing effort to develop and deploy accident tolerant fuels (ATFs), high burnup fuels (HBFs), and LEU+ fuel; and, as said for the enrichment segment, the preparations for small, advanced, and microreactors (SAMRs), which will need new fuels based on the HALEU products.

Westinghouse continued pursuing the manufacturing of fuel alternatives for VVER reactors. The first batch of its NOVA fuel designed and produced for the VVER-440 reactor refuelled unit 2 of the Loviisa power plant in Finland. In addition, Bulgaria's Kozloduy unit 5, a VVER1000 reactor, was also loaded with the Robust Westinghouse Fuel Assembly (RWFA) Westinghouse-designed fuel. Ukrainian operator Energoatom announced progress with its plans to build a new facility to produce fuel assemblies, including RWFA Westinghouse technology for VVER-1000 reactors.

In response to the accelerated need for an alternative fuel supply for VVER reactors in the European Union, Framatome is fabricating fuel identical to the proven design currently used by the European VVER reactors.

In parallel, the French company is developing and qualifying European sovereign fuels of its own design for VVER-440 and VVER-1000 reactors financed as part of the SAVE project with EUR 10 million from the European Union under the Euratom Research and Training Programme. Framatome is leading the SAVE project for the development and deployment of a European fuel solution for VVER reactors and involves 17 stakeholders, including utilities that operate VVER reactors in Europe.

General Atomics is developing fuel rods that can endure higher temperatures using new materials that have been used in manufacturing the first batch of full-length silicon carbide composite tubes (SiGA).

Westinghouse has produced low-enriched uranium plus advanced doped pellet technology, which contains uranium enriched to levels around 8%, and produced 3D-printed bottom nozzles, tested at Southern Nuclear's Farley plant in Alabama. These solutions should enhance fuel performance and improve safety.

In 2024, Framatome completed the last cycle of operation at the Gosgen plant in Switzerland and at Georgia Power's Vogtle plant in the US with its new PROtect enhanced accident tolerant fuel, which closed the assessment of chromium-coated lead fuel assemblies.

The Kazakh-Chinese joint venture Ulba-FA LLP, which produces nuclear fuel for Chinese nuclear power plants, is now working at full capacity producing fuel assemblies equivalent to 200 tonnes of low-enriched uranium.

The use of MOX fuel is also being developed. Orano operates the only plant in Europe that currently produces commercial quantities of MOX assemblies, and it signed a contract with Japan's Mitsubishi Heavy Industries to manufacture 64 mixed-oxide fuel assemblies for Japanese power plants.

Rosatom Corporation announced that its ongoing cycles of testing of innovative uranium-plutonium REMIX fuel in the MIR research reactor aim to demonstrate the safety of MOX fuel for use in VVER-type reactors. The prospection of using a full load of MOX fuel could reduce the consumption of natural uranium by 50% compared with a standard fuel load.

Oklo Inc.'s Aurora Fuel Fabrication Facility at Idaho National Laboratory received conceptual design clearance from the US DOE. The site will host the fabrication plant for fuel for Aurora's 'powerhouse' liquid metal-cooled fast reactor plant which will be located at the same site. The fuel will be fabricated using HALEU.

Finally, there is still interest in developing thorium-based fuels. Clean Core Thorium Energy announced that it reached a milestone in the pre-licensing review process from the Canadian nuclear authority. Accelerated irradiation testing and qualification of its patented ANEEL thorium and HALEU fuel is underway at Idaho National Laboratory.

4.6. Reprocessing and recycling

The back end of the nuclear fuel cycle is strictly related to the recycling and reprocessing of spent fuel, although the front-end phases of the cycle are also involved in the expansive push to improve and innovate driven by the growing demand for nuclear energy and the development of advanced technologies in reactor design.

The number of facilities capable of processing irradiated materials to separate all or part of the contained elements is small and expected to remain so worldwide. Like enrichment, reprocessing technology is sensitive from a proliferation perspective, which means that commercial operations in this segment are necessarily restricted.

In 2024, growth in this segment was fuelled by the large prospects for nuclear power expansion and by the geopolitical situation, which caused countries to reduce their dependence on Russia.

In France, reprocessing capacity has been determined mainly by the requirement to process domestic fuel, but spare capacity was sold via contracts to foreign fuel owners.

Indeed, in 2024, a new full core load with recycled uranium fuel allowed Unit 2 of the French Cruas-Meysse nuclear power plant to restart. This event underlines France’s intention to revitalise the national reprocessing industry, confirmed by the decision to continue with its treatment-recycling strategy for used nuclear fuel beyond 2040, to extend the life of existing recycling plants, and to undertake studies for a new MOX fuel fabrication plant and a new reprocessing plant.

Linked to the French initiative, Orano USA and SHINE Technologies decided to collaborate on the development of a US pilot recycling plant expected to recycle 100 tonnes per year of used nuclear fuel. Using commercial-scale aqueous recycling methods, the plant will be integrated with non-proliferation measures.

Other enhancements to the recycling processes included Moltex’s waste to stable salt (WATSS) process for converting used nuclear fuel into an asset (coupling WATSS with its molten salt reactor fuel in the Stable Salt Reactor – Wasteburner (SSR-W) significantly reduces nuclear waste volumes and produces new fuel for advanced reactors) and Oklo Inc.’s completion, in cooperation with Argonne and Idaho National Laboratories, of the demonstration of its advanced fuel recycling process in 2024 (the company is also developing a liquid metal fast reactor that could benefit from this advanced recycling capability).

The Russian state nuclear energy corporation Rosatom is carrying on its ambitious strategic Breakthrough project to develop a closed fuel cycle. The construction works for the Pilot Demonstration Energy Complex at the Mining and Chemical Combine facility ended in late 2024. The complex will host the innovative lead-cooled BREST-OD-300 fast reactor, a module for the production (fabrication/refabrication) of dense uranium-plutonium nitride nuclear fuel and a module for reprocessing irradiated fuel. Thus, a stationary, closed nuclear fuel cycle will be created at one site. The BREST-OD-300 reactor is expected to start operating in 2026.

Other noteworthy developments in 2024 include:

- Laurentis Energy Partners (Canada) opening a new facility for recycling low-level nuclear wastes focused on minimising volumes derived from nuclear energy production;
- the continuous cooperation of the Japanese Federation of Electric Power Companies (FEPC) with France’s Orano to progress research on reprocessing MOX fuel; and
- the completion of the RECUMO building, in Mol (Belgium), planned for 2026, where residues from the production of medical radioisotopes (Mo-99) will be purified and the recovered uranium will be reused as fuel for reactors or as a target for new radioisotopes production.

4.7. Storage and repository of nuclear spent fuel

In 2024, as in previous years, the general trend has been to speed up and improve the storage and repository strategies to better manage all kinds of radioactive waste. Below is an overview of the main results and progress in several countries.

Finland's Radiation and Nuclear Safety Authority is completing its assessment of Posiva Oy's operating licence application for its used nuclear fuel repository. The Finnish deep geological repository is nearing completion, but authorities postponed the final decision until the end of 2025.

In Sweden, the National Radiation Safety Authority approved the safety report submitted by Svensk Kärnbränslehantering AB (radioactive waste management company), thus allowing groundworks to start in order to extend the final repository (Forsmark) to all levels of waste.

> In 2024, the general trend has been to speed up and improve the storage and repository strategies.

Andra, the French waste management company received approval from the Aube department to increase the authorised capacity of the Cires very-low-level radioactive waste disposal facility and is waiting for permission to start the construction of Cigeo deep geological repository. The administrative process could take between three and five years.

In Switzerland, Nagra (the national waste management cooperative) submitted an application to the Swiss Federal Office of Energy to construct the planned deep geological repository for radioactive waste and a used nuclear fuel encapsulation plant.

Finally, the Lithuanian state-owned enterprise Ignalina Nuclear Power Plant developed a general concept design for the construction of a geological disposal facility in clay-based rocks, with the assistance of Finnish company Posiva.

Beyond Europe, there were further developments in Canada, where, after positive consultation with communities, Wabigoon Lake Ojibway Nation in Ontario and the township of Ignace were selected to host the proposed deep geological repository.

US-based SHINE Technologies (Wisconsin) selected Deep Isolation technology as the preferred solution for the storage of high-level waste after deploying its technology for recycling used fuels.

The African continent has been under the spotlight in recent years due to the possible deployment of nuclear energy generation. In addition to the historic uranium mining business, a promising development is the multinational repository concept. DeepGeo (a US-based company with regional teams in Africa, Canada and Finland) has signed a partnership agreement with the African Commission on Nuclear Energy hosted in Africa, to host a multinational repository for spent nuclear fuel. A proportion of the income will be used to facilitate nuclear energy deployment.

5. Key achievements

5.1. Mission and governance

Mandate and strategic objectives

The Supply Agency of the European Atomic Energy Community, also known as the Euratom Supply Agency (ESA), was established by Article 52 of the Euratom Treaty [54]. The Agency was set up to take responsibility for the common supply policy for ores, source materials and special fissile materials, with the purpose of ensuring the regular supply of the materials concerned to Community users. The policy is based on the principle of equal access to sources of supply for all Community users.

ESA's strategic objective is the security of supply of nuclear materials, in particular nuclear fuel, for power and non-power uses.

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The prerogatives of ESA stem from the Euratom Treaty and its secondary legislation. The Agency has the exclusive right to conclude contracts for the supply of nuclear materials coming from inside or outside the Community, as well as a right of option on nuclear materials produced in the Community. It also monitors transactions for providing services in the nuclear fuel cycle, including by acknowledging the notifications that market players must submit to it, in which they give details of their commitments.

In the interest of its Treaty missions, the Agency's Statutes [55] entrust it with a market observatory role to identify market trends that could affect the security of the EU's supply of nuclear materials and services. This mission extends to aspects of the supply of medical radioisotopes in the EU in the light of Council Conclusions on this issue [56].

ESA also provides the Community with expertise, information and advice on any subject connected with the operation of the market in nuclear materials and services.

Governance

The Euratom Treaty has endowed ESA with legal personality and financial autonomy, enabling it to make independent decisions on matters within its remit. The Agency operates under the supervision of the European Commission. The Agency's Statutes set out its governance in more detail.

In line with these Statutes, the Advisory Committee supports the Agency in carrying out its tasks by giving opinions and providing analyses and information. The Committee also acts as a link between ESA, producers and users in the nuclear industry, as well as Member State governments. ESA provides the Committee and its working groups with a secretariat and logistical support.

54 Treaty establishing the European Atomic Energy Community (consolidated version published in the Official Journal of the European Union C 203, 7.6.2016, p. 1).

