Annual Report 2020

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Foreword

On 1 June 1960, the newly established Supply Agency of the European Atomic Energy Community (Euratom) started operations, ensuring that all users in the Community received a regular and equitable supply of ores and nuclear fuel.

In 2020, the Agency celebrated 60 years of continued operations, demonstrating its resilience, its ability to adapt and its determination to modernise itself.

When the COVID-19 crisis hit in March, we protected ESA's most valuable asset: its staff. The lockdown united us in keeping the spirit of a common effort focused on the Agency's core objectives and values.

The transition to remote working was accompanied by introduction of new working methods, which allowed us to deliver in this challenging time on all the critical core processes: managing nuclear fuel contracts, facilitating the supply chain of medical radioisotopes and analysing market data.

The meetings of the Advisory Committee and of the European Observatory on the Supply of Medical Radioisotopes, which were for the first time ever conducted in a remote format, enabled efficient communication and decision-making, as did many meetings with our partners and stakeholders.

Our response to the limitations created by the coronavirus pandemic was to take it as an enforced opportunity to accelerate the adoption of new technologies to cut red tape. We expedited investment in the NOEMI application that will, for years to come, securely host data from contracts for the supply of nuclear materials and related services. This new IT system will also greatly improve monitoring of the nuclear energy market and production of reports from aggregated data. In the medium term, NOEMI will enable the Agency to electronically exchange documents and data with its counterparts.

As another opening into the future, the constructive dialogue with the Commission throughout 2020 led to the adoption on 15 January 2021 of the new Rules determining how the Agency is to balance demand and supply in the market. This milestone development will provide more process-driven transparency and clarity for Member States, operators and suppliers.

You will also notice the new format of our publications and website. We hope this will facilitate a more user-friendly access to information and data.

My wholehearted thanks and appreciation go to my colleagues at the Agency. Their dedication, flexibility and hard work fuelled our achievements in a year of unprecedented challenges.

Agnieszka Kaźmierczak
Director-General of the Euratom Supply Agency

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Executive summary

The Euratom Supply Agency (ESA), established by Article 52 of the Euratom Treaty, has the exclusive right to conclude contracts for the supply of nuclear materials in the EU and has the right of option on nuclear materials coming from inside the Community. ESA's strategic objective is the short, medium and long-term security of supply of nuclear materials, particularly nuclear fuel, for power and non-power uses, by means of the common supply policy. ESA has a duty to monitor the market in order to identify trends likely to affect the Union's security of supply of nuclear materials and services.

Exercising its prerogatives, ESA continued to conclude nuclear materials and fuel supply contracts, and to acknowledge notifications of contracts for small quantities of nuclear materials and notifications of transactions for the provision of services in the nuclear fuel cycle.

In line with the European Commission's policies, the Supply Agency strives for diversification of sources of supply in the nuclear fuel cycle for power and non-power uses – an important means for security of supply in the medium and long term. A large number of Europeans rely on nuclear electricity. Nuclear power plants generate a quarter of all electricity. This share rises above 50% in some countries. Disruptions in supply would have acute consequences for households, hospitals and industries. To prevent excessive dependence of Community users on any single external design or supplier, ESA continued to closely follow the situation as it evolved and encouraged efforts to diversify the supply of nuclear fuel.

ESA invariably scrutinised the security of supply of high-enriched uranium (HEU) and high-assay low-enriched uranium (HALEU), required to feed the production of medical radioisotopes and to fuel research reactors.

In 2020 ESA's Nuclear Fuel Market Observatory issued several market reports and analyses, published price indices and interacted with other international market analysis organisations.

The European Observatory on the Supply of Medical Radioistopes, in close cooperation with the industry association of nuclear medicine (NMEu), monitored the continuous supply of Mo-99/Tc-99m. The Observatory discussed COVID-19 pandemic-related concerns, Brexit preparedness and contingency actions. Europe's Beating Cancer Plan was also presented at the autumn meeting along with the European Commission's SAMIRA initiative (Strategic Agenda for Medical, Industrial and Research Applications of nuclear and radiation technology). The Observatory continued in 2020 to liaise with relevant stakeholders, mainly the EANM, the British Nuclear Medicine Society and the Irish Nuclear Medicine Association, to raise awareness and discuss Brexit contingency actions.

This Annual Report provides an overview of nuclear fuel supply and demand in the EU. Quantitative analysis shows that EU utilities are well covered until 2025 under existing contracts, in terms of both natural uranium and enrichment services. Natural uranium supplies, as well as provisions of services to the EU, continued to come from diverse sources. However, full reliance on a single design for VVER fuel remains a matter of concern.

ESA observed that uranium prices in 2020 remained closer to average production costs compared to previous years. Therefore, it remains concerned by the oversupply of uranium in the market, which depresses prices and delays investments in key segments. Such circumstances could prevail until late in the decade, hampering necessary strategic investments. Demand for natural uranium in the EU represented approximately one quarter of global uranium requirements.

To ensure security of supply, ESA recommends that operators apply best practices in the field of security of supply risk management, including an assessment of their risk exposure and implementation of the resulting action plans to address it. Furthermore, ESA sets out a number of specific recommendations regarding contractual terms, inventories, diversity of procurement options, investment, general market and contractual behaviours.

In 2020, in response to the COVID-19 pandemic, nuclear installation operators and national regulatory authorities in the EU implemented exceptional measures to maintain essential operations, while prioritising nuclear safety.

As several companies announced in the second quarter of 2020, the COVID-19 pandemic has significantly influenced the uranium market, leading to a significant decrease in uranium production and related services. Spot U_3O_8 prices have risen substantially and are expected to continue rising. The conversion market, which has experienced price increases over the past 2 years due to supply reductions and inventory drawdowns, is likely to experience the same situation.

Suppliers have also been seeing their inventories decline as a result of the pandemic, while utilities may be trying to revise their supply contracts or build the stock to ensure the security of their supplies and protect themselves from future price increases.

The Report presents the overview of Euratom activities. In 2020, special attention was given to safety, in particular with respect to long-term operations and to new safe reactor technologies, such as small modular reactors (SMRs) and their licensing. Similarly, the Euratom research and training programme was mainly aimed at improving the safety of nuclear technologies by supporting research on all aspects of nuclear safety and at advancing solutions for the management and disposal of spent fuel and radioactive waste and for the decommissioning of nuclear facilities. The Euratom perspective is complemented with an overview in the EU Member States of the major actions, events, decisions and announcements in the nuclear field.

Finally, the Report highlights some worldwide nuclear developments and examines nuclear fuel market trends.

The Annual Report concludes with an overview of ESA's management, administration and finances. The 2021 work programme is provided in annex.

E-meeting during COVID-19

© Euratom Supply Agency

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
EUP	enriched uranium product
HALEU	high-assay low-enriched uranium
HEU	high-enriched uranium
lb	pound
LEU	low-enriched uranium
MOX	mixed-oxide [fuel] (uranium mixed with plutonium oxide)
SWU	separative work unit
tHM	(metric) tonne of heavy metal
tSW	1 000 SWU
tU	(metric) tonne of uranium (1 000 kg)
U_3O_8	triuranium octoxide
DUF_6	depleted uranium hexafluoride
UF_6	uranium hexafluoride
BWR	boiling water reactor
EPR	evolutionary/European pressurised water reactor
NPP	nuclear power plant
PWR	pressurised water reactor
RBMK	light water graphite-moderated reactor (Russian design)
VVER	pressurised water reactor (Russian design)
kWh	kilowatt-hour
MWh	megawatt-hour (1 000 kWh)
GWh	gigawatt-hour (1 million kWh)
TWh	terawatt-hour (1 billion kWh)
MW/GW	megawatt/gigawatt
MWe/GWe	megawatt/gigawatt (electrical output)

1. ESA operations

1.1. Mandate and strategic objectives

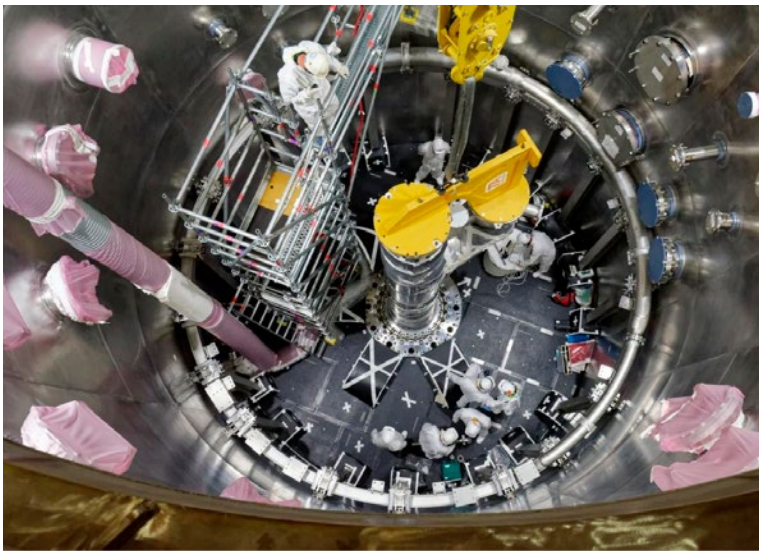
The Supply Agency of the European Atomic Energy Community (Euratom Supply Agency, ESA) was established by Article 52 of the Euratom Treaty [1] ('the Treaty') to further the common supply policy for ores, source materials and special fissile materials in the nuclear common market set up by the Treaty, based on the principle of regular and equal access of all users in the Community to sources of supply.

The prerogatives of the Supply Agency stem from the Treaty and secondary legislation, in particular its statutes and rules. It has the exclusive right to conclude contracts relating to the supply of nuclear materials coming from inside or outside the Community, and has a right of option on nuclear materials coming from inside the Community. It also monitors transactions related to services in the nuclear fuel cycle, including by acknowledging the notifications that market players are required to submit to it, giving details of their commitments.

To that end, the Treaty endows ESA with legal personality and financial autonomy, enabling it to make independent decisions on matters within its remit. It operates under the supervision of the European Commission [2] and is assisted by its Advisory Committee, which acts as a link between ESA and producers and users in the nuclear industry [3].

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

On-site installation of the reactor core vessel



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1.2. Core activities

In the interest of its strategic objective, ESA pursues the following core activities:

- managing contracts related to the supply of nuclear materials and/or services in the nuclear fuel cycle, in line with the applicable provisions, for power and non-power uses;
- facilitating future supply by promoting diversification in the nuclear fuel cycle, as a contribution to security of supply in the medium and long term;
- facilitating the continued supply of medical radioisotopes;
- monitoring and analysing developments in the nuclear fuel market and in relevant R&D fields, including publishing its Annual Report and providing information, including on the European and global nuclear markets;
- cooperation with stakeholders and partners.

1 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12012A/TXT
2 Article 53 of the Euratom Treaty.
3 Article 13.1 of the statutes.

During 2020, the coronavirus outbreak hugely affected the EU. The Agency has made every effort to reduce the pandemic's effect on its staff and stakeholders. ESA took all necessary steps to continue its duties and stayed fully operational. It demonstrated it can respond swiftly to challenges arising from the COVID-19 crisis. The statutory deadlines were met for the core activities of the Agency as well as the final accounts and the report on budget and financial management. The whole of ESA's annual report was published on 1 September 2020. The spring 2020 meetings of the Advisory Committee and of the European Observatory on the Supply of Medical Radioisotopes had to be postponed but were successfully organised and held in the autumn in a virtual format.

1.2.1. Contract management

The Supply Agency's activities in this field encompass:

- concluding nuclear materials and fuel supply contracts, pursuant to Article 52 of the Euratom Treaty;
- acknowledging notifications of contracts for small quantities of nuclear materials, pursuant to Article 74 of the Euratom Treaty [4];
- acknowledging notifications of transactions related to the provision of services in the nuclear fuel cycle, pursuant to Article 75 of the Euratom Treaty.

Nuclear materials coming from inside the Community may be exported only with the authorisation of the Commission.

In 2020, in its contractual management activities, 269 new registration references were recorded, 49% of which corresponding, pursuant to Article 52, to new contracts or to amendments or supplements to existing contracts and the remaining 51% corresponding to notifications relating to contracts covered by Articles 75 and 74 of the Treaty.

1.2.2. Security and diversification of the nuclear fuel supply chain

In line with its strategic objective and the European Commission's policies, the Supply Agency strives for diversification of 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 domestic nuclear industry – is an important means for security of supply in the medium and long term.

Diversification of supply sources – which also contributes to the domestic nuclear industry's viability – is an important means for security of supply in the medium and long term and, as such, is strongly acknowledged by the European Energy Security Strategy [5] and confirmed by the 2020 report on the State of the Energy Union [6].

