Euratom Supply Agency Annual Report 2022

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Foreword

For nuclear material supply, the year 2022 saw materialisation of the most critical risks in decades. In circumstances that went beyond any scenario that had been considered, the Euratom Supply Agency demonstrated its pivotal role in ensuring security of supply, using both its legal prerogatives and soft powers.

Following the war of aggression in Ukraine and the use of energy as a hybrid threat, Russia could no longer be considered a reliable partner. In a radically and suddenly changed context, the Agency was at the forefront of efforts to prevent shortages in the nuclear fuel and medical radioisotope supply chains and thus to protect EU citizens and businesses.

Throughout the year, we were continuously working with all interested parties – in utilities, industry and the medical radioisotopes supply chain - to get updates on the situation and analyse them. When possible, we helped mitigate the risks. Most importantly, we provided EU decision-makers with updates on the security of supply, based on information from our market stakeholders and the Agency's assessment.

The situation relating to fuel for Russian-designed VVER reactors, for which no alternative fuel had been licensed, was the most acute. In 2022, the Agency increased its longstanding efforts on diversification in this market segment, with the European Commission starting to work with all Member States concerned.

Furthermore, the Agency did not only focus on the short-term risks. We developed market analysis for the medium and long term and worked with industry and other stakeholders to raise awareness of the future challenges for security of supply. The EU dependency on Russia in several areas of the nuclear fuel cycle needs an appropriate response. This report presents the conclusions of this analysis and puts forward recommendations for the further actions that are needed.

At a time when the Agency was busiest in responding to crisis and therefore focusing all its resources on crisis management, the need for a revised governance became even more obvious. The Agency has regularly achieved its objectives and become more efficient through its own measures. It now needs and deserves an evaluation of its governance so that it will be ready for upcoming challenges.

I have been proudly leading the Euratom Supply Agency for more than 4 years. As this is my last report, I would like to extend my thanks to everyone I have worked with over the past years: utilities, industry, medical radioisotopes supply chain actors, members of the Advisory Committee, representatives of Member States and of partner third countries, international nuclear organisations, nuclear and radio medical associations and colleagues from the Commission.

But I owe my warmest gratitude to my colleagues in the Euratom Supply Agency. Through their professionalism and engagement, they have shown that so much more can be achieved than the mere staffing numbers would indicate.

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Executive summary

In 2022, Russia's invasion of Ukraine raised concerns in the European Union (EU) about energy security, including the security of supply of nuclear materials and fuel services. EU utilities rely on Russian suppliers to source up to 30% of nuclear materials and front-end services. Concerns were also detected in the supply chain of some medical radioisotopes.

The EU responded to these concerns by adopting the REPowerEU plan in May 2022. In response to the hardships and disruption on the global energy market, the EU emphasised the need to reduce dependency on imports of Russian fossil fuels by accelerating the rollout of renewables, increasing investment in energy efficiency and securing alternative supply sources. This includes supplies for the nuclear fuel cycle, which meant working with like-minded countries to boost the capacity of the front end of the nuclear fuel cycle.

Market analysis and recommendations

EU stakeholders took measures to reduce their reliance on Russian nuclear fuel supplies and to overcome the challenges and logistic issues triggered by the geopolitical situation. These measures included stepping up action on diversifying supply, with fuel the top priority, creating and using alternative delivery routes and planning to expand capacities at different stages of the fuel cycle, in particular for uranium enrichment and fuel fabrication.

The overview of nuclear fuel supply and demand, based on data provided by EU utilities in an annual survey, covers the purchase price for uranium, fuel loads, uranium quantities and origins, future requirements, contracted deliveries and inventory trends.

The gross volume of electricity generated by nuclear power plants in the EU accounted for 21.5% of the total EU electricity production, i.e., 16.7% less than in 2021, mainly due to reactors being shut down or taken offline for repairs or due to large-scale maintenance being delayed due to the COVID-19 pandemic.

The volume of fresh fuel loaded into the reactor decreased by 27%, and utilities purchased more material than was actually loaded, unlike over the previous eight years. In line with ESA recommendations, almost all the supply was provided under multiannual contracts.

Overall, deliveries of natural uranium to EU utilities are well diversified, although the number of countries of origin is narrowing. Four big producer countries provided over 90% of the natural uranium supplied. Deliveries from Russia fell by over 16%, mostly compensated by an increase in supply from other Commonwealth of Independent States countries.

Although the shares of enrichment services were practically unchanged in 2022, there has been a relative increase in the conversion services provided by EU industry and a noticeable reduction in services provided by Russian and Canadian suppliers.

Countries dependent on VVER-type reactors, which have a significant degree of vulnerability to the security of supply, plan to diversify their fuels and have taken initial steps to this end.

EU utilities requirements for the coming years are well covered under existing contracts for natural uranium, conversion and enrichment services. Nevertheless, it is important to recognise that it may not be possible over the mid and long term to cover all options in existing contracts from open market suppliers to make up for deliveries from high-risk suppliers.

An analysis of the conversion and enrichment markets conducted by the ESA concludes that the global supply from Western providers might not be sufficient in the event of unavailable supply from other service providers, such as Russia, unless some plants ramp up production and invest in expanding their capacities.

The ESA makes eight groups of recommendations to boost the security of supply and overcome the current areas of vulnerability. It recommends that national and supranational authorities define the security of supply conditions that utilities should meet, clearly set out the national nuclear energy objectives and technology, monitor geopolitical developments and connected risks, build strategic stocks and consider developing policy and measures on supply crisis management similar to those developed for other sources of energy. Utilities are recommended to monitor the risks and implement measures already identified including for transport and storage, continue to procure supplies through long-term contracts from a diverse range of geographies and providers, and preferably from EU or like-minded jurisdictions.

For the first time, the ESA report includes a specific group of recommendations on tackling the vulnerabilities in the security of supply of medical radioisotopes. The Agency advises authorities and organisations to take decisions to secure future supplies of high-assay low-enriched uranium (HALEU), to accelerate the licensing of alternative fuel for research reactors, diversify supply sources, invest in the recycling and enrichment of source materials and stable isotopes, and to build a monitoring and forecasting system for the supply of key medical radioisotopes.

Market and nuclear policy developments in the EU and worldwide

In a challenging context, marked by Russia's war of aggression against Ukraine, the Commission closely monitored the potential impacts of the conflict on the safety of Ukraine's nuclear facilities. It has reviewed its emergency preparedness and response measures to take in the event of radiological or nuclear event, in coordination with European nuclear safety and radiation protection authorities.

The EU and its Member States provided direct support to Ukraine for nuclear safety and radiation protection. The EU also provided funding to the International Atomic Energy Agency (IAEA) to support their activities in Ukraine.

The war in Ukraine demonstrates the need to tackle the physical protection of Nuclear Power Plants (NPPs). Therefore, at international level, the Commission has opened a discussion process on strengthening the international framework to protect nuclear sites in the context of armed conflicts.

As regards the security of supply of nuclear materials, the Commission (through the Directorate-General for Energy) launched consultations with Member States operating VVER reactors to accelerate the process of diversifying their fuel supplies.

The Commission approved the Complementary Climate Delegated Act concerning six specific economic activities in the area of nuclear energy and natural gas to be included in the list of economic activities covered by the EU Taxonomy.

The 15th European Nuclear Energy Forum (ENEF), organised by the Commission together with Czechia, was an opportunity for broad discussion among all stakeholders. The Forum focused on the role of nuclear energy in decarbonising the EU energy system by 2050 and how well the nuclear ecosystem is prepared to meet that goal.

Another part of the EU Member States' decarbonisation agenda involves a number of countries considering small modular reactors (SMRs). The Commission followed very closely stakeholder preparations for a new European Partnership on SMRs in the form of joint work involving industry, research and technological organisations, interested utilities, EU Member States and European regulators. The aim is to identify enabling conditions and constraints in the safe design, construction and operation of SMRs in Europe in compliance with the EU/Euratom legislative framework.

In 2022, the priority was on safeguard action. Applying state-of-art approaches and technology to tackle the safeguard challenges following the socio-political developments, 99.92% of Euratom's nuclear material underwent physical inventory verifications. It found no evidence of diversion of nuclear material in the EU, and all obligations under IAEA and Euratom nuclear cooperation agreements were fulfilled.

Construction works on the International Thermonuclear Experimental Reactor (ITER) reached 77.6% completion of the 'First Plasma' part at the end of 2022. However, challenges due to the COVID-19 pandemic, late arrivals of components, regulatory approval and component quality issues affected project implementation. The impacts are analysed, and the project baseline updated.

Projects run under the Euratom Research and Training Programme (2021-2025) and the Joint Research Centre (JRC) work programme continued to sustain European expertise in nuclear research and innovation in several nuclear areas. They include fusion, reactor safety, materials, fuels, waste management, disposal, medical and other applications of ionising radiation.

The report also highlights global nuclear advancements and progress in the nuclear fuel industry.

Key achievements and management in 2022

Mindful of high-risk supplies, the ESA concluded supply contracts and acknowledged notifications of service supply, with particular focus on the origin of materials and suppliers, contract terms, technology and supply chains.

In the light of Russia's war of aggression against Ukraine, the ESA also collected and analysed market data to identify trends that might affect the short to long-term supply of nuclear materials and fuel. The nuclear fuel market observatory issued several reports and contributed to IAEA and NEA working groups.

Following the military aggression, the Agency worked together with the European Commission and EU stakeholders to address logistical challenges and improve supply security, in particular with the aim to diversify VVER fuels. The ESA monitored VVER operational autonomy on the basis of fuel inventories and worked together with utilities to adapt to market changes.

With the support of its Advisory Committee, the ESA assessed the security of supply, the impact of the geopolitical events and monitored market developments.

The supply of medical radioisotopes also faced security challenges due to the EU's reliance on Russian production. The ESA provided expertise and called for revised risk assessments and alternative supplies to Russian fuel for research reactors.

The ESA continued its work to contribute to the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) to implement the HEU exchange agreement with the US DoE-NNSA until all research reactors are converted to operate with HALEU. It also worked to secure the long-term supply of HALEU for research reactor fuel and set targets to produce medical radioisotopes.

In 2022, the ESA continued to lead efforts to secure the supply of essential medical radioisotopes such as Molibdenum-99/Technetium-99m and Iodine-131 through the European Observatory, in cooperation with the NMEU's security of supply group.

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 (1 kg of separative work)
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)
SMR	small modular reactor
VVER	Voda-Voda Energo Reactor (Water Water Energy Reactor), 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 that the utilities or their procurement organisations provided 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 2022, gross electricity generation from nuclear plants in the 27 EU countries (EU-27) reached 609.2 TWh, ([1]) accounting for 21.5% of total EU-27 production. The output of nuclear power plants was 16.7% (122.5 TWh) lower than in 2021.

Juzbado facility

©Enusa

1.1. Fuel loaded

In 2022, 1 602 tU of fresh fuel was loaded into commercial reactors. It was produced using 10 993 tU of natural uranium and 57 tU of reprocessed uranium as feed, enriched with 8 340 tSW.

The fuel loaded into EU reactors had an average enrichment assay of 3.93%, with 80% falling between 3.03% and 4.83%. The average tails assay was 0.20%, with over 80% falling between 0.16% and 0.24%.

MOX (mixed oxide) fuel was used in several reactors in France and the Netherlands. MOX fuel loaded into nuclear power plants (NPPs) in the EU contained 3 007 kg plutonium in 2022, 38% less than in 2021. Use of MOX resulted in estimated savings of 277 tU and 197 tSW (see Annex 5).

The amount of natural uranium included in fuel loaded into reactors in 2022, including natural uranium feed, reprocessed uranium, and savings from MOX fuel, totalled 11 327 tU.

The total amount of natural uranium included in fuel loaded into reactors in 2022 was 11 327 tU.

The amount of natural uranium saved by using MOX fuel together with reprocessed uranium is in effect the same as the amount of feed material (that would otherwise have to be used) coming from domestic secondary sources. All this provided about 3.0% of the EU's annual natural uranium requirements.

1 Source: IEA statistics. OECD and Selected Countries, Electricity and Heat Generation. Gross electricity production

Table 1. Natural uranium equivalent included in fuel loaded by source in 2022

Source	Quantities (tU)	% of annual requirement
Uranium originating outside the EU-27	10 993	97
Indigenous sources (1)	334	3
Total annual requirements	11 327	100

(1) includes reprocessed uranium, savings from the usage of MOX fuel, small quantities of underfed material, re-enriched tails or uranium of EU origin

Reprocessing of spent fuel

It is up to the Member States and their corresponding national policies whether they opt to consider the spent fuel as radioactive waste or as a valuable source of new material after reprocessing. According to European Commission data, 7 Member States out of 27 reprocessed spent fuel or chose the reprocessing option, and 2 Member States kept that possibility open.

Plutonium and MOX fuel

MOX fuel is produced by mixing plutonium recovered from spent fuel and depleted uranium obtained from the enrichment process. Using MOX fuel affects reactor performance and safety requirements. Reactors have to be adapted for this kind of fuel and must obtain a special licence before using it.

MOX fuel behaves similarly (though not identically) to the enriched uranium-based fuel used in most reactors. It is used mainly for reasons relating to non-proliferation and economic considerations, and because it enables the use of plutonium recovered from spent fuel. Reprocessing spent fuel and recycling recovered plutonium with uranium in MOX fuel increases the availability of nuclear material, reduces the need for enrichment services and increases security of supply.

1.2. Future requirements

EU utilities have estimated their gross reactor needs for natural uranium and enrichment services over the next 20 years, considering possible changes in national policies or regulatory requirements that result in: the construction of new units (only projects already granted a construction licence are taken into account); lifetime extensions; early retirement of reactors; and phasing-out or decommissioning. Net requirements are calculated on the basis of gross reactor requirements, minus the savings obtained from planned uranium/plutonium recycling and inventory usage.

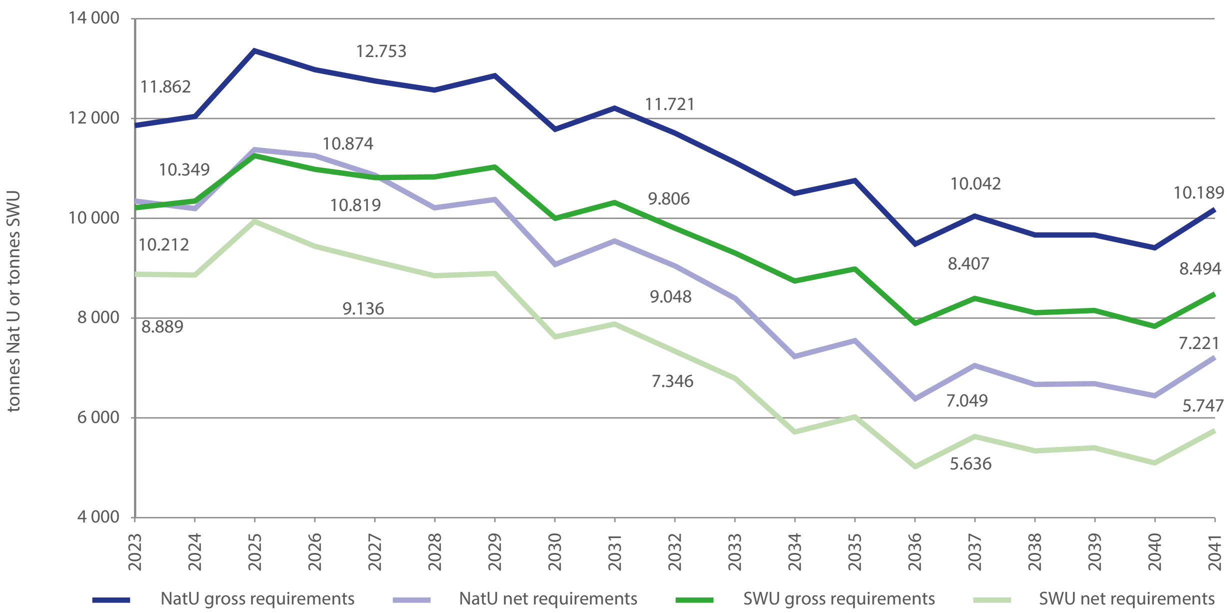
Compared with the previous year's estimate, EU average gross reactor needs for natural uranium increased by 2%, with no change for enrichment services. This is in contrast to the pattern in earlier years, when the EU average gross reactor needs were regularly revised downwards.

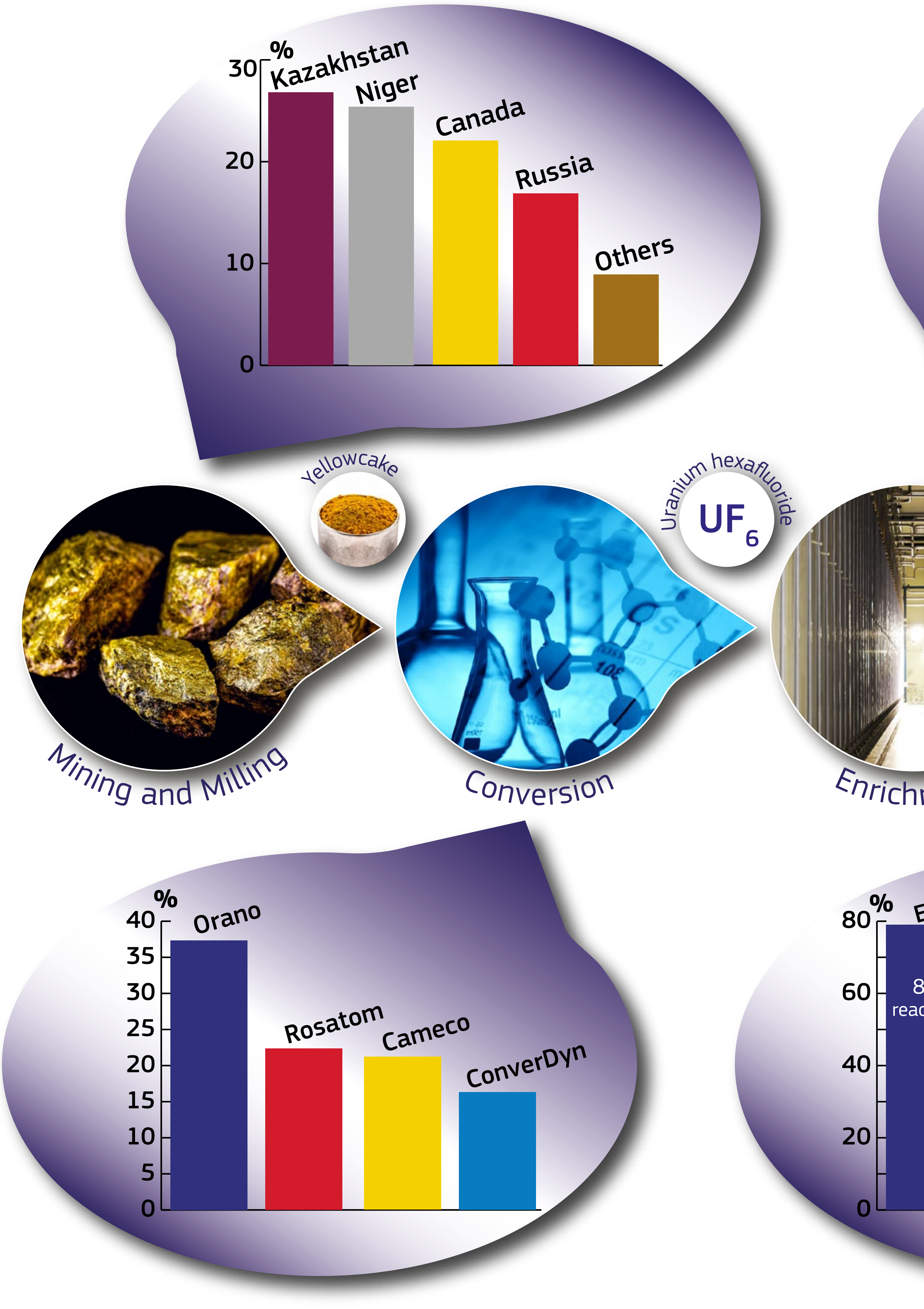
Natural uranium – average reactor requirements		
2023-2032	12 417 tU/year (gross)	10 236 tU/year (net)
2033-2042	10 009 tU/year (gross)	6 989 tU/year (net)

Enrichment services – average reactor requirements		
2023-2032	10 564 tSW/year (gross)	8 690 tSW/year (net)
2033-2042	8 362 tSW/year (gross)	5 570 tSW/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)




%
30
20
10
0
Kazakhstan
Niger
Canada
Russia
Others
Yellowcake
Uranium hexafluoride
UF_6
Mining and Milling
Conversion
%
40
35
30
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Orano
Rosatom
Cameco
ConverDyn
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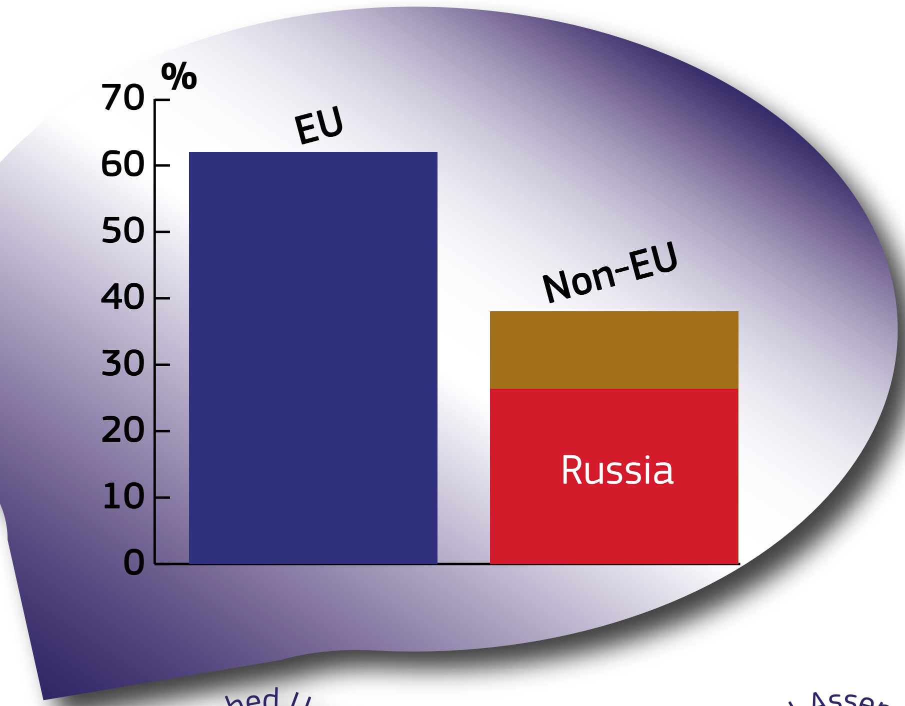
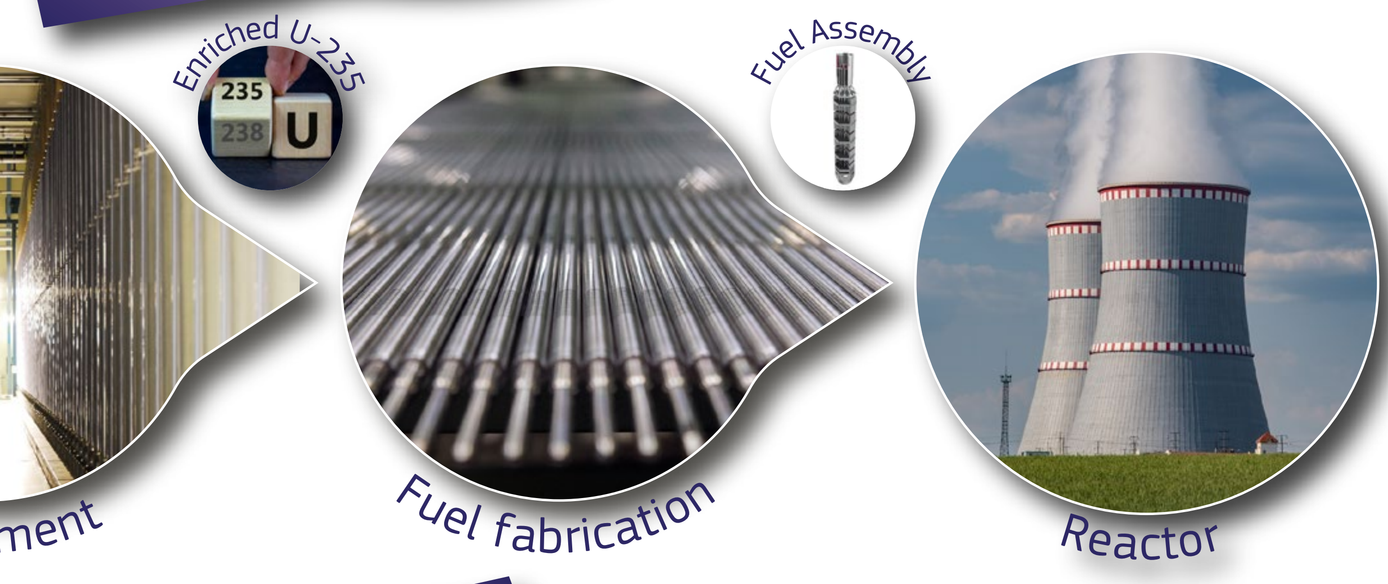
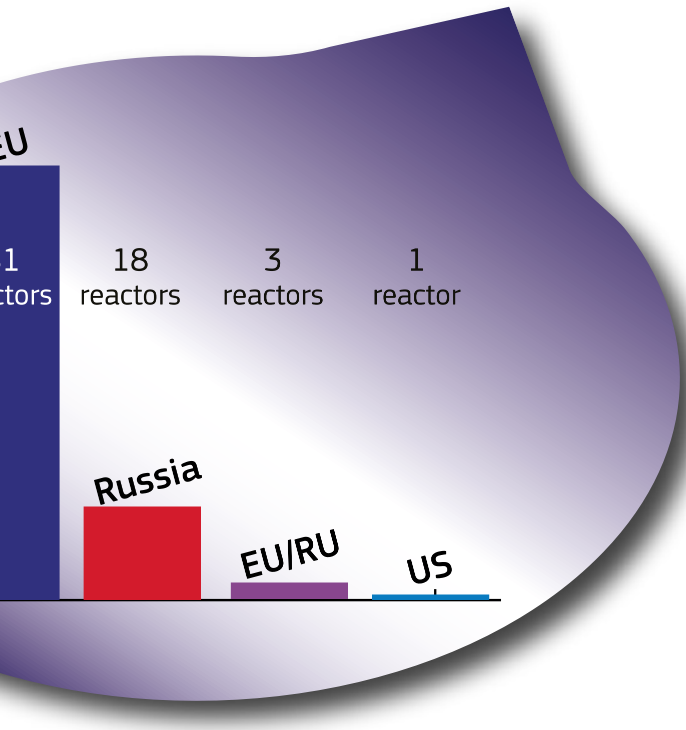






Nuclear Fuel Cycle front end supply in the EU in 2022

1.3. Supply of natural uranium

Conclusion of contracts

In 2022, in ESA's contract management activities, 214 new registration references were recorded. Of these, 40% were new contracts or amendments or supplements to existing supply contracts within the meaning of Article 52 of the Euratom Treaty, and the remaining 60% were notifications relating to contracts on related services or small quantities covered, respectively, by Articles 75 and 74 of the Treaty.

Table 2. Natural uranium contracts concluded by ESA (including feed contained in EUP purchases)

Type of contract	Number of contracts concluded in 2022	Number of contracts concluded in 2021
Purchase/sale by EU utilities/end users	**12**	**15**
— multiannual (1)	4	7
— spot (1)	8	8
Purchase/sale by EU intermediaries/producers	**8**	**8**
— multiannual	5	5
— spot	3	3
Exchanges and loans (2)	**3**	**4**
Amendments	**27**	**42**
TOTAL (3)	**50**	**69**

(1) Multiannual contracts are contracts providing for deliveries extending over more than 12 months, whereas spot contracts provide either for a single delivery or for deliveries over a maximum of 12 months, whatever the time between conclusion of the contract and the first delivery.
(2) This category includes exchanges of ownership and exchanges of U_3O_8 against UF_6. Exchanges of safeguard obligation codes and international exchanges of safeguard obligations are not included.
(3) Transactions for small quantities (as under Article 74 of the Euratom Treaty) are not included.

Volume of deliveries

The deliveries covered are those to EU utilities or their procurement organisations in 2022, excluding research reactors. Where stated, the natural uranium equivalent contained in enriched uranium purchases is also taken into account.

In 2022, demand for natural uranium in the EU accounted for approximately 18% of global uranium requirements. EU utilities purchased a total of 11 724 tU in 119 deliveries under multiannual and spot contracts.