55 Laid down by Council Decision of 12 February 2008 establishing Statutes for the Euratom Supply Agency (2008/114/EC, Euratom) (OJ L 41, 15.2.2008, p. 15).

56 Towards the secure supply of radioisotopes for medical use in the EU', 3053rd Employment, Social Policy Health and Consumer Affairs Council meeting, 6 December 2010; 17453/12, ATO 169/ SAN 321, 7 December 2012 and 11293/24 ATO 48/RECH 317/SAN 384 17 June 2024. See also the European and Social Committee opinion EESC-2024-00265-AS, 16 May 2024.

The Rules of the Agency, approved by the European Commission, determine the manner in which demand is to be balanced against supply of nuclear materials [57].

ESA was headed by an acting Director-General between October 2023 and April 2024. A new Director-General, appointed by the Commission on 27 February 2024, entered office on 1 May of the same year.

Advisory Committee

At its in-person meeting on 25-26 June 2024, the Advisory Committee delivered a favourable opinion on the ESA financial and budgetary statements for the year 2023, and on ESA's 2023 draft annual report. The Committee examined the short- to long-term security of supply situation as presented by the Agency and took note of progress made by its working group on prices and security of supply. Furthermore, the Committee was informed by the Commission about the work of the European Industrial Alliance on Small Modular Reactors (SMRs) and discussed to set up an Advisory Committee working group on SMRs and advanced modular reactors (AMRs).

At its 19-20 November hybrid meeting, the Committee discussed the short- and long-term security of supply of nuclear materials and the progress made by its working group on prices and security of supply. The Committee gave a favourable opinion on ESA's 2025 work programme and the draft estimate 2026 budget, together with ESA's 2026 draft establishment plan.

The Committee also agreed to postpone the start of its working group on SMRs/AMRs due to developments within the European Industrial Alliance on SMRs, namely the work planned there under Technical Working Group (TWG) 7, on the fuel cycle and waste management.

Furthermore, the Committee took note of the progress of the Nuclear Observatory and ESA Management of Information (NOEMI) project, presented by ESA.

5.2. Principal activities

5.2.1. Contract management

As in previous years, ESA published quarterly the number of transactions including contracts, amendments and notifications on the front-end activities that have been processed, including a breakdown into spot natural uranium contracts concluded by EU utilities, and spot natural uranium contracts concluded by all parties. The overall number was 259, an increase of 17% compared to the previous year. This amounted to a high workload for the small contract team, notably in relation to files requiring particular inquiries, review and follow-up.

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Table 9. Contracts by type in 2024

Type of contract (*)	2024	2023
Natural uranium (**)	**64**	**39**
Purchase/sale by EU utilities/end users	***25***	***23***
Multiannual	12	11
Spot	13	12
Purchase/sale between EU producers/ intermediaries	***8***	***0***
Multiannual	0	0

57 The Rules in force have been published in the Official Journal of the European Union L 218, 18.6.2021, p. 58.

Spot	8	0
Exchanges and loans	***0***	***0***
Contract amendments	***31***	***16***
Special fissile materials	**41**	**50**
New contracts	***21***	***27***
Purchase by an EU utility/end user	12	18
Sale by an EU utility/end user	5	4
Purchase/sale between two EU utilities/ end users	0	0
Purchase/sale other	2	4
Exchanges / Loans	2	1
Contract amendments	***20***	***23***
Enrichment notifications (***)	**38**	**36**
New notifications	***28***	***26***
Notifications of amendments	***10***	***10***

(*) Transactions for small quantities (as under Article 74 of the Euratom Treaty), services (as under Article 75 of the Euratom Treaty) other than enrichment and information communicated on any contracts other than supply contracts are not included

(**) Including feed contained in enriched uranium product (EUP) purchases
(***) Contracts with primary enrichers only

The incoming files registered in connection with requests under Chapter 6 of Title II of the Euratom Treaty ("EA") and related secondary legislation continue to represent a significant fraction (over 75%) of ESA workload linked to the supply, processing, conversion, shaping, transfer, import or export of ores, source materials or special fissile materials.

Indeed, the volume of cases with reference to Art. 52 EA (about 5 in 10), as well as those pursuant to Art. 75 EA, remain above average over the last three years. While the remaining fraction of incoming files registered, including notification dossiers linked to Art. 74 EA, has also grown, it remains small (about 2 in 10) as in recent years[58].

5.2.2. Security and diversification of the nuclear fuel supply chain

ESA plays a crucial role in ensuring the regular and equitable supply of ores and nuclear fuels for all users from Euratom Member States, while preventing excessive dependence on any single third-country supplier. Diversification of supply sources, which also contributes to the viability of the nuclear industry, is a significant means of securing supplies in the medium and long term as mandated by the Euratom Treaty.

ESA also monitors market developments to identify trends that could affect the security of supply of nuclear fuels, while putting forward recommendations and indicating measures to mitigate potential risks. In this respect, the Agency continued to work closely with its Advisory Committee as well as market actors and stakeholders.

In line with its strategic objective and the Commission's policies, the Agency has been striving to ensure and diversify sources of supply in the nuclear fuel cycle for power and non-power uses.

58 Because files earmarked with reference to Art. 52 EA may also involve notifications flagged pursuant to Art. 75 EA, and because some dossiers may relate to multiple transactions, the above-mentioned numbers need not add up.

The Agency has been striving to ensure and diversify sources of supply in the nuclear fuel cycle for power and non-power uses.

Security of supply of nuclear materials for power uses

The Agency continued to advise users to prioritise long-term commitments, particularly for securely sourced conversion and enrichment services, and to minimise exposure to providers based in or controlled by high-risk jurisdictions, or heavily dependent on unreliable supply chains. ESA encourages the diversification of suppliers to reduce dependence on any single non-EU design, supplier or region, and the creation of strategic inventories of nuclear supplies, thereby sustaining the viability of the EU industry throughout the fuel cycle, while closely monitoring and discouraging sources of supply deemed to be of high risk. The EU market analysis presented in the previous chapters suggests that these recommendations were generally followed.

As more Member States are embarking upon nuclear energy use and new nuclear technologies, such as SMRs and AMRs, new actors have entered the market. These new stakeholders, unfamiliar with the Agency's requirements and procedures, require additional support and guidance. ESA provided assistance to and raised awareness among these stakeholders regarding its security of supply policies and recommendations, as well as the users' obligations under the chapter of the Euratom Treaty on supply. The Agency also guided them through the relevant procedures.

Responding to market and geopolitical uncertainties, ESA continued to follow up on the short- to long-term challenges related to security of supply of nuclear materials and fuel, both from an economic perspective and in terms of inventory robustness.

ESA paid particular attention to contractual transactions that appeared vulnerable to geopolitical risks, notably because of the place of economic or geographical origin of supplies. As a result, ESA had to engage in an increased number of negotiations on specific contractual conditions to strengthen the EU's security of supply.

In collaboration with the Commission, the Agency focused on achieving the objectives of the REPowerEU Plan, which stresses the importance of diversification options also for Member States that depend on Russia for nuclear fuel and calls for 'working within the EU and with international partners to secure alternative sources of uranium and boosting the conversion, enrichment and fuel fabrication capacities available in Europe or in the EU's global partners'.

To this end, ESA, in cooperation with the Commission, continued to follow up on the steps towards alternative design and supplies of fuel for water-water energetic reactors (VVERs), including the medium-term plans of major EU fuel manufacturers. The Agency also monitored the operational autonomy of VVER plants, taking into account both stored fresh fuel and forthcoming deliveries.

Furthermore, the Agency provided input to the Commission on possible additional policy and regulatory actions or other measures that could be undertaken to address the security of supply of nuclear materials. ESA also collaborated with the Commission on the multilateral efforts to address global challenges in nuclear fuel supply security.

The Agency continued to monitor transport challenges related to nuclear materials and fuels from Russia, as well as deliveries originally routed through Ukraine. Previously identified challenges related to the transport of nuclear fuel through regions in conflict or with increased logistical risks continue to exist. Although alternative routes have been identified, the delivery challenges have not been alleviated in all cases. The ongoing Russian war of aggression against Ukraine remains a source of uncertainty in this regard.

Market uncertainty, driven primarily by geopolitical events, persisted throughout the reporting year. The renewed interest in nuclear energy as a low-carbon alternative to fossil fuels, both in the European Union and globally, as well as the emergence of new technologies such as SMRs and AMRs, contribute to uncertainties about the short- to long-term security of supply.

Therefore, ESA continued to closely monitor the nuclear market, tracking trends, prices and global supply chain developments, and to analyse them from an economic and industry viewpoint. The identification of market trends likely to affect the EU's medium- and long-term security of supply of nuclear materials and services remained a top priority.

ESA continued to closely monitor the nuclear market, tracking trends, prices and global supply chain developments.

In this respect, the Agency produced comprehensive statistical reports on nuclear market trends and updated previous years' forecasts of EU and global demand and supply of front-end fuel cycle services. These were based on data from contracts concluded or acknowledged by the Agency, information obtained from EU utilities through the annual survey and market data from various sources. The findings were supplemented by insights into market developments gathered from specialised media, stakeholders and open sources.

Within its remit, ESA assisted the Commission in handling European Parliament questions, petitions and national parliament resolutions, as well as in assessing notifications under Article 41 and international agreements communicated under Article 103 of the Euratom Treaty. The Agency also provided input on matters within its remit related to the legislative work of the Commission.

The Agency contributed to briefing requests, questions and requests for information from the College and senior managers of the European Commission, Members of the European Parliament, national parliamentarians, the press and nuclear sector associations having the security of nuclear supplies as their core subject.

Security of supply of nuclear materials for non-power uses

In line with its strategic objective, ESA continued to scrutinise security of supply of high-enriched uranium (HEU) and high-assay low-enriched uranium (HALEU), required to feed the production of medical radioisotopes and to fuel research reactors. These strategic materials are currently not produced in the Community and have to be imported, mainly from the US.

Some EU research reactors still need supply of HEU until their conversion to HALEU, in line with international nuclear security and non-proliferation commitments. In 2024, in cooperation with the US and the Euratom Member States concerned, ESA reviewed progress in implementing the Memorandum of Understanding with the US Department of Energy-National Nuclear Security Administration [59] (DoE-NNSA) on the exchange of HEU and updated the cooperation arrangements in relation to the future supply of HALEU.

In addition, some EU research reactors that produce vital medical radioisotopes are dependent on Russian fuel and materials. In this respect, ESA continued to call for action to address security of supply vulnerabilities. Some EU research reactor operators that had already licensed alternative fuel phased out the Russian supply of fuel. Some are participating actively in Euratom research projects to develop alternative fuel design and break the Russian monopoly on the supply of fuel to medium-power research reactors of original Soviet design.