Security of energy supply

ESA monitors the situation of EU producers who export nuclear material produced in the EU, as it has option rights over such material under Article 52 of the Euratom Treaty. Where the material is exported from the EU, ESA may require the contracting parties to accept certain conditions relating to the security of supply on the EU market.

Throughout the year, the Agency continued its dialogue with Community fuel manufacturers interested in diversification solutions, in particular for the hexagonal fuel assemblies and components market. These were manufacturers in Germany, France, Spain and Sweden. Several meetings were also held with interested operators.

In its 2019 report, the Supply Agency recommended that Community utilities operating nuclear power plants apply best practices to security of supply risk management. This includes assessing their risk exposure and implementing the resulting action plans to address it.

In general, multiannual contracts with diverse sources of supply are considered appropriate for utilities to cover most of their current and future requirements for uranium and

4 Commission Regulation (Euratom) No 66/2006 provides details of how transactions involving small quantities of nuclear materials are handled.
5 COM(2014) 330 final, of 28.5.2014 https://www.eesc.europa.eu/resources/docs/european-energy-security-strategy.pdf
6 Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2020) 950 final.

> To prevent excessive dependence of Community users on any single external design or supplier, ESA continued to follow attentively and encouraged efforts to diversify the supply of nuclear fuel.

services. Parties engaging in contracts that bundle supplies of fuel assemblies with other transactions, conditions or stages of the cycle were advised to negotiate clauses expressly providing for unbundled procurement by the operator of uranium and services from other suppliers, without penalties. Utilities were advised to maintain sufficient inventories of nuclear materials (including fabricated fuel) to cover future requirements and to use market opportunities to increase them. Ideal security of supply means at least two alternative suppliers for each stage of the fuel cycle.

To prevent excessive dependence of Community users on any single external supplier, ESA continued to follow attentively, and encouraged efforts to diversify, the supply of nuclear fuel for reactors for which appropriate alternative offers were not available. Operators dependent on single suppliers for fuel assemblies and components were advised to step up engagement with industry and cooperation with ESA and other players to bring about alternative solutions. ESA continued to follow the steps towards supply diversification of fuel for VVER-1000 reactors in Czechia and Bulgaria as well as the medium/long-term plans of major EU fuel manufacturers in this respect.

ESA addressed issues related to security of supply in the final national energy and climate plans (NECP) prepared by Member States for 2021-2030 [7] and gave recommendations relating to security of supply of nuclear materials and diversification policies.

Supply of nuclear materials for non-power uses

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

In cooperation with the Member States concerned, ESA continued to facilitate the supply of HEU to users who still need it until their conversion to HALEU, in line with international nuclear security and non-proliferation commitments. In 2020, in close cooperation with the Euratom Member States concerned, ESA renewed the Memorandum of Understanding (MoU) it had signed in 2014 with the US Department of Energy-National Nuclear Security Administration (DoE-NNSA) for the exchange of HEU needed to supply European research reactors and medical radioisotope production facilities. Renewal of the MoU was the Euratom Supply Agency's first deliverable on the SAMIRA action plan supporting Europe's Beating Cancer Plan (see Chapter 3.3.2).

A dedicated Working Group on HALEU was reinstated at the October meeting of the ESA Advisory Committee, with the objective to explore possible specific industrial and commercial options for building a European capacity for producing HALEU metal responding to EU needs for the research reactors' fuel and medial radioisotopes production (see Chapter 1.3.1).

> ESA continued to scrutinise security of supply of high-enriched uranium (HEU) and high-assay low-enriched uranium (HALEU), which are required to feed the production of medical radioisotopes and to fuel research reactors.

7 Regulation on the governance of the energy union and climate action (EU/2018/1999).

1.2.3. Market monitoring

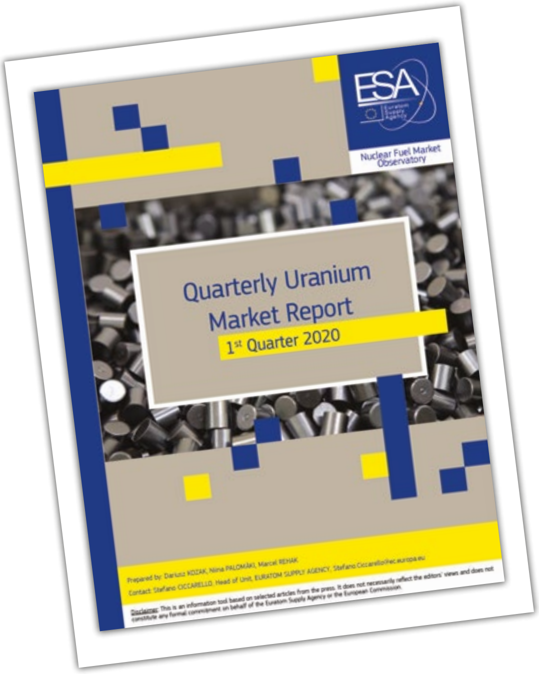
In the interest of its Treaty missions, the Supply Agency's statutes entrust it with a market observatory role. In particular, ESA has a duty to monitor the market in order to identify trends likely to affect the Union's security of supply of nuclear materials and services. ESA has to provide the Community with expertise, information and advice on any subject connected with the operation of the nuclear market.

In 2020, in line with these obligations, ESA's Nuclear Fuel Market Observatory issued several market reports and analyses, published price indices and cooperated with other international market analysis organisations.

ESA's annual report continues to be its main reporting tool. As in previous years, ESA conducted a survey of EU nuclear power operators. The survey provided detailed analysis of the supply and demand for natural uranium, conversion and enrichment services in the EU. The Supply Agency published three natural uranium price indices with calculated weighted averages of the prices paid by EU utilities within multiannual and spot contracts. Its analysis contained forecasts of future demand for uranium and enrichment services and assessed security of supply of nuclear fuel to EU utilities. ESA provided detailed analysis of future contractual coverage for natural uranium and enrichment services and diversification of supply. It gave an analysis of EU inventories of nuclear material.

In 2020, ESA issued four quarterly uranium market reports [8], covering global and specific Euratom developments on the nuclear market. The reports include general data about natural uranium supply contracts concluded by ESA or notified to it, a description of activity on the natural uranium market in the EU, and the quarterly spot price index for natural uranium whenever three or more spot contracts have been concluded.

To create greater transparency in the EU natural uranium market, reduce uncertainty and help improve security of supply, ESA regularly publishes reports and price trends [9] on its website. ESA also issues a weekly nuclear news brief for European Commission readers.



1.2.4. European Observatory on the Supply of Medical Radioisotopes

In the light of the Council Conclusions 'Towards the secure supply of radioisotopes for medical use in the EU' dated 2010 [10] and 2012 [11], ESA's market observatory role was widened in 2013 to cover aspects of the supply of medical radioisotopes in the EU.

In the Council Conclusions on 'Non-power nuclear and radiological technologies and applications' [12] adopted in June 2019, the Council further supported 'the continuing monitoring of the production chain of medical radioisotopes through the European Observatory on the Supply of Medical Radioisotopes and the ESA's efforts and actions in ensuring the secure supply of source material'.

In 2020, ESA continued to coordinate activities to improve the security of supply of Mo-99/Tc-99m and to chair, jointly with the industry association of nuclear medicine (NMEu) [13], the European Observatory on the Supply of Medical Radioisotopes [14].

8 https://ec.europa.eu/euratom/observatory_quarterly.html
9 https://ec.europa.eu/euratom/observatory_price.html
10 https://ec.europa.eu/euratom/docs/118234.pdf
11 https://ec.europa.eu/euratom/docs/2012_council_radioisotopes.pdf
12 https://ec.europa.eu/euratom/docs/2020_Security_report_2.pdf
13 http://nuclearmedicineeurope.eu
14 https://ec.europa.eu/euratom/observatory_radioisotopes.html

Transport

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The Observatory assesses, monitors and supports the EU supply of widely used medical radioisotopes, focusing on Molybdenum-99/Technetium-99m (Mo-99/Tc-99m). The Observatory is composed of representatives of the European Commission services, international organisations and various industry stakeholders, most of which are grouped within the NMEu.

The European Observatory's spring 2020 meeting – chaired jointly by ESA and NMEu - had to be postponed due to the difficult circumstances and travel restrictions caused by the COVID-19 situation. The Observatory's first e-meeting since its creation in 2012 was held in the autumn. The agenda included the standard points of discussion and other updates from the NMEu, the OECD/NEA and the European Association of Nuclear Medicine (EANM) as well as a presentation of Europe's Beating Cancer Plan and its follow-up action, the European Commission's SAMIRA initiative (Strategic Agenda for Medical, Industrial and Research Applications of nuclear and radiation technology). The COVID-19 impact on the supply of medical radioisotopes was a major point of discussion.

The meeting also assessed Brexit-related supply issues and mitigation measures and discussed the state of play in the UK and Ireland and the stakeholders concerned. Through ESA, the Observatory continued in 2020 to liaise with relevant stakeholders, mainly the EANM, the British Nuclear Medicine Society and the Irish Nuclear Medicine Association to raise awareness and discuss the Brexit contingency actions.

In September, before the Observatory's e-meeting, ESA presented the Observatory's activities to the Council Working Party on Atomic Questions, focusing on the response to the COVID-19 pandemic. The presentation included the topics dealt with during the 2019 Observatory meetings. The 2019-2020 supply disruptions for medical radioisotopes and the related mitigation measures taken by the Observatory were also presented.

1.2.5. Annual Report 2019

In its 2019 Annual Report, ESA gave an overview of its own activities and developments in the EU and world nuclear fuel markets and nuclear energy during the year. It set out ESA's findings and recommendations on the supply of and demand for nuclear fuels, reflecting ESA's diversification policy and security of supply. It also discussed issues relating to the security of supply of medical radioisotopes. ESA's work programme for the following year was part of the report.

Due to the COVID-19 emergency and measures to mitigate its impact, publication of the ESA 2019 Report was delayed. The analysis of supply and demand, which is the statutory part of the annual report, was posted on the ESA website in June. The text of the whole report was published on ESA's website in September and the final layout was published in November [15]. In September, the report was presented to the Council Working Party on Atomic Questions and in November sent to the European Commission, the Council of the EU and the European Parliament.

15 https://ec.europa.eu/euratom/ar/last.pdf

1.2.6. Outreach activities

Throughout 2020, ESA pursued contacts with the EU and international authorities, utilities, industry and nuclear organisations to further its objectives, engaging in continuous dialogue with suppliers, industry and utilities. It monitored market developments and EU demand. It provided advice and follow-up to ensure appropriate implementation of the common supply policy.

The Supply Agency responded to queries about the UK's withdrawal from the EU and Euratom from individuals or undertakings with commercial relations with companies in the UK.

1.3. Advisory Committee

In line with ESA's statutes, the Advisory Committee [16] assists it in carrying out its tasks by giving opinions and providing analyses and information. The Advisory Committee also acts as a link between ESA, producers and users in the nuclear industry, and Member State governments. ESA provides the Advisory Committee and its working groups with the secretariat and with logistical support.

Due to the COVID-19 situation and related travel restrictions, the Advisory Committee met only once in 2020 and its meeting took place in a virtual, instead of the usual face-to-face, form. Before the Advisory Committee's e-meeting, a new Chairperson and Vice-Chairpersons were elected for the new term of office from 2020 to 2023. At the October meeting, the Committee delivered its opinions on ESA's 2019 Annual Report, ESA's budget amendment 2020, the work programme and draft budget for 2021 and the budget estimate for 2022. The Committee discussed a follow-up to the two reports by the Advisory Committee's Working Groups - on Prices and Security of Supply [17] and on European Supply of LEU 19.75% [18]. During the meeting, the Committee also discussed how ESA is to handle contracts for the long-term storage and/or disposal of spent fuel.

1.3.1. Advisory Committee's Working Groups

At the Advisory Committee's e-meeting in October, the future of its two Working Groups was discussed in the context of the Committee's new term of office. For both Working Groups: on Prices and Security of Supply and on European Supply of LEU 19.75%, the Committee decided to reinstate them and asked Members to express their interest in participating. The Committee also gave instructions to begin work on the draft terms of reference and work plans of both Working Groups.

The report by the Advisory Committee's Working Group on Prices and Security of Supply was published in March 2020. It is the third report of its kind and updates the previous 2015 edition, the first report being published back in 2010. Its conclusions were included in ESA's 2019 Annual Report. The Working Group's report was sent to stakeholders and the European Commission and was presented at the Council Working Party on Atomic Questions in September. ESA was pleased to see that the report was widely acknowledged by the industry and international institutions.

1.4. International cooperation

The Agency has long-standing and well-established relationships on nuclear energy with two major international organisations: the International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency (NEA).

In 2020, the ESA continued its cooperation with these organisations by participating in working groups: the joint NEA/IAEA Uranium Group (UG) and the NEA Expert Group on Uranium Mining and Economic Development (UMED).