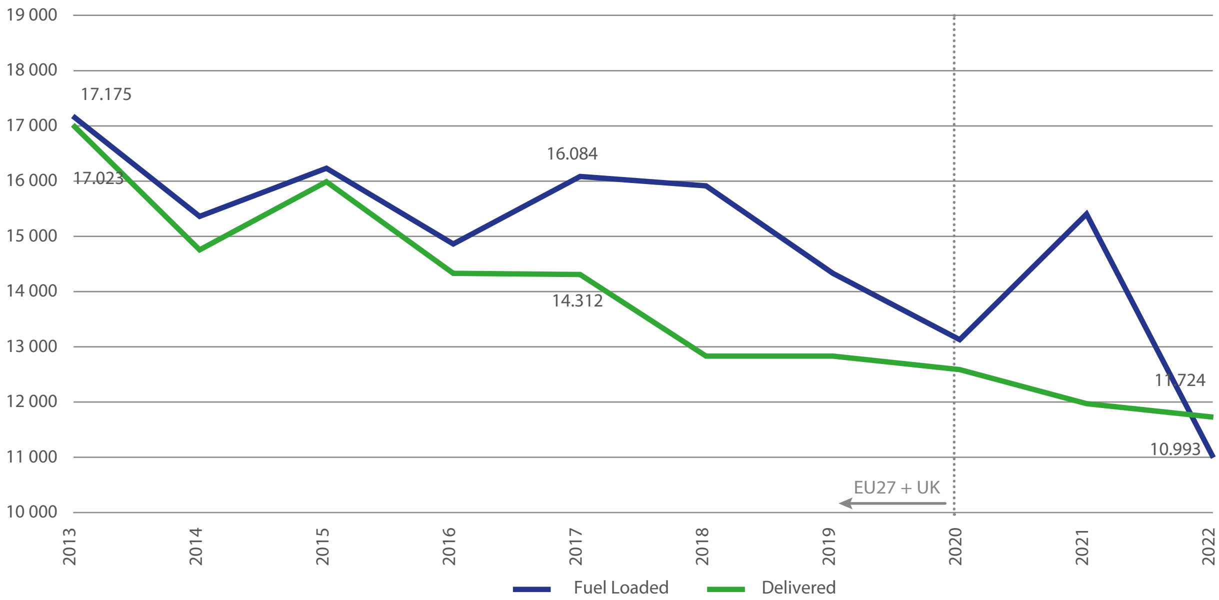
As in previous years, supplies under multiannual contracts were the main source for meeting demand in the EU. Deliveries of natural uranium to EU utilities under multiannual contracts accounted for 11 493 tU (of which 10 820 tU with reported prices) or 98% of total deliveries. The remaining 2% (231 tU) was purchased under spot contracts.

On average, the quantity of natural uranium delivered was 100 tU per delivery under multiannual contracts.

Natural uranium contained in the fuel loaded into reactors in 2022 totalled 10 993 tU. In contrast to previous years since 2013, when utilities bought less uranium than they loaded into reactors, in 2022 EU utilities loaded 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 under purchasing contracts (see Annex 2 for the corresponding table for 1980-2022).

For the first time in 8 years, in 2022 utilities bought more material than loaded into reactors.

Figure 2. 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

In the interests of market transparency, ESA publishes three EU natural uranium price indices annually. These are based only on deliveries to EU utilities or their procurement organisations under natural uranium and enriched uranium purchasing contracts in which the price is stated.

The natural uranium delivery price stated in purchase contracts concluded in recent years (mainly new multiannual contracts but also a non-negligible percentage of the spot contracts) is generally agreed on by using formulae based on uranium price and inflation indices.

ESA's price calculation method converts the currency of the original contract prices into euro per kg uranium (kgU) in the chemical form U_3O_8, using the average annual exchange rates published by the European Central Bank. The average prices are then calculated after weighting the prices paid by the quantities delivered under each contract. A detailed analysis is presented in Annex 8.

Since uranium is mostly traded in US dollars on the global market, fluctuations in the EUR/USD exchange rate influence the level of the price indices calculated. In 2022, the European Central Bank' annual average EUR/USD rate was 1.05.

To calculate a natural uranium price excluding the conversion cost when the latter was included but not specified, ESA applied a rigorously calculated average conversion price, based on reported conversion prices under multiannual contracts for natural uranium.

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

1. ESA spot U_3O_8 price: the weighted average of U_3O_8 prices paid by EU utilities for uranium delivered under spot contracts was calculated to be:	
EUR 137.26/kgU contained in U_3O_8	-
USD 55.59/lb U_3O_8	-

The ESA multiannual U_3O_8 price was EUR 101.28/kgU U_3O_8 (USD 41.02/lb U_3O_8).

The multiannual prices paid varied widely, with approximately 80% (assuming a normal distribution) falling within the range from EUR 48.14 to EUR 138.74/kgU (from USD 19.50 to USD 56.19 /lb U_3O_8).

2. ESA multiannual U_3O_8 price: the weighted average of U_3O_8 prices paid by EU utilities for uranium delivered under multiannual contracts was calculated to be:	
EUR 101.28/kgU contained in U_3O_8	up 14% from EUR 89.00/kgU in 2021
USD 41.02/lb U_3O_8	up 1% from USD 40.49/lb U_3O_8 in 2021

Usually, multiannual prices trade at a premium to spot prices, as buyers are willing to pay a risk premium to lock in future prices. However, 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.

Spot prices are the most widely indexed prices in multiannual contracts. The ESA multiannual U_3O_8 price paid for uranium originating in countries belonging to the Commonwealth of Independent States (CIS) – namely Russia, Kazakhstan, and Uzbekistan – was 23% lower than the price for uranium of non-CIS origin.

The ESA MAC-3 multiannual U_3O_8 price was EUR 76.19/kgU U_3O_8 (USD 30.86/lb U_3O_8).

3. ESA 'MAC-3' multiannual U_3O_8 price: the weighted average of U_3O_8 prices 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 76.19/kgU contained in U_3O_8	down 18% from EUR 92.75/kgU in 2021
USD 30.86 /lb U_3O_8	down 27% from USD 42.17/lb U_3O_8 in 2021

The ESA MAC-3 index takes account only of multiannual contracts signed recently (2020-2022) or older multiannual contracts for which the uranium pricing method was amended during the same period, thus incorporating current market conditions and providing insights into the future of the nuclear market. The ESA MAC-3 multiannual U_3O_8 price paid for uranium originating in CIS countries was 11% lower than the price for uranium of non-CIS origin.

The ESA multiannual U_3O_8 and MAC-3 multiannual U_3O_8 prices paid for uranium originating in CIS were lower than the respective prices for uranium of non-CIS origin.

Figures 3a and 3b show the ESA average prices for natural uranium since 2013. The corresponding data are presented in Annex 3.

Figure 3a. Average prices for natural uranium delivered under spot and multiannual contracts, 2013-2022 (EUR/kgU)

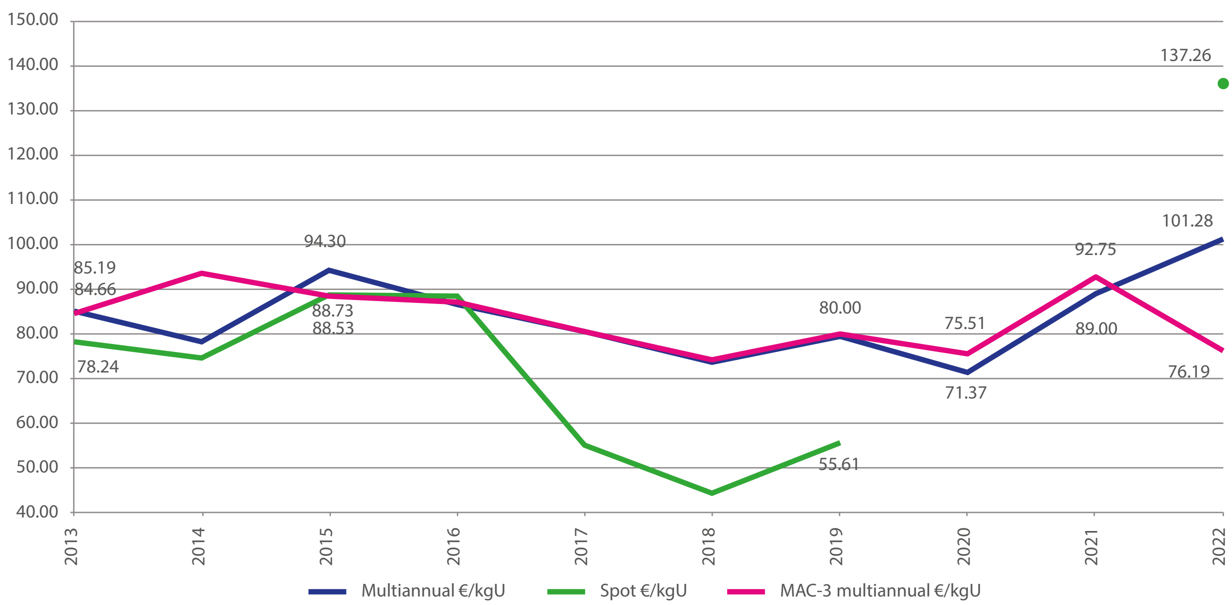
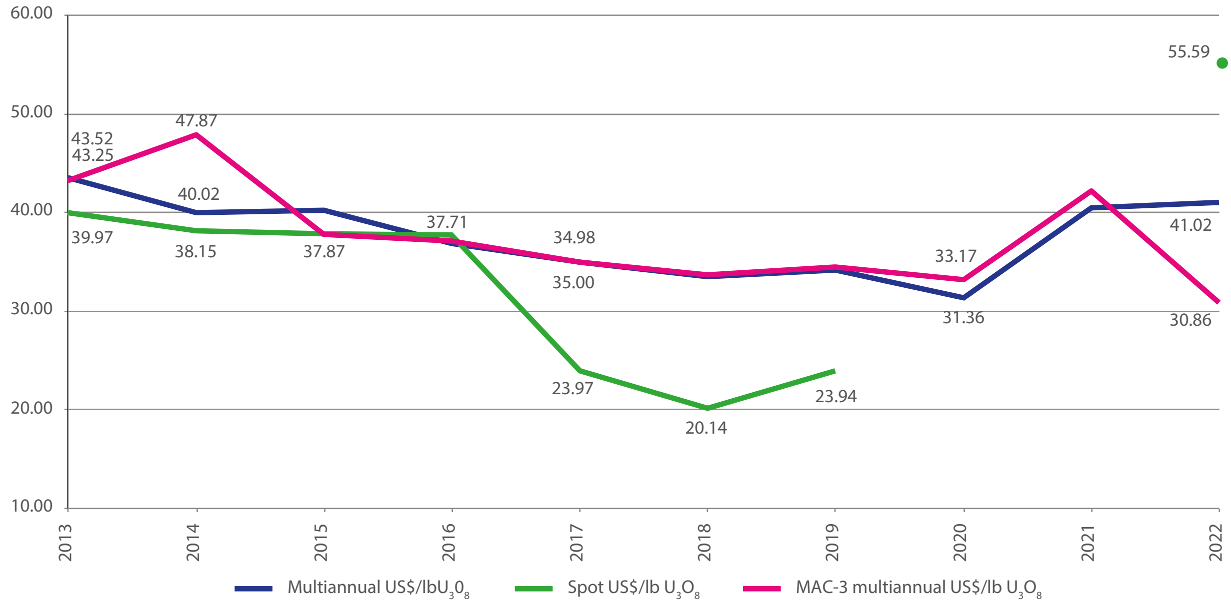


Figure 3b. Average prices for natural uranium delivered under spot and multiannual contracts, 2013-2022 (USD/lb U_3O_8)



Origins

In 2022, natural uranium supplies to the EU continued to come from diverse sources. The origins of natural uranium supplied to EU utilities remained similar to 2021, though there were some changes in market share.

Table 3. Origins of uranium delivered to EU utilities in 2022 (tU)

Origin	Quantity	Share (%)	Change in quantities 2021/2022 (%)
Kazakhstan	3 145	26.82	14.24
Niger	2 975	25.38	2.39
Canada	2 578	21.99	50.42
Russia	1 980	16.89	-16.05
Uzbekistan	441	3.76	171.00
Australia	327	2.79	-82.41
South Africa and Namibia	262	2.23	5 545.60
EU	17	0.15	-17.40
Re-enriched tails	0	0	-100
Other [(1)]	0	0	-100
Total	**11 724**	**100**	

Because of rounding, totals may not add up.
(1) material saved through underfeeding, mixed origin and unknown

Four countries provided more than 91% of all-natural uranium supplied to the EU in 2022. Kazakhstan, Niger, and Canada were the top three countries delivering natural uranium, providing 74.19% of the total. Russia followed, with a 16.89% share, which included natural uranium contained in enriched uranium products (EUP).

> Over 91% of natural uranium supplied to the EU came from four producing countries.

In terms of trends, deliveries of uranium from Australia decreased by more than 82% and from Russia by 16%. They were offset by deliveries from Canada, up by more than 50%, Uzbekistan, up 171%, and deliveries from the South Africa and Namibia region.

Natural uranium produced in the countries of the Russia-centred CIS accounted for 47.47% of all-natural uranium delivered to EU utilities. CIS deliveries amounted to 5 565 tU (including re-enriched tails), which is 1.7% more by weight than the year before. Natural uranium originating in non-CIS countries accounted for 6 159 tU, a drop of more than 5% compared with the previous year.

In contrast to previous years, deliveries of uranium from Africa increased to 3 237 tU.

Figure 4. Origins of uranium delivered to EU utilities in 2022 (% share)

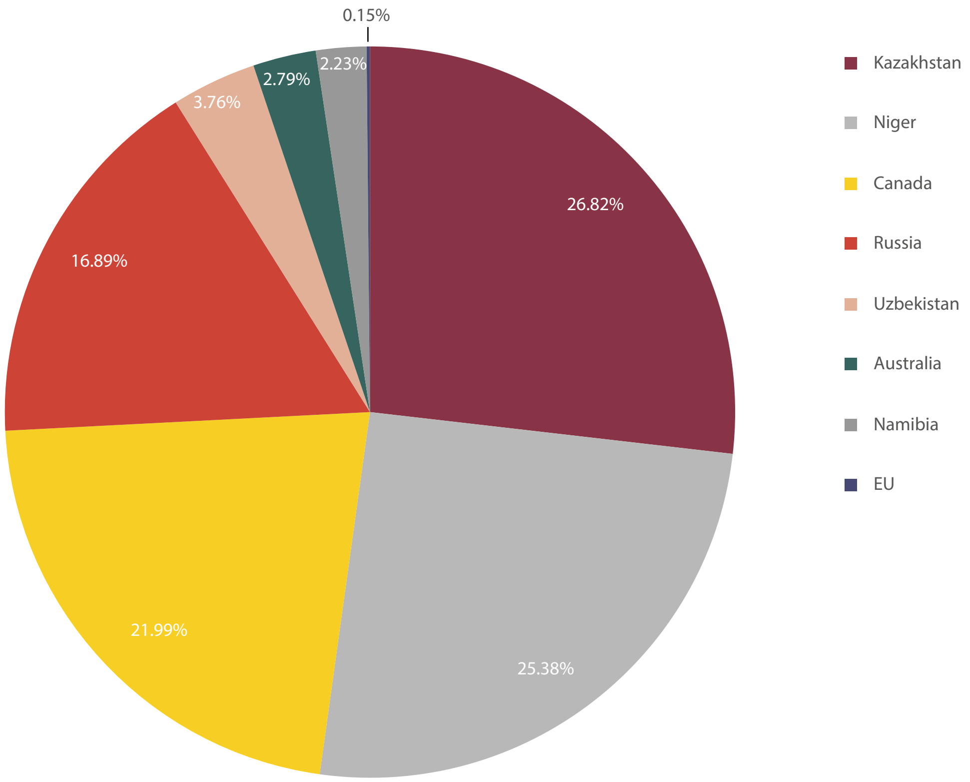
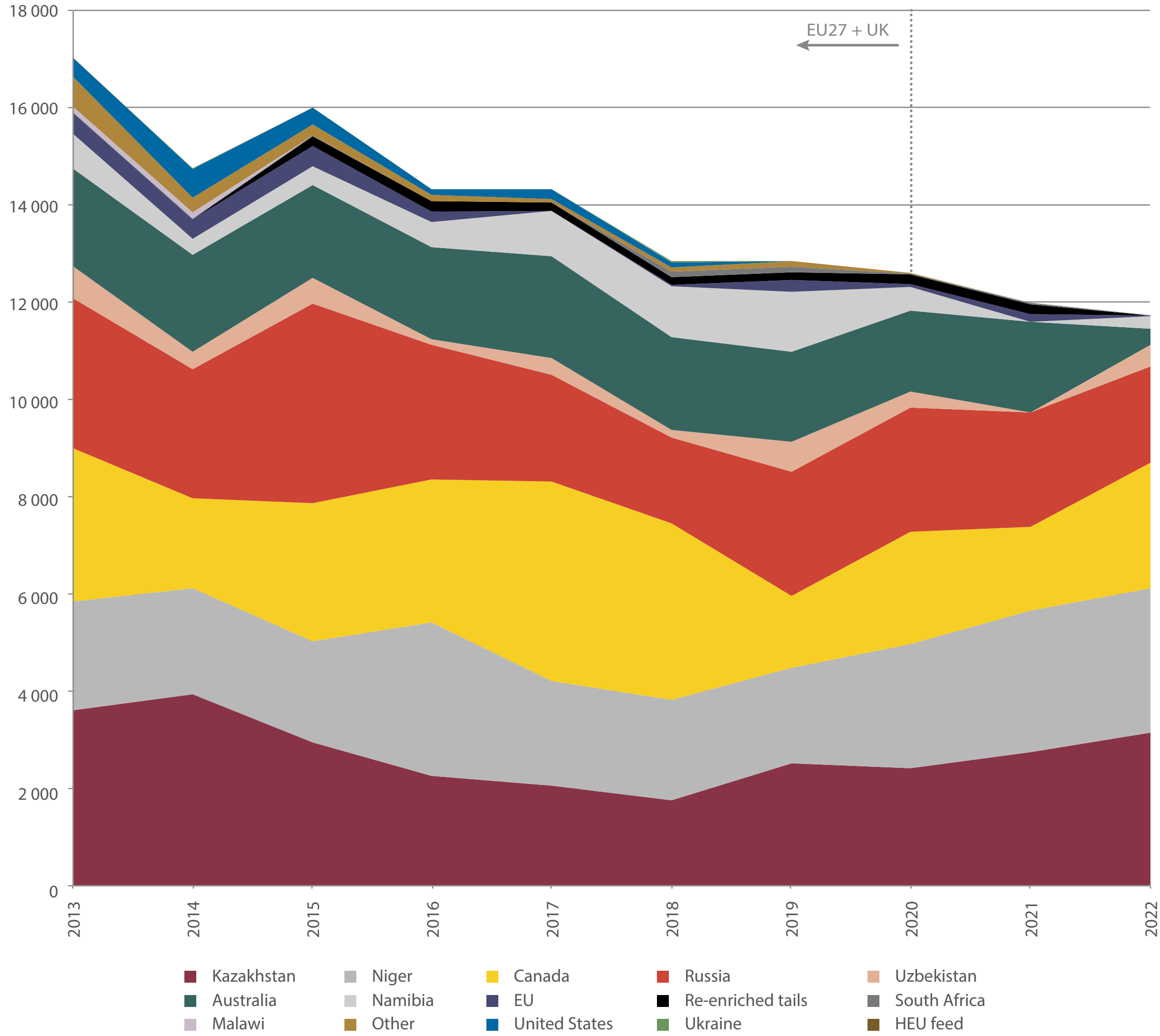


Figure 5. Purchases of natural uranium by EU utilities, by origin, 2013-2022 (tU)



Conversion services

During 2022, EU utilities, producers and intermediaries notified ESA of three new contracts to provide conversion services and four amendments to already notified conversion contracts.

Conversion service deliveries to EU utilities were 10% lower than in 2021.

Under separate conversion contracts, 7 660 tU were converted, accounting for 70% of all conversion service deliveries to EU utilities. The remaining 30%, or 3 274 tU, were delivered under contracts other than conversion contracts (purchases of natural UF_6, EUP, bundled contracts for fuel assemblies).

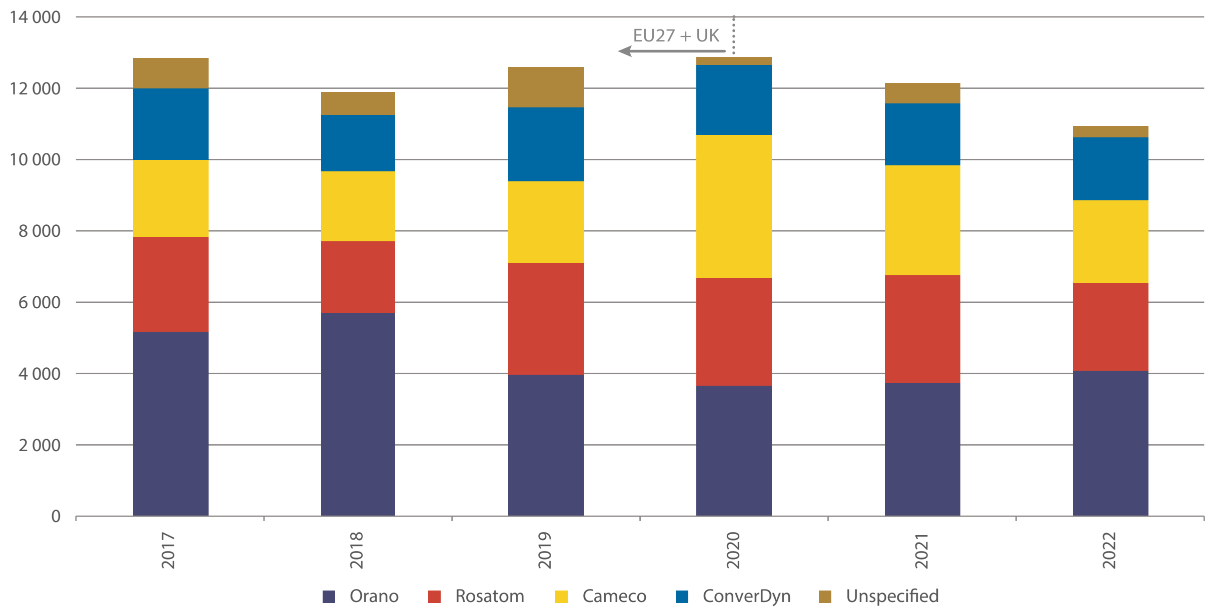
As regards the providers of conversion services, 37.34% of EU requirements were provided by Orano Conversion (Philippe COSTE facility), followed by Rosatom (22.35%), Cameco (21.16%), and ConverDyn (16.30%).

Table 4. Provision of conversion services to EU utilities

Converter	Quantity in 2022 (tU)	Share in 2022 (%)	Change in quantities 2021/2022 (%)	Quantity in 2021 (tU)	Share in 2021 (%)
Orano (EU)	4 083	37.34	10	3 723	30.67
Rosatom (Russia)	2 444	22.35	-20	3 039	25.04
Cameco (Canada)	2 314	21.16	-25	3 095	25.50
ConverDyn (US)	1 782	16.30	5	1 695	13.97
Unspecified	311	2.84	-47	584	4.81
Total	**10 934**	**100**	**-10**	**12 137**	**100**

Because of rounding, totals may not add up.

Figure 6. Supply of conversion services to EU utilities by provider, 2017-2022 (tU)



1.4. Conclusion of contracts

Table 5 shows the aggregate number of contracts, notifications, and amendments (2) relating to supply and services, including special fissile materials (enrichment services, enriched uranium, and plutonium), handled in 2022 according to ESA procedures.

Table 5. Contracts concluded by or notified to ESA

Type of contract and legal basis in the Euratom Treaty	Number of contracts in 2022
Small quantity (Art. 74)	22
Enrichment (Art. 75)	25
Services (Art. 75)	78
Contracts acknowledged under Art. 74 and Art. 75	**125**
Natural uranium (Art. 52)	50
Fissile material (Art. 52)	35
Supply contracts concluded under Art. 52 (except depleted uranium)	**85**
Depleted uranium (Art. 52)	**4**
TOTAL	**214**

1.5. Special fissile material

Deliveries of low-enriched uranium

The enrichment services (separative work) provided to EU utilities in 2022 totalled 10 732 tSW, delivered in 1 628 tonnes of low-enriched uranium (tLEU), which contained the equivalent of 12 356 tonnes of natural uranium feed. In 2022, enrichment service deliveries to EU utilities were 4% higher than in 2021, with nuclear power plant operators opting for an average enrichment assay of 4.22% and an average tails assay of 0.19%.

Enrichment service deliveries to EU utilities were 4% higher than in 2021.

Table 6. Origin of enrichment services to EU utilities

Enrichment origin	EUP tU 2022	Uranium feed 2022 (tU)	Quantities in 2022 (tSW)	SW Share in 2022 (%)	Quantities in 2021 (tSW)	SW Share in 2021 (%)
EU	1 037	7 706	6 678	62	6 385	62
Russia	458	3 710	3 239	30	3 190	31
Other	132	939	815	8	715	7
TOTAL	**1 628**	**12 356**	**10 732**	**100**	**10 290**	**100**

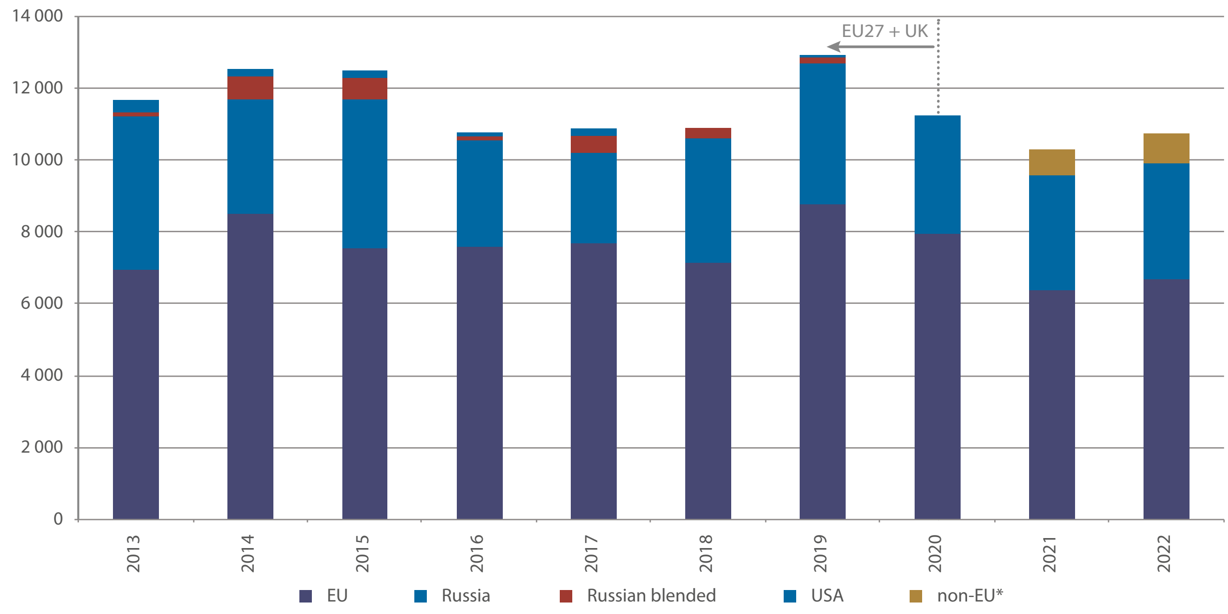
Enrichment services in the EU (by Orano-GBII and Urenco) covered 62% of EU requirements, totalling 7 706 tSW.

Deliveries of separative work from Russia (Tenex and TVEL) to EU utilities under purchasing contracts totalled 3 710 tSW, accounting for 30% of total deliveries. The aggregated

2 The aggregate number of amendments includes all the amendments to existing contracts processed by ESA, including technical amendments that do not necessarily lead to substantial changes in the terms of existing agreements.

total includes SWUs (separative work units) delivered under contracts concluded before joining the EU ('grandfathered' under Article 105 of the Euratom Treaty), which covered less than 4% of total EU requirements. No deliveries of downblended Russian highly enriched uranium were reported.

Figure 7. Supply of enrichment to EU utilities by provider, 2013-2022 (tSW)

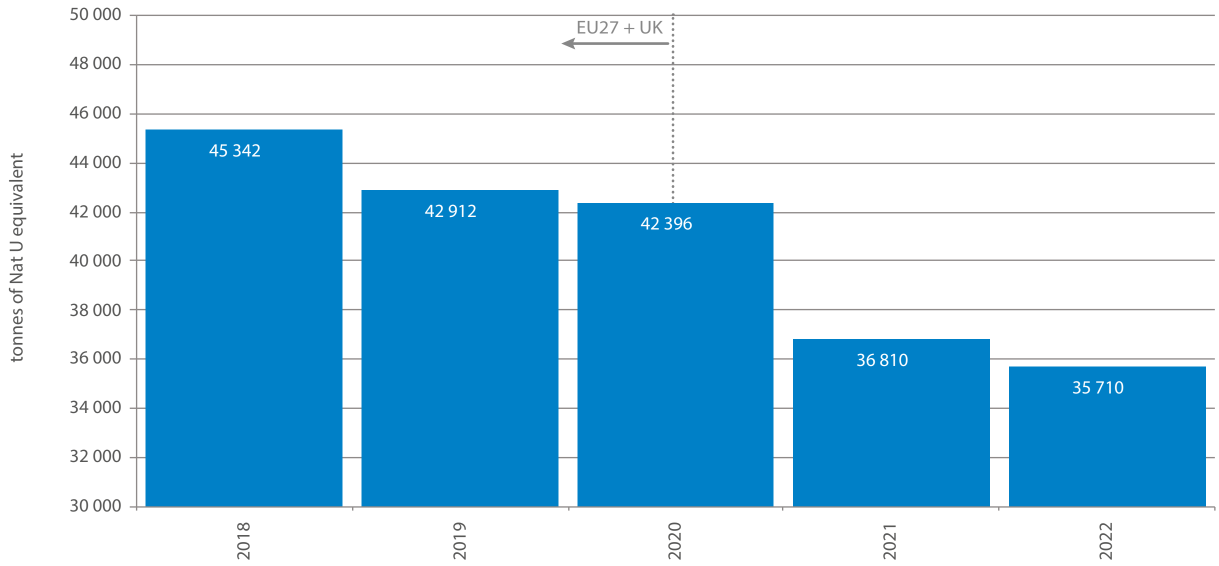


** non – EU – starting from 2021*

1.6. Inventories

At the end of 2022, the natural uranium equivalent in inventories owned by EU utilities totalled 35 710 tU. The inventories comprised uranium at different stages of the nuclear fuel cycle (natural uranium, in-process for conversion, enrichment, or fuel fabrication), stored at EU or other nuclear facilities.