5.2.3. Market monitoring and analysis

Market monitoring

In response to the Russian war of aggression against Ukraine, ESA continued to monitor the impact of geopolitical developments in the EU and update its analysis of current and future conversion and enrichment capacity worldwide. In its market analysis, ESA confirmed its previous conclusion that EU utilities' demand for both natural uranium and fuel fabrication and related services faces an increased risk related to Russian supply and the new geopolitical situation. Analysis from the nuclear industry (converters and enrichers) indicated that total Western geopolitical region conversion capacity may not be sufficient. Similarly, the capacity of the same countries to supply enrichment would be insufficient if the services from other countries such as Russia were not available. The Agency assessed that replacing the additional conversion and enrichment capacity could take several years. European industry requires adequate signals to maintain and build up capacity both for natural and reprocessed uranium, especially for conversion, fuel design and fabrication. This is because industrial investments would not be viable without some form of political and contractual commitment for the long term.

59 'Memorandum of Understanding between the Department of Energy/National Nuclear Security Administration (DOE/NNSA) of the United States of America and the Euratom Supply Agency concerning the Exchange of Highly Enriched Uranium Needed for Supply of European Research Reactors and Isotope Production Facilities', originally signed in 2014 and renewed for the next five years in 2021.

Annual report 2023

In its 2023 annual report, ESA gave an overview of its own activities and developments in the nuclear fuel markets and nuclear energy, both in the EU and worldwide.

As in previous years, ESA conducted a survey of EU nuclear power operators. The survey provided a detailed analysis of supply and demand for natural uranium and for conversion and enrichment services in the EU in 2023. The Agency published three indices for natural uranium prices with calculated weighted averages of the prices paid by EU utilities under multiannual and spot contracts. Its analysis contained forecasts of future demand for uranium and enrichment services and assessed the security of supply of nuclear fuel to utilities in the EU. ESA provided detailed analyses of future contractual coverage for natural uranium and enrichment services and of diversification of supply. It also carried out an analysis of EU inventories of nuclear material.

The report set out ESA's findings and recommendations on supply and demand for nuclear fuels. It reflected the Agency's diversification policy and work on security of supply and discussed the security of supply of medical radioisotopes. As the political and economic events in 2021-2023 seriously impacted the global nuclear market, ESA's recommendations became more relevant and urgent than ever.

ESA's recommendations in its 2023 annual report took account of developments since the start of the Russian war of aggression against Ukraine. ESA made three groups of recommendations to boost the security of supply and overcome the current areas of vulnerability. For the second time, the ESA report included a specific group of recommendations on tackling vulnerabilities in the security of supply of medical radioisotopes.

The report was published on ESA's website in August and its print version was made available in November [60]. The report was sent to the European Parliament, the Council and the Commission, and was presented to the Council Working Party on Atomic Questions.

Publication and knowledge sharing

ESA regularly publishes reports [61] and information on price trends on its website [62] to provide transparency with regard to the EU's natural uranium market, reduce uncertainty and help improve security of supply.

In 2024, ESA's nuclear fuel market observatory issued four quarterly reports on the uranium market. The reports include general data about natural uranium supply contracts concluded by ESA or notified to it, and the quarterly spot price index for natural uranium [63]. The Agency also issues a weekly nuclear newsletter for Commission staff.

5.2.4. Supply of medical radioisotopes

Medical radioisotopes are essential for radiology and nuclear medicine. While many of these are produced within the EU, it remains dependent on Russian production for some critical stable isotopes and some radioisotopes.

Medical radioisotopes are essential for radiology and nuclear medicine.

The supply of precursor material to produce medical radioisotopes remains a particular concern. The EU is to a certain extent dependent on Russia for the enrichment of the stable isotopes needed to produce several important medical radioisotopes, in particular Ytterbium-176 (Yb-176), which is needed to produce Lutetium-177 (Lu-177) [64]. Enriched isotopes would be also needed in the longer term to develop non-fission alternative production routes for Technetium-99m (Tc-99m), Molybdenum-98 (Mo-98) and Molybdenum-100 (Mo-100), which are at present partly sourced from Russia.

ESA continued to provide expertise and analysis of the situation and worked closely with the relevant Commission services and other stakeholders. The Agency regularly updated the Council Atomic Question Working Party [65] on the

60 ESA Annual reports.

61 ESA Publications.

62 Market Observatory.

63 Provided at least three spot contracts have been concluded.

64 The EU is a large supplier of Lu-177, which has seen spectacular growth in recent years.

65 Council of the European Union – Working Party on Atomic Questions.

supply situation. ESA also liaised with the industry association Nuclear Medicine Europe (NMEU) to gather relevant information.

SAMIRA

ESA contributes to the implementation of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) [66]. SAMIRA is the energy sector's contribution to the EU's Beating Cancer Plan, and a response to the Council's successive conclusions on non-power nuclear and radiological technologies and applications.

In cooperation with the Commission, the Agency leads on certain SAMIRA activities aimed at securing the supply of source materials for radioisotope production. This includes: (i) ensuring the supply of HEU until the full radioisotope production chain is converted to operate with HALEU; and (ii) exploring options for the future supply of HALEU to the EU (see below for developments in these areas).

In addition, ESA contributes to the development of the European Radioisotopes Valley Initiative (ERVI), which aims to provide a framework to ensure the security of supply of medical radioisotopes.

European Observatory on the Supply of Medical Radioisotopes

In order to secure the supply of widely used medical radioisotopes, focusing on Molybdenum-99/Technetium-99m (Mo-99/Tc-99m), ESA continued to co-chair the European Observatory on the Supply of Medical Radioisotopes in 2024, together with NMEU.

Set up in 2012, the Observatory monitors the EU supply chain for Mo-99/Tc-99m and engages in a variety of topics on the EU supply of widely used medical radioisotopes. It is composed of representatives of the Commission, EU Member States, international organisations and industry. The Observatory is a vehicle for gathering information on potential shortages and for dispatching it to interested parties, sometimes directly through ESA. It enables stakeholders to contact appropriate EU bodies and services promptly to raise awareness of and facilitate responses to supply issues at Member State and EU level.

The Observatory is a vehicle for gathering information on potential shortages and for dispatching it to interested parties.

In 2024, the Observatory continued its close cooperation with the NMEU's Security of Supply Workgroup on the supply of Mo-99/Tc-99m and Iodine-131 (I-131). Following Mo-99 production disruption caused by the delayed restarts of the High Flux Reactor (HFR) (twice) and the Open-Pool Australian Lightwater Reactor (OPAL), which are research reactors, the Agency ensured a steady flow of information from the NMEU's Emergency Response Team to Commission services, Member States (through the Council Working Party on Atomic Questions and the Health Security Committee) and various stakeholder groups.

The 21st plenary meeting of the Observatory, held on 25-26 September 2024 in Geneva, hosted by the European Organization for Nuclear Research (CERN), saw the participation of around 40 members (from the Commission, industry, international organisations and Member State administrations). The meeting provided an opportunity to hear about CERN's role in radioisotope mass separation, as well as about the European Commission's PRISMAP project, managed by CERN, which provides a wide range of radionuclides for medical research. The project built a strong network of world-leading European facilities, including nuclear reactors, medium- and high-energy accelerators and radiochemical laboratories.

The Observatory reviewed the global research reactor scheduling for the remainder of 2024 and 2025. The Commission's Directorate-General for Energy provided an update on the latest developments related to the creation of an ERVI in the context of the SAMIRA action plan. The European Medicines Agency presented its ongoing initiatives to secure supply of medicines in the EU and to prevent shortages of medicinal products. The Commission's Directorates-General for Research and Innovation, Joint Research Centre (JRC), and Internal Market, Industry, Entrepreneurship and SMEs, as well as the European Research Executive Agency, also presented their activities related to medical radioisotopes and SAMIRA. The meeting also heard presentations from three French facilities: the Institut Laue–Langevin (ILL) research reactor, the Jules Horowitz Reactor (JHR), which is currently under construction, and the Orano Stable Isotopes facility. Alongside the new Dutch research reactor Pallas, these facilities will bring more

66 Commission Staff Working Document on a Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA), SWD(2021) 14 final, 5.2.2021.

radioisotope production capacity to the market. NMEU, the European Association of Nuclear Medicine (EANM) and the Organisation for Economic Co-operation and Development's (OECD) Nuclear Energy Agency (NEA) also presented their activities, including the Workshop on Medical Radioisotopes Supply planned for October in Paris. Following the meeting, a technical visit to the two CERN facilities ISOLDE and MEDICIS was held.

ESA presented the Observatory's activities and the results of its 2023 and 2024 meetings to the Council Working Party on Atomic Questions in October. It reported on the 2024 disruptions to supply of medical radioisotopes and the related mitigation measures taken by the Observatory in response to them.

5.2.5. Cooperation with stakeholders and partners

Throughout 2024, ESA continued contact and collaboration with EU institutions, Member State authorities, utilities, industry and nuclear organisations to strengthen the security of supply of nuclear materials in light of the Russian war of aggression against Ukraine. It monitored market developments given the new market situation and provided advice and follow-up to ensure appropriate application of the common supply policy and the mitigation of new risks.

ESA worked closely with the Commission to promote diversification of supply and contributed to the work of the relevant Commission departments. In the context of the REPowerEU initiative, ESA engaged, together with the Commission, in a multilateral assessment of demand for, and capacity of, front-end nuclear fuel cycle services in like-minded non-EU countries.

The Agency regularly reported to the Council's Working Party on Atomic Questions on the Agency's activity throughout the year, the supply situation in the EU of nuclear materials, services and medical radioisotopes, and the market trend.

In February, ESA took part in the Belgian EU Presidency workshop on securing access to radiopharmaceuticals for European patients, held in Brussels. Following this, ESA was closely involved in the discussion to prepare the Council Conclusions on the security of supply of radioisotopes for medical use, adopted in June 2024.

Also in February, ESA participated in the fifth annual VVER Fuel Forum in Bratislava. The primary focus of the forum was to share experiences and best practices with VVER-1000 and VVER-440 fuel deployment in operating reactors. The Agency emphasised the importance of expediting fuel diversification efforts amid the global energy disruption as consequence of Russia's full-scale invasion of Ukraine.

The Agency has long-standing and well-established relationships on nuclear energy with international organisations, namely the International Atomic Energy Agency (IAEA), the NEA and nuclear industry associations. In 2024, ESA continued to cooperate with these organisations by participating in working groups, conferences and seminars.

ESA continued to support the joint NEA/IAEA Uranium Group, which is responsible for publishing the two-yearly report 'Uranium Resources, Production and Demand' ('the Red Book')[67], to which ESA contributes its analysis of supply and demand for nuclear fuel in the EU. The report provides up-to-date information on established uranium production centres and mine development plans as well as projections of nuclear generating capacity and reactor-related requirements.