The NEA/IAEA UG is responsible for publishing the biennial report 'Uranium resources, production and demand' (known as a 'Red Book'), to which ESA contributes its analysis of EU supply and demand for nuclear fuel. The 28th edition of the 'Red Book' was published in December 2020 [19]. It offers updated information on established uranium production centres and mine development plans as well as projections of nuclear generating capacity and reactor-related requirements through 2040.

The NEA UMED analyses uranium mining's potential contribution to economic and social development, and explores whether uranium activities are managed to ensure that local and national economies benefit. The expert group examines case studies in various countries in order to understand how uranium mining affects economic development, jobs, infrastructure, education and medical care [20]. ESA contributes to such examinations and analyses.

16 https://ec.europa.eu/euratom/committee.html
17 https://ec.europa.eu/euratom/docs/2020_Security_report_2.pdf
18 https://ec.europa.eu/euratom/docs/ESA_HALEU_report_2019.pdf
19 https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand
20 https://www.oecd-nea.org/jcms/pl_28160/expert-group-on-uranium-mining-and-economic-development-umed

2. ESA analysis of supply and demand of nuclear material and services 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.

At the end of 2020, 122 commercial nuclear power reactors were operating in 13 Member States and the UK and were being managed by 18 nuclear utilities. Four reactors were under construction in France, Slovakia, and Finland.

According to the latest available data published by the European Commission, the gross electricity generation from nuclear plants within the EU-28 in 2019 was stable at 821.52 TWh, accounting for 25.5% of total EU-28 production [21].

Unless otherwise mentioned, past deliveries of material and services refer to the EU-27 and the UK. The future requirements refer to the EU-27 only.

In 2020, 122 commercial nuclear power reactors were operating in 13 Member States and the UK.

Ranger Uranium mine in the Northern Territory Australia

2.1. Fuel loaded

In 2020, 1 908 tU of fresh fuel was loaded into commercial reactors. It was produced using 13 124 tU of natural uranium and 188 tU of reprocessed uranium as feed, enriched with 9 988 tSW. The quantity of fresh fuel loaded was 10% (i.e. 220 tU) less than in 2019. The fuel loaded into EU reactors had an average enrichment assay of 3.94%, with 85% falling between 3.43% and 4.52%. The average tails assay was 0.22%, with over 90% falling between 0.20% and 0.24%.

MOX fuel was used in several reactors in France and the Netherlands. MOX fuel loaded into nuclear power plants (NPPs) in the EU contained 5 308 kg Pu in 2020, a 1% increase from 2019. Use of MOX resulted in estimated savings of 481 tU and 340 tSW (see Annex 5).

21 Eurostat Energy Statistics, 2019.

The amount of natural uranium included in fuel loaded into reactors in 2020 totalled 13 793 tU.

The amount of natural uranium included in fuel loaded into reactors in 2020, including natural uranium feed, reprocessed uranium, and savings from MOX fuel, totalled 13 793 tU.

Savings in natural uranium resulting from the use of MOX fuel together with reprocessed uranium give the amount of feed material (which otherwise would have to be used) coming from domestic secondary sources. All this provided about 5.0% of the EU's annual natural uranium requirements.

Table 1. Natural uranium equivalent included in fuel loaded by source in 2020

Source	Quantities (tU)	Share (%)
Uranium originating outside the EU-27 and the UK	13 124	95
Indigenous sources (1)	669	5
Total annual requirements	**13 793**	**100**

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

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 [22], 7 Member States out of 27 had reprocessed spent fuel or chosen the reprocessing option, and 2 Member States are keeping 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. Use of 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. The main reasons for its use are the possibility of using plutonium recovered from spent fuel, non-proliferation concerns, and economic considerations. 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 contributes to security of supply.

2.2. Future requirements [23]

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 which already have a construction licence), lifetime extensions, the early retirement of reactors, 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.

Natural uranium — average reactor requirements		
2021-2030	12 917 tU/year (gross)	11 316 tU/year (net)
2031-2040	10 460 tU/year (gross)	7 760 tU/year (net)

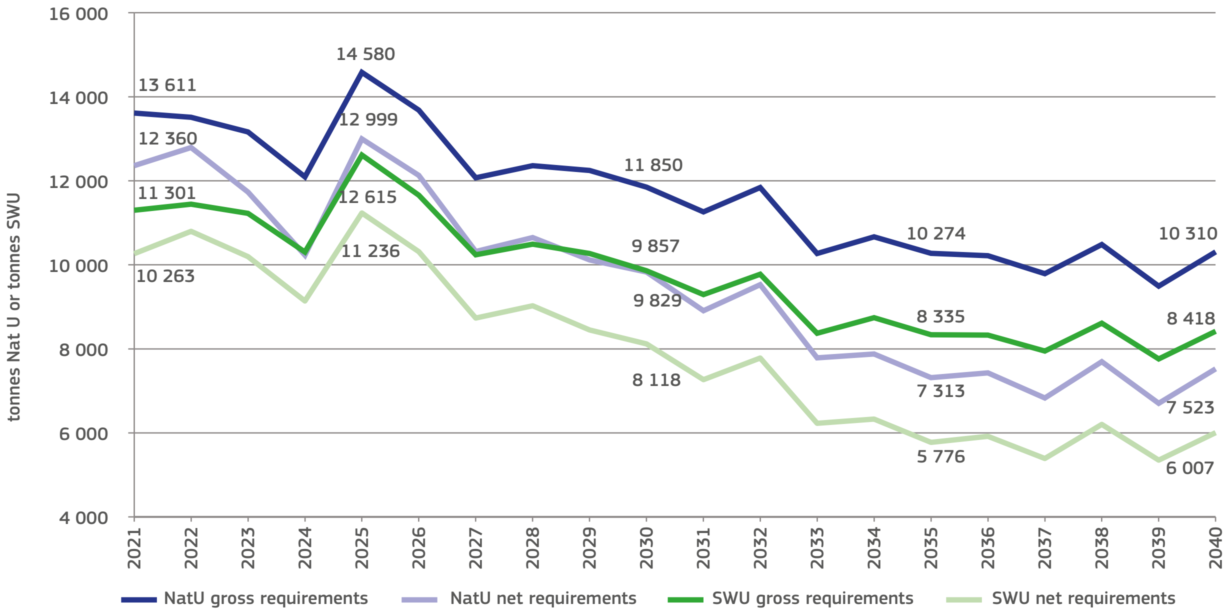
Enrichment services — average reactor requirements		
2021-2030	10 941 tSW/year (gross)	9 627 tSW/year (net)
2031-2040	8 558 tSW/year (gross)	6 224 tSW/year (net)

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).

Compared to last year's annual survey, future aggregate requirements declared by the utilities fell slightly in the first ten-year period, and more steeply in the second decade. For 2021-2030, forecasts of average gross requirements for natural uranium decreased by 12% (-1 723 tU), and by 10% (1 275 tSW) for separative work. For 2031-2040, the forecasted average gross demand for natural uranium decreased by 8% (-867tU) and for enrichment services by 9% (-859 tSW).

22 https://eur-lex.europa.eu/legal-content/EN/TXT/ PDF/?uri=CELEX:52019DC0632&from=EN
23 It only includes EU-27 Member States.

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



2.3. Supply of natural uranium

Conclusion of contracts

In 2020, ESA processed a total of 76 natural uranium contracts and amendments to contracts, of which 41 were newly concluded and registered. Of 33 new purchase/sale contracts, 22 involved EU utilities, and the remainder were signed by EU intermediaries or producers. Table 2 gives further details of the types of supply, terms and parties involved.

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

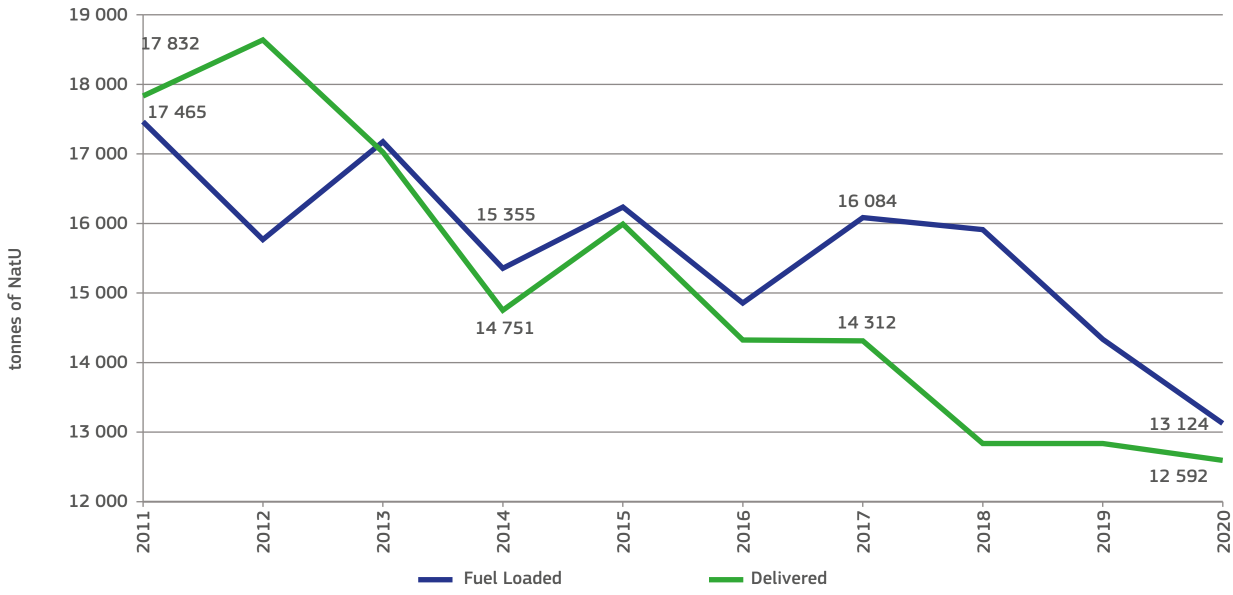
Type of contract	Number of contracts concluded in 2020	Number of contracts concluded in 2019
Purchase/sale by EU utilities/end users	**22**	**27**
— multiannual (1)	10	12
— spot (1)	12	15
Purchase/sale by EU intermediaries/producers	**11**	**14**
— multiannual	1	3
— spot	10	11
Exchanges and loans (2)	**8**	**9**
Amendments	**35**	**55**
TOTAL (3)	**76**	**105**

(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.

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)



Volume of deliveries

The deliveries covered are those to EU utilities or their procurement organisations in 2020, excluding research reactors. The natural uranium equivalent contained in enriched uranium purchases, when stated, is also taken into account.

In 2020, demand for natural uranium in the EU represented approximately one quarter of global uranium requirements. EU utilities purchased a total of 12 592 tU in 137 deliveries under multiannual and spot contracts. As in previous years, supplies under multiannual contracts constituted the main source for meeting demand in the EU. Deliveries of natural uranium to EU utilities under multiannual contracts accounted for 12 191 tU (of which 11 135 tU with reported prices) or 97% of total deliveries, whereas the remaining 3% (337 tU) was purchased under spot contracts. On average, the quantity of natural uranium delivered was 79 tU per delivery under multiannual contracts. Quantities of natural uranium delivered under spot contracts varied substantially, making it impossible to calculate an average of cognitive meaning.

Natural uranium contained in the fuel loaded into reactors in 2020 totalled 13 124 tU. For the past 7 consecutive years, EU utilities have been loading more material into reactors than they have been buying it, which results in a steady decrease in inventory levels. 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 1980-2020).

Average delivery prices

In the interests of market transparency, ESA publishes three EU natural uranium price indices annually. These are based only on deliveries made 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 for new multiannual contracts but also for a non-negligible percentage of the spot contracts) is generally agreed by using formulas based on uranium price and inflation indices.

For the past 7 consecutive years, EU utilities have been loading more material into reactors than they have been buying it, which results in a steady decrease in inventory levels.

ESA's price calculation method is based on currency conversion of the original contract prices into EUR 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 according to 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. The annual average ECB EUR/USD rate in 2020 stood at 1.14.

To calculate a natural uranium price excluding the conversion cost whenever 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.

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 as:
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.

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 as:	
71.37 EUR /kgU contained in U_3O_8	down 10% from EUR 79.43/kgU in 2019
31.36 USD /lb U_3O_8	down 8% from USD 34.20/lb U_3O_8 in 2019

3. ESA 'MAC-3' multiannual U_3O_8 price: the weighted average of U_3O_8 prices paid by EU utilities, only for 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 as:	
75.51 EUR /kgU contained in U_3O_8	down 5.6% from EUR 80.00/kgU in 2019
33.17 USD /lb U_3O_8	down 3.7% from USD 34.45/lb U_3O_8 in 2019

The ESA U_3O_8 spot price reflects the latest 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.