Figure 8. Total natural uranium equivalent inventories owned by EU utilities at the end of the year, 2018-2022 (in tonnes)



The changes in the aggregated 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 (12 417 tU per year), uranium inventories are sufficient to fuel EU utilities' nuclear power reactors for 3 years on average. However, the average conceals a wide range, although all utilities keep a sufficient quantity of inventories for at least one reload.

> Uranium inventories can fuel EU utilities' nuclear power reactors for 3 years on average.

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

1.7. Future contractual coverage rate

As it is not always feasible for the maximum quantities of uranium and services contracted to be delivered, last year ESA introduced minimum contracted quantities into the coverage rate indicator.

The EU utilities' aggregated contractual coverage rate for a given year is calculated by dividing the maximum and minimum contracted deliveries in that year – under already-signed contracts – by the utilities' estimated future net reactor requirements 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.

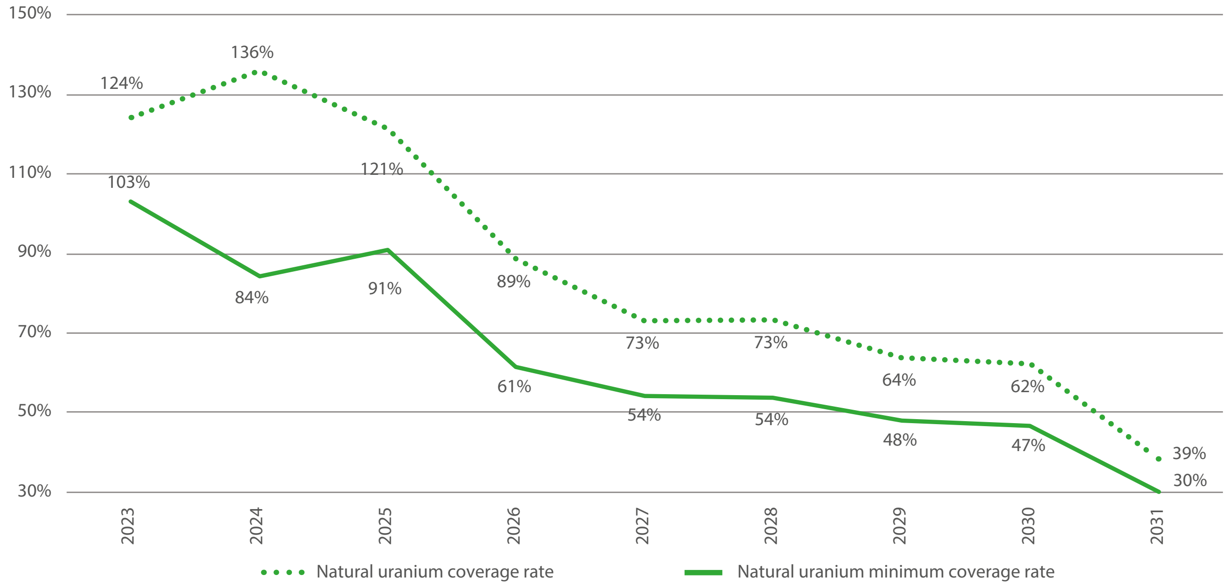
For net reactor requirements (the denominator), a distinction is made between demand for natural uranium and demand for enrichment services. Average net reactor requirements for 2022-2031 are estimated at 10 236 tU and 8 690 tSW per year (see table in Annex 1). ESA assumes the same quantity of requirements 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 UF_6, EUP or bundled contracts for fuel assemblies.

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, this situation changes when minimum contractual arrangements are calculated.

The supply of natural uranium is well secured from 2023 to 2026, with a maximum contractual coverage rate oscillating above 100%, dropping to 89% in 2026. In the long term, the uranium maximum coverage rate drops to around 70% in 2027 and then stabilises for one year before decreasing further to 64% in the 2029. It ends at 39% in the last year of analysis in 2031. The uranium minimum contractual coverage rate hovers between 91% and 103% from 2023 to 2025 and then drops to 61% in 2026, to continue its slow decrease in 2027 and beyond 2028. It ends at 30% in 2031.

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

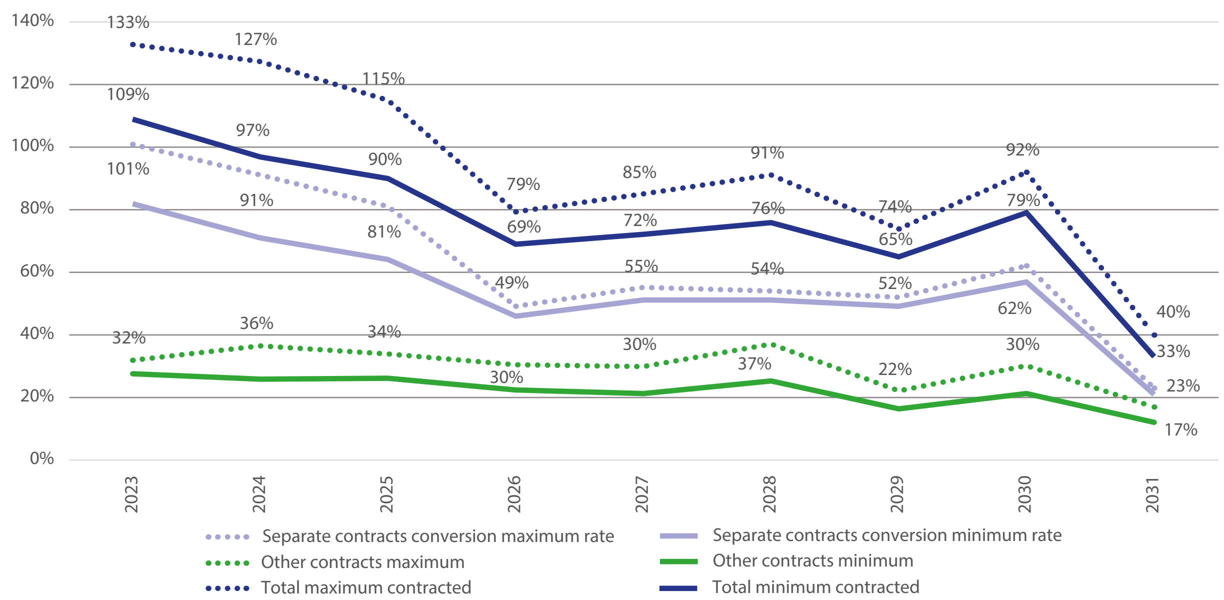
Figure 9. Coverage rate for natural uranium, 2023-2031 (%)



Quantitative analysis of conversion services shows that EU utilities' net reactor requirements are well covered under existing 'contracts, with maximum conversion services coverage rates above 100% until 2025. Supply is well secured until 2030, with a maximum contractual coverage rate fluctuating between 74% and 92% in 2026-2030. This drops to 40% in 2031, the last year in the analysis.

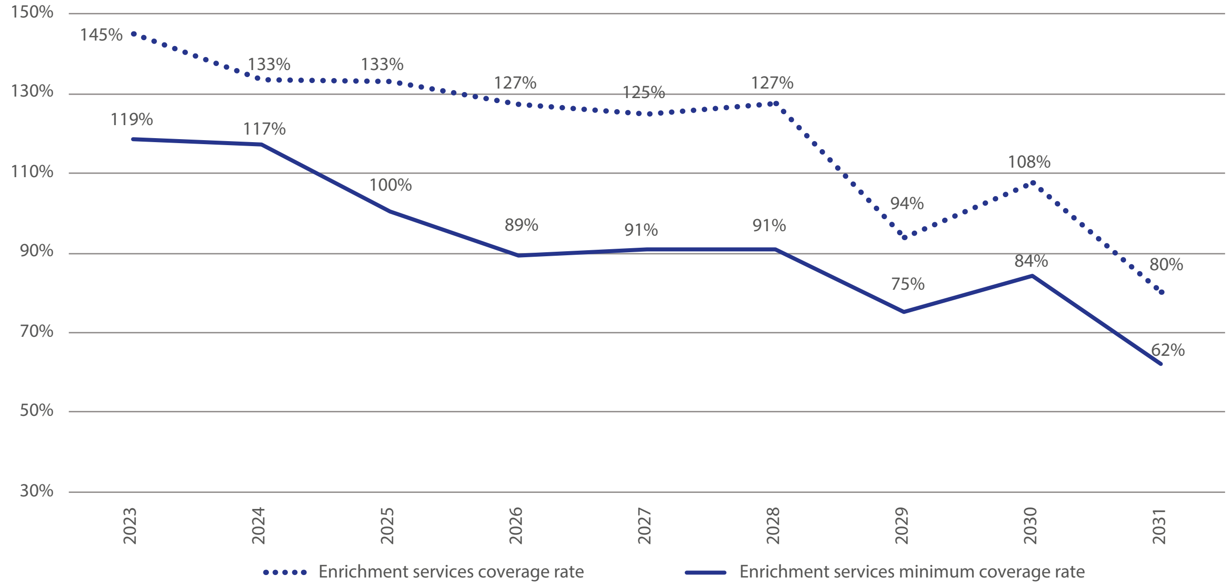
However, the picture is somewhat different for the minimum contractual coverage rate: minimum contracted supply of conversion services is between 90% and 109% of requirements in the first 3 years of analysis. It then fluctuates between 65% and 79% in 2026 to 2030 and drops to 33% in 2031.

Figure 10. Coverage rate for conversion services, 2023-2031 (%)



The supply of enrichment services is well secured in the whole analysis period. The maximum coverage rate varies between 94% and 145% up to 2030 but drops to 80% in 2031. The enrichment services minimum contractual coverage rate oscillates in a range from 91% to 119% in 2023-2028, then drops to 75% in 2029, bounces back up to 84% in 2030%, to end at 62% in 2031.

Figure 11. Coverage rate for enrichment services, 2023-2031 (%)



2. Security of supply

The regular and uninterrupted supply of fuels, both for power and non-power applications of nuclear energy, is of paramount importance for the European Union. Nuclear power plants generate a quarter of all electricity in the EU, with this share amounting to more than 40% in several Member States (France, Slovakia, Hungary, Bulgaria). Furthermore, millions of Europeans rely on the diagnostic and therapeutic uses of ionising radiation each year. Disruptions in supply would therefore have dire consequences for people, hospitals and industry.

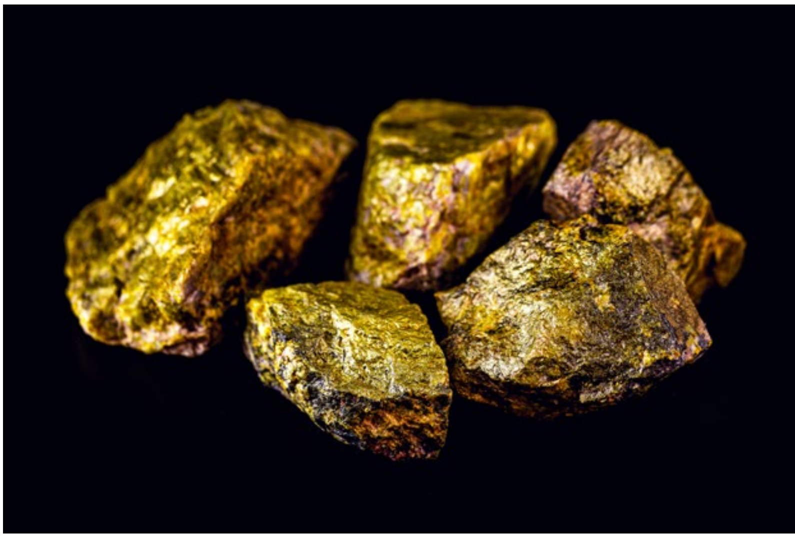
In 2022, the functioning of the nuclear market was profoundly affected by the major geopolitical developments that have occurred in Europe since the beginning of the reporting period. Russia's invasion of Ukraine has severely disrupted the global supply system for all sources of energy. It has also jeopardised the EU's security of supply for nuclear materials and services and aggravated dependence issues.

In response to the invasion, the EU decided to phase out or reduce its dependence on Russia, including in nuclear fuel supplies. According to the measures advocated in the REPowerEU Plan ([3]) of 2022, diversification options are important for Member States currently dependent on Russia for nuclear fuel for their reactors serving either power generation or non-power uses. It underlines the need to work together with global partners in order to secure alternative sources of uranium and boost the conversion, enrichment and fuel fabrication capacities.

As in other energy sectors, nuclear industry and power operators should aim to guarantee regular and sufficient supplies irrespective of the structure of the market for supplies. As outlined in previous Euratom Supply Agency (ESA) reports, various measures are available to reduce the risk of interruptions in supply or limit their effects – such as diversified and unbundled contracts, an appropriate level of inventories also for production, alternative transport routes and means etc. Since the market conditions are not sufficiently stable and the current geopolitical situation could potentially have a severe impact on the supply chain or logistics, mitigation measures should be in place to ensure the operation of power plants in the long term.

Ensuring security of supply from ore to nuclear fuel is a strategic objective of the Agency. It monitors developments in the nuclear fuel market and in relevant technological fields in order to identify market trends that could affect the security of the EU's supply of nuclear materials and services.

Uranium ore



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This chapter presents the Agency's analysis and recommendations based on data and information from monitoring the EU nuclear fuel market and global developments.

2.1. Analysis of market trends

The Agency has compiled comprehensive statistical reports on trends in the nuclear market (see Chapter 1) on the basis of (i) data related to the contracts it concluded or acknowledged; (ii) information gathered from EU utilities in the annual survey at the end of 2022; and (iii) market data from other sources. They are complemented by information on the developments affecting the market gathered through specialised media, information from stakeholders and open sources.

Demand

In 2022, 27% less fresh fuel (1 602 tU) was loaded into commercial reactors than in the previous year.

Natural uranium contained in the fuel loaded into reactors in 2022 totalled 10 993 tU, with the uranium delivered totalling 11 724 tU. In 2022, utilities bought more material than that loaded into reactors. This was in contrast to the

3 REPowerEU Plan: Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of Regions, adopted on 18.05.2022 – COM(2022) 230 final.

past 8 consecutive years, when EU utilities were loading more material into reactors than they were buying, which caused a steady drop in inventory levels. The level of inventories at EU level did not increase over the course of last year, but there were several utilities that purchased higher quantities of nuclear materials as part of security of supply measures.

Estimates of future reactor requirements for uranium and separative work had been steadily falling in recent years. In 2022, the trend stopped. On the one hand, requirements for Germany stopped and no longer caused the cumulative amounts to fall, while some Member States delayed or reversed the phasing out of nuclear.

Diversification

Key goals for the long-term security of supply involve ensuring that EU utilities have diverse sources of supply and do not depend too much on any single design or supplier from a non-EU country and maintaining the viability of the EU industry at every stage of the fuel cycle. ESA has recommended for many years that utilities cover most of their current and future requirements under multiannual contracts from diverse sources of supply.

Origin

In line with this recommendation, deliveries of natural uranium to the EU under multiannual contracts accounted for 98% of total deliveries in 2022. The remaining 2% were spot contracts. As for the mining origin, only four big producing countries – Kazakhstan, Niger, Russia and Canada – provided more than 90% of the natural uranium delivered to the EU, with the relative shares of individual producing countries varying.

Uranium originating in Australia noted a 82% decrease year on year. Deliveries from Russia decreased by 16% but were compensated by a strong increase in deliveries from other Commonwealth of Independent States (CIS) countries, namely from Kazakhstan and Uzbekistan. This increased deliveries from CIS countries by almost 2% in total. Canada was also among the countries with a high increase in deliveries of natural uranium to the EU, up by 50% year on year. Overall, deliveries of natural uranium to EU utilities are well diversified, although the number of countries of origin is narrowing. A number of utilities buy their natural uranium from only one supplier.

> Deliveries of Natural uranium from Russia decreased by 16%.

Conversion

As regards the providers of conversion services, 37.34% of EU requirements were covered by Orano Conversion (Philippe Coste facility), followed by Rosatom (22.35%), Cameco (21.16%) and ConverDyn (16.30%).

The aggregated volume of conversion contracts (separate and 'bundled' with other services) shows an increase in conversion services from Orano (10% up) and ConverDyn (5% up), and a decrease of 25% from Rosatom and 20% from Cameco compared with 2021.

A major part of conversion services is delivered under separate conversion service contracts, with half of the services delivered by the conversion plant located in France, and the rest delivered by Canada, the US and Russia. However, about one-third of the conversion services delivered to the EU in 2022 were supplied in contracts 'bundled' with other services (fresh fuel fabrication, EUP). For most 'bundled' contracts, conversion is done in Russia.

Enrichment

As for sources of supply of enriched uranium to EU utilities, 62% of enrichment services originated in the EU. The remaining services were provided by non-EU sources. Deliveries of separative work from Russia to EU utilities accounted for 30% of total deliveries.

Utilities opted for the same enrichment assay on average. This amounted to 4.22%, but the contracted tails assay was lower and amounted to 0.19% (compared to 0.22% in the previous year). On volume of deliveries, both EU enrichers increased their deliveries by 5%, while non-EU enricher deliveries increased by 4%, out of which Russia increased its deliveries by 2%.

Western-type reactor operators opted for fewer deliveries from Russia (down 16% compared with the previous year). This was compensated by deliveries from plants in the global West.

ESA notes the positive aspects (despite certain limitations) of recycling materials obtained from reprocessing spent fuel. Re-enriched reprocessed uranium fuel was at roughly the same level as last year. MOX fuel loaded into NPPs in the EU resulted in estimated savings of 3% of all-natural uranium loaded into reactors in the EU.

Fuel fabrication

Most EU utilities have access to at least two alternative fuel fabricators. In stark contrast with the situation elsewhere in the EU, dependence on a single design and supplier of fuel for water-water energy reactors (VVER) remains a significant vulnerability to the security of supply. The Agency notes the efforts by operators and producers to design, license and create fabrication capacity as well as contract alternative fuel for VVER reactors. Countries dependent on VVER-type reactors plan to diversify and have taken their first steps to diversify fuels. Some have signed contracts with alternative suppliers or are in the negotiation process (4).

> Dependence on a single design and supplier of fuel for VVER reactors remains a significant vulnerability to the security of supply.

VVER utilities have been increasing their fuel stocks to tide them over until alternative fuel is available and licensed. This has led to an increase in the conversion and enrichment services delivered from Russia by 30% and 22% respectively year on year.

Pellet loading into fuel rods

©Enusa

Inventories

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

Several utilities increased their stocks in 2022 to address the current geopolitical situation and unstable market conditions. On average, the inventory could fuel a utility for three years, but this masks a wide range of coverage. Whether this inventory level is sufficient for a particular utility depends on its profile and risk factors. ESA considers that inventories remain at a healthy level for most utilities.

The overall EU inventory level decreased by 3%, a trend observed for at least 8 consecutive years and one that reflects the decreasing cumulative needs.

Changes in the total volume of natural uranium inventories do not necessarily reflect the difference between uranium delivered to EU utilities and the natural uranium equivalent loaded into reactors, as the level of inventories is also influenced by movements in loaned material, sales of uranium to third parties and occasional transfers of material mined in the Community.

EU and global fuel cycle market (conversion and enrichment)

ESA developed an analysis of the conversion and enrichment markets based on (i) the information reported directly to it by EU-based enrichment and conversion plants, service providers and fuel producers; (ii) data coming from the Euratom utilities as part of the annual survey; (iii) World Nuclear Association global uranium demand scenarios (5); and (iv) other open-source information.

Fleet requirements from Euratom Member States for the coming years are well covered by contractually secured supplies and services on average. Nevertheless, it is important to know that it may not be possible to execute all options in existing contracts from open market suppliers to make up for deliveries from high-risk suppliers.

> In the medium and long term, the market in the 'global West' may not be self-sufficient for conversion and enrichment services unless some plants ramp up production and expand their capacity by making investments.

4 At the time of publication in September 2023, Hungary had not yet contractually committed to an alternative supplier.
5 The Nuclear Fuel Report, Global Scenarios for Demand and Supply Availability 2021-2040, Nuclear Fuel Report: Global Scenarios 2019-2040 – World Nuclear Association (world-nuclear.org)

On enrichment services, an analysis of demand scenarios shows that there is a lack of capacity in the enrichment sector when considering both global and 'global West' demands. The nominal as well as real output of EU facilities would allow the EU to be self-sufficient. The US has a less privileged position, with huge needs and relatively small domestic capacity.

When the capacity of enrichment plants in the West is analysed, there is a missing capacity of up to 2 500 tSWU by 2030. The gap could be compensated to a limited extent by existing inventories, but it may induce enrichers to switch to overfeeding the centrifuges. However, overfeeding would require considerably more converted uranium, which would stress the upstream conversion process. Overfeeding would also raise demand for UF_6 produced by conversion plants by up to 20% of the current needs. An additional conversion capacity of 2 500 tU would need to be installed.

In the stable demand scenario, western reactors will be missing about 6 000 tU of conversion capacity per year, which could be mitigated if the ramping up of existing plants is completed on time. If the nominal capacities of the conversion facilities in France (Orano Conversion - Philippe Coste facility) and in the US (ConverDyn) were to be reached, they would be just enough to cover the global West demand for conversion services until 2032.

In the event of increased demand, e.g., due to the overfeeding strategy in enrichment plants, the western world could even have a capacity shortage of up to 10 000 tU each year after 2025. Restarting the Springfield facility in the UK may help but would not happen before 2026. If several new reactors are built in the EU as scheduled, the global West would have a capacity shortage after 2032. The timeliness of bringing new capacity online, commissioning new builds and taking decisions on nuclear plant life extensions would also be decisive factors.

The Agency notes a continuous lack of sufficient investment in the fuel cycle, which is undermining the long-term security of supply.

The extent of the potential capacity shortage in conversion and enrichment depends on the trade exchange between the global West and emerging economies. On the one hand, the volume of commercial commitments undertaken by western industry with customers outside the global West reduces the capacity available to western utilities. On the other hand, western users' gaps may be filled by new capacity in emerging economies other than Russia.

Concerning conversion and enrichment services for reprocessed uranium, the analysis shows a lack of capacity in the Western market (particularly for conversion), which could jeopardize the ability to benefit from the advantages offered by reprocessed uranium in terms of energy independence, environmental impacts and economics.

Medical radioisotopes

For the first time, the Agency is also including in its findings aspects related to the European production of medical radioisotopes. This is based on information from stakeholders and its own analysis.

ESA notes that foreign dependencies exist in several steps of the medical radioisotope supply chain. This threatens the EU's strong position in producing medical radioisotopes and endangers the development and application of nuclear medicine products and procedures.

EU's strong position is threatened by foreign dependencies in the medical radioisotopes supply chain.

One of the key conditions for the uninterrupted supply of medical radioisotopes is the availability of nuclear materials for the production of irradiation targets and fuel for research reactors. High-assay low-enriched uranium (HALEU) is currently not produced in the EU but is imported from the US and Russia. However, uncertainties exist regarding both sources – Russia being a high-risk partner and US stocks estimated to last until 2035-2040, depending on the actual consumption of the existing stockpile.

If we cannot ensure the provision of HALEU after 2035, the production of the most frequently used medical radioisotopes is at risk. The Agency's Advisory Committee working group recently identified options for achieving different levels of security of HALEU supply for the EU. These range from continuing to purchase it from the US and Russia, an ESA HALEU bank with a 10-year reserve, to autonomy thanks to European production. Depending on the option selected, a set of actions, commitments and financing would be necessary from the EU, its Member States, industries and end users.

The EU still has technical know-how on how to convert uranium metal, but this may soon be lost as the metallisation process on an industrial scale has been suspended in the EU for more than 10 years.

ESA also notes as a point of concern dependence on Russia for the enrichment of stable isotopes needed for the production of several new medical radioisotopes.

An increasing variety and volume of enriched isotopes will be needed for radionuclide production to support the development of new treatments in the fight against cancer. In addition, enriched isotopes currently sourced partly from Russia will be needed in the longer term to develop non-fission alternatives to the most used radionuclide in nuclear medicine, Technetium-99m (Tc-99m), which will remain essential in the next few decades. The continuing EU dependence on Russian imports could therefore have a significant impact on Member States' ability to meet existing patient needs and support the development of future cancer treatments.

The European capacity for enrichment of source materials and stable isotopes needs strengthening, which is only possible with investment. The lack of EU-based electromagnetic or other suitable enrichment capability is a major concern. Similarly, recycling/reusing costly enriched source materials would help reduce waste and increase EU competitiveness but requires new dedicated installations to be built. Maintaining and developing European capacity for the enrichment of stable isotopes through centrifugation, possibly combined with another method of enrichment, is equally important. Developing cyclotron-based radionuclide production would increase the need for centrifugation-enriched materials, so could only be achieved by expansion of the European capabilities.

The European capacity for enrichment of source materials and stable isotopes needs strengthening.

Yet another important missing element for maintaining the uninterrupted supply of medical radioisotopes is a system for monitoring the supply and producing long-term forecasts. It will inform decision makers and stakeholders about the data needed to develop policy, shape strategy as well as make decisions on investment in the supply chain. ESA notes that such a system needs to cover a broader spectrum of radioisotopes and production methods.

2.2. Recommendations

Based on its analysis, ESA concludes that, in the medium and long term, EU utilities' demand for both natural uranium and fuel fabrication and related services faces an increased risk related to the Russian supply and connected to the new geopolitical situation. In fuel fabrication, 100% reliance on a single design and supplier of VVER fuel remains a matter of concern to some extent as the utilities concerned have been taking medium-term measures.

In the short term, a limited number of utilities remain contractually bound to single suppliers. ESA considers that contracts that bundle the sale of fuel assemblies with other transactions and/or conditions or stages (uranium, conversion, enrichment, fuel fabrication) represent a vulnerability in security of supply, in principle.

Analysis of the nuclear industry (converters and enrichers) indicates that the total open market conversion capacity may not be sufficient. Similarly, there is insufficient capacity to supply enrichment from the same open market sources if the services from current non-open market players such as Russia are no longer available. Building the additional conversion and enrichment capacity required could take several years, while it is unclear whether financial support from the Community to increase the security of supply would receive the unanimous support of all Euratom Member States.

The Agency puts forward the following recommendations for actions needed to address existing vulnerabilities.

EU and national level policy

Clear policy needed

Following the national objectives for security of energy supply and energy mix choices, the Member States that embrace nuclear power generation should define the conditions that their nuclear utilities should meet to ensure the security of supply. Clarity on nuclear energy objectives, technology, nuclear fleet (long-term operation and new builds) and supply chains would provide the utilities and industry with a stable environment to take strategic and operational decisions.

Address supply chain vulnerabilities

Clear political and policy decisions at both EU and Member State level are needed to address the supply vulnerabilities identified in the interests of both power and non-power uses of nuclear energy.

The Community and Member States should determine their acceptable level of exposure with respect to high-risk profile partners or operations/transactions. They should 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).

Based on its analysis, the Agency believes that industry investment, particularly with regard to enrichment and conversion capacities, would not be viable without some form of political commitment. It therefore urges decision makers to consider the issue as a matter of utmost priority.

Preparedness at EU level

The Community should give consideration to developing emergency policies and measures for crisis management, similar as for other sources of energy. This could include retaining EU industry capacity and essential services for EU users, building common emergency stocks, and reinstating a common purchase and distribution mechanism under the Euratom Treaty.

On strategic stockpiling for use in emergency situations, the Community would benefit from a coordinated approach, mindful of the Euratom Treaty provisions and the special capital, financing and technical effort involved. Due consideration should be given to adequate amounts of material at different stages of the fuel cycle (e.g., natural uranium, converted uranium, enriched uranium products, fuel assemblies), given the time needed to recover from an emergency.

Multilateral approach needed

The EU, Euratom Member States, producers and users could benefit from an international multilateral approach involving all countries concerned to coordinate – rather than compete on – the phasing out of suppliers with a high-risk profile.

Monitor security of supply

The security of energy supply should be monitored at different levels: EU/Euratom, national and utility level. This should be a coordinated effort to include all viewpoints and interests.

Energy regulators, safety regulators, grid operators and electricity holdings should factor the nuclear supply risk into their risk assessment and preparedness. All parties concerned should cooperate to strengthen mechanisms for data and information sharing on the evolution of factors affecting the supply for nuclear fuels and relevant products.

The Commission, ESA and national authorities should jointly monitor the implementation of diversification plans for VVER reactor fuel and take action to eliminate any risks or threats to their timely completion.

Maintain and advance technology

Strategic industrial investment should be encouraged, especially in technologies. Investment needs to be stepped up to adapt current industrial capacity to the market and to geopolitical developments, and to maintain an appropriate level of technology and technical expertise in the front end and back end of the fuel cycle.

All options should be explored to ensure the continued existence in Euratom of (i) Community capacities for producing enriched uranium; and (ii) nuclear fuel designs sufficient to ensure a diversification of supply sources freely available to users in the Community. This should also include the supply of HALEU for research reactors and radioisotopes.

Support the nuclear common market

Renewed consideration should be given to fully implementing the nuclear common market by adopting appropriate measures to underpin its efficiency. In that respect, increased cooperation between nuclear safety authorities in the individual Member States, in full mutual trust of implementing the highest safety standards, could facilitate the licensing, among other things, of alternative or advanced fuel designs and medical radioisotope packaging. It could even pave the way for an alignment of relevant norms, standards and procedures.

Maintain skills and knowledge management

Further efforts are needed to make the nuclear sector (power and non-power use) attractive to skilled workers and young graduates.

Risk assessment, response and monitoring

Monitor risk exposure

Market players should continue monitoring the market and carrying out contractual due diligence as a means of controlling their exposure to a changing market and averting security of supply vulnerabilities.

Risk factors connected to security of supply include:

- legal and economic ownership;
- physical location of the nuclear materials and control over them;
- geographical origin, which may be different from customs origin;
- risk profile of transactions or commercial partners and suppliers;
- consequences of the evolving geopolitical situation.

Develop and implement mitigating measures

Based on Community and national decisions, all market parties concerned, in particular utilities, research reactor operators and radioisotope producers, should establish and implement as needed alternative plans to mitigate identified risks.