In March, ESA participated in the Nuclear Energy Summit, organised jointly by the IAEA and Belgium, where it contributed to a roundtable discussion on 'Securing the Fuel Supply Chain'. This was a reflection focused on ensuring the availability of capacity and the building of new infrastructure to meet the projected increase in demand by 2050, as well the fuel supply chain of SMRs and AMRs under development.

The Agency took part in the French Nuclear Society (SFEN) annual convention, which was held in March in Paris and brought together key stakeholders from the nuclear industry. As part of this event, the Agency participated in the first roundtable discussion, entitled 'Supply Today.' This session focused on the current landscape of nuclear supply chains, addressing challenges, opportunities and strategies to ensure a stable and sustainable supply of nuclear materials and technology.

In April, the Agency participated in the European Parliament's Science and Technology Options Assessment (STOA) Panel workshop, 'Strategic Autonomy and the Future of Nuclear Energy in the EU: Use and Availability of High-Assay Low-Enriched Uranium (HALEU)'. This event provided a comprehensive overview of HALEU, including its applications, the latest technological advancements, the potential of SMRs, its availability and its supply chain. Also in April, ESA

67 NEA (2023), Uranium 2022: Resources, Production and Demand, OECD Publishing, Paris

attended the European Research Reactor Conference (RRFM) organised by the European Nuclear Society (ENS) in Warsaw. The conference programme revolved around a series of plenary sessions dedicated to the latest global developments in research reactor technology and management.

In May, ESA was invited to present its activities at the General Assembly of NMEU. The meeting also provided an opportunity to engage with stakeholders on the supply of medical radioisotopes.

In September, ESA attended the 2024 World Nuclear Symposium in London. Agency representatives met participants from the nuclear industry, utilities and the emerging EU market, providing insights into the market situation, learning about market developments and exchanging information on existing and future supply challenges.

In September, ESA was also represented in the Euratom delegation to the IAEA's General Conference.

In October, ESA presented the work of the Observatory at the Second International Workshop on Medical Radioisotopes Supply, co-organised by the OECD NEA, the US DoE and the European Commission's JRC, held in Paris. The event gathered around 130 onsite and 100 online participants, including governmental decision-makers, private sector representatives, health organisations and researchers, to chart the development of supply chains for conventional and innovative nuclear radioisotopes in the medical field.

The Agency held regular meetings with utilities to discuss risk preparedness and implementation of mitigation measures, also following-up on the fuel diversification process. It also met with the EU nuclear industry representatives to share information and market outlook.

6. Management

Legal status

The Supply Agency of the European Atomic Energy Community was established by the Euratom Treaty[68] ('the Treaty') and is mostly governed by Title II, Chapter 6, of the latter. The Statutes of the Agency[69] determine its governance in more detail.

The Agency is endowed with legal personality and financial autonomy[70] and operates under the supervision of the Commission[71] on a non-profit making basis. It has its seat in Luxembourg[72]. The Statutes[73] define the governance of the Agency in detail.

ESA's objective is the security of supply of nuclear materials, notably nuclear fuel, for civilian, power and non-power uses, by means of the common supply policy. To that end, the Agency is entrusted with specific prerogatives under the Treaty, in particular the exclusive right to conclude supply contracts. Likewise, ESA plays a market-monitoring role by identifying market trends likely to affect the security of the European Union's supply of nuclear materials and services.

In line with its statutory mission, powers and responsibilities, ESA is assigned the task of providing the Community with expertise, information and advice on any subject connected with the operation of the market in nuclear materials and

68 Article 52 of the Treaty establishing the European Atomic Energy Community (OJ L 27 6/12/1958 p. 534).

69 Council Decision of 12 February 2008 establishing Statutes for the Euratom Supply Agency (OJ. L 41, 15/02/2008).

70 Article 54 of the Euratom Treaty.

71 Article 53 of the Euratom Treaty.

72 Article 2 of the Statutes. To that end, a seat agreement has been concluded by ESA and the European Commission with the Luxembourgish Government.

73 Council Decision of 12 February 2008 establishing Statutes for the Euratom Supply Agency (OJ. L 41, 15/02/2008).

services.

Since 2004, the seat of the Euratom Supply Agency (ESA) has been in Luxembourg[74]. The Agency concluded an agreement with the Luxembourgish Government on its seat, together with the European Commission.

6.1. Budgetary and financial management

The option for ESA to collect a charge on transactions to defray its operating expenses, as per Article 54 of the Euratom Treaty, was postponed indefinitely, by the Council, in 1960. Consequently, the Agency's administrative expenses must be covered entirely by the European Union budget. The European Commission is responsible for adopting ESA's budget and ESA's Director-General serves as the authorising officer for executing that budget. ESA's financial operations comply with the relevant provisions in its Statutes and the EU Financial Regulation[75], along with accounting rules and methods set by the European Commission. ESA covers part of its operational costs through its own budget, while the European Commission directly funds another portion.

Budget

The Agency's 2024 budget was EUR 270 000, which was 4.6% higher than the final 2023 budget of EUR 258 160. ESA was financed entirely by the EU budget contribution under Section III – Commission, budget item 20 03 14 01 'Euratom contribution for operation of the Supply Agency'.

ESA's Advisory Committee was consulted on the 2024 draft budget through a written procedure launched on 10 January 2023 and closed on 25 January 2023. The Committee delivered a favourable opinion.

Later in 2023, ESA management decided to simplify the Agency's budget structure to streamline and reduce administrative burden and to improve efficient budget implementation, given the budget's small size the administrative nature of expenditure. Following the structural change, the 2024 budget was presented by ESA's Accounting Officer at the Advisory Committee meeting on 14 December 2023 in Luxembourg.

ESA's 2024 budget was adopted by the Commission on 13 December 2023[76]. During the year no budget amendments were performed.

ESA's revenue and expenditure were in balance.

Budget execution

In 2024, in accordance with Articles 28 and 68 of the EU Financial Regulation, the Director-General signed three decisions involving internal budget transfers to address emerging requirements.

The operating costs covered by the ESA budget included:

- ESA Advisory Committee meetings;
- development of the NOEMI core business information systems and related infrastructure;
- duty travel and participation in seminars, conferences;
- subscriptions to nuclear market information media and data sources;
- ESA publications and communication activities.

74 Article 2 of the Statutes.

75 Regulation (EU, Euratom) 2024/2509 of the European Parliament and of the Council of 23/09/2024 on the financial rules applicable to the general budget of the Union, repealing Regulation (EU, Euratom) No 1046/2018 (2018 Financial Regulation).

76 C (2023)8660.

As of 31 December 2024, ESA had recorded a high level for the budget execution of current year's funds of 99.53% or EUR 268 732.25 (ref. 4.2.4) of commitment appropriations (98.47% or 254 212.46 in 2023) with cancellations amounting to EUR 1 267.75 or 0.47% (EUR 3 947.54 or 1.53% in 2023). The executed payments on the same funds amounted to EUR 182 306.19, giving an implementation rate of 67.52% of available appropriations (EUR 122 916.67 or 47.61% in 2023).

The carrying forward of outstanding commitments of 2024 (committed amounts not yet paid for) to the 2025 financial year stood at EUR 86 426.06 or 32.01% of committed amounts (EUR 131 295.79 or 50.86% in 2024). That amount mainly involves IT services for the ICT project NOEMI.

In 2024 the Agency achieved an implementation rate on payments for carried-over funds from the previous year of EUR 125 632.64 or 95.69% of available funds (EUR 101 304.31 or 97.74% in 2023) with cancellation amounting to EUR 5 663.15 or 4.31% of the same appropriations.

In-kind contribution from the Commission

Most of the Agency's operating costs are directly financed by the Commission. In addition, in 2024, the Euratom Supply Agency was exempted from charge-back on any baseline services provided to it by the Commission, including for hosting the IT system in a secure environment.

The basic categories of expenses covered largely relate to staff (e.g. salaries and allowances, socio-medical infrastructure, training), infrastructure (e.g. buildings, offices and associated costs), general information and communication technology infrastructure and services, EC administrative software applications and hosting of ESA's IT systems.

In 2024, the Agency's total operating cost covered by the Commission amounted to EUR 2 903 410.73 (EUR 2 738 844.43 in 2023). This includes direct personnel costs for the Agency's staff, estimated at EUR 2 226 233.33 (EUR 2 087 800.00 in 2023), and other related operating costs (for building and other administrative costs, ICT and hosting of ESA's IT system) which totalled EUR 677 177.40 (EUR 651 044.43 in 2023).

These off-budget expenditures and the underlying transactions are not disclosed in ESA's accounts but are included in the Commission section of the EU annual accounts.

Financial accounts

In 2024, the assets owned by the Agency totalled EUR 1 210 786.64 (EUR 1 058 925.85 in 2023). They were financed by liabilities of EUR 156 750.66 (12.95%) and equity of EUR 1 054 035.98 (87.05%)

The 2024 provisional accounts, budget outturn and report on budget implementation were submitted to the European Court of Auditors and the Commission's Accounting Officer on 28 February 2025. The final accounts were issued on 16 May 2025. After receiving a positive opinion from the Advisory Committee, they were submitted to the EU institutions on 13 June 2025.

Accounting officer

Based on the Service Level Agreement with the Translation Centre for the Bodies of the European Union concluded in March 2023, which designated the accountant of the Translation Centre to fulfil the role of the accounting officer for ESA, the Commission formally nominated him in September 2024[77].

77 Nomination of the accounting officer of the Euratom Supply Agency – C (2024) 6832.

6.2. Human resources

<table>
<tr><th>Human resources</th><th colspan="3">2024</th></tr>
<tr><td>Number of officials (or temporary agents)</td><td>Authorised[78]</td><td>Actually filled as of 31.12.2024</td><td>Effective throughout the year</td></tr>
<tr><td>Administrators (AD)</td><td>8</td><td>8</td><td>7.67</td></tr>
<tr><td>Assistants (AST)</td><td rowspan="2">9</td><td>7</td><td>7</td></tr>
<tr><td>Assistants secretarial (AST/SC)</td><td>2</td><td>2</td></tr>
<tr><td>Total</td><td>17</td><td>17</td><td>16.67</td></tr>
</table>

Staff allocation

ESA staff are Commission civil servants (officials) and the number of staff set out in ESA's establishment plan is incorporated into the global staff numbers of the Commission. ESA received no new posts in 2024.

Following the departure of the former Director-General in September 2023, the position remained vacant until the newly appointed Director-General, selected by the Commission, assumed duties on 1 May 2024. There were no departing staff members during 2024. At the end of 2024, the Agency had a staff of 17 persons (8 in administrator and 9 in assistant posts).