The ESA multiannual U_3O_8 price was EUR 71.37/kgU U_3O_8 (USD 31.36/lb U_3O_8).

The multiannual prices paid varied widely, with approximately 70% (assuming a normal distribution) falling within the range from EUR 49.73 to EUR 110.23/kgU (from USD 21.85 to USD 48.43/lb U_3O_8).

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 (namely Russia, Kazakhstan, and Uzbekistan) was 34% lower than the price for uranium of non-CIS origin.

The ESA MAC-3 multiannual U_3O_8 price was EUR 75.51/kgU U_3O_8 (USD 33.17/lb U_3O_8).

The data were spread across a wide range, with approximately 70% of prices reported as falling between EUR 55.24 and EUR 116.46/kgU (USD 24.27 to USD 51.16/lb U_3O_8).

The ESA MAC-3 index takes into account only multiannual contracts signed recently (2018-2020) 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 21% lower than the price for uranium of non-CIS origin.

> The ESA multiannual U_3O_8 and MAC-3 multiannual U_3O_8 price paid for uranium originating in CIS was respectively 34% and 21% lower than the price for uranium of non-CIS origin.

Figures 3a and 3b show the ESA average prices for natural uranium since 2011. The corresponding data are presented in Annex 3.

Figure 3a. Average prices for natural uranium delivered under spot and multiannual contracts, 2011-2020 (EUR/kgU)

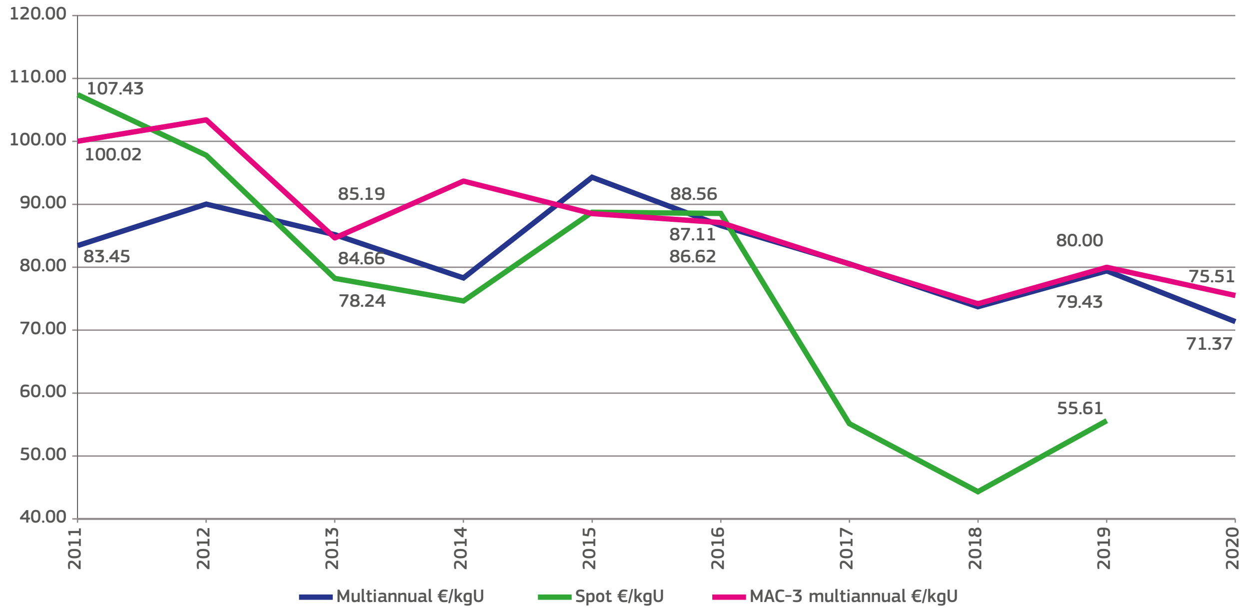
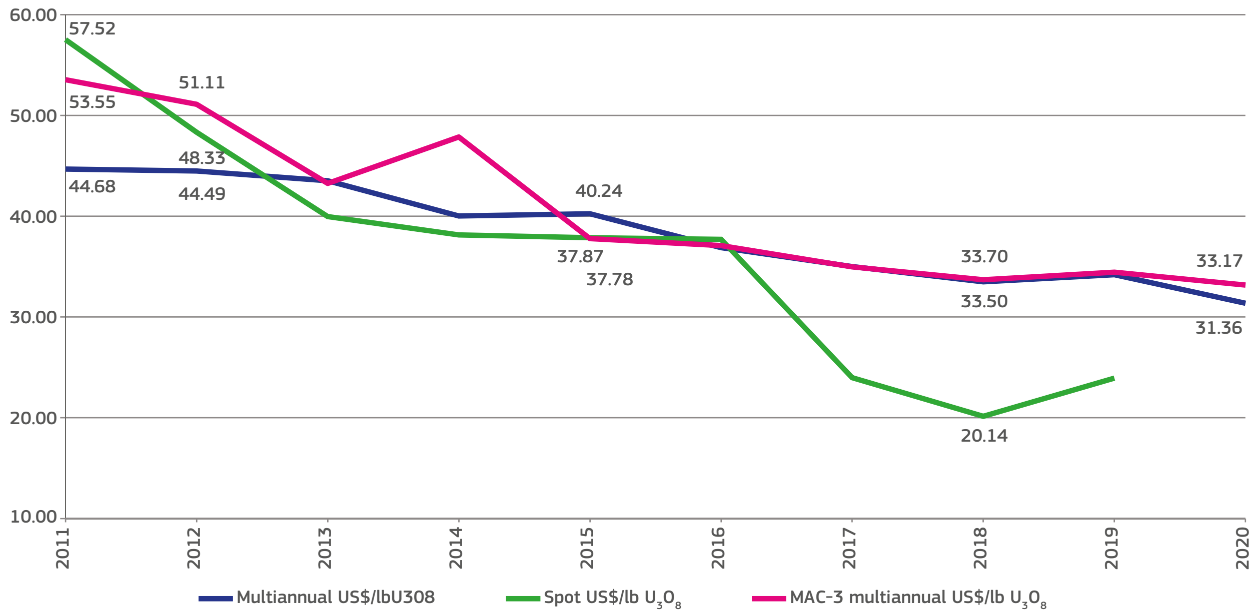


Figure 3b. Average prices for natural uranium delivered under spot and multiannual contracts, 2011-2020 (USD/lb U_3O_8)



Origins

In 2020, natural uranium supplies to the EU continued to come from diverse sources. The origin of natural uranium supplied to EU utilities has remained similar to 2019, although there have been some changes in market share.

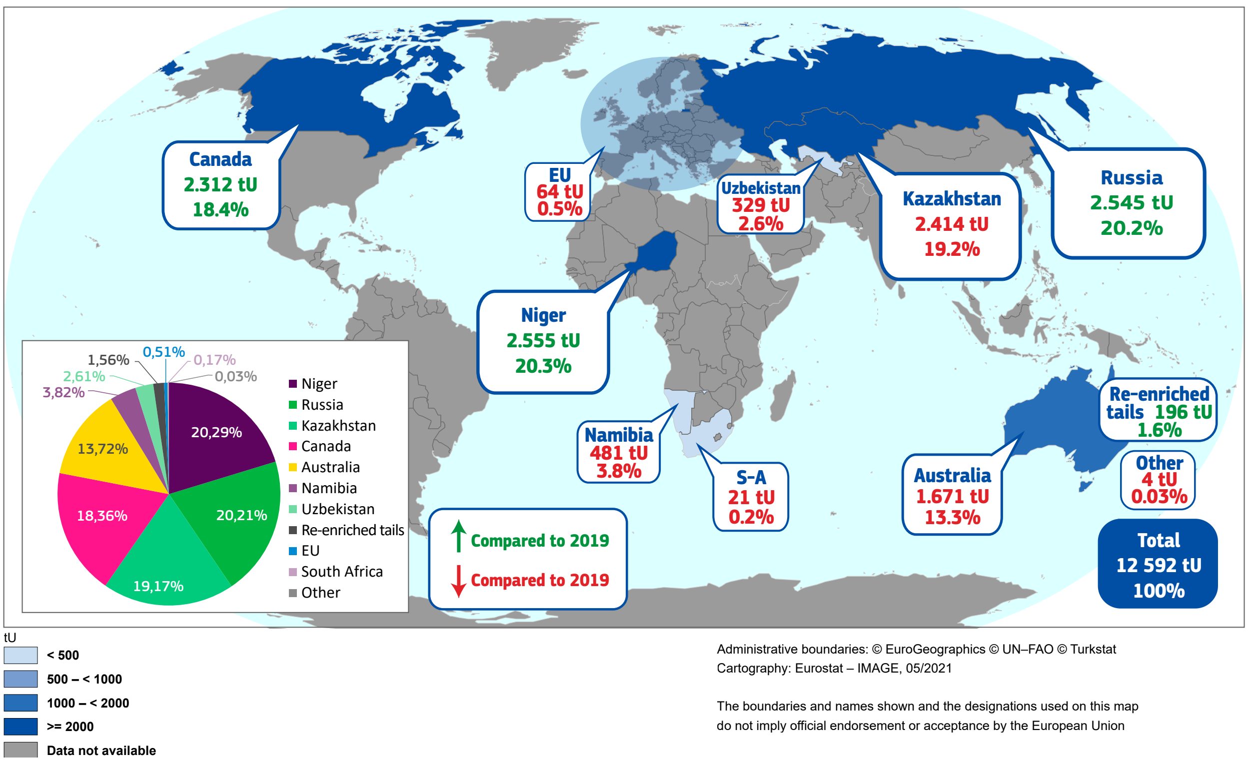
Table 3. Origins of uranium delivered to EU utilities in 2020 (tU)

Origin	Quantity	Share (%)	Change in quantities 2019/2020 (%)
Niger	2 555	20.29	30.2
Russia	2 545	20.21	0.1
Kazakhstan	2 414	19.17	-4.2
Canada	2 312	18.36	55.7
Australia	1 671	13.27	-9.7
Namibia	481	3.8	-61.0
Uzbekistan	329	2.61	-46.2
Re-enriched tails	196	1.56	21.9
EU	63	0.51	-74.5
South Africa	21	0.17	-82.04
Other(1)	4	0.03	-96.0
Total	**12 592**	**100.00**	**-1.9**

Because of rounding, totals may not add up.

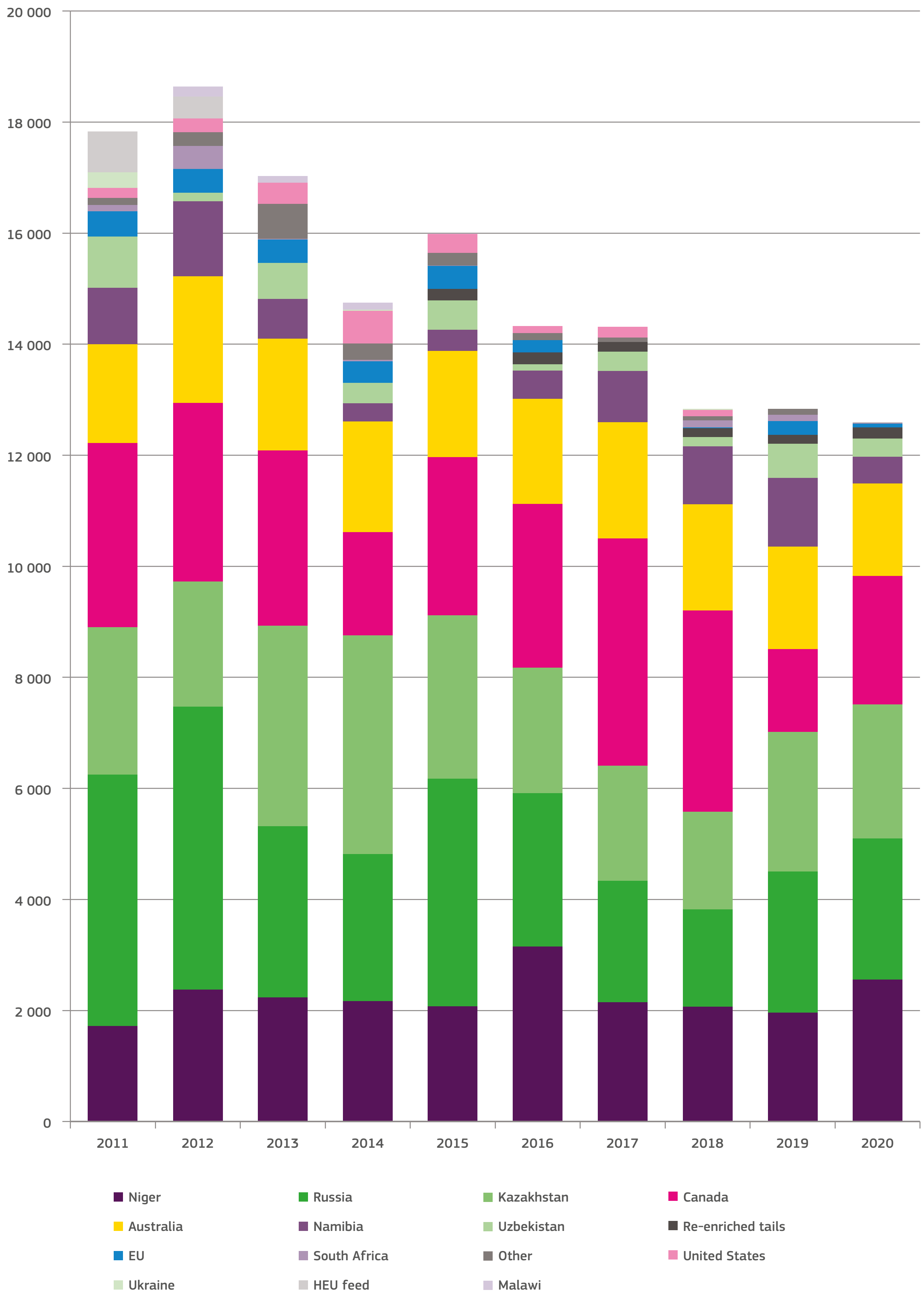
([1]) material saved through underfeeding, mixed origin and unknown

Figure 4. Origins of uranium delivered to EU utilities in 2020 compared to 5-year average



Because of rounding, totals may not add up.