Supply of material and services

Maintain diversified sources

Taking into account the narrowing of uranium origins in 2022 and a single non-EU supplier purchase by a number of utilities, the Agency stresses the need for multiannual contracts with diverse sources of supply.

In the current geopolitical situation, more diversification within friendly jurisdictions is an appropriate way of securing future deliveries. Ideal security of supply means at least two alternative suppliers for each stage of the fuel cycle, and whenever possible at least one EU supplier for services.

Long-term commitments help trigger investment and therefore increase the conversion and enrichment capacity in the EU and/or in low-risk, reliable EU partner countries. At the same time, western producers should bear in mind that excessively high prices encourage users to explore other supply options, which is likely to stall western investment.

Look for new and secondary sources

Prospecting for and exploiting mineral deposits for the benefit of users in the Community domestically or in favourable jurisdictions should be seriously considered, with due respect for sustainability aspects.

To help preserve natural resources and promote a more circular nuclear economy, all available solutions should be pursued to facilitate the production, circulation and use of alternative and recycled uranium and plutonium products. Efforts are needed in relation to the development of EU capacity to replace the dependence on technologies like reprocessing, uranium and plutonium recycling or the fast breeder option. This includes new investment as well as the preservation and protection of research investment already made and knowledge already acquired by Euratom.

Material for advanced fuel (LEU+, HALEU)

Member States and utilities should consider drawing up reliable and trustworthy plans for the adoption of advanced fuel or reactors requiring low enriched uranium plus (LEU+) or HALEU, and then liaise with ESA to form a consistent view of the future needs for such material.

Fuel fabrication

Diversification

The utilities and research reactor operators that depend on a non-EU fuel design or supplier should continue developing and implementing diversification plans that cover all diversification aspects and all steps in the process. Special care should be given to accelerating the market introduction of alternative fuel design solutions for reactors that are currently bound to a single non-EU design, particularly reactors planned for long-term operation.

The new builds should map out at an early stage the supply diversification strategy for fuel.

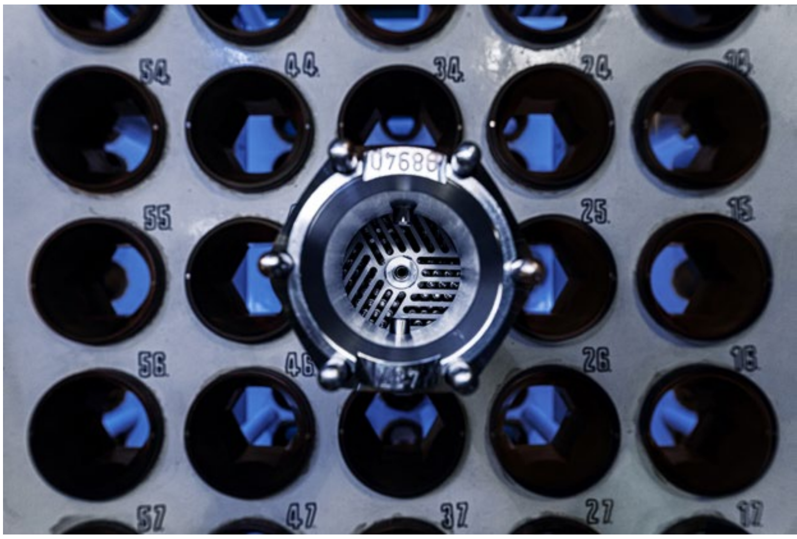
Actively search for diversified EU solutions

Operators of power reactors dependent on a single non-EU design for fuel assemblies and components should engage in a long-term solution through program of developing an alternative fuel design based on European intellectual property rights and a European supply chain.

Cooperation

Cooperation between industry, operators and regulators is vital to reduce the time to design and market alternative VVER nuclear fuel, furthering the security of supply with safety at the fore. All options should to be explored to ensure the continued existence in the Community of domestic capacities for designing and producing alternative fuel.

Fuel assembly in storage rack



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Stocks and inventories

National reserves

In the absence of a Community initiative, Member States that have not done so yet should consider building emergency stocks.

Adequate operational inventories

Utilities are advised to maintain – in low-risk locations (e.g. the EU) – adequate inventories of nuclear materials to cover future requirements, and to use market opportunities to increase them. Appropriate inventory levels should be maintained not only by utilities but also by producers to avoid risks of shortages in the nuclear fuel supply chain.

EU Member States, producers and users are invited to take a coordinated rather than competitive approach, considering the financing and technical efforts involved.

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 should also include a number of reloads to tide them over until the availability of alternative fuel in the event of definitive interruptions to the fuel supply that are dependent on a non-EU design and supplier.

Location of inventories

Analysis of inventories of EU utilities shows that it is undefined the location of a part of inventories related to future deliveries. All other conditions being equal, owners of nuclear fuels and related materials are invited to prefer physical storage and transportation at locations and by carriers in Euratom or friendly jurisdictions, e.g., storage facilities on Member State territories.

Tendering and contractual aspects

Contract now for long-term needs

Long-term commitments are required to trigger investments that can enable increased conversion and enrichment capacity in the EU and/or in low-risk, reliable EU partner countries. Supply contracts concluded for a period longer than 10 years are possible with additional authorisations ([6]).

Planning tenders

In planning their tenders, market players should carefully consider the selection criteria to give due weight to the security of supply risks. Fuel supply diversification for the same reactors needs to be actively pursued. Market players are strongly recommended to inform ESA about their tender plans and seek its opinion and advice on matters in the Agency's remit in order to facilitate the smooth conclusion of contracts.

Unbundling options

Contracts that bundle supplies of fuel assemblies with other transactions and/or conditions, potentially connected to various stages of the nuclear fuel cycle, can lead to dependence on a single supplier and hamper market functioning and transparency. Parties engaged in such contracts with third-country suppliers are recommended, following negotiations, to be allowed to have different suppliers in the various stages of the fuel cycle without facing any kinds of penalties and to seek transparency in the prices of the individual transactions covered by their contract.

Technical data sharing

Relevant contracts must state the condition to address intellectual property rights and other limitations in order to allow (i) sharing of the relevant technical data, with a view to enabling other suppliers to design alternative fuel, and (ii) testing of such alternative fuel, so it can be licensed by the regulatory authorities.

Open new build contracts

Particular attention should be paid to investment in building new nuclear power plants in the EU using non-EU technology. This will ensure that these plants are not dependent exclusively on a single non-EU design of nuclear fuel: any new investment has to be conditional on being able to diversify the fuel design. Contract terms must expressly provide for the licensing and use of fuel assemblies from other suppliers, in particular by providing for the disclosure of fuel compatibility data and the testing of alternative fuel assemblies.

Contractual terms

Parties engaging in contracts with non-EU parties should be mindful of financial and payment terms. A careful approach is recommended, given possible future developments such as excessive price volatility or unstable or unilateral currency exchange rates and inflation rates. Payment in EUR should be preferred.

Attention is drawn to the fact that 'force majeure' may not be understood/interpreted in the same way by all contractual parties.

Holding accounts

Market players who rely on third-party contractual or holding account arrangements to hedge their supply security vulnerabilities are advised to take due account of potential geographical, political and other risks, while giving their agreement on fungibility, storage location and transportation clauses.

6 Article 60 of the Euratom Treaty.

Transport

Alternative routes and modes of transport

Users and producers should continue to monitor transport risks and establish alternative routes and alternative modes of transport, taking into account origin and transit risks.

Carriers

Industry, users and their associations should consider taking joint action to:

- inform carriers about the existing restrictive measures and the exemptions for nuclear fuel cycle transport;
- increase the set of available carriers of nuclear materials and fuels in the different transport means;
- make available an appropriate information source on EU and global carriers that are able to transport nuclear goods.

Alignment

Efforts should be continued to develop a uniform pan-European arrangement for handling cross-border transport package approvals that is valid in each country.

Medical radioisotope supply chain

Alternative fuel for research reactors

Research reactor operators dependent on a non-EU supplier or fuel design should accelerate the development and implementation of their diversification plans. Special efforts should be taken to push forward EU fuel design and production solutions, namely those coordinated through Euratom research programmes ([7]).

Of paramount importance is the cooperation between industry, operators and nuclear regulators to increase the efficiency of these projects.

Address HALEU vulnerability

Clear political decisions are needed at both EU and Member State level to address HALEU future supply vulnerabilities. The EU, national authorities, industry and users should explore all options ([8]) to ensure EU autonomy and the continued HALEU supply to Community users for medical and research purposes.

Consideration should be given to establishing EU production by taking advantage of the domestic industry, its capacities, know-how and technology, in particular maintaining EU technical know-how on the metallisation process.

Improve security of supply of source materials and stable isotopes

The EU, Member States and industry should address foreign dependencies of supply of source materials and stable isotopes needed for the production of medical radioisotopes. This will ensure that current patient needs are met and will support the development of future cancer treatments by:

- diversifying the sources of supply;
- recycling/reusing costly enriched source materials;
- maintaining and developing the European capacity for enrichment of source materials and stable isotopes, regardless the method of enrichment.

Forecast and monitoring system

To provide patients with a reliable supply of medical isotopes for diagnosis and treatment, the EU, Member States, industry and nuclear medicine stakeholders should build on the experience of the European Observatory on the Supply of Medical Radioisotopes and establish a system to monitor the security of supply of key medical radioisotopes, regardless of their production method, and establish long-term forecasts of requirements in the EU.

In addition, such a system could provide decision makers and stakeholders with facts and information for shaping strategy, developing policy, and making investment decisions in the supply chain.

7 Euratom Research and Training Programme (europa.eu)
8 HALEU report May 2022, 05.07.2022 (europa.eu)

3. Overview of EU developments

3.1. Euratom

3.1.1. EU nuclear energy policy

Like the previous year, 2022 was an important year for EU energy policy. In addition to the challenges posed by the pandemic and the energy price crisis, it was marked by the Russian war of aggression against Ukraine.

In this context, the Commission closely monitored the potential impacts of the conflict on the safety of Ukraine's nuclear facilities. The Commission also reviewed its emergency preparedness and response measures applicable in case of radiological/nuclear events, in coordination with European nuclear safety and radiation protection authorities.

The EU and its Member States provided direct support to Ukraine for nuclear safety and radiation protection in the form of material assistance, notably through the EU Civil Protection Mechanism (EUCPM) and the European Instrument for International Nuclear Safety Cooperation (INSC). In addition, the EU provided funding to the International Atomic Energy Agency (IAEA) to support their activities in Ukraine, including the IAEA's experts' safety and security missions to Ukraine's nuclear power plants (NPPs).

As regards security of supply in the nuclear field, the Commission, through its Directorate-General for Energy, launched consultations with Member States operating VVER reactors, which are fully dependent on Russian nuclear fuel [9], to accelerate diversification of fuel supply. The Commission also reached out to different international partners and commercial suppliers to review the supply situation on the market for nuclear fuel and related services, such as uranium conversion and enrichment, in the short and medium term.

The Commission continued to monitor the impacts of the COVID-19 pandemic and the resilience of the nuclear sector in cooperation with the European Nuclear Safety Regulators Group (ENSREG). In March 2022, it published a study [10] on the topic.

Despite all these additional challenges, the Commission vigorously pursued the European Green Deal by following up on the RePowerEU Communication [11] and putting forward the REPowerEU plan aimed at reducing the EU's dependence on imports of Russian fossil fuels by:

- accelerating the rollout of renewables,
- increasing investment in energy efficiency,

and

- diversifying the EU's energy supplies and suppliers.

The first two points build on the Commission's European Green Deal initiative. The main legislative aspects of REPowerEU aim to increase the ambition of the revisions to the Renewable Energy Directive, the Energy Efficiency Directive and the Energy Performance of Buildings Directive.

> The Commission approved the Complementary Climate Delegated Act concerning six specific economic activities in the area of nuclear energy and natural gas to be included in the list of economic activities covered by the EU Taxonomy. The Complementary Delegated Act was published in the Official Journal following scrutiny by the European Parliament and Council, with applicability from 1 January 2023.

9 Bulgaria, Czechia, Finland (partially dependent), Hungary, Slovakia.
10 Resilience of the nuclear sector in Europe in the face of pandemic risks - Publications Office of the EU (europa.eu)
11 Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions

Related to the above, the Commission approved the Complementary Climate Delegated Act ([12]) concerning six specific economic activities in the area of nuclear energy and natural gas to be included in the list of economic activities covered by the EU Taxonomy. The Complementary Delegated Act was published in the Official Journal following scrutiny by the European Parliament and Council, with applicability from 1 January 2023.

As another part of their decarbonisation agenda, a number of EU Member States are considering new nuclear technology options, including small modular reactors (SMRs). Preparatory activities for a European Partnership on SMRs were launched by stakeholders; the Commission followed these activities very closely. It is envisaged that the first European SMRs will become operational at the start of the next decade. This initiative is being developed in the form of a collaboration scheme involving industrial stakeholders, research and technological organisations, interested utilities and EU Member States, and European regulators.

The preliminary goal is to identify enabling conditions for and constraints on safe design, construction and operation of SMRs in Europe in the next decade and beyond in compliance with the EU legislative framework in general and the Euratom legislative framework in particular, to contribute to decarbonisation of the EU energy sector.

In November 2022, the Commission, together with Czech Republic as hosting country, organised the 15th European Nuclear Energy Forum (ENEF) in Prague. The Forum was an occasion for broad discussion among all stakeholders on the opportunities and risks of nuclear energy. The focus was on the role of nuclear energy in decarbonising the EU energy system by 2050 and how well the nuclear ecosystem is prepared for that.

The Commission continued to review the correct and effective transposition and implementation by the EU Member States of the Euratom legal framework on nuclear safety, radioactive waste management and radiation protection. In April 2022 the Commission published its second report on the implementation of the amended Nuclear Safety Directive ([13]), which highlighted the good level of implementation of the Directive's obligations and made recommendations for further improvement. In November 2022 the Commission organised a dedicated workshop on the implementation of the Directive, at which representatives of the Member States, international organisations and non-governmental organisations (NGOs) came together to identify key nuclear safety topics to be focused on in the coming years.

The Commission continued the dialogue with the Member States to ensure proper implementation of the Radioactive Waste Directive. Six reasoned opinions were issued. At the same time, one infringement case was closed.

3.1.2. Radioactive waste management and nuclear decommissioning

The Commission prepared its fourth report for the European Parliament and the Council on the implementation of Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel, based on the Member States' national reports, and it was adopted on 16 February 2023. It also drafted its third report for the European Parliament and the Council on the implementation of Council Directive 2011/70/Euratom on the responsible and safe management of spent fuel and radioactive waste. This report is expected to be formally adopted in early 2023.

Concerning the Nuclear Decommissioning Assistance Programmes (NDAP) in the 2021-2027 Multiannual Financial Framework (MFF), a budget of EUR 1.18 billion ([14]) was allocated to support decommissioning activities in Lithuania, Bulgaria, Slovakia and Joint Research Centre (JRC) facilities. In Ignalina (Lithuania), all spent fuel assemblies from Units 1 and 2 have now been removed and safely stored. Substantial progress was also achieved in Bohunice (Slovakia), where the dismantling of the primary circuit in both units was completed, and in Kozloduy (Bulgaria), where the decommissioning operator successfully completed the decontamination of the primary circuits of Units 1-4, with outstanding results. Each of the decommissioning operators also created one decommissioning knowledge product in 2022, thus contributing to the new objective of knowledge dissemination across the EU, a task led by the JRC.

12 COMMISSION DELEGATED REGULATION (EU) 2022/1214, formally adopted on 9 March 2022, amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities.

13 Report from the Commission to the Council and the European Parliament on the progress made with the implementation of Directive 2009/71 Euratom establishing a Community framework for the safety of nuclear installations amended by Directive 2014/87/Euratom

14 The EU's 2021-2027 long-term Budget and NextGeneration EU, Facts and Figures (p46)

3.1.3. External dimension of nuclear energy policy considering Russia's war of aggression against Ukraine

The Commission remained engaged in strengthening nuclear safety globally through close collaboration with international organisations and neighbouring non-EU countries. It continued its collaboration with international organisations in the nuclear field such as the IAEA and the OECD Nuclear Energy Agency (NEA) and was represented in the Executive Committee meetings of the International Framework for Nuclear Energy Cooperation (IFNEC).

In September 2022, the European Atomic Energy Community (Euratom) signed a new memorandum of understanding (MoU) with IAEA on nuclear safety cooperation, updating the previous agreement from 2013 and extending activities to include emerging areas of common interest, such as education and training, SMRs and the safety of fusion installations. The MoU also aims to further strengthen the cooperation in the areas of radiation safety, waste safety and emergency preparedness and response.

In September 2022, the European Atomic Energy Community (Euratom) signed a new memorandum of understanding (MoU) with IAEA on nuclear safety cooperation, updating the previous agreement from 2013 and extending activities to include emerging areas of common interest, such as education and training, SMRs and the safety of fusion installations.

Nuclear safety in the EU neighbourhood was pursued through the post-Fukushima nuclear safety stress tests in non-EU countries, organised by the ENSREG with the support of the Commission. Following the completion of the stress tests peer review of the Belarusian NPP in Astravets, attention turned to the next ENSREG peer review, namely the stress tests on the Akkuyu NPP project on the southern coast of Türkiye. The peer review team completed the desktop review of the plant's nuclear safety stress test report, and a document review visit to the national regulatory authority took place in May 2022. The second peer review mission is scheduled to take place in the second quarter of 2023, depending on the progress on the construction site.

Much of the attention, in line with the Euratom Treaty objectives, was paid to the impacts of the Russian war of aggression in Ukraine – both in Ukraine and in the EU. Ukraine's nuclear energy sector has been significantly affected following Russia's military actions. The nuclear safety developments in Ukraine were one of the main concerns for ENSREG, the members of which were regularly informed of the situation by the Ukrainian nuclear safety regulator SNRIU. In view of the increased risk of radiological incident, the Commission worked together with the European nuclear safety and radiation protection authorities in ENSREG, the Western European Nuclear Regulators' Association (WENRA) and Heads of the European Radiological Protection Competent Authorities (HERCA) to develop situation-specific accident scenarios and strengthen accident preparedness and response.

In the field of nuclear emergency preparedness and response (EPR), the Commission ensured the continuous operation of the European Community Urgent Radiological Information Exchange (ECURIE) system for the exchange of urgent information in the event of a radiological emergency and the European Radiological Data Exchange Platform (EURDEP) system for the exchange of radiation monitoring data. An upgraded version of the EURDEP web interface was launched in cooperation with the Commission's JRC. The ECURIE annual crisis-management exercise, ECUREX 2022, was also successfully carried out in cooperation with the competent national authorities. A special ECURIE procedure was established to ensure systematic monitoring of radiation levels in conflict areas in the context of Russia's war of aggression against Ukraine.

The war in Ukraine demonstrated the need to address the physical protection of NPPs. If targeted by military action, NPPs could pose risks to the EU. Therefore, at the international level, the Commission has started a discussion process on strengthening the international framework to protect nuclear sites in the context of armed conflicts.

Russia's war of aggression against Ukraine has also significantly disrupted the world's energy system, leading to issues regarding security of supply in the EU given the risks of dealing with Russia as an untrustworthy partner and supply chain disruptions that might occur as a consequence of the war. The Commission has worked closely with the Euratom Supply Agency and other stakeholders on diversification of supply. On one hand, it has encouraged diversification in the supply of nuclear fuel for the Russian-designed VVER-type reactors in operation in the EU. These reactors, located in Bulgaria, Czechia, Finland, Hungary and Slovakia, are fully dependent on Russian fuel. The Commission held several meetings in 2022 with government and utilities' representatives from countries operating Russian-designed reactors. Furthermore, in the EU countries operating VVER reactors there is a dependency on Russia at about 60% for both uranium conversion and enrichment. In other EU countries operating non-VVER reactors, a similar dependency exists, albeit at lower levels of about 25%. Diversification away from dependency on Russia has been stressed in the REPowerEU plan and in a European Parliament Resolution of 7 April 2022.

There is further dependency on Russia in the domains of certain medical radioisotopes and the fuel for research reactors.

The Commission conducted preparatory work for potential policy actions in the area of security of nuclear fuel supply and supply of related nuclear fuel cycle services.

3.1.4. Cooperation with the United Kingdom in the nuclear field (post-BREXIT)

Following the successful conclusion of the Euratom/UK Nuclear Cooperation Agreement (NCA) at the end of 2020, the Commission and the United Kingdom signed the detailed technical Administrative Arrangements for the implementation of the Euratom/UK NCA in January 2022.

EU and UK

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The Commission and the United Kingdom signed the detailed technical Administrative Arrangements for the implementation of the Euratom/UK NCA in January 2022.

In accordance with the provisions of the NCA, the United Kingdom participated as observer in the work of ENSREG and the Group of Experts referred to in Article 31 of the Euratom Treaty and continues to provide data to the EURDEP. The Commission has further invited the United Kingdom to take part in the ECURIE. The United Kingdom has still to complete the required internal approval process.

3.1.5. Euratom safeguards

'Euratom safeguards' is the legal and technical term which describes 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 Commission department responsible for Euratom safeguards, which it implements by means of a set of 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 used appropriately and peacefully in the EU.

In 2022, the Commission continued to prioritise its safeguards activity by applying state-of-the-art approaches that reflect the nuclear and information technology developments associated with the changing political and social environment and the related particular safeguards challenges. 99.92% of all nuclear materials under Euratom safeguards were subject to physical inventory verifications during the year.

The Commission continued to work in close cooperation with the International Atomic Energy Agency (IAEA) on encouraging the joint use of common safeguards equipment and on the implementation of the 'safeguards by design' concept integrating relevant safeguards considerations during the design phase of nuclear installations.

As a result of applying Euratom safeguards in the framework of 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 agreements concluded with the IAEA and bilateral agreements with non-EU countries were complied with.

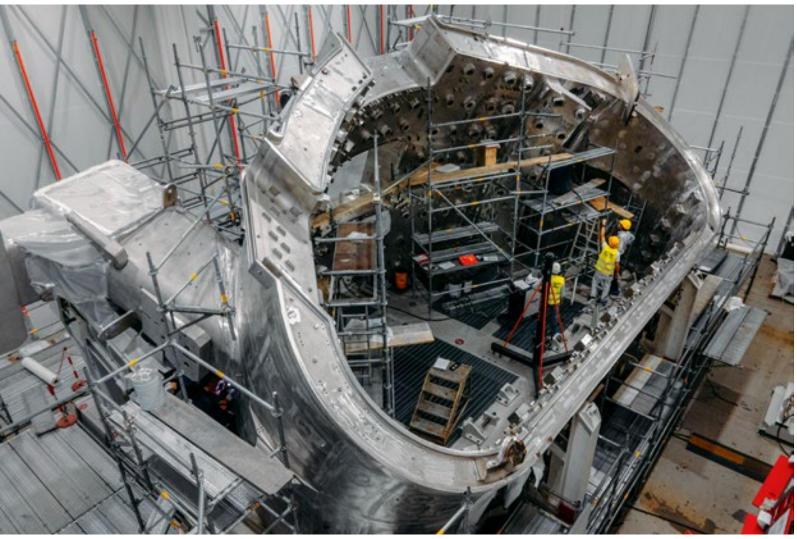
Finally, an in-depth evaluation of Commission Regulation (Euratom) No 302/2005 of 8 February 2005 on the application of Euratom safeguards was completed in 2022. It shows that the Regulation has been successfully implemented; however, a targeted review of Regulation 302/2005 should be considered in view of the technological progress and developments in the nuclear sector over the last 17 years.

3.1.6. ITER and fusion energy

Throughout 2022 the Commission continuously supported the construction of ITER, an experimental device for magnetically confined fusion designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy, and the development of fusion energy in broader context. It is useful to recall that the EU decided to allocate EUR 5.61 billion to the project in the period from 2021 to 2027 following the adoption of a Council decision ([15]) in February 2021. ITER is therefore well anchored among EU priorities.

ITER construction is ongoing, with 77.6% of construction needed for 'First Plasma' (an important milestone after which it will be possible to begin the experiments) completed at the end of 2022.

F4E vacuum vessel 5 in preparation



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ITER: 77.6% of construction needed for 'First Plasma' completed at the end of 2022.

Nevertheless, the COVID-19 pandemic, late arrival of components, pending approvals by the nuclear safety regulator and quality issues concerning components delivered have affected the project's implementation. The ITER Organisation and the ITER Members are analysing the impact of these issues in order to update the project baseline (scope, schedule and estimated cost). The first elements of this baseline were presented in spring 2022, but the ITER Members requested the ITER Organisation to further work on the baseline and present a proposal by the end of 2023 following the repair of some components supplied.

As part of the second phase of activities of the Broader Approach Agreement, Euratom and Japan started exploiting the fusion and materials testing facilities that have been built. The expertise gained under the Broader Approach activities is being used by ITER, particularly in the assembly phase. Japan and Euratom have also been testing and commissioning the JT-60SA tokamak in Naka, the largest and most modern tokamak in the world until ITER is completed. Problems with coils have pushed its First Plasma to 2023 but resolving the problems together with European and ITER staff provided important lessons for ITER testing and commissioning.

3.1.7. European Commission research and innovation programmes

Actions launched in 2022 by the European Commission under the Euratom Research and Training Programme for 2021-2025 ([16]) play a pivotal role in maintaining strong European competencies in the main areas of nuclear research and innovation. This will help ensure the highest standards of safety for existing and future nuclear installations and for developing fusion energy, as well as for medical and other applications of ionising radiation.

15 COUNCIL DECISION (Euratom) 2021/281 of 22 February 2021 amending Decision 2007/198/Euratom establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it
16 Euratom Research and Training Programme

In 2022 the Commission awarded 28 grants totalling EUR 117 million for research projects in nuclear safety, radiation protection and non-power applications of nuclear technologies.

In 2022 the Commission awarded 28 grants totalling EUR 117 million for research projects in nuclear safety, radiation protection and non-power applications of nuclear technologies. One of the projects is the co-funded European partnership PIANOFORTE ([17]), with funding of EUR 30 million. Its purpose is to provide a scientific and technological basis for a robust system of radiation protection and more consolidated science-based policy recommendations to decision-makers in all these different fields. At the same time it aims to innovate in ionising radiation-based medical applications combating cancer and other diseases through new and optimised diagnostic and therapeutic approaches, taking radiation safety into account throughout.

The European Commission also launched in 2022 a new call for research proposals with funding of EUR 10 million, to launch an action to carry out necessary safety analyses and tests and establish procedures needed for the licensing of VVER nuclear fuel manufactured by suppliers outside Russia. This action will address the issue of security of supply of fuel for Russian-designed VVER reactors in the EU and Ukraine. The operation of these reactors currently depends mainly on Russian-produced nuclear fuel. Increased risks resulting from Russia's invasion of Ukraine have made it necessary to strengthen the security of supply situation for these reactors. Almost EUR 1 million from the Euratom Programme was awarded in 2022 as Maria Curie-Skłodowska Fellowships to five post-doctoral researchers in different areas of nuclear research such as waste management, fusion energy and medical applications.

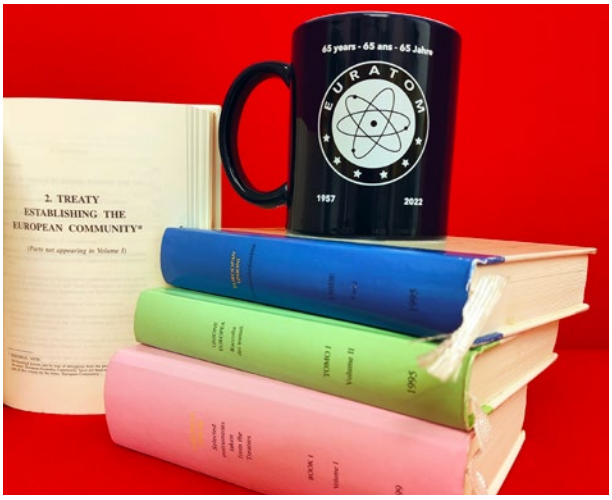
Following the success of the first High-level European Nuclear Industry Roundtable in May 2021 ([18]), Commissioner Mariya Gabriel convened the second Nuclear Roundtable on 15 March 2022 to discuss the future of research in SMRs and medical applications using nuclear technologies ([19]).

In 2022, the second year of implementation of EUROfusion ([20]), the co-funded European Partnership for fusion energy research, researchers used the Joint European Torus (JET) device to release a record 59 megajoules of sustained fusion energy. These results are the clearest demonstration of the potential for fusion energy to deliver safe and sustainable low-carbon energy. This achievement comes as part of a dedicated experimental campaign designed by EUROfusion to optimally prepare for the start of the ITER project.

The 10th edition of the Euratom research and training conferences on the fission safety of reactor systems (FISA 2022) and radioactive waste management (EURADWASTE'22), organised with the French Presidency of the Council of the EU and the European Commission, was held in Lyon. FISA/EURADWASTE'22 ([21]) showed the progress made and the key achievements of the Euratom research and training projects carried out since 2019 and stimulated discussions on the state of play of nuclear research and innovation, challenges and opportunities.

The Euratom Joint Programme for Radioactive Waste Management (EURAD) ([22]) is a unique platform providing support for Member States in the design and implementation of their national programmes for waste management as required by the Euratom Directive. In 2022, EURAD delivered research and tools needed for the implementation of deep geological repositories, at the same time addressing important safety concerns. As underlined by the independent mid-term review of EURAD carried out in 2022, EURAD has a strategic role for developing knowledge management and transfer among Member States and generations.

Euratom 65 years



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17 Research and Education for Radiation Protection
18 High level European nuclear Roundtable - Publications Office of the EU (europa.eu)
19 Small modular reactors and medical applications of nuclear technologies - Publications Office of the EU (europa.eu)
20 Eurofusion
21 Research and Innovation - FISA 2022 - EURADWASTE '22
22 European Joint Programme on Radioactive Waste Management

3.1.8. European Commission's JRC activities

The general objective of the 2021-2025 Euratom Research and Training Programme is to pursue nuclear research and training activities, with an emphasis on the continuous improvement of nuclear safety, security and radiation protection, complementing the Horizon Europe's objectives. The programme is implemented through direct and indirect actions, the direct actions being implemented by JRC.