As in previous years, the recruitment of staff in Luxembourg remains more difficult than, for example, Brussels due to the discrepancy between the salary levels and the high cost of living. Due to the small size of the Agency, it is critical to be able to fill all vacated posts at the shortest possible notice.

Equal opportunities

The Agency offers equal opportunities to foster a rich, diverse and inclusive working environment. ESA staff is well gender balanced at all levels. In 2024, the staff was composed of eight women (47%) and nine men (53%).

At the end of 2024, 13 different EU nationalities were represented in the Agency.

6.3. Information management and communication

NOEMI

The Nuclear Observatory and ESA Management of Information (NOEMI) project has made significant progress in 2024. A key milestone achieved was the finalisation of the security plan, which included the integration of a dedicated solution to strengthen access security. Additionally, several process improvements were implemented, including the integration of current 'Proforma' import and the addition of in-app calculation tools.

78 Establishment plan under the EU General Budget 2024, Definitive Adoption (EU, Euratom) 2024/207, OJ L, 22.2.2024, p. 1185, footnote (3).

At the end of 2024, the tool for producing reports was finalised, thus reaching another important milestone in the project's development. Looking ahead to 2025, the plan is to integrate full-text search feature, a notification system and a tool for auditing system and user actions, as part of the security plan. The project team will then shift its focus to business management tasks, dashboard functionalities, and additional reports functionalities, with an expected final delivery in 2026.

Security

In 2024, the Agency nominated a local information security officer (LISO), shared with the European Commission, DG Energy Luxembourg.

The LISO follows IT security and identifies shortfalls and improvements. His tasks are also to raise IT security awareness, including good practice and management of classified and sensitive information. He also advises on IT projects and IT systems security. In particular, he follows up and reviews the implementation of the NOEMI security plan and of the measures identified on the basis of vulnerability tests.

The Agency's staff is fully security cleared. The validity of security clearances is reviewed and renewed regularly.

Communication

ESA implements its own comprehensive communication and outreach policy, tailored to address the evolving needs of its stakeholders. In response to the ongoing security of supply challenges in Europe and the uncertainty surrounding the nuclear fuel and medical radioisotopes supply chain, the Agency maintained a strong commitment to targeted outreach and continuous dialogue with key stakeholders.

Notably, the Agency has observed a significant influx of new entrants in the nuclear market, particularly from the emerging Small Modular Reactor (SMR) and Advanced Modular Reactor (AMR) industry. To support these newcomers, as well as traditional stakeholders, ESA provides guidance on the supply provisions outlined in the Treaty and secondary legislation, including the submission and notification of contracts.

In addition, the Agency has been approached by various media outlets, including press and specialised news organisations, seeking expertise and insights on matters related to nuclear fuel supply.

6.4. Audit and discharge

Audit by the European Court of Auditors

The European Court of Auditors (ECA) audits ESA's financial and budgetary accounts and the underlying transactions on an annual basis in line with internationally accepted public-sector auditing standards. The Court's responsibility is to provide the European Parliament and the Council with a statement of assurance as to the reliability of the annual accounts and the legality and regularity of the underlying transactions.

ESA duly notes the Court's observations and takes the necessary measures as needed. It also carefully follows any observations of a 'cross-cutting nature' that accompany the Annual Report of the EU Agencies.

ECA has approved the Agency's accounts for the 2023 financial year and issued an unqualified opinion on both the accounts and the legality and regularity of revenue and expenditure transactions.

However, ECA followed-up on the 2022 observation that ESA had systematically awarded contracts below EUR 15 000 (very low value contracts according to the Financial Regulation) without issuing corresponding evaluation reports and award decisions. The Court found two similar cases in early 2023, prior to the implementation of the ESA's measures.

On 4 July 2024, the Agency submitted the follow-up replies to the Court's observations on the 2023 audit to ECA. ESA took note of European Court of Auditors' follow-up point which refers indeed to cases which were prior to the introduction of the new procedures.

Discharge

The European Parliament, acting on a Council Recommendation, is the discharge authority for ESA.

On 11 April 2024, the European Parliament granted the Acting Director-General of the Euratom Supply Agency discharge in respect of the implementation of the Agency's budget for the 2022 financial year[79]. Furthermore, on 7 May 2025, the European Parliament granted the Director-General of the Euratom Supply Agency discharge for the implementation of the budget for the financial year 2023[80] .

6.5. Internal control and assurance

Internal control and risk management

ESA has an internal control framework, designed to provide reasonable assurance of achievement of the five key objectives outlined in Article 36 of the Financial Regulation. These objectives encompass:

1. ensuring the effectiveness, efficiency, and economy of operations;
2. maintaining the reliability of reporting;
3. safeguarding assets and information;
4. preventing, detecting, correcting, and following up on fraud and irregularities;
5. managing risks related to the legality and regularity of underlying transactions.

This framework complements the EU's Financial Regulation and other relevant rules and regulations relevant in this context, with the aim of aligning the Agency's standards with the highest international standards, as set by the COSO principle-based system.

In 2024, ESA conducted a comprehensive review of its risk assessment, covering all aspects of the Agency's work and operational and administrative processes. Consequently, the Agency reviewed and refined its controls, introducing adjustments to ensure that they are aligned with the identified risks and areas requiring monitoring.

Management assurance

ESA conducted a comprehensive self-assessment of the effectiveness of its internal control system. This evaluation comprised three components:

1. an assessment of predefined monitoring indicators, which included a survey to gather feedback and insights from staff;
2. a review of audit results, including new and outstanding recommendations, to identify areas for improvement and ensure that corrective actions were implemented;
3. an examination of non-compliances and exception cases to determine their root causes and implement measures to prevent their recurrence.

The annual assessment for 2024 confirmed that the Agency's internal control system is operating effectively, with no significant risks identified that could impact the reliability of its operations or financial reporting or that could lead to a reservation in the Annual Declaration of Assurance. Based on the internal control system, its assessment and the assurance they provide, the Director-General – as Authorising Officer – was able to sign the declaration of assurance,

79 Decision (EU, Euratom) 2024/2333 of the European Parliament of 11 April 2024 on discharge in respect of the implementation of the budget of the Euratom Supply Agency for the 2022 financial year, 10 October 2024

80 European Parliament decision of 7 May 2025 on discharge in respect of the implementation of the budget and the closure of the accounts of the Euratom Supply Agency for the financial year 2023 (2024/2030(DEC))

which is included as Annex A of this report.

6.6. Improving effectiveness and efficiency

As a result of the challenging geopolitical environment and of new developments in the nuclear context, ESA has experienced a substantial increase in its operational and policy support workload. As a result, the contract management and analytical functions of the Agency need to be strengthened.

The examination of transactions that could be vulnerable to geopolitical risks, notably because of the place of economic or geographical origin of supplies, often with a need to discuss specific contractual conditions to strengthen security of supply, represents a major, rising workload. ESA also has to respond to an increased demand for advice and support for new stakeholders and to accommodate new contractual parties.

In addition, ESA is tasked with following more complex market developments and faces an increased demand for analytical work and input on market statistics, often in a short time frame. in addition, there is a need to set up the system of monitoring and long-term forecasts for a broad spectrum of medical radioisotopes and production methods.

In the last few years, efficiency gains were made by obtaining additional support by the Commission, for example by sharing the local information security officer function with a Commission department and by developing synergies with other Agencies, for example by appointing the accounting officer of the Translation Centre as the Agency's accounting officer.

The Agency will continue to explore how further specialised support could be obtained by sharing functions, tools or systems with Commission services or other Agencies (e.g. on data protection or for other administrative functions, such as organising duty travel). As the number of tasks and the expectations of stakeholders continue to grow, ESA has made significant progress in increasing its effectiveness and efficiency and, despite its limited resources, has managed to deliver on its objectives. At the same time, ESA is not in a position to continue to fully address the increased work through internal efficiency gains and the reallocation of human resources.

Annexes

Annex 1
EU-27 gross and net requirements (quantities in tU and tSW)

(A) 2025-2034

Year	Natural uranium		Separative work	
	Gross requirements	**Net requirements**	**Gross requirements**	**Net requirements**
2025	13 105	10 759	11 068	09 382
2026	14 103	11 974	11 873	10 442
2027	12 208	10 621	10 272	08 854
2028	13 250	11 479	11 470	10 009
2029	10 899	8 985	9 420	7 836
2030	11 256	8 788	9 682	7 515
2031	10 559	7 645	8 994	6 458
2032	11 357	8 169	9 593	6 653
2033	10 199	7 078	8 512	5 636
2034	10 377	6 883	8 757	5 508
Total	117 314	92 380	99 640	78 294
Average	11 731	9 238	9 964	7 829

(B) Extended forecast 2035-2044

Year	Natural uranium		Separative work	
	Gross requirements	Net requirements	Gross requirements	Net requirements
2035	9 863	6 473	8 269	5 118
2036	9 701	6 522	8 145	5 190
2037	9 112	6 142	7 632	4 868
2038	9 801	6 839	8 282	5 527
2039	8 654	5 699	7 307	4 558
2040	9 290	6 343	7 783	5 042
2041	8 665	5 716	7 199	4 456
2042	8 483	5 531	7 065	4 319
2043	7 588	4 630	6 282	3 531
2044	8 152	5 191	6 735	3 981
Total	89 308	59 085	74 700	46 590
Average	8 931	5 908	7 470	4 659

Annex 2
Fuel loaded into EU reactors and deliveries of fresh fuel under purchasing contracts

Year	Fuel loaded			Deliveries		
	LEU (tU)	Feed equivalent (tU)	Enrichment equivalent (tSW)	Natural U (tU)	% spot	Enrichment (tSW)
1980		9 600		8 600	(*)	
1981		9 000		13 000	10.0	
1982		10 400		12 500	< 10.0	
1983		9 100		13 500	< 10.0	
1984		11 900		11 000	< 10.0	
1985		11 300		11 000	11.5	
1986		13 200		12 000	9.5	
1987		14 300		14 000	17.0	
1988		12 900		12 500	4.5	
1989		15 400		13 500	11.5	
1990		15 000		12 800	16.7	
1991		15 000	9 200	12 900	13.3	10 000
1992		15 200	9 200	11 700	13.7	10 900
1993		15 600	9 300	12 100	11.3	9 100
1994	2 520	15 400	9 100	14 000	21.0	9 800
1995	3 040	18 700	10 400	16 000	18.1	9 600
1996	2 920	18 400	11 100	15 900	4.4	11 700
1997	2 900	18 200	11 000	15 600	12.0	10 100
1998	2 830	18 400	10 400	16 100	6.0	9 200
1999	2 860	19 400	10 800	14 800	8.0	9 700
2000	2 500	17 400	9 800	15 800	12.0	9 700
2001	2 800	20 300	11 100	13 900	4.0	9 100
2002	2 900	20 900	11 600	16 900	8.0	9 500