Figure 5. Purchases of natural uranium by EU utilities, by origin, 2011-2020 (tU)



Niger, Russia, and Kazakhstan were the top three countries delivering natural uranium to the EU in 2020, providing 59.67% of the total. Deliveries from Russia included purchases of natural uranium contained in enriched uranium products (EUP). In fourth place, uranium mined in Canada amounted to 18.36% of the total. Uranium from Australia accounted for 13.27% of the total. The five big producing countries, together with sixth-placed Namibia, provided more than 95% of all natural uranium supplied to the EU.

Natural uranium produced in CIS countries accounted for 5 484 tU (including re-enriched tails), or 43.55% of all natural uranium delivered to EU utilities, a 6% decrease on the year before.

Deliveries of uranium from Africa decreased by 5.4% to 3 057 tU, compared to 3 311 tU in 2019. Uranium mined in Africa originated in three countries – Niger, Namibia, and South Africa, with Niger representing 86% of African-origin deliveries in 2020.

Conversion services

During 2020, EU utilities, producers and intermediaries notified ESA of 17 new contracts on the provision of conversion services and 3 amendments to already notified conversion contracts.

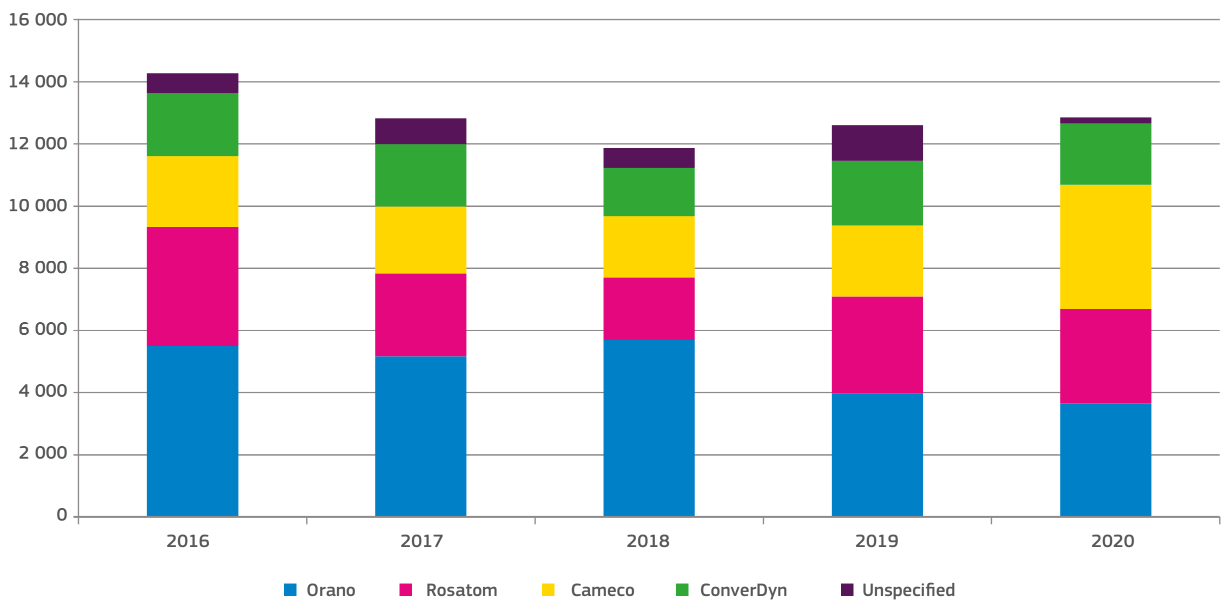
Under separate conversion contracts, 9 011 tU were converted, accounting for 70% of all conversion service deliveries to EU utilities. The remaining 30%, or 3 839 tU, were delivered under contracts other than conversion contracts (purchases of natural UF_6, EUP, bundled contracts for fuel assemblies). As for the providers of conversion services, 28% of EU requirements were provided by Orano / Comurhex, followed by Rosatom (24%), Cameco (31%) and ConverDyn (15%).

Table 4. Provision of conversion services to EU utilities

Converter	Quantity in 2020 (tU)	Share in 2020 (%)	Quantity in 2019 (tU)	Share in 2019 (%)	Change in quantities 2020/2019 (%)
Orano (EU)	3 651	28	3 976	32	-8
Rosatom (Russia)	3 040	24	3 115	25	-2
Cameco (Canada)	3 993	31	2 284	18	75
ConverDyn (US)	1 970	15	2 080	17	-5
Unspecified	196	2	1 154	9	-83
Total	**12 850**		**12 600**	**100**	**2**

Because of rounding, totals may not add up.

Figure 6. Supply of conversion services to EU utilities by provider, 2016-2020 (tU)



2.4. Special fissile material

Conclusion of contracts

Table 5 shows the aggregate number of contracts, notifications, and amendments [24] relating to special fissile materials (enrichment services, enriched uranium, and plutonium) handled in 2019 and 2020 in accordance with ESA's procedures.

Deliveries of low-enriched uranium

In 2020, the enrichment services (separative work) provided to EU utilities totalled 11 224 tSW, delivered in 1 792 tonnes of low-enriched uranium (tLEU), which contained the equivalent of 13 556 tonnes of natural uranium feed. In 2020, enrichment service deliveries to EU utilities were 13% lower compared to 2019, with NPP operators opting for an average enrichment assay of 4.02% and an average tails assay of 0.22%.

Table 5. Special fissile material contracts concluded by or notified to ESA

Type of contract	Number of contracts concluded/ notifications acknowledged in 2020	Number of contracts concluded/ notifications acknowledged in 2019
A. Special fissile materials		
New contracts	**25**	**37**
Purchase (by an EU utility/end user)	7	12
Sale (by an EU utility/end user)	5	11
Purchase/sale (between two EU utilities/end users)	1	5
Purchase/sale (intermediaries/ producers)	4	6
Exchanges	6	4
Loans	2	0
Contract amendments	**18**	**36**
TOTAL (1)	**43**	**73**
B. Enrichment notifications (2)		
New notifications	**11**	**8**
Notifications of amendments	**19**	**21**
TOTAL	**30**	**29**
Grand total	**73**	**102**

(1) In addition, there were transactions involving small quantities (pursuant to Article 74 of the Euratom Treaty) which are not included here.

(2) Contracts with primary enrichers only.

Table 6. Providers of enrichment services to EU utilities

Provider of service	Quantities in 2020 (tSW)	Share in 2020 (%)	Quantities in 2019 (tSW)	Share in 2019 (%)	Change in quantities 2020/2019 (%)
Orano-GBII and Urenco (EU-27 plus UK)	7 955	71	8 764	68	-9
Tenex/TVEL (Russia)	2 961	26	3 927	30	-25
Russian blended (1)	0	0	160	1	-
Other	307	4	60	1	408
TOTAL (2)	**11 224**	**100**	**12 912**	**100**	**-13**

(1) Including enriched reprocessed uranium.

(2) Because of rounding, totals may not add up.

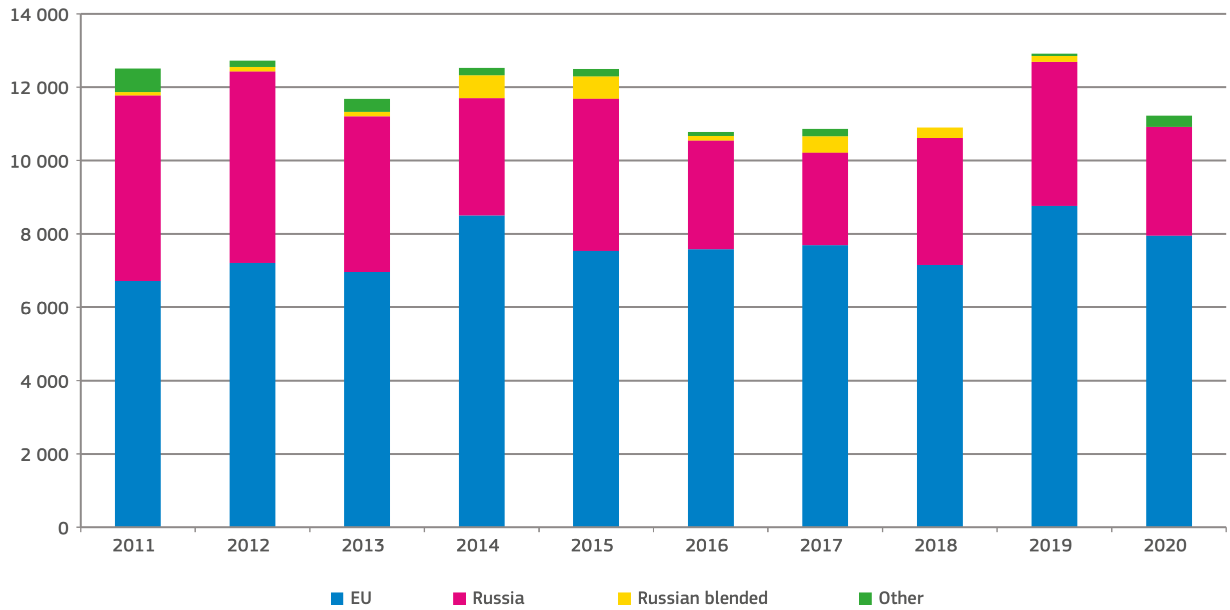
24 The aggregate number of amendments includes all the amendments to existing contracts processed by ESA, including technical amendments that do not necessarily lead to substantial changes in the terms of existing agreements.

The two European enrichers (Orano-GBII and Urenco) provided enrichment services totalling 7 955 tSW, meeting 71% of EU requirements, a decrease of 9% in a year-on-year comparison.

Deliveries of separative work from Russia (Tenex and TVEL) to EU utilities under purchasing contracts totalled 2 961 tSW, accounting for 26% of total deliveries, a 25% decrease from the year before. The aggregate total includes SWUs delivered under contracts concluded before accession to the EU ('grandfathered' under Article 105 of the Euratom Treaty), which covered less than 4% of total EU requirements.

Deliveries of separative work from Russia to EU utilities accounted for 26% of total deliveries, a 25% decrease from the year before.