JRC nuclear strategy

The current Euratom programme carried a reduction of the budget allocated to research activities compared with the previous work programme. This budget reduction can have significant implications for the scope and implementation of the JRC nuclear work programme, and therefore the JRC developed a strategy for its nuclear work focusing on the prioritisation and consolidation of current activities and infrastructure and on strengthening collaboration with its research stakeholders to obtain synergies.

Work programme activities

The JRC work programme addresses state-of-the-art solutions for the long-term operation of existing nuclear reactors, together with research for current and new reactor designs as regards safety, materials and fuels, including waste management and disposal. It includes studies on accident-tolerant fuel. It also contributes to understanding the behaviour of spent fuel and issues related to nuclear waste management and decommissioning. Research on specific safety and safeguards characteristics of SMRs will be stepped up in the 2023-2024 work programme.

The JRC continued assessing the sustainability of the supply of medical radioisotopes in the EU and conducting research on new radioisotope applications and alternative methods of production of radioisotopes of medical interest. These activities support EU initiatives such as the strategic agenda for medical ionising radiation applications (SAMIRA ([23])) and the EU's Beating Cancer Plan.

In support of the Euratom and international safeguards regime, JRC develops tools and techniques, provides analytical support and reference materials, manages the on-site lab at La Hague, participates in verification campaigns and delivers training courses to Euratom inspectors. JRC services are part of the technical assistance provided by the EC support programme on nuclear safeguards to the IAEA.

At the European nuclear security training centre, training courses are provided on nuclear safeguards for nuclear inspectors and on nuclear security for front-line officers. The nuclear security activities increase detection capabilities, contributing to global capacity building. In 2022, JRC celebrated the 30th anniversary of nuclear forensics research.

To maintain a high level of EU competence in the nuclear field, JRC carries out education and training activities and opens its installations to EU users to share knowledge and facilitate researcher mobility. After 2 years (2020-2021) of severe access restrictions due to the pandemic, a gradual return to normality was possible, with previous activity levels resumed in 2022. In 2021-2022 a total of 1 720 researchers and students benefited from these activities in fields such as nuclear safety, including actinide materials, nuclear reactor materials and nuclear fuels, nuclear safeguards and security, and safe medical applications of radioisotopes.

In the same period, 2021-2022, the JRC scientist contributed to 262 scientific articles published in peer-reviewed journals and conference proceedings. The technical outputs delivered to users were 17 sets of reference materials and 4 validated methods, which contributed to the modification of international standards, 28 technical systems and 16 scientific datasets and databases.

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The outputs produced by direct actions to address specific EU priorities included technical reports, science-for-policy reports and parts of policy documents, some of which produced tangible and evident impacts in different steps of the policy cycle.

23 See 3.3.2 below.

After the start of the Russian aggression on Ukraine, the JRC was involved in the risk and scenario analysis of the potential nuclear and radiological threat arising from the evolving situation, including support for the environmental monitoring of radiation levels (EURDEP) and the emergency information exchange system (ECURIE). The JRC contributed to EU trade policies analysing the impact of trade restrictive measures and dual-use export regulation.

The JRC continues providing support for the implementation of EU Nuclear Directives and to the Instrument for Nuclear Safety Cooperation (INSC) and for Neighbourhood, Development and International Cooperation (NDICI).

In 2022 the JRC drafted its work programme for 2023-2024, which was approved in February 2023. The programme aims to increase collaboration with non-nuclear areas to achieve more impact through the mutual interconnection and integration of activities into policy-oriented portfolios.

3.2. Country-specific developments

At the end of 2022, 103 commercial nuclear power reactors were operating in 13 EU Member States. There were three reactors under construction/commissioning in France and Slovakia (see Table 7).

Table 7. Nuclear power reactors in the EU-27 in 2022

Country	Reactors in operation (under construction/commissioning)	Net capacity (MWe) (under construction/ commissioning)
Belgium (*)	6	4 936
Bulgaria	2	2 006
Czechia	6	3 932
Germany (**)	3	4 055
Spain	7	7 117
France	56 (1)	61 370 (1 630)
Hungary	4	1 902
Netherlands	1	482
Romania	2	1 300
Slovenia (***)	1	696
Slovakia (****)	4 (2)	1 804 (880)
Finland	5	4 394
Sweden	6	6 869
Total EU-27	**103 (3)**	**100 863 (2 510)**

(*) Permanent shutdown of Doel-3 on 23 September 2022.
(**) In October 2022, Germany decided to keep the three remaining nuclear power reactors, due to be taken off-grid in December, to operate them until mid-April 2023.
(***) The Croatian power company HEP owns a 50% stake in the Krško NPP in Slovenia.
(****) Mochovce-3 reached its first criticality on 22 November 2022 and the first grid connection took place on 31 January 2023.
Source: WNA and EU Member States.

Belgium

The Doel nuclear power plant's Unit 3 was permanently shut down in September, with decommissioning scheduled to start in 2026.

ENGIE Electrabel confirmed that Tihange 2 nuclear power plant will be shut down on 31 January 2023 as per the previously announced schedule. Negotiations between the company and Belgium's government continue to extend the lifespan of Tihange 3 and Doel 4.

According to the International Energy Agency (IEA), Belgium's energy security and emissions reduction goals raise concerns due to Belgium's plans to phase out five of its seven nuclear reactors by 2025. The survey in March 2022 showed increasing support for Belgian NPP lifetime extensions, particularly after the start of the Russian aggression in Ukraine.

Belgium formed a consortium with French and Canadian nuclear authorities to collaborate on research into the underground storage of spent fuel and nuclear waste, with a focus on the properties and suitability of clay rock, the sealing of storage facilities and the ageing process of materials.

Bulgaria

Kozloduy nuclear power plant agreed in June to purchase certain remaining equipment on the Belene nuclear power plant site, which can be used to extend the service lives of the two operating VVER-1000 pressurised water reactors at Units 5 & 6 of the Kozloduy nuclear power plant. The sale of the equipment was approved by the Bulgarian government.

At the end of 2022 the Bulgarian National Assembly called on the Council of Ministers to ensure that a contract and licensing for the supply of non-Russian nuclear fuel is concluded by 2024.

Westinghouse signed a 10-year contract to supply VVER-1000 fuel for Unit 5 of the Kozloduy nuclear power plant, and in addition a preliminary fuel supply agreement was signed between Kozloduy nuclear power plant and France's Framatome, with the aim of securing fuel deliveries to Unit 6 of the plant for a 10-year period.

Croatia

The Croatian government indicated its interest in participating in the development of a second reactor at the Krško NPP in Slovenia during discussions between the leaders of the two countries on energy issues. It is anticipated that a final investment decision on a new reactor at Krško will be made by 2027.

Czechia

The government plans to end coal-fired electricity generation while increasing nuclear power capacity and renewable energy by creating the conditions for energy transformation and developing coal regions to phase out coal by 2033 prioritising the replacement of coal with additional nuclear capacity. Currently the state energy strategy is being updated.

In May the Temelín Unit 2 received a permit for operational lifetime extension from the national regulator 'for an indefinite period' by continuously proving that the reactor meets all the conditions for safe operations.

The power company ČEZ launched a tender to select the engineering, procurement and construction (EPC) contractor for a new nuclear unit of up to 1.2 GW at its Dukovany plant site, receiving initial bids from EDF, Korea Hydro and Nuclear Power, and Westinghouse. The construction of Dukovany-5 is scheduled to begin in 2029, with the reactor expected to start operations in 2036. The state is evaluating the construction of a further 1 new unit at Dukovany and 2 units at Temelín sites.

Long-term contracts were awarded to Westinghouse and Framatome in April to supply nuclear fuel assemblies to the Temelín NPP, with deliveries expected to start in 2024.

ČEZ also chose Temelín as the location for the first SMR and Tusimice and Detmarovice brownfield sites were selected for the conducting of research to check their suitability for SMR siting. ČEZ signed memorandums of understanding (MoU) with seven relevant vendors of lightwater SMRs (NuScale, Rolls-Royce SMR, GE Hitachi, Nuward, KHNP, Holtec and Westinghouse) to obtain the information needed for the SMR projects feasibility assessment. Moreover, ČEZ signed the MoU with Ontario Power Generation to share experience from nuclear project deployment.

In November, ČEZ announced the acquisition of Skoda JS, a nuclear services and engineering company, to strengthen its domestic energy security. It obtained a full 100% stake in the firm.

Denmark

A partnership agreement was signed in April between Denmark's Seaborg Technologies and Samsung Heavy Industries for a development of floating NPPs using Seaborg's compact molten-salt reactor technology, with the aim of producing floating NPPS to be moored in industrial harbours. The plants may also feature hydrogen or ammonia production facilities that utilise the nuclear power for low-carbon production.

Estonia

Estonia is conducting a comprehensive analysis to evaluate which SMRs best fulfils its needs at an affordable price.

Fermi Energia sent tender documents in September to NuScale Power, Rolls-Royce SMR and GE Hitachi (GEH), seeking to deploy SMRs in Estonia. The companies were expected to submit their bids along with cost estimates and technical documentation by the end of 2022.

Finland

Olkiluoto 3 NPP (OL3) successfully achieved initial criticality in December 2021 and gradually continued to increase its power level. Following this, the plant was connected to the grid in March and started to supply electricity, with its full power output of 1 600 MWe achieved in September.

The nuclear waste management company Posiva Oy submitted the application for an operating licence for its encapsulation plant and deep geological repository. The building of the used fuel encapsulation plant was handed over to Posiva to start installing the nuclear systems.

In January, the Environmental Impact Assessment (EIA) for Fortum's Loviisa NPP Units 1&2 lifetime extensions was approved as meeting the legislative requirements, with no significant adverse environmental impacts found. The licence application for lifetime extensions was submitted to the Finnish government on March 18.

In May, Fennovoima abandoned its Hanhikivi NPP project and terminated the EPC contract with Rosatom's RAOS due to significant delays and RAOS's inability to deliver the project. Fennovoima then formally withdrew the construction licence application later in May. In December, the Hanhikivi-1 contract termination was declared unlawful by a contractual dispute review board (DRB), an arbitration panel established under the contract to accelerate dispute resolutions. The recommendation is not final or binding as both companies submitted notices of dissatisfaction.

In November, Fortum and Westinghouse entered into an agreement to develop and provide fuel for the Loviisa NPP in parallel with Russian fuel supplier TVEL until expiry of the reactors' operating licences in 2027 and 2030.

It was reported in December that Fortum and EDF had entered into a framework cooperation agreement to explore collaboration on large power plant deployment and small modular nuclear reactors in Finland and Sweden as part of Fortum's 2-year feasibility study aimed at examining the requirements for new nuclear power in the two countries.

France

In February, President Emmanuel Macron announced a plan to increase the use of nuclear power in France (including the construction of six new EPR nuclear reactors) and expand the use of solar and offshore wind. The construction of six EPR nuclear reactors is expected to require a budget of between EUR 52 billion and EUR 56 billion.

In October, a public consultation concerning France's future energy mix was initiated by the government along with a public debate regarding EDF's proposal to construct the initial two EPR reactors at Penly site (Normandy).

A new law was approved by the French Cabinet in November to simplify the initial approval process for licence applications, aimed at expediting the construction of new reactors by several years.

Details of the French government's plan to acquire complete ownership of EDF were unveiled in July, with the government's current 84% stake in the utility to be supplemented by a proposed EUR 9.7 billion deal to purchase the remaining 16% of EDF shares.

In February, EDF was instructed by the French Nuclear Safety Authority to expand its inspections for corrosion issues on pipe welds in nuclear reactors and to conduct a more in-depth analysis of the problem and potential safety hazards. EDF already has a strategy to check all its 56 reactors after faults were found in five of them. In April, EDF found possible indications of stress corrosion in four reactors. In July, the French Nuclear Safety Authority approved the comprehensive strategy EDF submitted regarding the stress corrosion phenomenon. All the reactors would be inspected by 2025 as part of already scheduled outages, with priority given to the most sensitive reactors.

The removal of all used fuel from the Fessenheim NPP's two units was accomplished in August, eliminating 99.9% of the site's radioactivity.

France's nuclear research and technical support agency IRSN formed a consortium with Belgian and Canadian nuclear authorities to work together on research related to the underground storage of nuclear waste and spent fuel.

In June, EDF announced that its SMR NUWARD™ will be the case study for a European early joint regulatory review led by the French Nuclear Safety Authority with the participation of the Czech and Finnish safety authorities.

In November, ASN announced that it had granted approval to Orano to reprocess spent mixed oxide (MOX) fuel from the Dutch Borssele NPP.

EDF announced in December a delay in the fuel loading for its Flamanville-3 nuclear unit: previously expected to take place in the second quarter of 2023, it was postponed to the first quarter of 2024.

Germany

Despite the Russian gas crisis, the government decided in September to maintain Germany's nuclear phase-out schedule, with a rapid solar programme and the possibility of employing fuel oil-fired power barges. In November, German legislators passed a resolution postponing the scheduled closure of Germany's final three NPPs (Isar 2, Neckarwestheim 2, and Emsland) from the end of 2022 to mid-April 2023.

Hungary

Hungary's Prime Minister reaffirmed Hungary's commitment to continuing the expansion of the Paks NPP (Paks-II) led by Rosatom. Large-scale excavation works started in September to prepare the construction of Units 1 and 2 of Paks-II.

In November, the General Court of the European Union dismissed the action for annulment against the European Commission decision regarding state aid for the construction of two reactors in Hungary at the Paks-II nuclear power plant using Russian financing. The action for annulment had been filed by Austria. Following appeal, the case is currently pending at the European Court of Justice [24].

24 General Court, T-101/18; decision of 30.11.2022; Court of the EU, case C-59/23 P; in progress.

In December, Paks NPP received approval from Hungary's parliament to extend its operating life for further 20 years.

Italy

The Italian state-owned company, Societa Gestione Impianti Nucleari SpA, declared the successful completion of the dismantling of the Fabbricazioni Nucleari di Bosco Marengo nuclear fuel fabrication plant, making it the first Italian decommissioned nuclear facility having reached 'brown field' status.

Latvia

A new partnership was announced by Latvia and USA under the FIRST (Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology) programme aimed at exploring the potential of advanced nuclear technologies in Latvia's energy mix while also supporting clean energy innovation and strengthening strategic ties between the two nations.

Lithuania

Lithuania decided to demolish the Maišiagala radioactive waste storage facility. The waste will be permanently disposed of. A tender for buildings and equipment has been launched.

The national regulator granted licences to the Ignalina NPP to commence operation of their solid radioactive waste management and storage facilities, together with permission for waste transportation to a very-low-level radioactive waste repository.

Netherlands

The Foundation Preparation Pallas-reactor submitted permit applications in June to construct and operate a new research reactor and handle the intake and discharge of cooling water.

The government confirmed plans to build two large third generation LWRs, with a capacity of 1 000 MWe-1 650 MWe each, at the existing Borssele NPP by 2035. Additionally, the government plans to extend the operating life – currently until 2033 – of the Borssele NPP.

Poland

In March, Polskie Elektrownie Jądrowe (PEJ) submitted the environmental impact assessment report for the first nuclear reactor with a generating capacity of up to 3 750 MWe in Poland.

The US-Poland nuclear cooperation progress was reflected in a bilateral roadmap that outlines the construction of six large nuclear reactors with US technology and a strategic framework for civil nuclear energy cooperation.

In October, Poland's government announced its decision to collaborate with Westinghouse Electric Co. and the US government to construct its first nuclear power plant, which involves the supply of three AP1000 PWRs by Westinghouse. PEJ and Westinghouse signed an agreement outlining their cooperation in December.

A privately owned utility ZE PAK SA signed a letter of intent with Korea Hydro & Nuclear Power (KHNP) to build APR-1400 PWRs with a capacity of 1 400 MWe and started the site assessment process for the site in Pątnów in central Poland.

An amendment to the law on nuclear investments was adopted in August by the government to shorten the time of investment implementation.

The Korea Atomic Energy Research Institute (KAERI) signed an MoU with Poland's National Centre for Nuclear Research to supply nuclear fuel for Poland's research reactor, MARIA, using high-density low-enriched uranium silicide (U3Si2) plate-shaped nuclear fuel manufacturing technology. Two trial bundles of fuel for MARIA are expected in 2024 to undergo safety screening, aiming to qualify for nuclear fuel supply in 2026.

Romania

In January, the Energy Minister announced the option for Romania to receive up to EUR 16 billion in EU funds by 2030 to upgrade its energy infrastructure. Romania aims to phase out coal-fired power stations by 2032 and to replace them with nuclear, gas and renewables.

A draft law submitted to Romania's parliament in December covered a state support agreement with Nuclearelectrica to complete two units at Cernavodă. The law aims to put Cernavodă 3 into operation by the end of 2030 and Cernavodă 4 the following year, which will double the contribution of nuclear energy in the energy system from approximately 20% to 36% using the 700MW CANDU 6 units.

The Export-Import Bank of the United States (ESIM) sent letters of intent to cover a USD 50 million loan for preliminary engineering work on Cernavodă Units 3 and 4, to be completed by 2025, and to provide a loan of USD 3 billion to cover a third of the costs to finish the construction.

Nuclearelectrica, Romania's nuclear utility, announced that its shareholders have approved the investment decision to refurbish Unit 1 of the Cernavodă NPP, with the expected cost of the refurbishment to be around EUR 1.85 billion and the work to be carried out in 2027-2029.

The Romanian government sold the uranium inventory from the former National Uranium Company (CNU) to Nuclearelectrica to repay state aid. The CNU's uranium mine in Suceava County closed permanently in November 2021 due to the inefficient economic recovery of the remaining reserves. As part of its strategy to diversify the sources of raw materials and complete all operations in its integrated nuclear fuel chain, Nuclearelectrica also acquired the uranium processing line from CNU.

Nuclearelectrica signed an MoU with NuScale Power to study the feasibility of deploying the first SMR plant at the Doicesti site in Romania, with a potential capacity of 462 MWe, and plans to open the fourth NuScale SMR simulator at the University Politehnica of Bucharest. Nuclearelectrica also signed an MoU with Poland's KGHM on facilitating the exchange of technical, economic, legal, financial, and organisational knowledge and experience related to SMR installation.

Slovakia

Slovakia's nuclear regulator denied the final appeal from Austrian environmental group Global 2000 against the launch of the Mochovce-3, upholding its previous decision to approve the commissioning and start-up of the VVER-440/213 unit.

Following this, 471-MW Mochovce Unit 3 received the commissioning permit from the Slovakian regulator in January, and authorisations for fuel loading and start-up were granted in August. Fuel loading started in the beginning of September. The initial criticality and the minimum controlled power level were reached at the end of October, followed by test work to prepare for its formal energy launch phase. Later some problems were detected during the start-up test. Commercial operation will take place during 2023.

Slovenia

The government adopted a strategy to phase out coal for electricity production by 2033 and to continue to rely on the Krško NPP, co-owned with Croatia. In January 2023 an environmental permit was approved for lifetime extension of the Krško NPP from 40 to 60 years. Serious discussion on the potential future of the nuclear power plant Krško 2 was initiated in 2019 during preparation of the National Energy and Climate Plan and is recently converging into a decision to start the planning process for one or more units with a power range up to 2 400 MWe.

Spain

The on-site interim dry storage facility for spent fuel in Garoña received the first spent fuel container. This starts the activities to empty the Garoña NPP's spent fuel pool prior to the decommissioning work.

After receiving a negative report from the Spanish Nuclear Safety Council, the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) denied in November 2021 Berkeley's request for the construction authorization of the Retortillo uranium concentrate plant in Salamanca province. Later on – in November 2022, Berkeley submitted a written notification to the Spanish Prime Minister and the MITECO, where in accordance with Article 26.1 of the Energy Charter Treaty, it proposed initiating negotiations to reach an amicable solution.

Sweden

The final spent fuel repository and the related fuel encapsulation plant in Oskarshamn got the green light for construction in January.

According to a survey conducted in March, support for nuclear power in Sweden is at an all-time high, with 84% in favour of continuing use of nuclear power. The construction of new reactors if needed was supported by 56% of respondents. Only 10% want to close nuclear plants, while 6% remain hesitant about the issue.

The new government – elected in September – has expressed its support for new nuclear reactors, including financial support of up to EUR 35.8 billion.

Mochovce NW view

©Slovenske Elektrarne

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

Radioisotopes are utilised in the field of medicine for both diagnostic and therapeutic purposes. These isotopes are highly effective in diagnosing and treating serious conditions such as cancer, cardiovascular disease and brain disorders. Medical facilities around the world, including over 10 000 hospitals, use radioisotopes in nearly 100 different nuclear medicine procedures. Annually, this results in almost 49 million medical procedures worldwide. In the European Union alone, more than 1 500 nuclear medicine centres provide treatment to approximately 10 million patients each year. Nuclear medicine is especially valuable in the fight against cancer, with around 60% of nuclear medicine procedures in oncology, depending on national practice. The application of medical radioisotopes in cancer treatment is rapidly expanding and the market for novel radiopharmaceuticals is expected to grow significantly in the coming years.

Currently, nuclear research reactors are the primary source of radioisotopes, though other non-fission technologies such as cyclotrons and accelerators are also under development. The production of radioisotopes depends on complex and highly specialised supply chains that often extend across multiple countries and continents, requiring 24/7 just-in-time delivery.

The most commonly used radioisotope is Technetium-99m (Tc-99m), which is employed in 80% of all nuclear medicine diagnostic procedures. Tc-99m is produced through a multi-step process that begins with the irradiation of uranium targets in nuclear research reactors to produce Molybdenum-99 (Mo-99). Afterward, Mo-99 is extracted from the targets in specialised processing facilities and used to manufacture Tc-99m generators, which are then transported to hospitals for use in medical procedures. Any interruption to the supply chain can have severe consequences for patients.

The European Union is a key player in the nuclear medicine field, with a complete supply chain network that includes:

- a uranium fuel and target manufacturer: Framatome-CERCA in France;
- four research reactors irradiating uranium targets: BR2 in Belgium, HFR in the Netherlands, MARIA in Poland, and LVR-15 in Czechia;
- two uranium targets-processing facilities: Curium in the Netherlands and IRE in Belgium;
- major Tc-99m generators-manufacturing sites in the Netherlands, France, and Poland.

The EU supplies over 60% of the world market for Mo-99/Tc-99m and has contributed to many important developments in nuclear medicine, including significant pharmaceutical and clinical advances.

For findings on the security of supply chain for medical radioisotopes, see Chapter 2.1. Analysis of market trends - Medical radioisotopes.

3.3.1. Reactor scheduling and monitoring the supply of Mo-99

The Security of Supply Working Group, established by Nuclear Medicine Europe (NMEU, the industry association of nuclear medicine) ([25]), works closely with stakeholders across the supply chain to coordinate the maintenance schedules of reactors to prevent and address disruptions in the supply of Mo-99/Tc-99m. Within this group, the Emergency Response Team (ERT), consisting of representatives from research reactors, Mo-99 processors and Mo-99/Tc-99m generator manufacturers, is responsible for monitoring production and supply issues to identify any potential shortages of Mo-99. The ERT's and Security of Supply Working Group's monitoring and coordination efforts are vital for maintaining the supply chain for Mo-99/Tc-99m and thus ensuring the uninterrupted supply of Mo-99/Tc-99m to medical facilities worldwide.

In 2022, the group dealt with several major events bringing risk of shortages. From December 2021 to February 2022 it focused on the unplanned production stop at the high-enriched uranium (HEU) Mo-99/I-131 production line at the Belgian IRE, and then between January and March 2022 on the unplanned outage of the HFR research reactor. During this period, the MARIA research reactor added additional operating days, which helped reduce the loss of HFR production capacity. The BR2 reactor also resumed operations earlier than originally planned to ease the supply.

At the end of the year, the group addressed the delays of two reactors restarting from scheduled maintenances, SAFARI (South Africa) and BR2. Following discussion within the ERT, the HFR and LVR-15 research reactors started up earlier after maintenance to increase the availability of medical radioisotopes.

NMEU's ERT support was instrumental in dealing with those supply disruption issues. The joint communication team (JCT),

25 Nuclear Medicine Europe - Security of Supply

created with the Observatory, provided regular information updates received from the ERT to various stakeholder groups, including the EU administrations, OECD/NEA and IAEA.

3.3.2. SAMIRA

The Commission continued its support for the safe, high-quality and reliable use of radiological and nuclear technology in healthcare. In 2022, it laid the groundwork for the implementation of the SAMIRA action plan in three priority areas: (i) securing the supply of medical radioisotopes, (ii) improving radiation quality and safety in medicine, and (iii) facilitating innovation and technological development of medical ionising radiation applications. Actions carried out this year in each of these areas include:

- The Commission conducted a targeted consultation and organised meetings with stakeholders and Member States to gather their positions on the European Radioisotope Valley Initiative (ERVI). A feasibility study and further stakeholder engagement activities are being planned with a view to defining a concrete roadmap for the ERVI initiative, focusing on actions in which the EU can have decisive added value.
- The Commission launched a Steering Group on Quality and Safety (SGQS) of medical applications of ionising radiation with representatives of Member States' health and radiation protection authorities. The SGQS work programme consists of actions to develop high-quality evidence, clinical guidelines and practical tools and support their implementation in clinical practice across the EU.
- The Commission continued supporting the development of a strategic research agenda and roadmap for medical applications of nuclear and radiation technology, due in 2023. The agenda aims to promote synergies between the Euratom Research and Training Programme and the "Health" and 'Digital' clusters of the EU research programme Horizon Europe.

The SAMIRA implementation activities are subject to regular reporting and monitoring through the mechanisms established under the EU's Beating Cancer Plan.

The Commission continued its support for the safe, high-quality and reliable use of radiological and nuclear technology in healthcare. In 2022, it laid the groundwork for the implementation of the SAMIRA action plan.

3.3.3. Studies and research

Supply chain's back end

In March 2022, the European Commission's JRC issued its 'Study on sustainable and resilient supply of medical radioisotopes in the EU' ([26]), which provided the current information on the diagnostic nuclear medicine market in the EU, focusing on the market of Mo-99/Tc-99m generators. The study included the assessment of nuclear medicine practices in EU countries (including reimbursement schemes) and the quantification of the financial resources dedicated to the purchase of Tc-99m generators in the EU. It also gave some recommendations requiring additional investigation within the EU.

Nuclear safety of research reactors

In January, the European Commission launched a study on 'Safe, sustainable operation of research reactor facilities in the EU' ([27]). Its main objectives are to review the current national, international and European-level safety requirements and operating practices applicable, to assess the compliance of the EU's research reactors with these requirements and practices and to formulate relevant recommendations. The study also aims to look at possible improvements in periodic safety reviews (PSRs) and the overall ageing management programmes (OAMPs) for research reactors.

Conversion of high-performance research reactors

The LEU-FOREvER ([28]) project, coordinated by the French Alternative Energies and Atomic Energy Commission (CEA) and involving nine research partners, was completed in September

26 Study on Sustainable and Resilient Supply of Medical Radioisotopes in the EU
27 E-Tendering - Europe
28 Low Enriched Uranium Fuels fOR REsEarch Reactors

2022. The project aimed at promoting the development of sustainable and innovative low-enriched uranium (LEU) fuel elements for the whole spectrum of European research reactors. The Czech LVR-15 research reactor was selected as a case study, and preliminary design by AREVA NP and Technicatome was based on Si-U-based flat fuel plates. To improve economic competitiveness, AREVA NP reinvestigated its manufacturing process and proposed optimisations.

Building on the data of Heracles-CP ([29]) and LEU-FOREvER, the EU-Qualify ([30]) project continued in 2022. Coordinated by the Belgian Nuclear Research Centre (SCK-CEN) and involving five partners, the project will generate data needed for the generic fuel qualification of two main fuel types (U-Mo and 'high-loaded' uranium silicide U3Si2). On the basis of the data, the project aims at investigating the future needs of each EU research reactor type in terms of volume and fuel design requirements and at preparing technical requirements for the safety of manufacturing, storage, transport and reprocessing of this research reactor fuel.

Prismap

The key objective of the Prismap ([31]) project is to establish European infrastructure and a common entry point for researchers and physicians, thus speeding up the introduction of new medical radioisotopes. The Prismap ([32]) network groups together 23 European academic institutions and research centres. They will pool their knowledge, expertise and infrastructure to provide a sustainable source of high-purity grade novel radionuclides for medical research.

TOURR

The primary objective of TOURR is to develop a strategy for research reactor utilisation in Europe and prepare the ground for its implementation. It covers assessment of the current status of the European research reactor fleet (including plans for upgrade), evaluation of urgent EU needs, developing tools for the optimal use of the research reactor fleet and raising awareness among decision-makers on the (future) role of research reactors. In this context, the ambition of the TOURR project is to secure access and availability of research reactors as a vital part of the European Research Area ([33]) and to provide support for the stable supply of medical radioisotopes.

The mid-term workshop of the 2020-2023 project 'Towards Optimised Use of Research Reactors in Europe' (TOURR) ([34]) was held in October. The next expected deliverables are a strategy for the optimised use of European research reactors and an online platform supporting optimisation.

SECURE

In October the 'Strengthening the European Chain of sUpply for next generation medical RadionuclidEs' (SECURE) ([35]) project kicked off.

The ambition of the SECURE consortium is to identify and use efficiently the current resources for new radionuclides, particularly for alpha emitters and the relevant beta-emitting theranostics radionuclides. The development of alternative technologies for the production of such therapeutic radionuclides for improved patient treatment requires multidisciplinary scientific and technological knowledge. Radioisotopes that are critical for the success of nuclear medicine were selected. Research activities will address some of the major challenges to securing their future availability by removing critical barriers to sustainable production and by developing guidance and recommendations for exploring the full clinical potential and safe application of radioisotopes.