2003	2 800	20 700	11 500	16 400	18.0	11 000
2004	2 600	19 300	10 900	14 600	4.0	10 500
2005	2 500	21 100	12 000	17 600	5.0	11 400
2006	2 700	21 000	12 700	21 400	7.8	11 400
2007 (**)	2 809	19 774	13 051	21 932	2.4	14 756
2008 (**)	2 749	19 146	13 061	18 622	2.9	13 560
2009 (**)	2 807	19 333	13 754	17 591	5.2	11 905
2010 (**)	2 712	18 122	13 043	17 566	4.1	14 855
2011 (**)	2 583	17 465	13 091	17 832	3.7	12 507
2012 (**)	2 271	15 767	11 803	18 639	3.8	12 724
2013 (**)	2 343	17 175	12 617	17 023	7.1	11 559
2014 (**)	2 165	15 355	11 434	14 751	3.5	12 524
2015 (**)	2 231	16 235	11 851	15 990	5.0	12 493
2016 (**)	2 086	14 856	11 120	14 325	3.1	10 775
2017 (**)	2 232	16 084	12 101	14 312	3.8	10 862
2018 (**)	2 225	15 912	12 075	12 835	5.0	10 899
2019 (**)	2 129	14 335	10 880	12 835	9.6	12 912
2020 (**)	1 908	13 124	9 988	12 592	3.0	11 224
2021 (**)	2 197	15 401	11 588	11 975	4	10 290
2022	1 602	10 993	8 340	11 724	2	10 715
2023	1 771	12 672	9 611	14 578	7	12 260
2024	1 761	12 120	9 166	13 667	6	10 405

(*) Data not available. (**) The LEU fuel loaded and feed equivalent contain Candu fuel.

Annex 3
ESA average prices for natural uranium

Year	Multiannual contracts		Spot contracts		New multiannual contracts		Exchange rate
	EUR/kgU	USD/lb U_3O_8	EUR/kgU	USD/lb U_3O_8	EUR/kgU	USD/lb U_3O_8	EUR/USD
1980	67.20	36.00	65.34	35.00			1.39
1981	77.45	33.25	65.22	28.00			1.12
1982	84.86	32.00	63.65	24.00			0.98
1983	90.51	31.00	67.89	23.25			0.89
1984	98.00	29.75	63.41	19.25			0.79
1985	99.77	29.00	51.09	15.00			0.76
1986	81.89	31.00	46.89	17.75			0.98
1987	73.50	32.50	39.00	17.25			1.15
1988	70.00	31.82	35.50	16.13			1.18
1989	69.25	29.35	28.75	12.19			1.10
1990	60.00	29.39	19.75	9.68			1.27
1991	54.75	26.09	19.00	9.05			1.24
1992	49.50	24.71	19.25	9.61			1.30
1993	47.00	21.17	20.50	9.23			1.17
1994	44.25	20.25	18.75	8.58			1.19
1995	34.75	17.48	15.25	7.67			1.31
1996	32.00	15.63	17.75	8.67			1.27
1997	34.75	15.16	30.00	13.09			1.13
1998	34.00	14.66	25.00	10.78			1.12
1999	34.75	14.25	24.75	10.15			1.07
2000	37.00	13.12	22.75	8.07			0.92
2001	38.25	13.18	(*) 21.00	(*) 7.23			0.90
2002	34.00	12.37	25.50	9.27			0.95
2003	30.50	13.27	21.75	9.46			1.13
2004	29.20	13.97	26.14	12.51			1.24
2005	33.56	16.06	44.27	21.19			1.24
2006	38.41	18.38	53.73	25.95			1.26
2007	40.98	21.60	121.80	64.21			1.37
2008	47.23	26.72	118.19	66.86			1.47
2009	55.70	29.88	77.96	41.83	(**) 63.49	(**) 34.06	1.39
2010	61.68	31.45	79.48	40.53	78.11	39.83	1.33
2011	83.45	44.68	107.43	57.52	100.02	53.55	1.39
2012	90.03	44.49	97.80	48.33	103.42	51.11	1.28

2013	85.19	43.52	78.24	39.97	84.66	43.25	1.33
2014	78.31	40.02	74.65	38.15	93.68	47.87	1.33
2015	94.30	40.24	88.73	37.87	88.53	37.78	1.11
2016	86.62	36.88	88.56	37.71	87.11	37.09	1.11
2017	80.55	35.00	55.16	23.97	80.50	34.98	1.13
2018	73.74	33.50	44.34	20.14	74.19	33.70	1.18
2019	79.43	34.20	55.61	23.94	80.00	34.45	1.12
2020	71.37	31.36	(***)	(***)	75.51	33.17	1.14
2021	89.00	40.49	(***)	(***)	92.75	42.19	1.18
2022	101.28	41.02	(***)	(***)	76.19	30.86	1.05
2023	115.79	48.16	149.28	60.46	103.56	41.95	1.08
2024	**142.26**	**59.23**	**132.32**	**55.09**	**155.50**	**64.74**	**1.08**

(*) The spot price for 2001 was calculated based on an exceptionally low total volume of only 330 tU covered by four transactions.

(**) ESA's price method took account of the ESA 'MAC-3' new multiannual U_3O_8 price, which includes amended contracts from 2009 onwards.

(***) In 2020, 2021 and 2022 the ESA U3O8 spot price was not calculated because there were not enough transactions (less than 3) to calculate the index.

Annex 4
Purchases of natural uranium by EU utilities, by origin, 2014-2023 (tU)

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Canada	2 845	2 946	4 099	3 630	1 485	2 312	1 714	2 578	4802	4 741
Russia	4 097	2 765	2 192	1 759	2 543	2 545	2 358	1 980	3419	2 185
Kazakhstan	2 949	2 261	2 064	1 754	2 518	2 414	2 753	3 145	3061	3 391
Niger	2 077	3 152	2 151	2 067	1 962	2 555	2 905	2 975	2089	1 154
Namibia	385	504	923	1 046	1 234	481	5	262	549	146
Australia	1 910	1 896	2 091	1 909	1 851	1 671	1 860	327	372	1 474
Uzbekistan	526	115	348	166	612	329	0	441	271	249
South Africa	1	0	0	118	115	21	21	0	13	0
United States	343	125	193	110	0	0	0	0	4	0
Malawi	2	0	0	0	0	0	0	0	0	3
Ukraine	0	0	0	19	0	0	0	0	0	0

EU	412	220	0	18	251	64	163	17	0	0
Re-enriched tails	212	212	171	161	161	196	196	0	0	0
Other	229	130	80	80	103	4	0	0	0	0
HEU feed	0	0	0	0	0	0	0	0	0	0
Total	**15 990**	**14 325**	**14 312**	**12 835**	**12 835**	**12 592**	**11 975**	**11 724**	**14 578**	**13 984**

Annex 5
Use of plutonium in MOX in the EU and estimated natural uranium and separative work savings

Year	**kg Pu**	**Savings**	
		tNatU	tSW
1996	4 050	490	320
1997	5 770	690	460
1998	9 210	1 110	740
1999	7 230	870	580
2000	9 130	1 100	730
2001	9 070	1 090	725
2002	9 890	1 190	790
2003	12 120	1 450	970
2004	10 730	1 290	860
2005	8 390	1 010	670
2006	10 210	1 225	815
2007	8 624	1 035	690
2008	16 430	1 972	1 314
2009	10 282	1 234	823
2010	10 636	1 276	851
2011	9 410	824	571

2012	10 334	897	622
2013	11 120	1 047	740
2014	11 603	1 156	825
2015	10 780	1 050	742
2016	9 012	807	567
2017	10 696	993	691
2018	8 080	726	510
2019	5 241	470	331
2020	5 308	481	340
2021	4 859	439	311
2022	3 007	277	197
2023	4 787	427	300
2024	6 934	605	422
Grand total	252 943	27 231	18 507

Annex 6
EU nuclear utilities that contributed to this report

ČEZ, a.s.
EDF
ENUSA Industrias Avanzadas, S.A., S.M.E
EPZ
Fortum Power and Heat Oy
Ignalina NPP
Kozloduy NPP Plc
Nuklearna elektrarna Krško, d.o.o.

Oskarshamn NPP (OKG)
Paks NPP Ltd
Slovenské elektrárne, a.s.
Societatea Nationala Nuclearelectrica S.A.
Synatom sa
Teollisuuden Voima Oyj (TVO)
Vattenfall Nuclear Fuel AB

Annex 7
Uranium suppliers to EU utilities

BHP Billiton
Cameco Inc. USA
Cameco Marketing INC.
Itochu International Inc
KazAtomProm
Macquarie Bank Limited, London branch
NUKEM GmbH
Orano Cycle
Orano Mining
Peninsula
Rio Tinto Marketing Pte Ltd
Tenex (JSC Techsnabexport)
TVEL
Uranium One
Urenco Ltd

Annex 8
Calculation method for ESA's average U_3O_8 prices

ESA price definitions

To provide reliable objective price information comparable with previous years, only deliveries made to EU utilities or their procurement organisations under purchasing contracts are taken into account for calculating the average prices.

In the interest of market transparency, ESA calculates three uranium price indices on an annual basis:

1. The ESA spot U_3O_8 price is a weighted average of U_3O_8 prices paid by EU utilities for uranium delivered under spot contracts during the reference year.

2. The ESA multiannual U_3O_8 price is a weighted average of U_3O_8 prices paid by EU utilities for uranium delivered under multiannual contracts during the reference year.

3. The ESA 'MAC-3' multiannual U_3O_8 price is a weighted average of U_3O_8 prices paid by EU utilities, but only under multiannual contracts which were concluded or for which the pricing method was amended in the previous 3 years (i.e. between 1 January 2022 and 31 December 2024) and under which deliveries were made during the reference year. In this context, ESA considers amendments as separate contracts, if the amendments directly affect the prices paid.

To ensure statistical reliability (sufficient amounts) and safeguard the confidentiality of commercial data (i.e. ensure that details of individual contracts are not revealed), ESA price indices are calculated only if there are at least five relevant contracts.

In 2011, ESA introduced its quarterly spot U_3O_8 price, an indicator published on a quarterly basis if EU utilities have concluded at least three new spot contracts.

All price indices are expressed in US dollars per pound (USD/lb U_3O_8) and euro per kilogram (EUR/kgU).