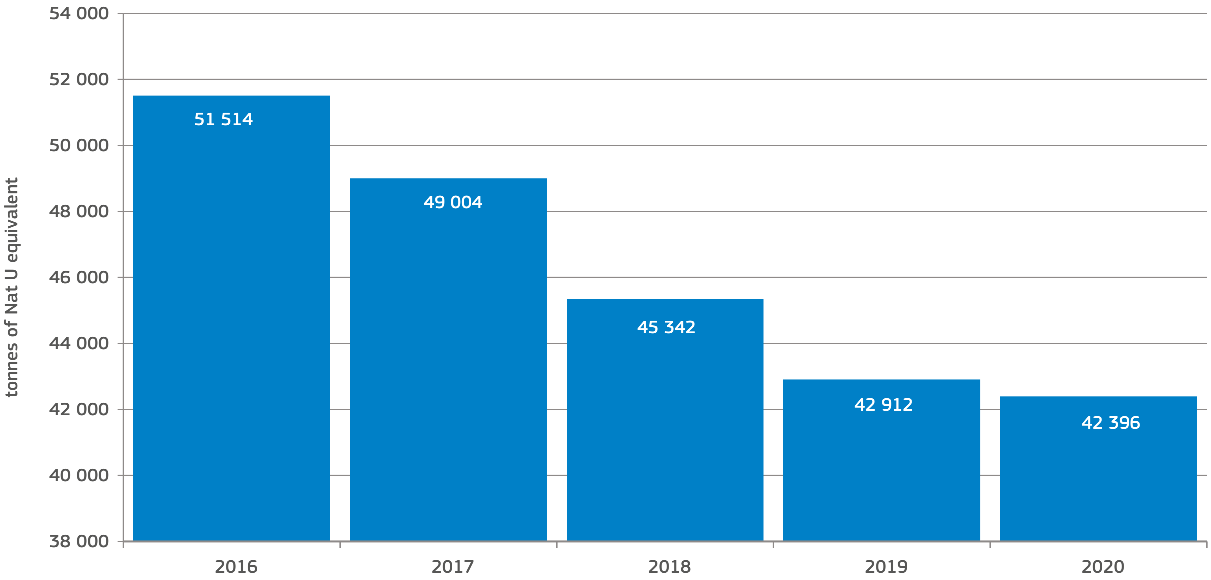
Figure 7. Supply of enrichment to EU utilities by provider, 2011-2020 (tSW)



Inventories

At the end of 2020, the natural uranium equivalent in inventories owned by EU utilities totalled 42 396 tU, a 1% decrease from the end of 2019 and an 18% decrease since the end of 2015. The inventories represent 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, 2016-2020 (in tonnes)



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

Based on average annual EU gross uranium reactor requirements (approximately 15 400 tU per year), uranium inventories can fuel EU utilities' nuclear power reactors for 2.75 years on average. However, the average conceals a wide range, although all utilities keep a sufficient quantity of inventories for at least one reload.

Future contractual coverage rate

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

The EU utilities' aggregate contractual coverage rate for a given year is calculated by dividing the maximum 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. Figure 9 shows the contractual coverage rate for natural uranium and SWUs, and Figure 10 shows the contractual coverage rate for conversion services for EU utilities.

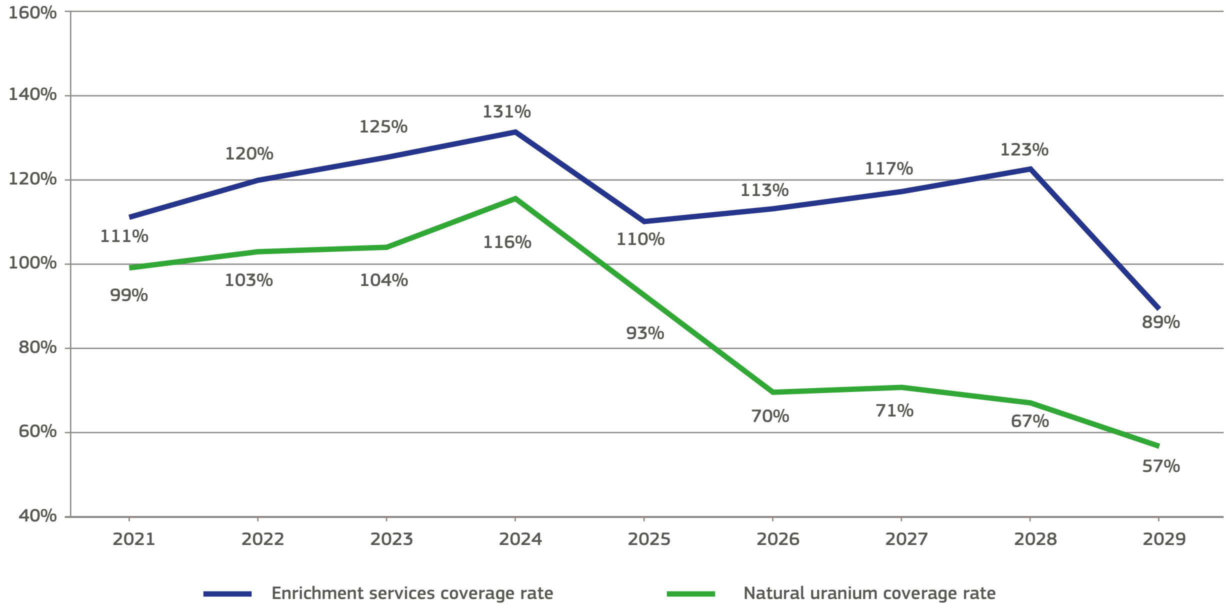
For net reactor requirements (the denominator), a distinction is made between demand for natural uranium and demand for enrichment services. Average net reactor requirements for 2021-2030 are estimated at 11 316 tU and 9 627 tSW per year (see table in Annex 1). ESA assumes the same quantity of requirements 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 for both natural uranium and enrichment services.

The supply of natural uranium is well secured from 2021 to 2025, with a contractual coverage rate of 116% in 2020 and 93% in 2025. In the long term, the uranium coverage rate drops to about 70% in 2026 and continues its decrease to end at 57% in 2029.

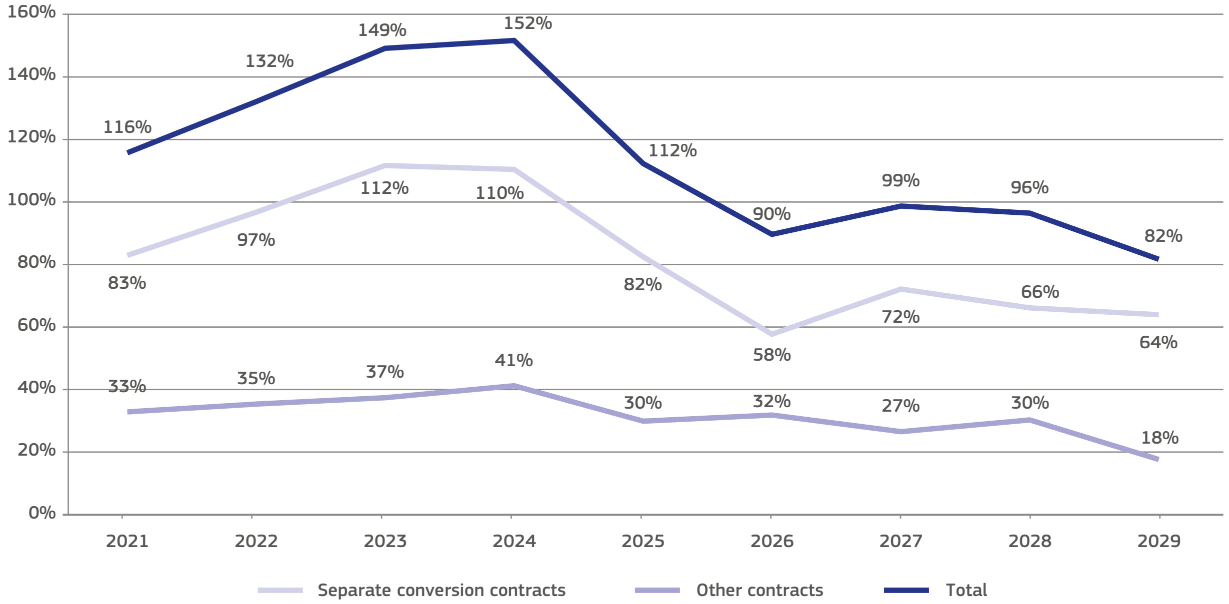
The supply of enrichment services is well secured in the whole period of analysis. It is more than 100% until 2028 and drops to 89% in 2029.

Figure 9. Coverage rate for natural uranium and enrichment services, 2021-2029 (%)



Quantitative analysis of conversion services shows that EU utilities' net reactor requirements are well covered under existing contracts, with conversion services coverage rates above 100% until 2025. Supply is well secured until 2029, which is the whole period of analysis, with a contractual coverage rate fluctuating between 82% and 99% in years 2026-2029.

Figure 10. Coverage rate for conversion services, 2021-2029 (%)



2.5. Findings on the security of supply

To fulfil its statutory mission of identifying market trends likely to affect the security of the EU's supply of nuclear materials and services, ESA continued monitoring the EU nuclear fuel market against world developments. ESA compiled comprehensive statistical reports on trends in the nuclear market on the basis of data related to the contracts it concluded or acknowledged, information gathered from EU utilities in the annual survey at the end of 2020, and the market data from other sources.

Diversification

Key goals for the long-term security of supply are to ensure that EU utilities have diverse sources of supply and do not depend excessively on any single design or supplier from a non-EU country and to maintain the viability of the EU industry at every stage of the fuel cycle.

ESA has recommended that utilities cover most of their current and future requirements under multiannual contracts from diverse sources of supply. In line with this recommendation, deliveries of natural uranium to the EU under multiannual contracts accounted for 97% of total deliveries in 2020. As for mining origin, the relative shares of individual producer countries changed in comparison with the previous year, with Niger, Russia, Kazakhstan, Australia, Canada, and Namibia together providing 95% of the natural uranium delivered to the EU. Natural uranium delivered from CIS countries accounted for 43.55% of all natural uranium delivered to EU utilities, which was a 6% decrease on the year before. Deliveries of uranium from Africa decreased by 5.4% to 3 057 tU, compared to 3 311 tU in 2019 and deliveries from Australia dropped by 9.7% in 2020. The biggest drop was in figures for deliveries from South Africa, which was 82% down, followed by deliveries from the EU (-74.5%) and Namibia (-61%). In contrast, deliveries of uranium from Canada increased by 55.7%. Overall, the deliveries of natural uranium to EU utilities are well diversified, but a number of utilities buy their natural uranium from only one supplier.

> Forecasts of average gross requirements indicate a 12% decrease for natural uranium and a 10% decrease for separative work over the next 10 years.

> Niger, Russia, Kazakhstan, Australia, Canada, and Namibia together provide 95% of natural uranium delivered to the EU.

Compared to last year's annual survey, future aggregate requirements declared by the utilities fell in the case of gross requirements for natural uranium and for services. Forecasts of average gross requirements indicate a 12% decrease for natural uranium and a 10% decrease for separative work over the next 10 years.

On diversification of sources of supply of enriched uranium to EU utilities, 71% of enrichment services were provided by the two European enrichment companies, Orano-GBII and Urenco. The remaining services were provided by Russia's Tenex/TVEL (26%) and by other sources. No deliveries of downblended Russian highly enriched uranium were reported. Of the 26% of SWUs of Russian origin, contracts 'grandfathered' under Article 105 of the Euratom Treaty accounted for less than 4% of total deliveries. In 2020, total deliveries of enrichment services were 13% lower than in the previous year.

When implementing its diversification policy, ESA takes account of the positive aspects of recycling materials obtained from the reprocessing of spent fuel. Re-enriched reprocessed uranium fuel accounted for approximately 2% (188 tU) of the total deliveries of feed material. MOX fuel loaded into NPPs in the EU contained 5 308 kg Pu in 2020 (a 1% increase compared with 2019), resulting in estimated savings of 481 tU and 340 tSW.

Most EU utilities have access to at least two alternative fuel fabricators [25]. The Supply Agency notes the continued dependence of VVER reactor operators on a single foreign nuclear fuel design or supplier. This remains a matter of concern and is considered to be a significant vulnerability, in stark contrast with the situation elsewhere.

25 In Ukraine, Energoatom has access to two VVER fuel suppliers.

In the short and medium term, EU utilities' needs for both natural uranium and enrichment services are well covered.

Contrary to the situation with supplies for VVER-440 reactors, some progress has been made in diversifying the supply of nuclear fuel for VVER-1000 designs. This development has been followed with interest and is further encouraged. (For fuel fabrication developments, see Section 4.6).

ESA welcomes efforts by VVER operators to build up strategic stocks of fuel assemblies as a precaution.

Inventories

The Supply Agency also recommends that EU utilities maintain sufficient strategic inventories and use market opportunities to increase their stocks, depending on their individual circumstances. The aggregate stock level at the end of 2020 totalled 42 396 t of natural uranium equivalent.

ESA finds that most of the utility inventories are at a healthy level. It notes a steady decrease for at least 7 consecutive years, in parallel with decreasing needs. Although on average the inventory could fuel a utility for 2.75 years, it conceals a wide range. Whether this inventory level is sufficient for a particular utility depends on its profile and risk factors.

EU fuel cycle industrial set-up

The Supply Agency notes a continuous lack of sufficient investments, which is endangering long-term security of supply, with few exceptions such as conversion in the EU. With technology, market and energy system changes expected in the coming decade, strategic industrial investment must not be further delayed. The long-term security of supply of nuclear fuel hinges on the EU nuclear industry being able to retain a skilled workforce and further develop their technology.