3.3.4. Projects on the non-power applications of nuclear technology

Molybdenum-99

SHINE Europe, a subsidiary of SHINE Technologies, LLC (USA), secured funding to begin designing an advanced medical-isotopes facility in Veendam, the Netherlands to produce medical isotopes, including Molybdenum-99 (Mo-99).

Ytterbium-176

In January, Eckert & Ziegler Radiopharma (EZR), the radiopharmaceutical production arm of Eckert &Ziegler, signed a joint venture and exclusive long-term supply agreements for Ytterbium-176 with Atom Mines LLC, an innovative producer of enriched Ytterbium isotopes and a subsidiary of the non-profit Pointsman Foundation, both based in Austin, Texas. Cancer therapies based on Lutetium-177 are proving highly effective, yet the world production of Ytterbium-176, the indispensable precursor for production of no-carrier-added (nca)-grade Lutetium-177, is, reportedly, only a few grams per year. The joint venture opens the way for EZR to make nca-grade Lutetium-177 available in large quantities to pharmaceutical companies worldwide to treat hundreds of thousands of patients per year.

29 Towards the Conversation of High-Performance Research Reactors in Europe
30 'European QUalification Approach for Low Enriched Fuel Systems for secure production supply of medical isotopes
31 The European medical isotope programme: Production of high purity isotopes by mass separation
32 Prismap - Medical Radionuclids
33 Research and Innovation - European Research Area (ERA)
34 Towards Optimised Use of Research Reactors in Europe
35 Strengthening the European Chain of sUpply for next generation medical RadionuclidEs

Lutetium-177

ITM Isotope Technologies Munich SE (ITM), a radiopharmaceutical biotech company, announced in October the successful completion of a new production line for the medical radioisotope nca Lutetium-177 at its production facility IAZ in Garching, near Munich. The new production line was inspected and approved by the competent authorities of the *Land* of Bavaria (Germany). With this extension, ITM has multiplied its production capacity for its nca Lutetium-177 to meet growing patient and physician demand and further strengthen its global market position.

Actinium-225

In May, the Nuclear Physics Institute of the Czech Academy of Sciences (UJF) and Eckert & Ziegler entered into a long-term cooperation agreement to produce the alpha emitter Actinium-225. The agreement stipulates investment in equipment and hot cells as well as in Radium-226 as a starting material for experiments and irradiations. The pilot unit is due to be built within 2 years and lead to the process for large-scale Actinium-225 commercial production.

Pantera SA/NV, the newly established joint venture between IBA (Ion Beam Applications S.A.) and the SCK-CEN (Belgium), aims to secure the large-scale production of Actinium-225, one of the most promising alpha-emitting radioisotopes to fight cancers. Pantera is completing technical feasibility studies before working on the final design and construction of its first facility in Mol, Belgium. Ground-breaking is due in 2024, with production starting in 2027.

Terbium

The Dutch government approved a substantial grant proposal to develop a plan to produce a variety of terbium isotopes for use in nuclear medicine. Within this project, SHINE Europe, together with the University Medical Center Groningen and Delft University of Technology, aims to develop and provide all the technologies and facilities needed to secure the entire supply chain for terbium-based nuclear medicine.

RECUMO facility

SCK-CEN has been allowed to expand an existing nuclear facility on its site to host the RECUMO project. The project is a continuation of the long-standing partnership between SCK-CEN and its sister company, the National Institute for Radio Elements (IRE). In the new facility, due to be built, the nuclear research centre will convert the radioactive residues resulting from the production of medical radioisotopes into low-enriched uranium and purify them. The high-quality material that is recovered can be reused as fuel for research reactors or as targets for radioisotope production.

In February 2023, a ground-breaking ceremony was held in Mol to mark the start of construction of the RECUMO facility, which is scheduled to begin operating in 2026.

PALLAS-reactor

In June, the Foundation Preparation PALLAS-reactor, which is responsible for obtaining a licensable design, securing private investors and constructing and operating the PALLAS reactor, applied to the nuclear regulator of the Netherlands (ANVS) for a permit under the Nuclear Energy Act to construct and operate the PALLAS research reactor. As part of the application, an environmental impact assessment and a safety report were also submitted. The foundation also applied to the Rijkswaterstaat (RWS) for a permit under the Water Act for the intake of cooling water from the North Holland Canal and the discharge of cooling water into the North Sea. In February 2023, ANVS granted the construction licence for PALLAS. The RWS also granted the licence for the reactor's cooling water.

Funding has been allocated: EUR 30 million in 2022 and EUR 129 million per year from 2023 onwards. The Dutch government has yet to make a final decision on the construction of the PALLAS reactor.

4. World market for nuclear fuels in 2022

This chapter presents some of the key global developments in 2022 at different stages of the fuel cycle. It relies on information gathered from various open sources.

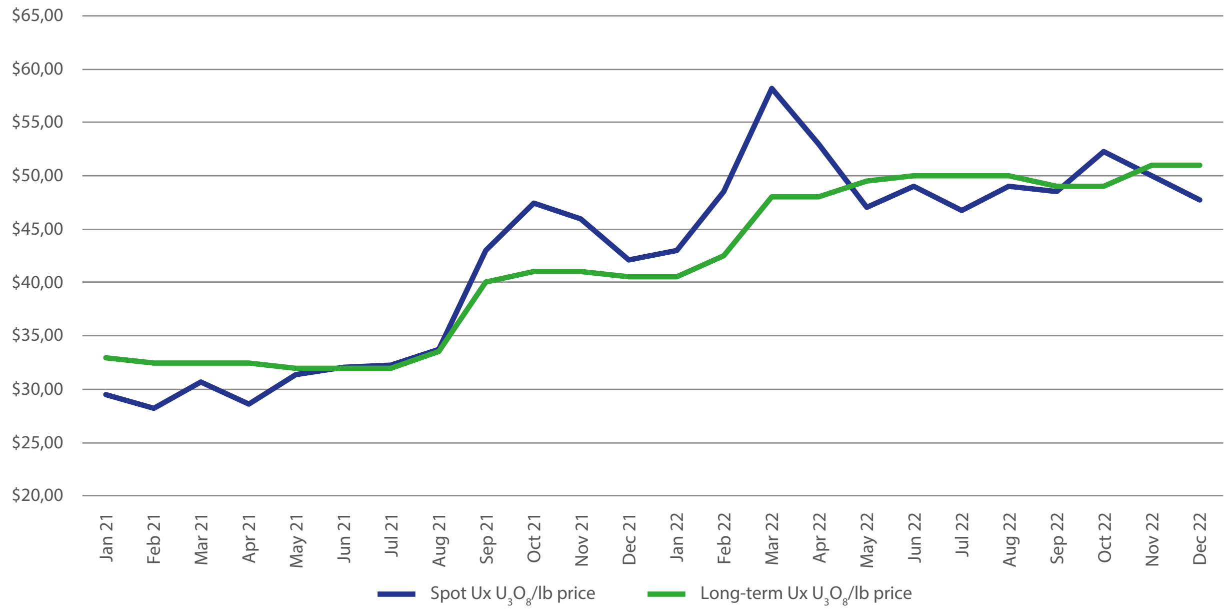
According to the IAEA, as of 31 December 2022, 411 reactors were connected to the grid, accounting for over 370 GWe global net installed capacity. The year saw six new nuclear reactors connected to the grid, five permanent shutdowns and eight construction projects started.

Echoing previous COP meetings, the contribution of nuclear energy as a low-carbon (green) energy source to help tackle the climate crisis, was underlined at COP-27. While there was a decrease in electricity supplied from nuclear reactors worldwide policy shifts favourable to nuclear power were noted in several countries, e.g., in Britain, France, Sweden, Japan, South Korea and USA where fuel loading at the Vogtle Unit 3 ended a two-decade-long hiatus for new reactors in the country. Growth prospects for nuclear power remain primarily centred in Asia and Far East, home to the majority of the reactors under construction.

As COVID-19 waned, constraints on extractive industries in general and uranium mining in particular partly subsided, but the late effects of the pandemic and supply chain risks remained elevated. The market was taken by surprise by geopolitical developments and actors were prompted to reconsider their exposure to supply risks and to consider alternative avenues. Early in the year, unrest in Kazakhstan gave rise to questions about the security of the circa 40% of global uranium supply that originates in that country. Soon after, the conflict in Ukraine disrupted supply routes and set in motion various realignments across energy markets. It also brought into focus the problem of relying on Russian industry for supplies, services, equipment and technology, estimated by one major industry player at 14% for uranium concentrates, 27% for conversion services and 39% for enrichment services. Meanwhile, the year closed with positive news about transport security, as Kazatomprom reported deliveries to Canada via an alternative (trans-Caspian) route.

Against this backdrop, uranium is increasingly perceived as a critical resource, as underlined for example in Canada's new critical minerals strategy, and as evidenced by the decision to build up a strategic reserve in the USA. In addition to governments, private trusts such as Yellowcake and Sprott have also started to build up physical uranium holdings.

Figure 12. Monthly spot and term U_3O_8/lb prices (in USD)



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The markets for industrial minerals saw increased activity in general. The market for uranium ore concentrates was no exception, with some volatility in the price of uranium following the Russian aggression in Ukraine. As earlier prospects of mine reopening materialise, including the restart of production at Cameco's McArthur River, attention has been shifting to the conversion and enrichment segments of the fuel cycle. Illustrating such interest, the year saw Cameco join Brookfield in a first step to take control of Westinghouse. Prices for uranium conversion and enrichment increased substantially, and more than doubled in the case of the former.

Increased activity was reported in various specialised segments, notably relating to small modular reactors (SMR), fast spectrum, advance reactors and salt reactors. SMRs are considered a promising option to replace old coal power plants and to complement the greater use of renewables. They could provide flexibility for the use of district heating, desalination and process heat for energy-intensive industries, and for the production of hydrogen. These developments and implication for the fuel cycle market need to be monitored and deserve a separate analysis.

4.1. Primary uranium supply

While initial projections estimated world uranium (U_3O_8) production to rise to circa 135 million pounds, not all production targets were reached, and Kazatomprom announced late in the year a 3% production shortfall due to the late effects of the COVID-19 pandemic.

The restart of production at the McArthur River mine and Key Lake mill, expected to reach produce an additional 15 million pounds of U_3O_8 by 2024 was accompanied by Cameco's statement that Cigar Lake production is to gradually decrease to 13.5 million pounds of U_3O_8. Although confirmed production data are not yet available, Kazakhstan is expected to continue being at the top of the list of primary uranium producers by a large margin, accounting for over two fifths of expected worldwide production of U_3O_8, followed by Canada at over one seventh, and Australia and Namibia at approximately one tenth of total 2022 production each.

Looking forward, aside from the announced restart of mine production at Langer Heinrich (Namibia), Kayelekera (Malawi) and Honeymoon (Australia), uranium supply could see new entrants in the medium term, such as Saudi Arabia, Peru and Jordan, where developments are ongoing. Also in the USA, news is emerging about the possible reactivation of mines that have been dormant for more than a decade. In Finland, Terrafame announced plans to start uranium recovery (as a by-product) at the Sotkamo mine as of 2024, using bio heap leaching.

In the medium and long term, demand for natural uranium or equivalent feed is likely to increase with the projected commissioning of new power plants. Prospective new builds and demand from advanced reactors could further accelerate this trend.

Demand is therefore expected to continue to grow at a significant pace in the coming decade. Depending on the scenarios, total demand for uranium is expected to grow at 1-3% per year, not counting life extensions, reversals of retirements and applications other than electricity generation.

Table 8. Natural uranium production in 2022 (compared to 2021, in tonnes of uranium equivalent).

Region/country	Production 2022	Share in 2022 (%)	Change 2021/2022 (%)	Production 2021	Share in 2021 (%)
Kazakhstan	21 227	43.0%	-2.7%	21 819	45.6%
Canada	7 351	14.9%	56.6%	4 693	9.8%
Namibia	5 613	11.4%	-2.4%	5 753	12.0%
Australia	4 553	9.2%	8.6%	4 192	8.8%
Uzbekistan	3 300	6.7%	-6.3%	3 520	7.4%
Russia	2 508	5.1%	-4.8%	2 635	5.5%
Niger	2 020	4.1%	-10.1%	2 248	4.7%
China	1 700	3.4%	6.3%	1 600	3.3%
Others	708	1.4%	1.9%	695	1.5%
South Africa	200	0.4%	4.2%	192	0.4%
Ukraine	100	0.2%	-78.0%	455	1.0%
United States	75	0.2%	837.5%	8	0.0%
Total	49 355	100.0%	3.2%	47 810	100.0%

Source: Data from the WNA (August 2023) and specialised publications (because of rounding, totals may not add up)

Yellow cake

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4.2. Secondary sources

Historically, mined uranium only met 70-80% of energy needed for utilities. The gap between demand and primary production is bridged through inventory draw-down and secondary sources, including commercial or government-held inventories, fabricated fresh fuel assemblies, sales by uranium enrichers, and other sources of uranium feed including down-blended uranium, reprocessed uranium and plutonium recovered from spent fuel, depleted uranium, and uranium saved through underfeeding.

Forecasting the gap remains challenging, as reliable data on secondary and other sources of uranium are not readily available on a global scale. Geopolitical developments are likely to increase the uncertainty. However, most analysts anticipate an accelerated depletion of such secondary sources towards end of the decade. This may be compounded by the build-up of physical uranium holdings by private trusts such as Yellowcake and Sprott. At the same time, secondary sources of supply are projected to decrease significantly - from 64 million pounds of U_3O_8 estimated for 2022 to less than 17 million pounds of U_3O_8 per year by 2035.

As primary production increasingly struggles to meet existing demand, and available conversion and enrichment capacity becomes tied by new demand or otherwise scarce due to geopolitical and other factors, uncertainty about the volume and price of secondary supplies can be expected to become a key contributor to market volatility in the future.

4.3. Uranium exploration

Spending on mineral exploration in uranium provinces has generally been dormant in the past decade. However, preliminary data suggest renewed interest partly fuelled by better price prospects. As the uranium market heats up, new entrants and existing players are expected to launch large-scale exploration plans.

Although not exclusively focused on uranium, spending on exploration is projected to increase modestly in countries such as Namibia and Canada. General exploration spending has also surged in Australia, amid calls for more spending on uranium exploration there. An agreement was drawn up for the development of new uranium mines in Uzbekistan. Moreover, new exploration permits have recently been issued in African countries, such as in Niger. Africa clearly remains a region of interest, with various exploration projects under way. However, mineral-rich African countries are subject to political stability risks.

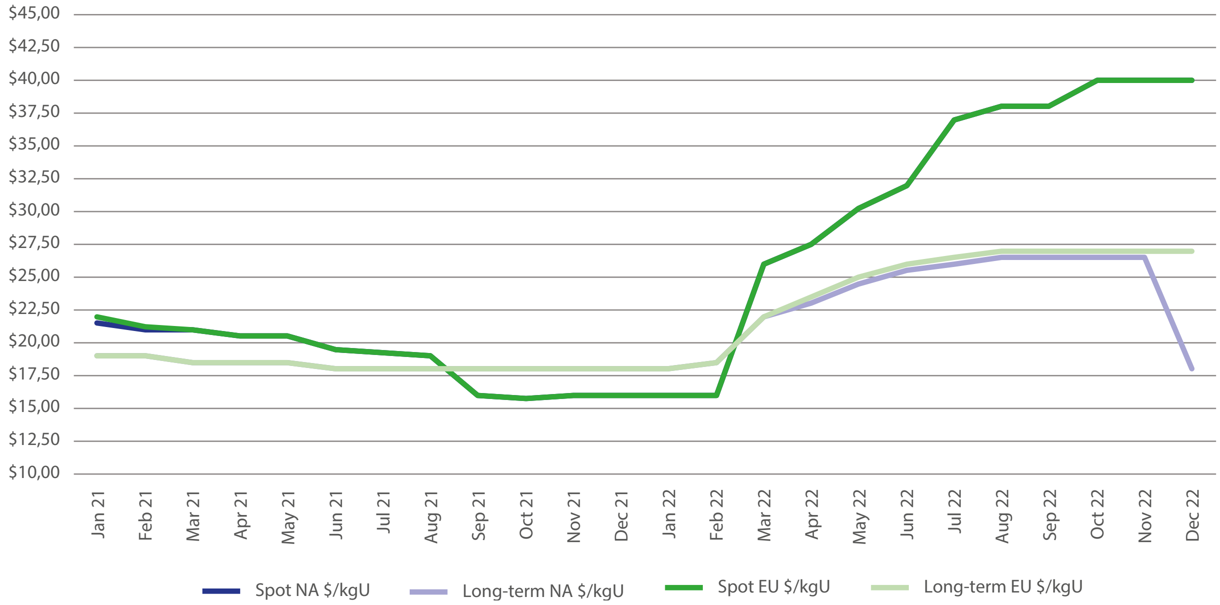
Though not entirely new, advances in remote detection technology are increasingly mentioned in connection with new uranium exploration targets, most recently for example in Canada. Elsewhere, desktop studies and reviews of historical data and drill logs are being used to identify possible new exploration targets.

Future trends in uranium exploration are not straightforward to predict, in particular because of increasing interplay with other rare earth and critical minerals such as vanadium (e.g., in Argentina), lithium (e.g., in Peru), niobium (e.g., in China and Malawi) and precious metals such as gold (e.g., in Australia).

4.4. Conversion

Whereas conversion prices have been fairly modest in previous years, 2022 saw a significant rise in market prices for conversion services, which more than doubled to reach historical highs.

Figure 13. Uranium conversion price trends (in USD)



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The onset of Russia's war of aggression in Ukraine has caused market actors to reassess their exposure to supply risks also in this market segment.

The number of conversion facilities in the market is limited, but some have been put on hold in recent years (e.g., in USA and UK), while others are not running at maximum capacity (e.g., in France). It has therefore been argued that some market flexibility exists in this segment of the fuel cycle. However, deploying additional capacity requires considerable time and investment as contracts tend to be long-term and fixed in price. Current conditions therefore suggest the market could be at a turning point.

Noteworthy developments in 2022 include NRC's green light for the Metropolis Works conversion plant in the USA and the awarding by the US NNSA of a five-year contract to ConverDyn to process ([36]) as part of the setting up of the new strategic reserve. Meanwhile, Cameco announced the earmarking of capital expenditure to increase production at their UF_6 conversion facility at Port Hope and also alluded to a potential role for Westinghouse's Springfields plant in meeting demand for conversion services overseas. In France, uranium dioxide production tests were announced for Orano's new Malvesi de-conversion unit, which is intended to feed the group's Melox plant. In the UK, Westinghouse's Springfields branch reported an operational status for its (HT-IDR) process streams capable of direct uranium hexafluoride re-conversion to uranium dioxide.

While the reactivation of idled capacity, such as in the USA, is expected to help ease stress in the conversion segment, the ramp-up to nameplate capacity will take time. On the other hand, as some of the capacity is already tied up for domestic use, the proportion that will be offered on the open market remains uncertain.

36 ca. one million pounds of uranium in concentrates, i.e., an estimated 10% of the plant capacity.

Table 9. Commercial UF_6 conversion facilities

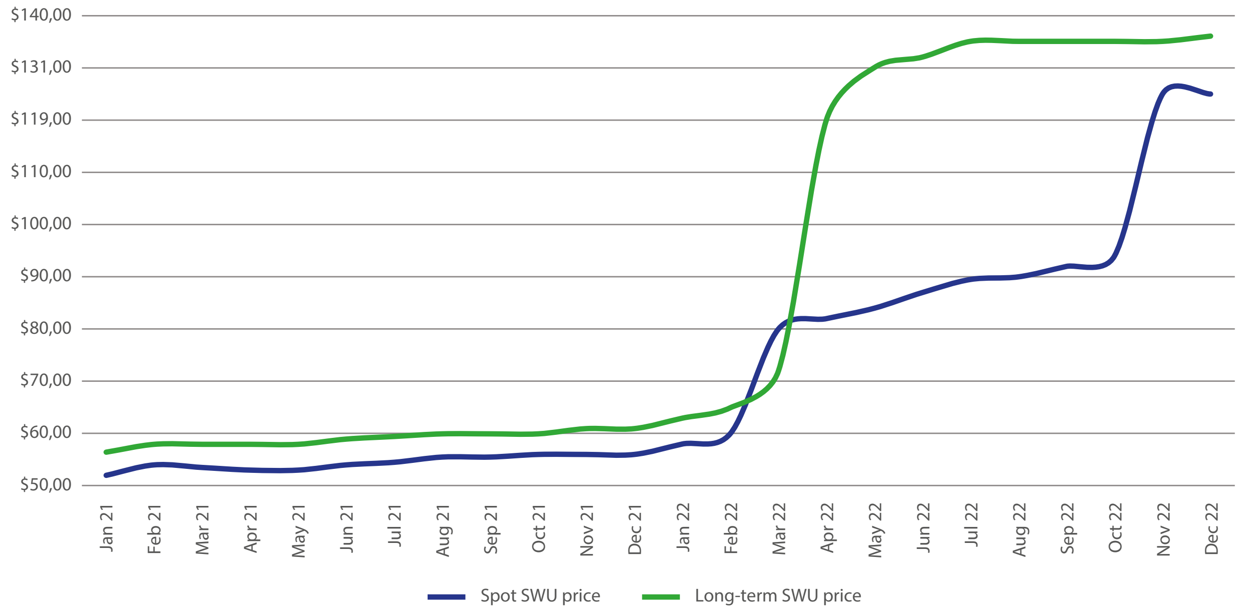
Company	Nameplate capacity in 2020 (tU as UF_6)	Share of global capacity (%)
Orano* (France)	15 000	24%
CNNC** (China)	15 000	24%
Rosatom (Russia)	12 500	20%
Cameco (Canada)	12 500	20%
ConverDyn*** (United States)	7 000	11%
Total nameplate capacity	**62 000**	**100%**

Because of rounding, totals may not add up.
Source: www.world-nuclear.org
** Approximate capacity installed 10 500 tU*
*** Information on China's conversion capacity is uncertain.*
**** Activity suspended since end of 2017.*

4.5. Enrichment

While different processes may be used to produce enriched uranium, the gas centrifuge technology currently prevails. 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. Dynamics in this market segment therefore hinge on the capacity available at the few plants in Pierrelatte (France), Novouralsk (Russia), Gronau (Germany), Almelo (the Netherlands), Capenhurst (UK) and Eunice (USA). Enrichment capacity at Hanzhu and Lanzou (China) is traditionally reserved for domestic use only.

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



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The onset of Russia's war of aggression in Ukraine and related geopolitical developments have had a significant impact on the enrichment market, with SWU prices doubling. Perceiving the high risks associated with supplies from Russia, various actors have reportedly opened up negotiations for alternative options.

Given the new market conditions, Urenco – for example - reported increased revenues and a strengthened EUR 10.8 bn order book extending into the 2030s. The firm, citing the nearly fourfold rise in SWU spot prices from the August 2018 low, now expects higher long-term demand and price levels. It announced plans to invest in and potentially expand enrichment capacity, while continuing to develop advanced fuels and to enhance stable isotope services.

Among other noteworthy developments in the uranium enrichment space, further details were unveiled about the George Besse II expansion project in France, which plans to increase the production capacity up to 12.5 MSWU starting in 2028 and full ramp up in 2030. The project is under board approval which is expected by the end of 2023. Also in France, Orano's Peythieu disclosed the firm's plans to move towards producing uranium enriched to 6% in U-235. In the USA, Urenco USA and Orano in consultation with NRC are also believed to be exploring options to handle LEU+ with enrichments above 5.5% (e.g., DN30 package exemption). Meanwhile Urenco USA announced the resumption of activities at the Centrifuge Assembly Building (CAB), and Centrus announced the signing of an HALEU demonstration contract with US DOE, to deliver some 20 kilograms of uranium enriched to 19.75% by the end of 2023.

Looking forward and considering the uncertainty about the availability of separative work in the open and competitive market, other than from Western plants, a further tightening in this segment of the fuel cycle can be expected, particularly after 2026.

Table 10 Operating commercial uranium enrichment facilities, with approximate 2020 capacity

Company	Nameplate capacity (tSW)	Share of global capacity (%)
Rosatom (Russia)	27 654	46%
Urenco (UK/Germany/Netherlands/United States)	18 230	30%
Orano (France)	7 500	12%
CNNC (China)	6 750	11%
Others * (INB, JNFL)	66	0%
Total nameplate capacity	**60 200**	**100%**

Because of rounding, totals may not add up.
Source: WNA, The Nuclear Fuel Report - Global Scenarios for Demand and Supply Availability 2019-2040.
** INB, Brazil; JNFL, Japan*

4.6. Fuel fabrication

Unlike other fuel cycle services, fuel fabrication is a bespoke service that requires preparing fuel assemblies to the exact requirements of the customer reactor unit. While some degree of competition is in principle possible, vendor consolidations over the years have led to a high degree of concentration. In some sub-sectors, such as fuel with hexagonal geometry, fuel using mixed oxides and fuel using reprocessed or blended uranium, competition is even more limited. Barriers to entry are high, and the introduction of new designs such as Accident Tolerant Fuel (ATF) is typically accompanied by several new patent applications.

In this market segment, the impact of the unfolding geopolitical developments has mainly affected transport security, as transportation of freshly manufactured fuel had to be rerouted in some cases.

Many developments took place in the fuel fabrication space in 2022. At Springfields (UK), Westinghouse announced the completion of all agreed fuel deliveries to EDF in France. Westinghouse also signed high value contracts with Czech utility company CEZ and Swedish utility company Vattenfall. In September, the firm announced a cooperation agreement with ENUSA for the development of VVER-440 fuel.

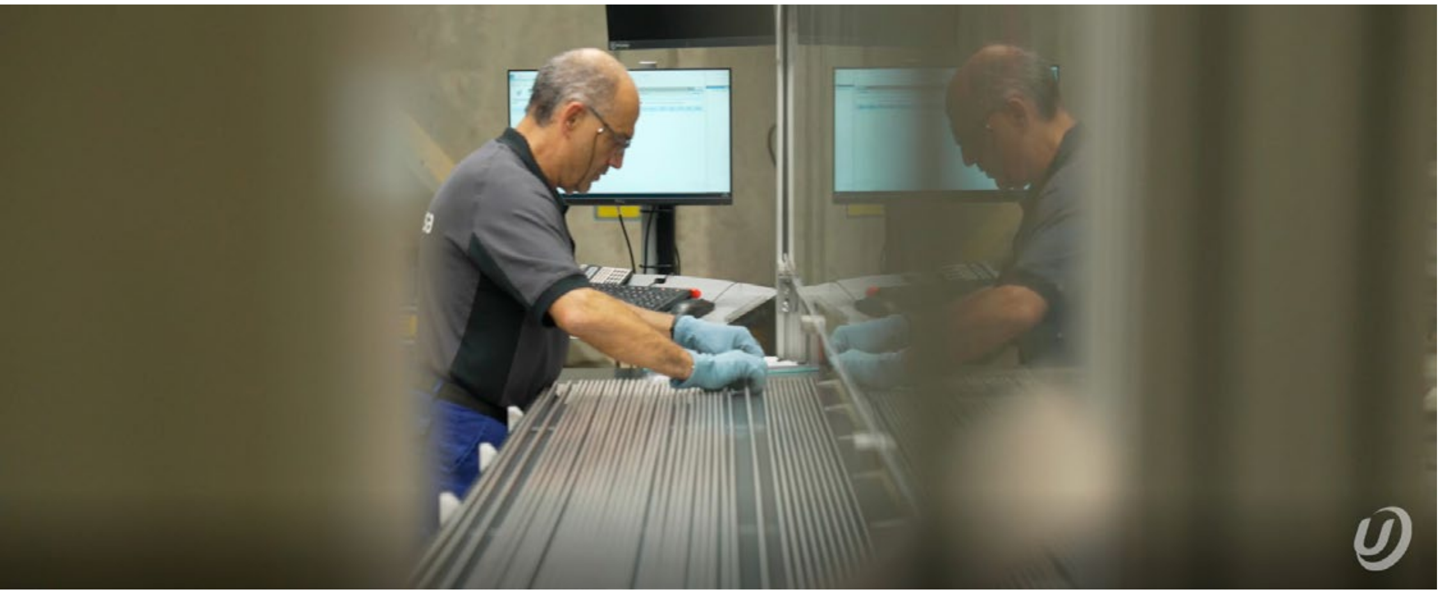
In the USA, BWXT was awarded a contract amendment for TRISO fuel manufacturing for the Idaho National Lab. Meanwhile, at Oak Ridge, the construction of TF3 commenced. This is North America's first commercial-scale advanced nuclear fuel facility, due to become operational in 2025. Westinghouse announced a Lead Test Assemblies programme using U-235 enrichment of up to 6% for the Vogtle-2 reactor. This is the first time that uranium enriched above 5% has been used in a US commercial power reactor. GNFA introduced a licence amendment request for the Wilmington fuel fabrication facility to allow an up to 8% enrichment.

In Russia, TVEL JSC announced a shipment of fuel made at JSC MSZ (AO 'MC3') in Elektrostal destined for the initial core and first reload of China's CFR-600 fast reactor at Xiapu County. The media reported the completion of the manufacturing of experimental fuel assemblies at the Siberian Chemical Combine in Seversk, which are to be loaded onto the BN-600 fast neutron reactor at Beloyarsk.

In Canada, an application for a 24% increase in production capacity at Cameco's fuel manufacturing plant in Port Hope received approval from the regulator.

In France, aside from a shipment of MOX fuel to Japan, the resumption of the production of TRIGA fuel elements at the CERCA site in Romans-sur-Isère, halted since 2014, marked a milestone towards transatlantic cooperation on micro-reactors and HALEU fuels.