Definition of spot vs multiannual contracts

The difference between spot and multiannual contracts is as follows:

• spot contracts provide either for one delivery only or for deliveries over a maximum of 12 months, whatever the time between conclusion of the contract and the first delivery;

• multiannual contracts provide for deliveries extending over more than 12 months.

The average spot-price index reflects the latest developments on the uranium market, whereas the average price index of uranium delivered under multiannual contracts reflects the average multiannual price paid by European utilities.

Methodology

The methodology applied has been discussed and agreed in the Advisory Committee working group.

Data collection tools

Prices are collected directly from utilities or via their procurement organisations on the basis of:

• contracts submitted to ESA;

- end-of-year questionnaires – backed up, if necessary, by visits to the utilities.

Data requested on natural uranium deliveries during the year

The following details are requested: ESA contract reference number, quantity (kgU), delivery date, place of delivery, mining origin, obligation code, natural uranium price specifying the currency, unit of weight (kg, kgU or lb), chemical form (U_3O_8, UF_6 or UO_2), whether the price includes conversion and, if so, the price and currency of conversion, if known.

Deliveries taken into account

The deliveries taken into account are those made under natural uranium purchasing contracts to EU electricity utilities or their procurement organisations during the relevant year. They also include the natural uranium equivalent contained in enriched uranium purchases.

Other categories of contracts, e.g. those between intermediaries, for sales by utilities, purchases by non-utility industries or barter deals, are excluded. Deliveries for which it is not possible to reliably establish the price of the natural uranium component are also excluded from the price calculation (e.g. uranium out of specification or enriched uranium priced per kg EUP without separation of the feed and enrichment components).

Data quality assessment

ESA compares the deliveries and prices reported to the data collected when the contracts are concluded, taking into account any subsequent updates. In particular, it compares the actual deliveries to the 'maximum permitted deliveries' and options. Where discrepancies appear between maximum and actual deliveries, the organisations concerned are asked to clarify.

Exchange rates

To calculate the average prices, the original contract prices are converted into euro per kgU contained in U_3O_8, using the average annual exchange rates published by the European Central Bank.

Prices which include conversion

For the few prices which include conversion but where the conversion price is not specified, given the relatively minor cost of conversion, ESA converts the UF_6 price into a U_3O_8 price. It does so by using an average conversion value based on reported conversion prices under the natural uranium multiannual contracts.

Independent verification

Two members of ESA's staff independently verify spreadsheets from the database.

As a matter of policy, ESA never publishes a corrective figure, should errors or omissions be discovered.

Data security

Confidentiality and physical protection of commercial data is guaranteed by appropriate measures.

Annex 9
ECA Audit Report 2023

EUROPEAN COURT OF AUDITORS
12, rue Alcide De Gasperi
1615 Luxembourg
LUXEMBOURG

Tel. +352 4398-1
Enquiries: eca.europa.eu/en/Pages/ContactForm.asp
Website: eca.europa.eu
Twitter: @EUAuditors

More information on the European Union is available on the internet (http://europa.eu).

Luxembourg: Publications Office of the European Union, 2024

Agencies funded under MFF heading 7 – European Public Administration

3.34. Euratom Supply Agency (ESA)

Introduction

3.34.1. The Euratom Supply Agency (ESA), located in Luxembourg, was established in 1958, with the adoption, by the Council of the European Atomic Energy Community, of ESA's statutes, subsequently repealed and replaced by Council Decision 2008/114/EC, Euratom. ESA's main task is to ensure that there is a regular supply of nuclear materials, in particular nuclear fuels, to EU users. It does so by managing a common supply policy based on the principle of equal access to sources of supply. *Figure 3.34.1* presents key figures for ESA[116].

Figure 3.34.1 – Key figures for ESA

* Budget figures are based on the total payment appropriations available during the financial year.

** "Staff" includes EU officials, EU temporary staff, EU contract staff and seconded national experts, but excludes interim workers and consultants.

The increase in ESA's 2023 budget is linked to the implementation of an IT project (Nuclear Observatory and ESA Management of Information) and to the service level agreement with the Translation Centre of the European Communities for the provision of accounting services to ESA – both requiring additional funds in 2023.

Source: Annual accounts of ESA for the 2022 and 2023 financial years; staff figures provided by ESA.

Information in support of the statement of assurance

3.34.2. Our audit approach, the basis for our opinion, the responsibilities of ESA's management and of those charged with governance, and the auditor's responsibilities for the audit of the accounts and underlying transactions, are described in section 3.1. The signature on page *370* forms an integral part of the opinion.

[116] More information on ESA's role and activities is available on its website: http://ec.europa.eu/euratom/index.html.

The ECA's statement of assurance provided to the European Parliament and the Council – Independent auditor's report

Opinion

3.34.3. We have audited:

(a) the accounts of the Euratom Supply Agency (ESA), which comprise the financial statements[117] and the reports on the implementation of ESA's budget[118] for the financial year ended 31 December 2023, and

(b) the legality and regularity of the transactions underlying those accounts,

as required by Article 287 of the Treaty on the Functioning of the European Union (TFEU).

Reliability of the accounts

Opinion on the reliability of the accounts

3.34.4. In our opinion, ESA's accounts for the year ended 31 December 2023 present fairly, in all material respects, ESA's financial position as at 31 December 2023, the results of its operations, its cash flows, and the changes in net assets for the year then ended, in accordance with its financial regulation and with accounting rules adopted by the Commission's accounting officer. These are based on internationally accepted accounting standards for the public sector.

[117] The financial statements comprise the balance sheet, the statement of financial performance, the cash flow statement, the statement of changes in net assets and a summary of significant accounting policies and other explanatory notes.

[118] The reports on the implementation of the budget comprise the reports, which aggregate all budgetary operations, and the explanatory notes.

Legality and regularity of the transactions underlying the accounts

Revenue

Opinion on the legality and regularity of revenue underlying the accounts

3.34.5. In our opinion, the revenue underlying ESA's accounts for the year ended 31 December 2023 is legal and regular in all material respects.

Payments

Opinion on the legality and regularity of payments underlying the accounts

3.34.6. In our opinion, the payments underlying ESA's accounts for the year ended 31 December 2023 are legal and regular in all material respects.

Follow-up of previous years' observations

3.34.7. An overview of the action taken in response to the ECA's observations from previous years is provided in the *Annex*.

Annex – Follow-up of previous years' observations

Number	Year of ECA observation	ECA observation (summary)	Corrective action taken and other relevant developments (summary)	Status of ECA observation (Open / Closed)
1	2022	ESA systematically awards low-value contracts (below €15 thousand) without issuing corresponding evaluation reports and award decisions. This is not in line with points 30.3-30.4 of Annex I to the Financial Regulation.	In 2023 ESA revised its procedures and introduced a new template for low-value contracts covering both an evaluation report and an award decision. However, we still found two similar cases in early 2023, prior to the introduction of the new template.	Open

ESA's reply

3.34.7. The Euratom Supply Agency takes note of European Court of Auditors's observations which refer indeed to cases which were prior to the introduction of the new procedures.

Annex 10
Declaration of assurance

EURATOM SUPPLY AGENCY

The Director General

Luxembourg,
ENER.AAE/MH

DECLARATION OF ASSURANCE
AAR 2024

I, the undersigned, Michael HŰBEL, Director General of the Euratom Supply Agency since 1 May 2024,

In my capacity as authorising officer,

– Declare that the information contained in the Annual Activity Report, forming part II of the Annual Report, gives a true and fair view ([1]);

– State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees on the legality and regularity of the underlying transactions.

This reasonable assurance is based on the declaration of assurance provided by the Acting Director General who was in function from 1 October 2023 to 30 April 2024 (see Annex I) and on my own judgment which is limited by the time of my appointment on 1 May 2024.

Based on the above confirm that I am not aware of anything not reported here which could harm the interests of the Euratom Supply Agency.

Electronically signed

Michael Hübel
ESA Director General

([1]) True and fair in this context means a reliable, complete and correct view on the state of affairs in the Agency.

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Michael.Huebel@ec.europa.eu

EURATOM SUPPLY AGENCY

Luxembourg,
ENER.AAE.1/SC

DECLARATION OF ASSURANCE
AAR 2024

I, the undersigned, Stefano CICCARELLO, Acting Director-General of the Euratom Supply Agency from 1 October 2023 to 30 April 2024

In my capacity as authorising officer during the period mentioned above

- Declare that the information contained in the Annual Activity Report, forming part II of the Annual Report, gives a true and fair view ([1]);
- State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees on the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment and the lessons learned from the reports of the Court of Auditors for several years prior to the year of this declaration.

I confirm that I am not aware of anything not reported here which could harm the interests of the Euratom Supply Agency

Electronically signed

Stefano CICCARELLO

([1]) True and fair in this context means a reliable, complete and correct view on the state of affairs in the Agency

Euratom Supply Agency, 2920 Luxembourg, LUXEMBOURG – Tel. +352 43011
Office: EUFO 02/389E – Tel. direct line +352 4301-36227

WebAddress
Stefano.CICCARELLO@ec.europa.eu

Electronically signed on 20/05/2025 18:06 (UTC+02) in accordance with Article 11 of Commission Decision (EU) 2021/2121

Work Programme 2025

Mission and Objectives

In line with the Euratom Treaty and its own Statutes, the mission of the Supply Agency of the European Atomic Energy Community ('ESA') is to maintain regular and equitable supply of nuclear materials (ores, source materials and special fissile materials) for all users in the Community.

ESA's strategic objective is the security of supply of nuclear materials, particularly nuclear fuel, for power and non-power uses, by means of the common supply policy.

In line with ESA's strategic objective, the following specific medium-term objectives have been defined:

Specific policy objectives

1. ensure continuous supply of nuclear materials for users in the Community in the short and medium/long term;
2. facilitate the future supply of nuclear materials, nuclear fuel cycle services and fuel, and encourage the diversification and emergence of reliable alternative sources;
3. facilitate the continued and equitable supply of medical radioisotopes;
4. provide the Community with expertise, information and advice on the nuclear materials and services market;

Specific supporting objectives

5. pursue contacts with EU and international authorities, international organisations, utilities, industry and nuclear organisations to further the objectives of ESA;
6. further improve the effectiveness and efficiency of ESA's organisation and operations.

This work programme sets out the main activities to be pursued in 2025.

The strategic priority, general and specific objectives, and activities have been linked to ensure that all actions contribute to the achievement of these objectives and to the achievement of the high-level priorities. The Work Programme takes due account of the priorities, policies and objectives set out by the Commission.