EU market and contractual set-up

The Supply Agency observed global stagnancy in uranium prices in 2020, maintaining them closer to average production costs. Therefore, it remains concerned by the oversupply of uranium in the market, which depresses prices and delays investments in key segments. Such circumstances could prevail until late in the decade, hampering necessary strategic investments.

Market access to conversion and enrichment services remains sufficient among EU players. EU fleet requirements for the coming years are, on average, well covered by contractually secured supplies and services.

A limited number of utilities remain contractually bound to single suppliers, often with clauses which impede unbundling. ESA considers that contracts bundling the sale of fuel assemblies with other transactions and/or conditions or stages (uranium, conversion, enrichment, fuel fabrication) in principle represent a vulnerability in security of supply. ESA is in communication with the interested parties to address this vulnerability.

2.6. Recommendations on the security of supply

After safety, the regular and undisrupted supply of fuel is a major concern of every nuclear power plant operator. A large number of Europeans rely on nuclear electricity. Nuclear power plants generate a quarter of all electricity in the EU[33]. This share rises above 50% in some countries. Disruptions in supply would have dire consequences for households, hospitals, and industries.

Ensuring security of supply from ore to nuclear fuel is a priority for ESA. To that end, ESA monitors the market and assesses the contracts submitted to it. It takes action as appropriate to address any vulnerabilities.

Based on its analysis, ESA concludes that, in the short and medium term, EU utilities' needs for both natural uranium and enrichment services are well covered. However, the 100% reliance on a single design and supplier of VVER fuel remains a matter of concern, and it also leverages supply of additional products and services from the same supplier.

In general, ESA recommends that operators should apply best practices in security of supply risk management, including an assessment of their risk exposure and implementation of the resulting action plans to address it.

Operators should apply best practices in security of supply risk management, including an assessment of their risk exposure.

Based on its findings, ESA recommends as follows:

Regarding contractual terms:

- generally, multiannual contracts with diverse sources of supply are considered appropriate for utilities to cover most of their current and future requirements for uranium and services;
- parties engaging in contracts that bundle supplies of fuel assemblies with other transactions and/or conditions or stages of the cycle are advised to negotiate clauses expressly providing for unbundled procurement by the operator of uranium and services from other suppliers, without penalties;
- in particular for new reactors, contract terms must expressly provide for licensing and use of fuel assemblies from other suppliers, notably by providing for the disclosure of fuel compatibility data and for the testing of alternative fuel assemblies.

Regarding inventories:

- utilities are advised to maintain sufficient inventories of nuclear materials (including fabricated fuel), preferably on EU territory, to cover future requirements, and to use market opportunities to increase them;
- to forestall risks of shortages in the nuclear fuel supply chain, appropriate inventory levels should be maintained not only by utilities (at least one reload) but also by producers;
- in building up inventories, due care must be paid to determining the appropriate chemical-physical specifications and amounts, given the lead times in the fuel cycle steps involved.

Regarding diversity of procurement options:

- ideal security of supply means at least two alternative suppliers for each stage of the fuel cycle;
- operators dependent on a single design of fuel assemblies and components are advised to step up engagement with industry and cooperation with ESA and other players to bring about alternative solutions;
- while taking concrete actions for the emergence of alternative designs or suppliers, utilities vulnerable at the fuel fabrication stage are advised to keep strategic inventories of source materials, or even of assembled fuel, and an appropriate number of reloads per reactor, depending on their exposure to security of supply risks.

Considering its findings on the fuel cycle industrial set-up and market and contractual set-up, ESA draws attention to the following:

Regarding investment:

- to keep current industrial capacity, technological level and technical expertise in the fuel cycle, investments would need to be stepped up;
- further efforts are needed to make the nuclear sector (power and non-power use) attractive to skilled workers and young graduates;
- strategic industrial investments should be encouraged, especially in technologies.

Regarding general market and contractual behaviours:

- market players are advised to pursue market monitoring and contractual due diligence as a means to control exposure to a changing market and avert security of supply vulnerabilities;
- reliable and well-timed exchange of information with market actors is needed to pursue an effective security of supply policy.

ESA invites the national authorities and regulators to consider the following:

- efforts to develop a harmonised pan-European arrangement for handling cross-border transport package approvals valid in each country should be continued;
- cooperation between industry, operators and regulators is vital to reduce the time to design and market alternative nuclear fuel, furthering security of supply with safety at the fore;
- particular attention should be paid to investments in building new nuclear power plants in the EU using non-EU technology to 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 fuel design;
- particular care should be given to accelerating the arrival on the market of alternative fuel design solutions for reactors presently bound to a single design from outside the EU, particularly reactors planned for long-term operating.

3. Overview of EU developments

3.1. Euratom

3.1.1. EU nuclear energy policy

In 2020, in response to the COVID-19 pandemic, nuclear installation operators and national regulatory authorities in the EU implemented exceptional measures to maintain essential operations, while prioritising nuclear safety. The Directorate-General for Energy (DG ENER) closely monitored the situation in cooperation with the European Nuclear Safety Regulators Group (ENSREG) and facilitated information exchanges amongst national authorities.

Work continued in 2020 to ensure that EU Member States effectively implemented the Euratom legal framework on nuclear safety and on responsible and safe management of spent fuel and radioactive waste, and that they protected workers and the public from radiation exposure.

Work is also ongoing to review the amended Nuclear Safety Directive's implementation, based on the national reports received in 2020. The work will culminate with the adoption in 2021 of the Commission's report to the Council and European Parliament on progress with the Directive's implementation.

Close collaboration with Member States' regulatory authorities within ENSREG was maintained, including on the follow-up to the first Topical Peer Review (TPR) on ageing management under the amended Nuclear Safety Directive, and on the timely preparation of the second TPR with a focus on fire protection. In December 2020, the Commission published the study 'Comprehensive Examination and Analyses of the Situation of Transport of Nuclear Materials'. The study assessed the state of the arrangements for the transport of radioactive material in the EU and identified gaps or overlaps where improvements are possible at national or EU level. Concrete recommendations were made to simplify technical and administrative requirements while at the same time improving safety, transparency and public acceptance.

The ECURIE system for exchanging urgent information in case of a radiological emergency and the EURDEP system for exchanging radiation monitoring data continued to operate fully. As required under the Euratom Treaty, the European Commission visited several Member States' facilities to verify their monitoring of radioactivity levels in the environment and assess their nuclear investment projects.

The Council extended EU financial support to the nuclear decommissioning assistance programmes (NDAP) in Bulgaria, Lithuania, and Slovakia for 2021-2027. All three sites reported effective progress: Bohunice (Slovakia) with the dismantling of large components in the reactor building; Ignalina (Lithuania) with the removal of 98% of spent fuel assemblies and their transfer to a dedicated safe facility; and Kozloduy (Bulgaria) with the initiation of the decontamination of the primary circuits, fulfilling the objectives set under the 2014-2020 multiannual financial framework. Since 2021, knowledge

> In response to the COVID-19 pandemic, nuclear installation operators and national regulatory authorities in the EU implemented exceptional measures to maintain essential operations, while prioritising nuclear safety.

Vaccine against COVID-19

© Cedric Bufkens

> Experience and lessons learnt from the nuclear decommissioning programmes are to be shared across the EU.

sharing has become an explicit objective under the new Council Regulations, with a requirement that experience and lessons learnt from the programmes be shared across the EU. Within this framework, the Commission's Joint Research Centre (JRC) will play a key role in dissemination.

Regarding the external dimension of nuclear energy policy, the European Commission continued to actively promote the highest levels of nuclear safety outside the EU. A priority action in 2020 was to follow up on the ENSREG peer review and issue recommendations based on the stress tests conducted on the Astravets Nuclear Power Plant (NPP) in Belarus in 2018. It involved multiple preparatory technical exchanges between the Belarusian nuclear regulator, GAN, and the EU peer review team of experts from ENSREG and the Commission. A final peer review mission is scheduled for the second semester 2021. Similarly, a stress test on the Akkuyu NPP in Turkey is to be conducted in 2022. The Commission is also planning a stress test on Iran's Bushner NPP.

In 2020, the European Union and India signed a Civil Nuclear Cooperation Agreement on research and development cooperation in the use of atomic energy focusing on the application of nuclear energy in agriculture, healthcare and industry, radioactive waste management, fusion, safety and security[26].

3.1.2. Euratom safeguards

Euratom safeguards are the nuclear material supervision system under the exclusive competence of the European Commission. The Commission's Directorate-General for Energy is responsible for Euratom safeguards, which it implements through a set of verification activities to ensure that in the EU 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 2020, the Commission continued to prioritise its safeguards activities by applying state-of-the-art approaches which reflect the nuclear and information technology developments associated with the changing political and social environment and the related particular safeguards challenges.

The Commission continued to work in close cooperation with the IAEA on fostering the joint use of common safeguards equipment and on the implementation of the 'Safeguards-by-Design' concept integrating relevant safeguards considerations already during the design phase of nuclear installations.

In the context of the unique challenge of COVID-19, the Commission continued to fulfil its mandate under the Euratom Treaty and international agreements, remaining in continuous contact with the IAEA so that both could ensure a coherent and efficient implementation of their respective safeguards services. In 2020, 99.83% of the more than 600 000 tonnes of civil nuclear materials in the EU and in the UK were subject to full-scope Euratom safeguards verification activities, including on-site physical inventory verifications.

2020 also marked the last year of applying Euratom safeguards in the UK (a member of Euratom since 1973) and the last year of the validity of the trilateral Agreement for safeguards in the implementation of the Treaty on the Non-Proliferation of Nuclear Weapons concluded between the IAEA, Euratom and the UK (and its respective additional protocol). In line with the EU-UK Withdrawal Agreement, the Commission continued to exercise its safeguards obligations, while smoothly preparing the end of its verification activities by 31 December 2020 when the UK's transition period would be over.

> In 2020, 99.83 % of the more than 600 000 tonnes of civil nuclear materials in the EU and in the UK were subject to full-scope Euratom safeguards verification activities, including on-site physical inventory verifications.

26 Agency's 2020 Q3 Report (#063b)

Throughout the last 48 years, Euratom safeguards played an indispensable role in providing a credible assurance for the responsible and peaceful use of nuclear materials in civilian applications in the UK as part of the global non-proliferation regime. In the future, the Commission and the UK will collaborate on nuclear safeguards on the basis of the bilateral Agreement between the UK and Euratom for cooperation on the safe and peaceful uses of nuclear energy provisionally applied since 1 January 2021 and which entered into force on 1 May 2021 (published in the Official Journal of the EU on 30 April 2021, L 150, p. 1-15) (see section 3.1.6 for a full description of the Nuclear Cooperation Agreement with the UK).

3.1.3. ITER and the Broader Approach

In 2020, DG ENER continued to support the construction of ITER and the development of fusion energy.

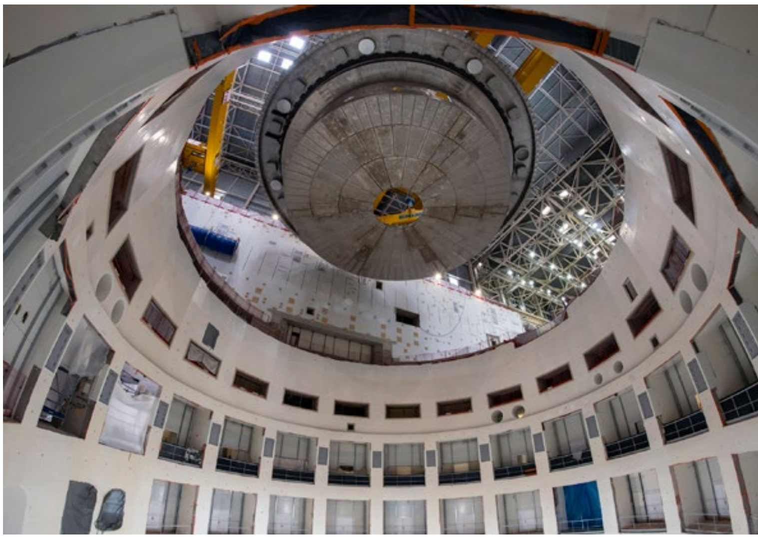
By year's end, ITER's construction was 71.1% complete. When fully completed, it will be possible to begin the first experiments ('First Plasma'). In practical terms, this means that the civil engineering works of the tokamak building and the first European toroidal magnets have been completed and the first poloidal magnets tested. Nevertheless, the COVID-19 pandemic has affected the project's implementation, and the ITER Organization and ITER Members are analysing the impact of this.

In March 2020, the European Commission and Japan entered a new phase of their cooperation, signing a Joint Declaration extending the Broader Approach Agreement. This bilateral cooperation complements the ITER project's activities and accelerates the realisation of fusion energy. Japan and the EU also completed the assembly of the JT-60SA tokamak in Naka. This device is the largest and most modern tokamak in the world and will remain so until ITER's completion.