Inspection of fuel rods



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4.7. Reprocessing and recycling

Like enrichment, reprocessing technology remains highly sensitive from a proliferation perspective. Therefore, the offer in this market segment will remain restricted, and the number of spent fuel reprocessing plants worldwide will remain small. Development of this limited international market has been hampered by the meagre prospects of future expansion of nuclear power, and the reticence of key countries to embrace a circular approach to the nuclear fuel cycle, with the notable exception of Russia, France and few others.

Much of the capacity of the reprocessing plants is devoted to domestic spent fuel, even if such plants also reprocess spent fuel from foreign utilities.

Reprocessed uranium and plutonium are routinely used in the manufacturing of new nuclear fuel bundles. These bundles are then used at some plants, for example in France, Switzerland and Japan. Their use is also envisaged for the manufacture of future advanced fuels, such as TRISO fuel in the USA.

Several developments in the back end of the fuel cycle took place in 2022. In the UK, Magnox reprocessing is coming to its end. In France, a reprocessing contract with Japan was announced, and details were unveiled about EDF's plans for a spent fuel storage pool at La Hague. Also at La Hague, work is under way to set up new evaporators at the UP3 plant, and details were released about the plan for 'convergence' with the UP2-300 plant management. The year also saw a new decree authorising Orano CE to operate the new 'Fleur' facility at Pierrelatte. In the USA, an application for a licence to build and operate a consolidated interim spent nuclear fuel storage facility in Lea County, New Mexico, was approved by NRC.

In 2022, Posiva's EKA project to build the final disposal facility for spent nuclear fuel, encompassing the encapsulation plant and the underground repository, progressed as planned. The construction stage was completed and excavations were finalised in the first five deposition tunnels in the course of the year, allowing the installation of equipment at the encapsulation building to commence. Furthermore, several announcements were made in 2022 relating to progress on deep geological repositories, notably in Switzerland, Sweden, Belgium and France.

4.8. Storage and repository of nuclear spent fuel

2022 saw a new decree authorizing Orano CE to operate the new 'Fleur' facility at Pierrelatte. In the USA, an application for a license to construct and operate a consolidated interim spent nuclear fuel storage facility in Lea County, New Mexico, was favourably received by NRC.

In 2022, Posiva's EKA Project for the construction of the final disposal facility for spent nuclear fuel, encompassing the encapsulation plant and the underground repository, progressed as planned and included the start of the installation of equipment at the encapsulation building upon completion of the construction stage and the finalising of excavations in the first five deposition tunnels. The year also saw several announcements relating to progress with deep geological repositories, notably in Switzerland, Sweden, Belgium and France.

5. Key achievements

5.1. Mission and governance

Mandate and strategic objectives

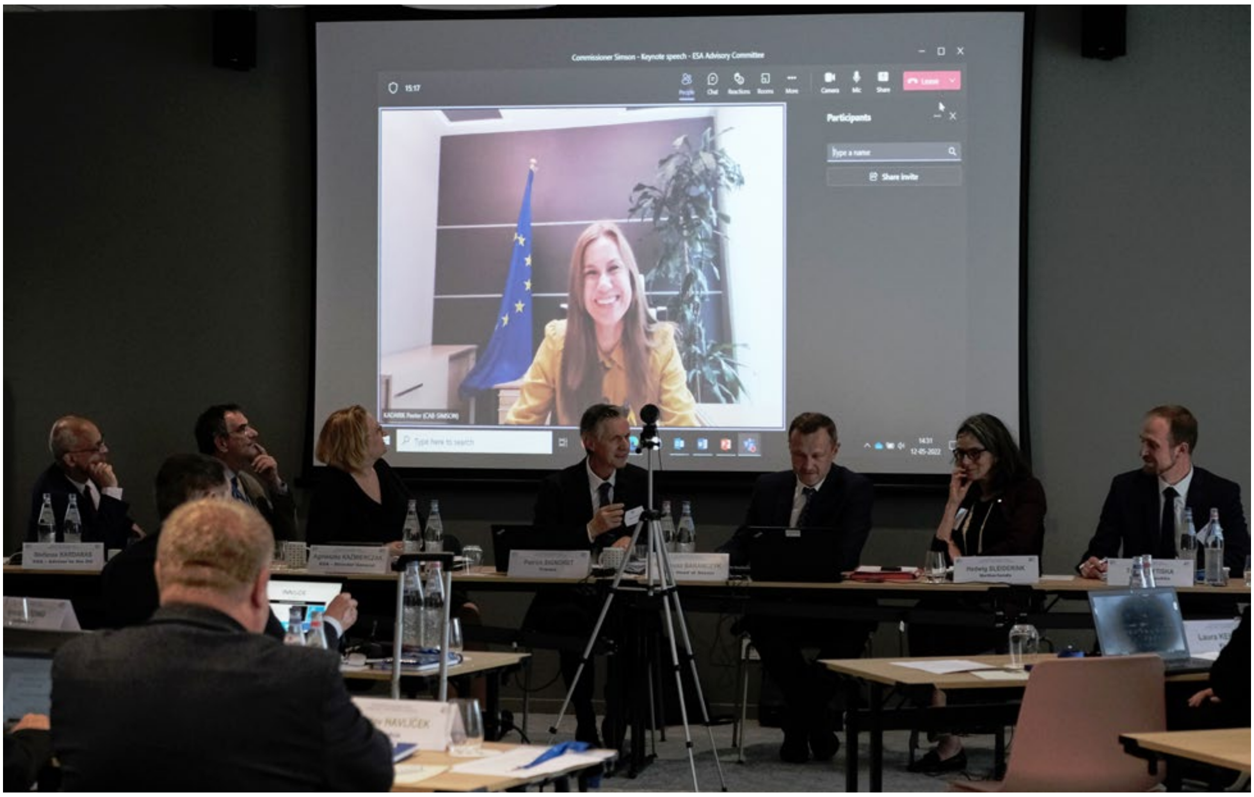
The Supply Agency of the European Atomic Energy Community, also known as the Euratom Supply Agency (ESA), was established by Article 52 of the Euratom Treaty [37] ('the Treaty'). The Agency was set up to further the common supply policy for ores, source materials and special fissile materials, with the purpose of ensuring the regular supply of the materials concerned in the nuclear common market set up by the Treaty. The policy is based on the principle of equal access of all users in the Community to sources of supply.

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

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

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 the provision of services in the nuclear fuel cycle, including by acknowledging the notifications that market players must submit, which give details of their

Commissioner Simson at ESA Advisory Committee meeting in May 2022



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37 Treaty Establishing the European Atomic Energy Community (2012/C 327/01).

commitments. The Treaty endows ESA with legal personality and financial autonomy, enabling it to make independent decisions on matters within its remit.

In the interest of its Treaty missions, the Agency's Statutes ([38]) entrust the Agency with a market observatory role to identify market trends that could affect security of the European Union'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 ([39]).

Governance

The Supply Agency was endowed by the Euratom Treaty with legal personality and financial autonomy and operates under the supervision of the European Commission. The Agency's Statutes ([40]) set out its governance in more detail.

In line with ESA's Statutes, the Advisory Committee helps the Agency carry out its tasks by giving opinions and providing analysis 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.

Key achievements

2022 was marked by Russia's invasion of Ukraine. This raised EU concerns about energy security in general, and in particular undermined the EU's security of supply for nuclear materials and fuel and aggravated dependence issues. Many European nuclear power plants rely on Russian suppliers for fuel, and EU utilities as a whole are 20-30% dependent on Russian supply of nuclear materials and the fuel cycle services.

> Russian invasion of Ukraine highlighted the importance of diversifying supply chains and reducing dependence on potentially unstable regions.

The functioning of the nuclear market has been profoundly affected by the developments in Europe since the invasion. In response to it, the EU continued to adopt far-reaching restrictive measures ([41]) aimed at hitting certain Russian organisations, individuals and a number of activities, but also affecting transport and trade. The EU is aware that the high amounts it pays for imports of energy resources from Russia help the latter sustain its war against Ukraine, and so it decided to phase out its dependence on Russia, which is significant in a number of sectors. Nuclear supplies, with all their specificities, might in the future follow this move.

Overall, the Russian invasion of Ukraine highlighted the importance of diversifying supply chains and reducing dependence on potentially unstable regions. The REPowerEU Plan ([42]) issued in May 2022 states: 'Diversification options are also important for Member States currently dependent on Russia for nuclear fuel for their reactors serving either power generation or non-power uses. This requires 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 EU's global partners.'

In 2022 ESA carried out its various core activities in the light of this particular context and related risks.

ESA Advisory Committee meeting May 2022

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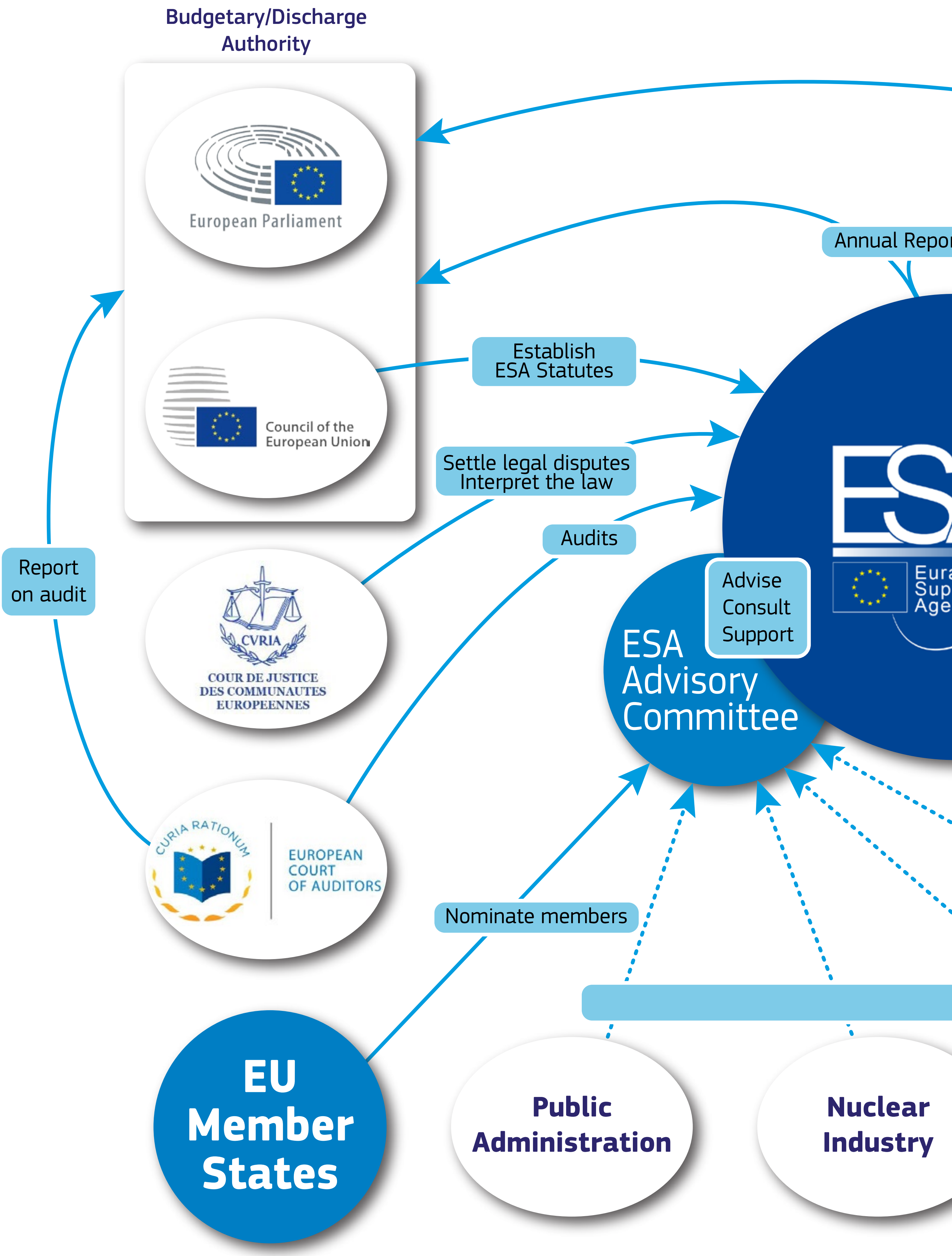
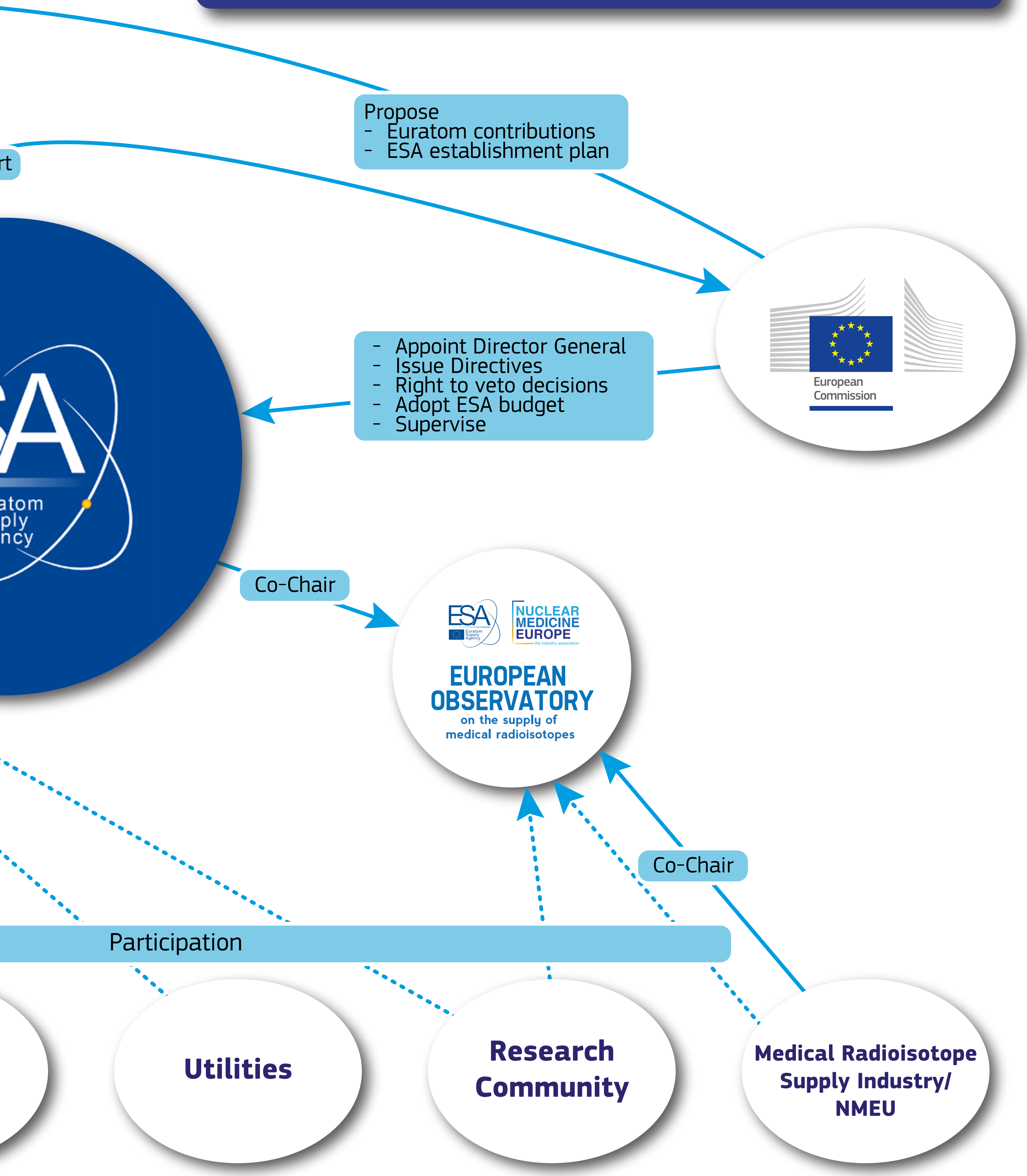
38 Council Decision 2008/114/EC, Euratom establishing Statutes for the Euratom Supply Agency.
39 'Towards the secure supply of radioisotopes for medical use in the EU' - 3053rd Employment, Social Policy Health and Consumer Affairs Council meeting, 6 December 2010 and 17453/12, ATO 169/SAN 321, 7 December 2012.
40 Council Decision (2008/114/EC, Euratom) of 12 February 2008 establishing Statutes for the Euratom Supply Agency.
41 Council Regulation (EU) No 833/2014 concerning restrictive measures in view of Russia's actions destabilising the situation in Ukraine, as amended by Council Regulation (EU) 2022/576 of 8 April 2022, with later amendments.
42 Communication COM (2022) 230 final from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of Regions.


Budgetary/Discharge Authority
European Parliament
Council of the European Union
Annual Repor
Establish ESA Statutes
Settle legal disputes Interpret the law
Audits
CVRIA
COUR DE JUSTICE DES COMMUNAUTES EUROPEENNES
Report on audit
CURIA RATIONUM
EUROPEAN COURT OF AUDITORS
Advise Consult Support
ESA Advisory Committee
Nominate members
EU Member States
Public Administration
Nuclear Industry

ESA's Governance



Advisory Committee

At its May in-person meeting, the Committee by-elected its new Chairperson and Vice-Chairperson following the announced replacement of the standing Chair as Committee member. The Committee delivered its opinions on ESA's 2021 annual report and on the audited financial and budgetary statements for 2021, approved the report delivered by its working group on the European supply of low-enriched uranium (LEU) at 19.75%, and took note of progress made by its working group on prices and security of supply. The Committee examined the short- to long-term security of supply situation as presented by the Agency, discussed the outlook, measures and actions, and approved the proposal to set up its sub-committee on the security of supply. At the meeting, the Agency presented the proposed revision of the Advisory Committee's Rules of Procedure and indicated that the Rules would be submitted for approval at the following meeting.

At this Committee meeting, the Commissioner for Energy, Kadri Simson, delivered a keynote speech to congratulate the Euratom Supply Agency on its 60 years of operation and to assure the Agency's Director-General and its staff of her – and that of her fellow Commissioners' – strong political support for their actions in the specific geopolitical context. She stated that ESA has been, and is presently more than ever, an indispensable actor for the strategic autonomy of the EU. The new geopolitical circumstances on our continent, following the Russian invasion of Ukraine, further highlight the importance of security of supply of energy resources for the EU. The Commissioner mentioned that policy options are being considered to enhance security of supply of nuclear fuels and other materials for the immediate future. For the medium and long term, it has been learnt, together with the Agency, that risk preparedness, based on sound risk assessment and including diversification of supply sources, is the key means to achieving security of supply. She added that, as has been seen, decisions taken by any user or producer affect the whole single nuclear market. She concluded that it is of utmost importance to work closely together in the spirit of solidarity and that there is a significant role for the Advisory Committee, which is meant to be the link between the various actors: ESA, Member State administrations, utilities, other users, and – lastly yet importantly – producers.

At its October e-meeting, the Committee delivered its opinion on ESA's 2023 work programme, was informed about the draft budget for 2023, and noted the approval of the revised Committee's Rules of Procedure. The Committee continues to look in the short- to long-term security of supply situation and agreed to finalise the mandate of its Sub-Committee on the Security of Supply.

In 2022, the Sub-Committee on Security of Supply met twice and continued to discuss the topics and issues related to security of supply of nuclear fuel to EU end users. The Sub-Committee offered advice on subjects connected with the operation of the market and potential disruptions in supply in the light of the current geopolitical tensions on the EU's eastern border. The work continued on the ESA analysis of nuclear industry capacity to meet future demands, focusing on risks to the long-term security of supply, trade and transport issues and prices.

5.2. Principal activities

5.2.1. Contract management

ESA concludes contracts for the supply of nuclear materials and fuel, as per Article 52 of the Euratom Treaty, and acknowledges notifications of contracts for small amounts of nuclear materials ([43]) and transactions for services in the nuclear fuel cycle, as per Articles 74 and 75 of the Euratom Treaty respectively.

Each submitted contract is checked for completeness of information as required under the Agency Rules ([44]).

For supply contracts, once all information is available, the case handlers analyse the contract to check whether the economic and commercial conditions and legal clauses are aligned with the Euratom Treaty and with the objective of security of supply.
After analysis, the Agency either concludes the supply contract, by providing the signature of an authorised official on the original copies received and assigning a registration number, or it informs the parties about the conditions under which the contract may be concluded.
The Agency may refuse to conclude the supply contract, providing the parties concerned with a reasoned decision.

The contracts that have been notified under Articles 74 and 75 of the Treaty are acknowledged and a registration reference is issued.

In 2022, 214 new registration references were issued. Among these references, 40% were associated with new contracts, amendments or supplements to existing supply contracts, as specified by Article 52 of the Treaty. The remaining 60% of references corresponded to notifications related to contracts on small quantities and services in the nuclear fuel cycle covered under Articles 74 and 75 of the Treaty respectively.

In 2022, ESA gave extra effort to reviewing contracts that involved risks of dependence on Russia. This required careful analysis of the contract clauses, information on technology and supply chains, availability of alternative fuel, and the utility's operational autonomy based on the existing fuel stock.

43 Commission Regulation (Euratom) No 66/2006 provides details of how transactions involving small quantities of nuclear materials are handled.
44 Agency Rules determining the manner in which demand is to be balanced against the supply of ores, source materials and special fissile materials (O.J. L 218, 18.6.2021).

ESA gave extra effort to reviewing contracts that involved risks of dependence on Russia.

ESA took steps to simplify the process of submitting and notifying contracts, while maintaining a high level of security. Dedicated secure IT tools for stakeholders to remotely complete and submit contracts were put at their disposal already in 2021. As a result of these efforts, in 2022 ESA witnessed a rise in the number of acts submitted with an electronic signature that conforms to the regulations on identification for electronic transactions in the single market ([45]).

5.2.2. Security and diversification of the nuclear fuel supply chain

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

Diversification of supply sources, which also contributes to the viability of the EU's nuclear industry, is a significant means of ensuring secure supplies in the medium and long term.

Soon after the war started, ESA assessed the short-term challenges to the security of supply of nuclear materials and fuel. The analytical work was later extended to cover medium- and long-term supply risks and possible supply scenarios.

Based on its risk assessment, the Agency implemented measures within its remit to strengthen the security of energy supply in the nuclear sector through diversification, building strategic inventory of nuclear supplies and limiting high-risk supplies. In parallel, it brought forward proposals for possible further policy and regulatory actions and measures that could be undertaken by the Commission.

The Agency monitored and regularly reported on the operational autonomy of nuclear power plants, taking into account the fresh fuel they had in stock or already expected to be delivered in the following couple of months.

The Agency held regular meetings with the utilities most exposed to high-risk supplies (dependent on the supply of fuel of Russian design or supply chain processes available only in Russia). The aim of the meetings was to discuss risk preparedness and action plan execution and to share information, concerns and market outlook.

ESA urged the utilities concerned to expedite diversification of fuel supply and to prepare nuclear fuel diversification plans for fuel supply to VVER reactors. VVER 1000 reactors already had an ongoing licensing process for alternative fuel design contracted to supply as of 2024/2025. Utilities operating VVER 440 engaged with different suppliers to establish an alternative to the traditional fuel and supplier.

For the remaining nuclear power plants, ESA appraised that the short-term risk was lower, as 2022 Russian deliveries of nuclear material were accounting for less than 10%, and enrichment for around 15% of EU needs. ESA urged all users to make a long-term commitment to conversion and enrichment services sourced from open market industry.

Meanwhile, various challenges emerged to the transport of nuclear fuels from Russia. Planned deliveries of nuclear material and fuel were hindered by logistical problems due to (i) prohibited transport routes, resulting from sanctions on air carriers, and (ii) carriers' refusal to transport and/or grant access to port or deal with Russian goods amid public sensitivity and/or reputational risks. The identification of alternative routes and carriers was essential. In this respect, ESA led a forum facilitating the process of setting up alternative supply routes, which included participation by utilities operating Russian reactors, the Commission department for transports and the European Union Aviation Safety Agency. By the end of December 2022, the risk was considered as mitigated.

In line with its strategic objective, the Agency monitored market developments, analysed them and identified trends that could affect the medium- and long-term security of the EU's supply of nuclear materials and services (see below).

The conflict increased public concerns about the dependency on Russian supplies. The Agency was solicited by, and replied to, an unprecedent number of 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.

45 Regulation (EU) No 910/2014 on electronic identification and trust services for electronic transactions in the internal market.

Member of the European Parliament Bartosz Arłukowicz at the EU MR Observatory meeting

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5.2.3. Market monitoring and analysis

The Agency is responsible for monitoring the market to identify trends likely to affect the EU's security of supply of nuclear materials and services.
ESA monitors developments in the nuclear fuel market and in relevant technological fields.
It publishes a market analysis in its annual report.
It provides information in its publications on the European and global nuclear markets.
It shares information and knowledge with other international market analysis organisations.

Market monitoring

Following the Russian aggression in Ukraine, ESA monitored the impact of the geopolitical developments in the EU and drew up an analysis of the current and future conversion and enrichment capacity in the world [46]. In its market analysis, ESA concluded that EU utilities' demand for both natural uranium and for fuel fabrication and related services face an increased risk related to Russian supply and connected with the new geopolitical situation. Analysis from the nuclear industry (converters and enrichers) indicated that total open market conversion capacity may not be sufficient. Similarly, the capacity of the same open market sources to supply enrichment would be insufficient if the services from current non-open market players 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 build up capacity, especially for conversion and 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.

ESA monitored the impact of the Russian aggression in Ukraine on the EU nuclear market and drew up an analysis of the current and future conversion and enrichment capacity in the world.

Annual Report 2021

ESA's annual report remains its principal reporting tool.

In its 2021 annual report, ESA gave an overview of its own activities and of developments in the nuclear fuel markets and nuclear energy, both in the EU and worldwide.

46 Overview the current and future global conversion and enrichment capacity analysis was included in the 3rd ESA Quarterly Market Report.

As in previous years, in 2022 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 2021. 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 made an analysis of EU inventories of nuclear material.

The report set out ESA's findings and recommendations on supply and demand for nuclear fuels, reflecting 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 and early 2022 seriously impacted the global nuclear market, the ESA recommendations became more relevant and urgent than ever.

ESA's recommendations in its 2021 annual report also took due account of the developments since the Russian aggression in Ukraine on 24 February 2022. Overall recommendations invited market players to: (i) review security of supply risk assessment and preparedness, including on transport and storage; (ii) create and maintain strategic stocks, taking a coordinated rather than competitive approach among Member States, producers and users; and (iii) sign long-term diversified contracts. In fuel fabrication, the 100% reliance on a single design and supplier of VVER fuel was identified as a matter of the highest concern, especially as it entailed supply of additional products and services from the same high- risk supplier.

With the geopolitical developments creating emergency circumstances affecting the security of nuclear supplies, the Agency considered it appropriate to include further analysis, trends and recommendations taking into account the 2022 events. The report was published on ESA's website on 10 August 2022 and its print version in November 2022. As required, the report was sent to the European Parliament, the Council of the EU and the Commission, and was presented to the Council Working Party on Atomic Questions.

Publication and knowledge sharing

ESA regularly publishes on its website reports and information on price trends to enhance transparency in the EU's natural uranium market, reduce uncertainty and help improve security of supply.

In 2022, ESA's nuclear fuel market observatory issued four quarterly uranium market reports. 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 ([47]). The 2022 quarterly reports featured overview articles on security of supply of nuclear fuel in the EU, the European Observatory on the Supply of Medical Radioisotopes, future needs and gaps in conversion and enrichment services deliveries, and securing the European supply of HALEU (high-assay low-enriched uranium).

The Agency also issues a weekly nuclear news brief for readers in the Commission.

5.2.4. Supply of medical radioisotopes

In line with its strategic objective, ESA leads action towards securing the supply of source materials for medical radioisotopes.

ESA contributes to the implementation of the Strategic agenda for medical ionising radiation applications (SAMIRA).

It is tasked with designing and launching a new platform and system to monitor the supply and long-term forecasts for a broad spectrum of radioisotopes and production methods.

It leads the European Observatory on the Supply of Medical Radioisotopes.

It facilitates the supply of materials required to produce medical radioisotopes and to fuel research reactors (high-enriched uranium (HEU) and high-assay low-enriched uranium (HALEU)).

With the EU being dependent on Russian production of critical stable isotopes and some radioisotopes, security of supply challenges were experienced in the supply chain of medical radioisotopes essential for nuclear medicine.

Of particular concern was the supply of precursor material to produce medical radioisotopes.

Of particular concern was the supply of precursor material to produce medical radioisotopes. The EU is dependent on Russia for enrichment of stable isotopes needed to produce several important medical radioisotopes, in particular Ytterbium-176

47 Provided at least three spot contracts have been concluded.

ESA chairing a session on medical radioisotopes at RRFM2022

©European Nuclear Society

(Yb-176) needed for Lutetium-177 (Lu-177) production (48). 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 sourced partly from Russia at present.

In this respect, ESA provided expertise and analysis of the situation to the appropriate services and forums (e.g., the EU Health Security Committee and the European Medicines Agency) and to the relevant European Commission departments (e.g., the Directorates-General for Health and Food Safety, for Energy and for Trade). ESA contributed to the Commission's work on the restrictive measures against Russia, providing its analysis on the need for exemptions. The Agency regularly updated the Council Atomic Question Working Party (49), appropriate services and forums on the supply situation. It also liaised with the industry association of nuclear medicine (NMEU) to gather relevant information.

In addition, some EU research reactors producing vital medical radioisotopes are dependent on Russian fuel and materials. In this respect, ESA assessed their dependencies on Russian supplies and called for a revised risk assessment to avert security of supply vulnerabilities. Some EU research reactor operators that had already licensed alternative fuel phased out the Russian supply of fuel. Some participate 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.

SAMIRA

ESA contributes to the implementation of the Strategic agenda for medical ionising radiation applications (SAMIRA) (50). SAMIRA is the energy sector's contribution to Europe's Beating Cancer Plan, and a response to the Council's conclusions on non-power nuclear and radiological technologies and applications.