AREAS OF ACTIVITY

ACTIVITY I. CONTRACT MANAGEMENT

ESA's main task is to ensure regular and equal access to supplies of nuclear materials for all users in the Community. To this end, it has a right of option on nuclear materials produced in the Community Member States and the exclusive right to conclude contracts for the supply of nuclear materials, coming from inside or outside the Community. In addition, it keeps track of transactions related to services in the nuclear fuel cycle.

To facilitate the operations of the common market for nuclear materials and fuels, ESA will:

1. assess and conclude, as appropriate, nuclear material supply contracts, pursuant to Article 52 of the Euratom Treaty, in line with the common supply policy;
2. review and acknowledge notifications of transactions involving small quantities, pursuant to Article 74 of the Euratom Treaty;
3. review and acknowledge notifications of transactions relating to the provision of services in the nuclear fuel cycle, pursuant to Article 75 of the Euratom Treaty, in line with the common supply policy.

When exercising these tasks, ESA will:

- pay particular attention to transactions that would appear vulnerable to geopolitical risks, notably because of the place of origin of supplies;
- assist utilities in managing issues related to supply of nuclear fuel, including transport;
- provide information and support to stakeholders on contract issues related to the common supply policy and by providing advice on ESA procedures and processes;
- support the European Commission's nuclear materials accountancy, on request, in verifying contract data contained in prior notifications of movements of nuclear materials.

ACTIVITY II. FACILITATING FUTURE SUPPLY OF NUCLEAR FUEL

ESA takes responsibility for the common supply policy with a view to ensuring the security of supply in the short-, medium- and long-term. Through appropriate diversification, in line with the European Energy Security Strategy and the REPowerEU Communication and relevant political decisions, it aims to prevent excessive dependence of Community users on any single external supplier, service provider or design and to facilitate existence, where and when possible, of European supply production capacities in the interest of the EU's strategic autonomy, in particular as regards fuel design and supply. ESA's actions support and complement, as appropriate, the EU policy framework and objectives related to energy security and security of supply in the nuclear sector.

To facilitate future supply, ESA will:

1. use its prerogatives under the Euratom Treaty to facilitate diversification of nuclear materials, nuclear fuel cycle services supply (notably conversion, enrichment, and fuel fabrication) and fuel design in the medium and long term, as stressed in ESA's recommendations in its annual reports;
2. facilitate emergence of alternative sources of nuclear materials, nuclear fuel cycle services and fuel design where such sources are presently not available, in particular for VVER reactors;
3. monitor the potential development of the Small Modular Reactors (SMR) / Advanced Modular Reactors (AMR) technology, explore its implications on future demand for nuclear materials and related services and anticipate the impact on ESA activities.

When exercising these tasks, ESA will stay in close communication with the European Commission services and the Advisory Committee and its working groups.

ACTIVITY III. FACILITATING THE CONTINUED AND EQUITABLE SUPPLY OF MEDICAL RADIOISOTOPES

In order to enhance the security of supply of Molibdenum-99/Technetium-99m and possibly other radioisotopes that are indispensable for nuclear medicine procedures, the Agency has been entrusted with the monitoring role for the supply chain of medical radioisotopes in the EU. ESA, jointly with the industry association Nuclear Medicine Europe (NMEU), chairs the European Observatory on the Supply of Medical Radioisotopes.

ESA will also contribute to the implementation of the European Commission's SAMIRA action plan (Strategic Agenda for Medical Ionising Radiation Applications of nuclear and radiation technology).

ESA will:

1. lead and coordinate the activities of the European Observatory on the Supply of Medical Radioisotopes;
2. undertake measures that facilitate supply of high-enriched uranium (HEU) until full conversion of the reactors and processes using it[1];
3. explore, assess, and propose ways to ensure future supply of high-assay low-enriched uranium (HALEU) for production of medical radioisotopes and as fuel for research reactors[1], based inter alia on the conclusions of the last working group report dedicated to the security of supply of HALEU, as published by ESA in July 2022;
4. explore ways of monitoring and forecasting the supply of a wide range of radioisotopes[1].

To exercise these tasks, ESA will also:

- further raise awareness about the importance of the security of supply of medical radioisotopes and their source materials;
- monitor the needs for HEU and HALEU for the production of medical radioisotopes and for fuelling research reactors;
- encourage (particularly in the context of the Euratom Research and Training programme) projects to secure fuel supply for research reactors and the production of medical radioisotopes.

Activity IV. Provision of expertise, information and advice on the nuclear materials and services market

Entrusted with the role of the Nuclear Fuel Market Observatory, ESA will continue to monitor the nuclear fuel and services market and relevant research and innovation activities to identify trends likely to affect the EU's security of supply. It will continue to produce analyses and reports.

The Agency needs to retain its position as a reliable and well-respected source of high-quality and neutral analyses of the Euratom nuclear fuel cycle market.

To deliver on its market monitoring responsibilities, ESA will:

1. monitor and analyse market conditions and technological developments which are likely to have an impact on the nuclear fuel market, including by the annual survey;
2. publish the market analysis as part of its Annual Report;
3. publish and disseminate information, including through yearly natural uranium price indices, reports, studies, newsletters, timely updates on ESA's website and through the meetings of the Advisory Committee, Council's Atomic Questions Working Party and other.

ESA will also support the activities of the Advisory Committee's working groups.

Activity V. Cooperation with stakeholders and partners

To efficiently carry out its tasks and contribute to security of supply, ESA will actively pursue its relations with EU and Euratom institutions and agencies, Member State authorities, operators, the research community and industry, and international players.

To further its objectives, ESA will:

1. provide its expertise and information on the nuclear market and contribute to any measures, which the Commission may wish to adopt and/or to propose to the legislator, aiming, under the current geopolitical circumstances, to consolidate security of supply for nuclear materials and services in the interest of European users;

2. cooperate with the European Commission services, in particular in order to:
    a. provide them with factual market information to take informed decisions as well as policy or legislative actions,
    b. contribute to Commission actions at international level aiming at facilitating future supply,
    c. mitigate risks related to transport and other issues related to the geopolitical situation,
    d. facilitate future supply of high-assay low-enriched uranium (HALEU) and related services for production of medical radioisotopes and as fuel for research reactors,
    e. contribute to the security of supply of a wide range of medical radioisotopes, in particular through supply monitoring and forecasting,
    f. facilitate stakeholder dialogue to address medical radioisotopes issues and concerns,
    g. contribute to monitoring the implementation of the Euratom cooperation agreements with non-EU countries as regards trade in nuclear materials,

h. contribute, on request, for matters within its purview, to the assessment of investment projects under Article 41 of the Treaty and international agreements communicated to the Commission under Article 103 of the Treaty;

3. proactively liaise with the Advisory Committee and its working groups in order to monitor the situation for factors and trends that could put at risk security of supply of nuclear materials and related services;
4. liaise with the operators and other concerned parties to encourage and facilitate diversification and other measures aimed at security of supply of nuclear materials and related services;
5. engage with medical radioisotopes supply chain stakeholders (industry, research and user organisations) in and outside the EU and representatives of Euratom Member States in order to:
    a. explore ways of monitoring and forecasting the supply of a wide range of radioisotopes,
    b. facilitate the continued supply of medical radioisotopes,
    c. assess the needs and secure the supply of HALEU;
6. in cooperation with the Euratom Member States concerned, with a view to advancing towards the minimisation of HEU use, coordinate the implementation of the Memorandum of Understanding with the US Department of Energy - National Nuclear Security Administration to facilitate supply of HEU and pave the way to securing future HALEU supply by an amended Memorandum with US partners.

ESA will also maintain regular contact with:

- international nuclear organisations such as the IAEA and the OECD NEA;
- other international players on the nuclear fuel market, including through membership of the World Nuclear Association, the World Nuclear Fuel Market and the European Nuclear Society.

ACTIVITY VI. MAKING ESA'S INTERNAL ORGANISATION AND OPERATIONS MORE EFFECTIVE

ESA will continuously review its procedures to further improve the management of the contracts it receives and the operations of its Nuclear Market Observatory. Given ESA's limited resources, it is of paramount importance to ensure that ESA remains effective and efficient.

To this end, ESA will focus its attention on:

1. ensuring compliance and effective internal control;
2. ensuring sound financial management, including by making use of the new Commission application "SUMMA";
3. ensuring competent, engaged and effectively utilised workforce,
4. keeping its work practices under review and updating them where appropriate;
5. the progressive implementation of ESA's document management and security policy with continued emphasis on the security of communication and information systems used by ESA;
6. the progressive implementation of the IT system supporting the work of ESA (NOEMI - Nuclear Observatory and ESA Management of Information).

***

[1] as provided for in the SAMIRA action plan

List of tables

Table 1. Natural uranium equivalent included in fuel loaded by source in 2024 13
Table 2. Origins of uranium delivered to EU utilities in 2024 (tU) 20
Table 3. Provision of conversion services to EU utilities 24
Table 4. Origin of enrichment services to EU utilities 25
Table 5. Nuclear power reactors in the EU-27 in 2024 50
Table 8. Natural uranium production in 2024 (compared to 2023, in tonnes of uranium) 66
Table 7. Commercial UF6 conversion facilities 69
Table 8. Operating commercial uranium enrichment facilities, with approximate 2022 capacity 71
Table 9. Contracts by type in 2024 76

List of figures

Figure 1. Reactor requirements for uranium and separative work in the EU (in tonnes NatU or SWU) ... 14
Figure 2. Estimated future use of secondary sources 15
Figure 3. Natural uranium equivalent feed contained in fuel loaded into EU reactors and natural uranium equivalent delivered to utilities under purchasing contracts (tonnes NatU) 16
Figure 3a. Average prices of natural uranium delivered under spot and multiannual contracts, 2015-2024 (EUR/kgU) 18
Figure 3b. Average price of natural uranium delivered under spot and multiannual contracts, 2015-2024 (USD/lb U3O8) 19
Figure 4. Origins of uranium delivered to EU utilities in 2024 (% share) 21
Figure 5. Origins of uranium delivered to EU utilities in 2024 by geographical regions (tU) 22
Figure 6. Purchases of natural uranium by EU utilities, by origin, 2015-2024 (tU) 23
Figure 7. Supply of conversion services to EU utilities by provider, 2019-2024 (tU) 24
Figure 8. Supply of enrichment to EU utilities by provider, 2015-2024 (tSW) 26
Figure 9. Total natural uranium equivalent inventories owned by EU utilities at the end of the year, by chemical form, 2022-2024 (in tonnes) 27
Figure 10. Coverage rate for natural uranium, 2025-2033 (%) 28
Figure 11. Coverage rate for conversion services, 2025-2033 (%) 29
Figure 12. Coverage rate for enrichment services, 2025-2033 (%) 29
Figure 13. Uranium conversion price trends (in USD) 68
Figure 14. Monthly spot and long-term SWU prices (in USD) 70