> ESA contributes to the implementation of the Strategic agenda for medical ionising radiation applications (SAMIRA).

The agency leads activities aimed at securing the supply of source materials for radioisotope production. This means: (i) protecting the supply of high-enriched uranium (HEU) until the full radioisotopes production chain is converted to operate with high-assay low-enriched uranium (HALEU); and (ii) exploring options for the future supply of HALEU to the EU.

In addition, ESA is tasked with designing and launching a new platform and system for monitoring the supply and long-term forecasts for a broad spectrum of radioisotopes and production methods. ESA has to take into account the further development

48 The EU is a large supplier of Lu-177, which has demonstrated spectacular growth in recent years.
49 Council of the European Union - Working Party on Atomic Questions (WPAQ)
50 Commission Staff Working Document on a Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA), 5.2.2021.

of the European Radioisotopes Valley Initiative (ERVI), which is crucial for ensuring the endorsement of a wide group of stakeholders and sufficient resources. The Agency closely cooperated in this area with the Commission in 2022.

ESA at Working Party on Atomic Questions

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European Observatory on the supply of Medical Radioisotopes

In 2022, ESA continued to lead and coordinate activities to improve the security of supply of widely used medical radioisotopes, focusing on Molybdenum-99/Technetium-99m (Mo-99/Tc-99m). It co-chaired the European Observatory on the Supply of Medical Radioisotopes jointly with Nuclear Medicine Europe (NMEU), the industry association of nuclear medicine.

Established in 2012, the Observatory monitors the EU supply chain of Mo-99/Tc-99m and engages on a variety of topics on the EU supply of widely used medical radioisotopes. The Observatory is composed of representatives of the Commission, EU Member States, international organisations and industry.

In the 10 years since its establishment, the Observatory has confirmed its importance. It has become a vehicle for gathering information (through industry participation) on potential shortages and consequently for dispatching information to interested parties, sometimes directly through ESA. It enables industry to reach out promptly to appropriate EU bodies and services on awareness raising and response facilitation at Member State and European Commission level.

In 2022, the Observatory continued its close cooperation with the NMEU's Security of Supply Workgroup on the uninterrupted supply of Mo- 99/Tc-99m and Iodine-131 (I-131). Following a Mo-99/I-131 production disruption and outage of several reactors, the Agency ensured a steady flow of information from the NMEU's Emergency Response Team to various stakeholder groups, including the Council Working Party on Atomic Questions and the Health Security Committee (HSC).

The in-person meeting in June 2022 in Brussels marked the tenth anniversary of the Observatory and saw the participation of around 50 members (from industry, international organisations and Member State administrations). The meeting was largely devoted to the impact on the supply of medical radioisotopes of the Russian military aggression in Ukraine. In this context, a panel discussion on the security of supply of medical radioisotopes was held, involving representatives from the European Medicines Agency, the European Association of Nuclear Medicine (EANM), NMEU and ESA. It was followed by discussions on possible production of stable isotopes in the EU, with Urenco and Orano presenting their projects to start domestic production of target materials, namely Mo-98, Mo-100 and Yb-176. Currently, these isotopes are mainly supplied by Russia. The topic was completed by presentation of the recent report of the ESA Advisory Committee Working Group on European production of HALEU. HALEU production is equally dependent on supplies from Russia. NMEU, EANM and the International Atomic Energy Agency (IAEA) gave updates on their activities. The European Commission Directorate-General for Energy gave a presentation on the state of play of the SAMIRA and ERVI initiatives. A keynote speech was delivered on the outcomes of the Special Committee on Beating Cancer (BECA) by its Chair, Bartosz Arłukowicz MEP. The meeting was concluded with updates from EU Member States and a presentation about the impact of proposed changes to IAEA Safety Series No 6 (SS6) on the transportation of radioactive materials.

ESA presented the Observatory's activities and the results of its 2021 and 2022 meetings to the Council Working Party on Atomic Questions, outlining the 2022 supply disruptions for medical radioisotopes and the related mitigation measures taken by the Observatory in response to them.

5.2.5. Cooperation with stakeholders and partners

To further its objectives, ESA pursues international cooperation and outreach activities to stakeholders.

Throughout 2022, ESA pursued contacts with EU authorities, utilities, industry and nuclear organisations to strengthen the security of supply of nuclear materials in the light of the Russian aggression in Ukraine. It monitored market developments in view of the new market situation and provided advice and follow-up to ensure appropriate application of the common supply policy and mitigation of the new risks.

> ESA worked closely with the Commission to promote diversification of supply and contributed to the work of the Commission departments in that area.

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

The Agency held regular meetings with utilities to discuss risk preparedness and implementation of mitigation measures. It also met with the EU nuclear industry to share information and market outlook.

The Agency has long-standing and well-established relationships on nuclear energy with international organisations, namely the IAEA and the OECD Nuclear Energy Agency and nuclear industry associations. In 2022, ESA continued to cooperate with these organisations by participating in working groups, conferences and seminars. ESA continued to support the IAEA expert group, created in July 2021, with the aim to create a technical document on global secondary uranium supplies.

In September, ESA contributed to the 2022 World Nuclear Symposium in London, delivering a clear message to the participating top nuclear industry leaders, experts and executives on the need to tackle the risks related to the new market setup in a panel discussion on security of supply policy.

The Agency's market analysis and outlook were presented at the Warsaw Security Forum and at the World Nuclear Fuel Cycle, and the Agency was represented at the First International Conference on Nuclear Law and at the European Research Reactor Conference. ESA contributed to European Nuclear Society's events on medical radioisotopes (the 'Radioisotopes for life' webinar and 'Medical radioisotopes – challenges and opportunities for a sustainable supply' panel discussion).

Panel session at the World Nuclear Symposium 2022

©World Nuclear Association

6. Management

Legal status

ESA was endowed by the Euratom Treaty (51) with legal personality and financial autonomy (52) and operates under the supervision of the European Commission on a non-profit-making basis. The Agency's Statutes set out its governance and management in more detail.

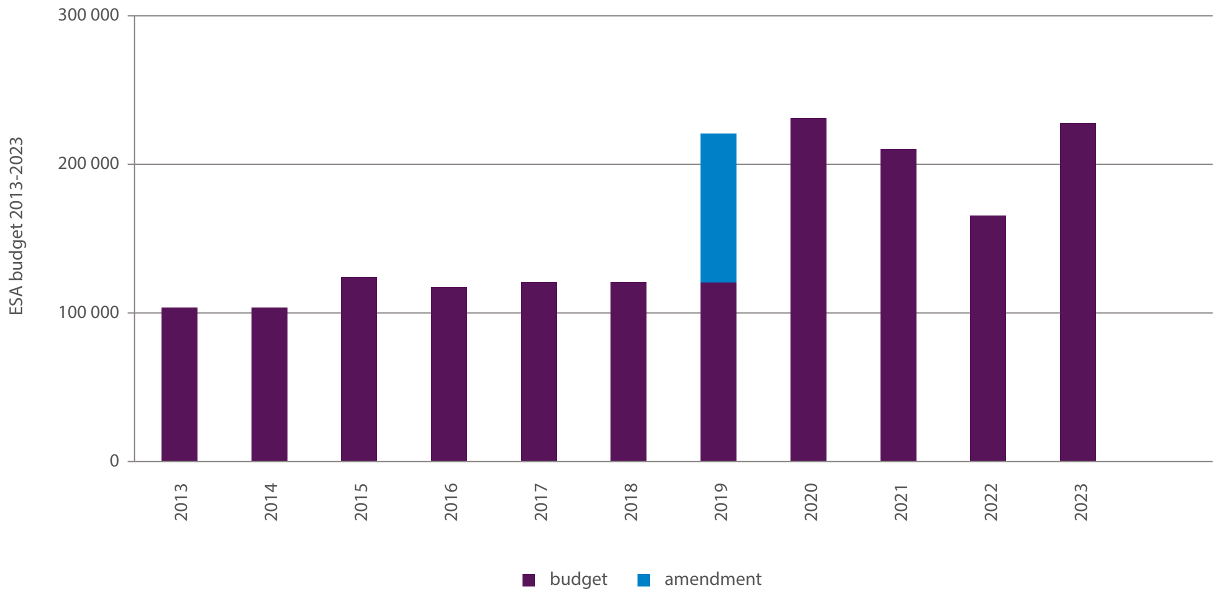
ESA's seat has been in Luxembourg since 2004. Together with the European Commission, ESA has concluded a seat agreement with the government of the Grand Duchy of Luxembourg.

6.1. Budgetary and financial management

The European Commission adopts ESA's budget, and ESA Director-General is responsible for its execution, acting as authorising officer.

For its financial operations, the Agency applies the relevant provisions of its Statutes and of the EU Financial Regulation (53) as well as the accounting rules and methods established by the European Commission.

Part of ESA's operating costs is covered by its own budget, and another part directly by the European Commission.



Budget

The Agency's adopted budget for 2022 (54) was EUR 167 000, 20.47% lower than in 2021 (EUR 210 000). ESA was financed entirely by the EU budget through the EC budget line 20 03 14 01 'Euratom contribution for operation of the Supply Agency'. Its revenue and expenditure were in balance.

The increase in the ESA budget since 2019 is related to the continued development of the Noemi IT system.

The Agency's adopted budget for 2022 was 20.5% lower than in 2021.

51 Article 52 of the Euratom Treaty.
52 Article 54 of the Euratom Treaty.
53 Regulation (EU, Euratom) 2018/1046 on the financial rules applicable to the general budget of the Union; Article 68 of the EU Financial Regulation stipulates its applicability to the implementation of the budget for ESA.
54 Commission Decision C(2021)8432 of 29.11.2021.

Budget execution

The executed commitment amount in 2022 totalled EUR 161 782.84 (96.8%). The Director-General approved 3 internal transfers within the budget chapters.

The payments executed on 2022 commitments amounted to EUR 58 137.37, giving an implementation rate of 34.81% of available appropriations. The payments executed on commitments made in 2021 amounted to EUR 101 516, i.e. 99.56% of the outstanding payment allocations.

The operating costs that ESA covered by its budget included:

- development of the Noemi nuclear contracts management application and maintenance of a stand-alone computer centre;
- Advisory Committee meetings;
- duty travel;
- participation in conferences;
- subscriptions to nuclear market media and data sources;
- ESA publications and communication activities.

In-kind contribution from the Commission

A large part of ESA's administrative expenses is covered directly by the European Commission budget, including salaries, premises, infrastructure, training, and some IT services and equipment.

In an internal estimate for 2022, the salaries of the Agency's staff were calculated at EUR 1 937 817 (EUR 1 784 258 in 2021). Other operating costs covered by the Commission amounted to:

- EUR 467 708 – buildings and IT-related expenses (EUR 486 000 in 2021);
- EUR 84 644 – hosting of the Noemi IT system (service provided and cost calculated for the first time).

This off-budget expenditure and the underlying transactions are not acknowledged in ESA's accounts but are included in the Commission section of the EU annual accounts.

The in-kind contribution and generous free baseline had a positive impact on ESA's administrative capacity.

Financial accounts

- In 2022, the assets owned by the Agency totalled EUR 932 902 (down from EUR 963 933 in 2021). They were financed by liabilities of EUR 96 741 (10%) and equity of EUR 836 159 (90%).

Following the departure of the Agency's accounting officer in January 2023 and inability to recruit a replacement to fill the available post, the accounting officer function in ESA is shared with the Translation Centre for the Bodies of the European Union. A service level agreement was concluded in March 2023. The 2022 provisional accounts, budget outturn and report on budget implementation were submitted to the European Court of Auditors and the Commission's Accounting Officer on 15 May.

The final accounts were issued on 16 June. They received the positive opinion of the Advisory Committee and on 30 June 2023 were duly submitted to the EU institutions.

6.2. Human resources

ESA staff are European Commission officials.

ESA's establishment plan is incorporated into the global staff numbers of the European Commission.

ESA staff salaries are paid by the European Commission, in line with Article 4 of ESA's Statutes, and are not charged to the Agency's budget.

Human resources	2022		
Number of staff	Authorised [55]	Actually filled as of 31.12.2022	Available throughout the year
		All staff	
Administrators (AD)	7	8	8.0
Assistants (AST)	10	7	6.5
Assistants/secretarial (AST/SC)		2	1.6
Total staff	**17**	**17**	**16.1**

Staff allocation

At the end of 2022, the Agency occupied 17 permanent posts (8 administrator posts, 7 assistant posts and 2 assistant/secretarial posts).

> At the end of 2022, the Agency occupied 17 permanent posts.

The higher number of administrators than authorised was the result of an upgrade of one assistant post. This was approved by the Commission in its establishment plan but accidentally omitted in the draft budget.

The difficulties in recruitment had negative effect on the actual staffing levels: 16.1 were available throughout the year, out of 17 in the establishment plan (vacancy rate of 5.4%). Despite the Agency's efforts, finding assistants in low grades proved difficult given the specialised profile required and the associated pay levels compared to the cost of living in Luxembourg. In 2022, ESA recruited 2 temporary agents on permanent posts (1 assistant and 1 assistant/secretarial).

Equal opportunities

ESA provides equal career opportunities for staff at all levels and promotes a gender-balanced workplace. Women make up 59% of ESA staff and men 41%. The equal opportunities policy is also reflected in management positions, which are equally distributed.

6.3. Information management and communication

Noemi

Since January 2020, ESA has been developing internally new software to support the management of its core tasks under the Treaty and the Statutes.

The Noemi ('Nuclear Observatory and ESA Management of Information') IT system started operation in December 2021.

Noemi will reinforce ESA's capabilities to monitor nuclear materials and fuel market and provide secure hosting of sensitive nuclear contract data.

At this first stage, Noemi operates as a secure integrated database of information from contracts for the supply of nuclear materials and for related services, as well as of data provided by nuclear users through annual reporting. To this end, it supports monitoring of the EU nuclear fuel cycle supply market and transactions and enables the export of data to produce analyses and reports.

During 2022, the system went through a systematic process of consolidation and corrective and evolutive maintenance in order to reach the maturity and user experience necessary before further development.

The system will further evolve in the years to come, increasing the efficiency and effectiveness of ESA operations. In the next stage, planned to start in 2023, it will integrate business workflows, operations monitoring and advanced user experience. The project's final stage will eventually enable full and secure digitalisation of ESA core operations, i.e., handling nuclear fuel cycle contracts and collecting and processing data on the nuclear materials and fuel market.

55 Authorised establishment plan under the EU General Budget 2022, OJ L 45, 24.2.2022 p. 1136 footnote 1.

Information security

To carry out its mission, ESA receives or collects data from nuclear market actors, and processes, analyses, and, if appropriate, publishes them.

It does so in full compliance with the applicable confidentiality requirements.

As records held by the Agency as part of its work under Chapter VI of the Treaty contain business secrets and sensitive information about undertakings, they must not be disclosed to other legal persons.

The Agency premises, provided by the Commission, have a high level of access security. All Agency staff and all external contractors hold security clearance. The Noemi IT system underwent a vulnerability assessment, which will be repeated after each development phase and/or all recommendations are implemented.

https://euratom-supply.ec.europa.eu/index_en

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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. ECA'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 ECA's observations and takes the necessary measures as needed. It also carefully follows observations of a cross-cutting nature accompanying the annual report on the EU agencies.

ECA signed off on the 2021 accounts and issued a clean opinion both on the accounts and on the legality and regularity of revenue and expenditure transactions (see Annex B).

Regarding follow-up observations from previous years, ECA closed a comment on the high cancellation rate of budget appropriations carried over after the ESA took steps to monitor its budget execution more closely.

ECA issued a clean opinion on the 2021 accounts and transactions underneath.

Discharge

The discharge authority for ESA is the European Parliament, acting on a Council recommendation. The European Parliament granted ESA's Director-General discharge for the implementation of the budget for the financial year 2020 ([56]).

6.5. Internal control and assurance

Internal control and risk management

The Agency has an internal control framework designed to provide reasonable assurance in achieving five objectives set out in Article 36 of the Financial Regulation.

In 2022, ESA performed a risk assessment update covering all areas of the Agency's work and its operational and administrative processes. Adjustments were introduced to align the controls in place with the risks.

Management assurance

In order to assess the effectiveness of internal controls, ESA carried out a light self-assessment. This consisted of an evaluation of changes to the pre-defined monitoring indicators, evaluation of audit results and new or outstanding recommendations, and analysis of non-compliance and exception cases.

The annual assessment for 2022 did not reveal any risks that could lead to a reservation in the annual declaration of assurance.

Based on elements of the internal control systems and the assurance they provide – the building blocks of assurance – the Director-General was in a position, as the authorising officer, to sign the declaration of assurance which accompanies this report (see Annex A).

56 TA-9-2022-0175-EN

6.6. Improving effectiveness and efficiency

2022 saw a substantial increase in the ESA's policy workload.

> 2022 saw a substantial increase in the ESA's policy workload.

First, the geopolitical developments meant that monitoring of the nuclear fuel and services market and the handling of nuclear fuel cycle contracts needed to be strengthened. The Russian aggression in Ukraine increased risks to the short- and long-term security of supply and added urgency and complexity to the task of monitoring the nuclear materials market to identify market trends that could affect security of EU supply (a task that originates in the Agency Statutes). An expanded analytical base is needed for action by ESA, the Commission and the Community operators to ensure the security of energy supply and address the risks of overdependence on Russia. This analytical capacity is crucial to ensuring the transparency of market operations and shedding light on practices by Russia and some other unfriendly market actors. To that end, ESA is further developing the Noemi IT system to enable full digital processing of nuclear supply contracts and market information in full compliance with the information protection rules. In parallel, it is working to extend its analytical capacity on the data available.

Second, ESA is tasked with setting up the system of monitoring and long-term forecasts for a broad spectrum of medical radioisotopes and production methods. The system is envisaged in Commission's SAMIRA action plan, adopted in 2021 under the umbrella of the EU's Beating Cancer initiative. This is a complex one-off task, which requires cooperation with various stakeholders in and outside the EU and specific expertise in data management and modelling not available in ESA.

The number of tasks and the expectations of stakeholders continue to grow. Repeated efforts have been made to achieve efficiency gains and reallocate human resources to the new upcoming tasks and challenges. Despite a steady reduction in the human resources allocation, in 2022 ESA managed to:

- create and run the nuclear market monitoring observatory (a task enshrined in its 2008 Statutes);
- assume increased responsibility for the supply of medical radioisotopes (following the 2012 Council Conclusions and 2021 SAMIRA action plan);
- fulfil the obligations of financial autonomy after this was reinstated in 2012 [57] (accounting officer, financial statements, annual audit by the European Court of Auditors, discharge);
- assume autonomously legal obligations (e.g., public access to documents, personal data protection) without the possibility to benefit from the support from Commission departments.

At this stage ESA is not in a position to continue addressing the increased workload through internal efficiency gains and reallocation of human resources. Further efficiency gains would only be possible by using synergies and support from the Commission through:

- provision of specialised support functions (e.g. a local information security officer);
- extending the use of corporate tools (e.g. to manage work-related travel) that the Commission has so far not provided to ESA;
- increasing the allocation to develop the Noemi IT system and introducing internal workflow and remote contract submission, planned for Phases 2 and 3 respectively, to streamline the process of handling information on contracts.

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57 Financial autonomy was reinstated in 2012, after the European Parliament noted that the lack of autonomous budget between 2008 and 2012 and de facto integration in the European Commission was at odds with the Agency's Statutes.

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This report and previous editions are available on ESA’s website: https://euratom-supply.ec.europa.eu/index_en

A limited number of paper copies of this report can be obtained, subject to availability, from the address listed above.

Further information

Additional information: http://europa.eu

Europa provides access to the websites of the European institutions and other bodies.

More information on the Commission’s Directorate-General for Energy: http://ec.europa.eu/energy. This website contains information on areas such as security of energy supply, energy-related research, nuclear safety, and liberalisation of the electricity and gas markets.

Annexes

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

(A) 2023-2032

Year	Natural uranium		Separative work	
	Gross requirements	Net requirements	Gross requirements	Net requirements
2023	11 862	10 349	9 680	8 889
2024	12 051	10 205	9 744	8 868
2025	13 356	11 387	11 266	9 951
2026	12 980	11 266	10 983	9 446
2027	12 753	10 874	10 819	9 136
2028	12 576	10 217	10 842	8 847
2029	12 872	10 377	11 033	8 904
2030	11 785	9 079	10 006	7 630
2031	12 218	9 556	10 327	7 886
2032	11 721	9 048	9 806	7 346
Total	**124 174**	**102 358**	**104 506**	**86 903**
Average	**12 417**	**10 236**	**10 451**	**8 690**

(B) Extended forecast 2033-2042

Year	Natural uranium		Separative work	
	Gross requirements	Net requirements	Gross requirements	Net requirements
2033	11 131	8 401	9 301	6 798
2034	10 510	7 230	8 749	5 718
2035	10 766	7 547	8 994	6 017
2036	9 490	6 383	7 904	5 030
2037	10 042	7 049	8 407	5 636
2038	9 666	6 682	8 113	5 350
2039	9 668	6 690	8 154	5 398
2040	9 417	6 447	7 846	5 098
2041	10 189	7 221	8 494	5 747
2042	9 213	6 245	7 658	4 911
Total	**100 092**	**69 895**	**83 620**	**55 703**
Average	**10 009**	**6 989**	**8 362**	**5 570**

Annex 2
Fuel loaded into EU-28 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

Year	Fuel loaded			Deliveries		
	LEU (tU)	Feed equivalent (tU)	Enrichment equivalent (tSW)	Natural U (tU)	% spot	Enrichment (tSW)
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 (**)	1 763	15 912	13 580	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**

(*) *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

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
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**

(*) 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, the ESA U_3O_8 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, 2013-2022 (tU)

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Kazakhstan	3 612	3 941	2 949	2 261	2 064	1 754	2 518	2 414	2 753	3 145
Niger	2 235	2 171	2 077	3 152	2 151	2 067	1 962	2 555	2 905	2 975
Canada	3 156	1 855	2 845	2 946	4 099	3 630	1 485	2 312	1 714	2 578
Russia	3 084	2 649	4 097	2 765	2 192	1 759	2 543	2 545	2 358	1 980
Uzbekistan	653	365	526	115	348	166	612	329	0	441
Australia	2 011	1 994	1 910	1 896	2 091	1 909	1 851	1 671	1 860	327
Namibia	716	325	385	504	923	1 046	1 234	481	5	262
EU	421	397	412	220	0	18	251	64	163	17
Re-enriched tails	0	0	212	212	171	161	161	196	196	0
South Africa	17	20	1	0	0	118	115	21	21	0
Malawi	115	125	2	0	0	0	0	0	0	0
Other	621	299	229	130	80	80	103	4	0	0
United States	381	586	343	125	193	110	0	0	0	0
Ukraine	0	23	0	0	0	19	0	0	0	0
HEU feed	0	0	0	0	0	0	0	0	0	0
Total	**17 023**	**14 751**	**15 990**	**14 325**	**14 312**	**12 835**	**12 835**	**12 592**	**11 975**	**11 724**

Annex 5
Use of plutonium in MOX in the EU-28 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**
Grand total	**241 222**	**26 199**	**17 785**

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
PreussenElektra (formerly E.ON Kernkraft GmbH)
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 interests 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 2020 and 31 December 2022) 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 2021


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LUXEMBOURG

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3.34. Euratom Supply Agency (ESA)

Introduction

3.34.1. The Euratom Supply Agency ("ESA"), located in Luxembourg, was created in 1958[183]. Its statutes were overhauled by Council Decision 2008/114/EC, Euratom[184]. ESA's main task is to ensure 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[185].

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 agents, EU contract staff and seconded national experts, but excludes interim workers and consultants.

Source: Annual accounts of ESA for the 2020 and 2021 financial years; staff figures provided by ESA.

Information in support of the statement of assurance

3.34.2. The ECA's audit approach comprises analytical audit procedures, direct tests of transactions, and an assessment of key components of an agency's supervisory and control systems. This is supplemented by evidence resulting from the work of other auditors, and by an analysis of information provided by ESA's management.

3.34.3. Please refer to section 3.1 of the report for the description of the basis for our opinion, the responsibilities of ESA's management and of those charged with governance, and

[183] OJ 27, 6.12.1958, p. 534/58.

[184] Council Decision 2008/114/EC, Euratom establishing Statutes for the Euratom Supply Agency.

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

the auditor's responsibilities for the audit of the accounts and underlying transactions. The signature on page 344 forms an integral part of the opinion.

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

Opinion

3.34.4. We have audited:

(a) the accounts of the Euratom Supply Agency (ESA), which comprise the financial statements[186] and the reports on the implementation of ESA's budget[187] for the financial year ended 31 December 2021, 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

3.34.5. In our opinion, ESA's accounts for the year ended 31 December 2021 present fairly, in all material respects, ESA's financial position at 31 December 2021, 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.

[186] 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.

[187] 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

3.34.6. In our opinion, the revenue underlying the accounts for the year ended 31 December 2021 is legal and regular in all material respects.

Payments

Opinion on the legality and regularity of payments underlying the accounts

3.34.7. In our opinion, the payments underlying the accounts for the year ended 31 December 2021 are legal and regular in all material respects.

Follow-up of previous years' observations

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

Euratom Supply Agency (ESA)

Annex – Follow-up of previous year's observations

Year	ECA's observations	Status of corrective action (Completed / Ongoing / Outstanding / N/A)
2020	Carry-overs of committed appropriations were high for Title II (administrative expenditure). This creates risks on the implementation of the payment appropriations of 2021 considering that in the previous years there was high cancellation rate. The ESA should further improve its budget planning and its implementation cycles.	Completed

ESA's reply

The Agency has taken note of the ECA's report.

Annex 10
Declaration of assurance

Ref. Ares(2023)6843152 - 09/10/2023

Euratom Supply Agency

Director-General

30 June 2023

DECLARATION OF ASSURANCE

I, the undersigned, Agnieszka Ewa Kaźmierczak

Director-General of the Euratom Supply Agency in 2022

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 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.

Agnieszka Ewa Kaźmierczak

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

Annex 11
Work Programme 2022

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 a 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 established:

Specific policy objectives

1. ensure continuous supply of nuclear materials for users in the Community in the short and medium term;

2. facilitate the future supply and encourage the diversification and emergence of reliable alternative sources of nuclear fuel supply, services and design;

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 2022.

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. It 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 uses its right of option on nuclear materials produced in the Community Member States and its exclusive right to conclude contracts for supply of nuclear materials, coming from inside or outside the Community and it keeps track of transactions related to services in the nuclear fuel cycle.

To facilitate the operations of the common market for the 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, taking due account of the European energy security strategy;

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 for the provision of services in the nuclear fuel cycle, pursuant to Article 75 of the Euratom Treaty, in line with the common supply policy, taking due account of the European energy security strategy;

4. implement the Rules that determine the manner in which demand is to be balanced against the supply of ores, source materials and special fissile materials;

5. provide information and support to stakeholders on contract issues related to the nuclear common supply policy and/or the Agency's Rules;

6. support the Commission's nuclear materials accountancy, on request, in verifying contract data contained in prior notifications of movements of nuclear materials;

7. contribute, on request, for matters within its purview, to the assessment of international agreements communicated to the Commission under Article 103 of the Treaty.

Activity II. Facilitating future supply

ESA takes responsibility for the common supply policy with the strategic objective of security of supply in order to prevent excessive dependence of Community users on any single external supplier, service provider or design through appropriate diversification, in line with relevant decisions at political level.

To facilitate future supply, ESA will:

1. help strengthen clarity to market actors on the common supply policy pursued by ESA;

2. advocate and encourage emergence of alternative sources of nuclear fuel supply, services and design where such sources are presently not available, in particular for VVER reactors.

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 Supply 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 contribute to implementation of the action plan of the Commission's SAMIRA initiative (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. continuously monitor the needs for HEU and HALEU for the production of medical radioisotopes and for fuelling research reactors;

3. undertake measures that facilitate future supply of high-enriched uranium (HEU);

4. explore, assess and propose ways to ensure supply of high-assay low-enriched uranium (HALEU) for production of medical radioisotopes and as fuel for research reactors;

5. explore ways of monitoring and forecasting the supply of a wide range of radioisotopes, as provided for in the SAMIRA action plan;

6. 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's ambition is to maintain 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;

2. conduct the annual survey and deliver the market analysis as part of its annual report;

3. support the activities of the Advisory Committee's working groups;

4. publish and disseminate information, including through yearly natural uranium price indices, reports, studies, newsletters, timely updates on ESA's website and through the Advisory Committee or other meetings.

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.

In particular, ESA will:

1. cooperate with the Commission on common supply policy matters;

2. liaise with the operators and other concerned parties to encourage and facilitate diversification;

3. in cooperation with the Euratom Member States concerned, coordinate the implementation of the memorandum of understanding with the US Department of Energy – National Nuclear Security Administration, in order to facilitate supply of HEU, until full conversion of the reactors and processes using it, and to advance towards the minimisation of HEU;

4. engage with interested parties in and outside the EU, both suppliers and users, to:

   a) facilitate the continued supply of medical radioisotopes, and

   b) meet the needs of HALEU;

5. maintain regular contact with:

   a) international nuclear organisations such as the IAEA and the OECD NEA;

   b) other international players on the nuclear fuel market, including through membership of the World Nuclear Association, the European Nuclear Society and the World Nuclear Fuel Market;

   c) medical radioisotopes supply chain stakeholders (industry, research and user organisations);

6. contribute to monitoring the implementation of the Euratom cooperation agreements with non-EU countries as regards trade in nuclear materials.

Activity VI. Making ESA's internal organisation and operations more effective

ESA keeps its procedures under review 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;

3. ensuring competent, engaged and effectively utilised workforce;

4. keeping its work practices under review and updating them where appropriate;

5. progressive implementation of ESA's document management and security policy;

6. progressive implementation of the IT system supporting the work of ESA (NOEMI - Nuclear Observatory and ESA Management of Information).

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ESA Euratom Supply Agency

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