In July 2020, the European Council agreed to allocate EUR 5.61 billion (in current prices) to the ITER project for the long-term 2021-2027 budget. ITER is therefore well anchored in the EU priorities.

In December 2020, Euratom and the United Kingdom reached an agreement in principle on the United Kingdom's participation in ITER activities through its membership in the European Joint Undertaking 'Fusion for Energy'.

ITER base lift 4 insertion



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3.1.4. European Commission research and innovation programmes

The Euratom research and training programme aims to maintain strong competences in nuclear research and innovation in the European Union. All Member States stand to benefit from the development of sound scientific and technical bases for the safe operation of reactors, secure management of radioactive waste, robust systems of radiation protection and the development of medical applications of ionising radiation. 2020 was the last year of implementation of the 2014-2020 Euratom programme. During these 7 years, five calls were concluded, with 254 proposals submitted for EUR 726 million in Euratom funding. Following an evaluation by independent experts, 98 projects were awarded EUR 416 million in funding. On average, Euratom provided 75% of the funding for these projects.

In 2020 the Commission provided close to EUR 140 million in support for 33 Euratom grants. Of the various projects, 20 concerned nuclear safety and received more than half of the call's budget (53%), 3 concerned radiation protection and medical applications and received 19% of the budget, 1 concerned radioactive waste management, PREDIS [27], and received 10% of the available budget. Euratom also launched 4 projects on decommissioning, with a budget of more than EUR 11 million. While all research projects use about 5% of

27 https://cordis.europa.eu/project/id/945098/fr

All Member States stand to benefit from the development of sound scientific and technical bases for the safe operation of reactors, secure management of radioactive waste, robust systems of radiation protection and the development of medical applications of ionising radiation.

their budget for education and training, mainly at PhD level, the Euratom programme also provided almost EUR 5 million in support for specific training and education projects in 2020. Their focus was on expertise in nuclear chemistry and radiochemistry, as well as on PhD/post-doctoral education in reactor physics and nuclear reactor safety.

3.1.5. European Commission's Joint Research Centre activities

The general objective of the 2019-2020 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, in particular to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way'. The direct actions implemented by the JRC are an important part of the Euratom programme and pursue specific objectives covering nuclear safety, radioactive waste management, decommissioning, emergency preparedness, nuclear security, safeguards and non-proliferation, standardisation, knowledge management, education and training and support for Union policy in these fields. To ensure that direct actions are in line with and complement the research and training needs of Member States, the JRC continuously interacts with the main research and scientific institutions in the EU and actively participates in several technological platforms and associations.

The JRC 2019-2020 work programme for nuclear activities is structured around some 20 projects, allocating 48% of its resources to nuclear safety, waste management, decommissioning and emergency preparedness, 33% to nuclear security, safeguards and non-proliferation, 12% to reference standards, nuclear science and non-energy applications and 7% to education, training and knowledge management.

The JRC work programme contributes to the development of codes, standards and test methods for the safety analysis of nuclear reactors and provides reference data, software tools and knowledge on the behaviour of nuclear fuel in normal and accidental conditions. An example is the operation of the Clearinghouse website and database and the publication of periodic reports (supported by French and German technical support organisations) to keep nuclear safety authorities informed of the operating experience of nuclear power plants. In 2020, the JRC analysed 16 selected events in NPPs and produced several studies on ageing-related events. JRC scientists participated in drafting two IAEA nuclear safety technical documents. In the context of the COVID-19 pandemic, nuclear power plants and regulatory bodies have taken measures to mitigate its consequences. Already in March 2020 (and updated in April 2020), the JRC prepared a report on the continued safe operation of NPPs.

An initiative to allow open access to the JRC research facilities was launched in 2020. This was linked to the objective of achieving greater impact with the Euratom programme's direct and indirect actions. The project developed tools to cope with the health crisis restrictions, including virtual access, which allowed experiments to continue.

To support the effective and efficient implementation of the EU safeguards system, the JRC develops dedicated methods for containment and surveillance as well as analytical techniques to improve the measurement quality. The JRC provided analytical support to safeguards authorities such as the European Commission's Directorate-General for Energy and IAEA, analysing about 600 nuclear and 100 environmental samples. The Euratom safeguards laboratories in reprocessing plants in France and the UK continued to operate nearly uninterrupted to ensure that large flows of nuclear materials were safeguarded even under the demanding conditions created by the COVID-19 pandemic. The Euratom programme's direct actions support some of the EU nuclear security actions. The JRC has a leading role in nuclear forensics. It co-chairs the Nuclear Forensics International Technical Working Group, participating in collective ITWG exercises and sharing best practices at the EU nuclear security training centre (EUSECTRA). This helps to improve capacity in the EU Member States and neighbouring countries.

Open access to the JRC research facilities was launched in 2020. This was linked to the objective of achieving greater impact with the Euratom programme's direct and indirect actions.

The JRC provides technical support for the implementation of the Council Directive establishing a Community framework for the nuclear safety of nuclear installations, the Council Directive on responsible and safe management of spent fuel and radioactive waste and the Council Directive on the supervision and control of shipments of radioactive waste and spent fuel. A study on the current challenges of the nuclear supply chain, in particular in relation to structures, systems and components, was released; it is a deliverable of a joint project by the JRC and the Directorate-General for Energy entitled 'Modernisation and Optimisation of the European Nuclear Supply Chain', to assess challenges for the long-term operation of nuclear power plants.

3.1.6. The UK's withdrawal from the EU

Following the United Kingdom's withdrawal from the EU and Euratom, intense negotiations were held in 2020 on the future partnership, including on civil nuclear issues. On 24 December 2020, the Parties agreed at negotiator level the Trade and Cooperation Agreement between the EU and Euratom, on the one part, and the UK, on the other part, (the 'TCA') and an Agreement between the UK and Euratom for Cooperation on the Safe and Peaceful Uses of Nuclear Energy (the "Euratom Agreement"). Both agreements were signed on 30 December 2020 and published in the EU Official Journal on 31 December 2020 in the English version only.

Given the UK's exceptional situation with the EU and Euratom, and the urgency of the situation with the transition period ending on 31 December 2020, the TCA, including for matters

EU and UK flags

© iStock.com atakan

falling under the Euratom Treaty, is applicable on a provisional basis as from 1 January 2021, pending the completion of the procedures necessary for its entry into force. The Euratom Agreement was also applicable on a provisional basis as from 1 January 2021.

Following the completion of the procedures necessary for their entry into force, the TCA and the Euratom Agreement were published in the EU Official Journal in all EU official languages on 30 April 2021 and entered into force on 1 May 2021.

The Euratom-UK Agreement provides for wide-ranging cooperation on safe and peaceful uses of nuclear energy, underpinned by commitments by both sides to comply with international non-proliferation obligations and to uphold a high level of nuclear safety standards. This Agreement facilitates, among other things: (a) the supply and transfer of nuclear material, non-nuclear material, technology and equipment; (b) trade and commercial cooperation relating to the nuclear fuel cycle; (c) cooperation and exchange of information in areas of mutual interest such as nuclear safeguards, physical protection, nuclear safety and radiation protection, including emergency preparedness and response; (d) the safe management of spent fuel and radioactive waste and the use of radioisotopes and radiation in agriculture, industry and medicine; (e) geological and geophysical exploration; development, production, further processing and use of uranium resources; cooperation on regulatory aspects of the peaceful use of nuclear energy; and (f) research and development, allowing the UK to continue to participate in the ITER project through the F4E Joint Undertaking.

3.2. Country-specific developments

At the end of 2020, 122 commercial nuclear power reactors were operating in 13 Member States and the UK. There were 4 reactors under construction in France, Slovakia and Finland and 2 in the UK. In 2020, 3 reactors were shut down in the EU (Fessenheim-1 and 2 in France and Ringhals-1 in Sweden) (see Table 7).

Table 7. Nuclear power reactors in the EU-27 and the UK in 2020

Country	Reactors in operation (under construction)	Net capacity (MWe) (under construction)
Belgium	7	5 942
Bulgaria	2	2 006
Czechia	6	3 932
Germany	6	8 113
Spain	7	7 085
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	4 (1)	2 794 (1 600)
Sweden (***)	7	7 779
Total EU-27	**107 (4)**	105 145 (4 110)
United Kingdom	15 (2)	8 923 (3 260)
Total	**122 (6)**	**114 068 (7 370)**

(*) Permanent shutdown of Fessenheim-1 on 22 February and Fessenheim-2 on 30 June 2020

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

(***) Permanent shutdown of Ringhals-1 on 31 December 2020

Source: WNA and EU Member States.

The major developments, decisions and announcements in the nuclear field in the EU Member States are presented below.

Belgium

The Constitutional Court of Belgium annulled the law extending by 10 years the operating lifetime of Doel 1 and Doel 2. The Court rules that an environmental impact assessment has to be performed by the end of 2022 to keep units running until 2025. In a public consultation organised by the Belgian Agency for the Management of Radioactive Waste on its draft long-term management plan for high-level and long-lived conditioned radioactive waste, the national nuclear regulatory authority was in favour of a geological disposal for high-level radioactive waste, stating that 'with the scientific knowledge of today, geological disposal is the safest long-term option'.

The new Belgian government has committed to the previously agreed nuclear phase-out by 2025. However, the possibility of extending the life of two nuclear power plants was left open. A final decision is to be made by November 2021 based on an assessment of the country`s security of supply.

To replace the to-be-phased-out nuclear units, ENGIE Electrabel is planning to build four gas-steam plants totalling 2 950 MW by 2025.

Bulgaria

The Belene project was to receive binding offers from 5 short-listed companies: 3 companies as potential strategic investors – China's National Nuclear Corporation (CNNC), Russia's Atomenergoprom JSC, part of Rosatom, and Korea's Hydro and Nuclear Power Corporation, and 2 as equipment supplier – France's Framatome S.A.S and US General Electric. However, in January 2021, the government abandoned the Belene project and announced a Kozloduy Unit 7 project to replace it.

Planning for a US-designed reactor at the Kozloduy site, Bulgaria signed a Memorandum of Understanding with the United States on strategic cooperation in nuclear energy for civilian purposes. The state-owned energy company Bulgarian Energy Holdings was to enter into negotiations with US companies developing new nuclear technologies for civilian purposes, including small modular reactors.

The National Nuclear Security and Support Center and Finland`s VTT signed a Memorandum of Understanding to further develop competences and research opportunities in the field of safe radioactive waste management, covering such areas as geological repositories, safety, stakeholder engagement and regulatory requirements.

Czechia

The country's finalised National Energy and Climate Plan introduced the long-term energy policy target for nuclear power to generate 46% to 58% of Czech electricity by 2040.

GE Hitachi Nuclear Energy and ČEZ signed a Memorandum of Understanding to assess the feasibility of constructing a 300 MWe water-cooled BWRX-300 reactor in Czechia. ČEZ, which had already signed a Memorandum of Understanding with the American NuScale in 2019, is already involved in developing an SMR via its fillial ÚJV Řež (Energy Well).

ČEZ announced its plans to spend approximately EUR 2 billion to extend the lifespan of the Dukovany NPP and keep it in operation for the next 25-27 years, in line with the plans to keep its plants operating for 60 years. In addition, the Czech government and ČEZ signed agreements for construction of a new 1200MWe unit at the Dukovany NPP. The Czech government plans to extend a loan covering 70% of the construction costs for the unit and proposed to sign a power offtake agreement with ČEZ for 60 years for all electricity produced after the start of the operation. If all goes according to schedule, a supplier will be selected by 2024 and construction will start in 2029. Commissioning is to be by 2036. Interest was expressed by China General Nuclear Power Corp, EDF Group, Korea Hydro & Nuclear Power, Rosatom and Westinghouse.

Unit 1 of Temelin NPP received a permit for another ten-year operation. ČEZ already began preparations to apply for another ten-year permit for Temelin-2.

Estonia

The national nuclear energy working group will analyse the feasibility of using nuclear power in Estonia to increase its energy security and reach 2050 climate goals.

The Estonian development company Fermi Energia is considering four SMR designs. It presented the positive results of a prefeasibility study on the economic impacts of siting, constructing, and operating an SMR in Estonia and identified location options. Construction is currently planned to begin in the 2030 timeframe at an estimated cost of EUR 1 billion. Fermi Energia has teamed up with Vattenfall, Fortum and Tractebel to construct this SMR.

Finland

The country's Radiation and Nuclear Safety Authority (STUK) published a report on the safety assessment and licensing of SMRs as the authority is preparing for the licensing of an SMR in Finland.

Business Finland, a government organisation for innovation funding, is financing a new SMR development project, Finnish Ecosystem for Small Modular Reactors (EcoSMR). Led by VTT Technical Center of Finland, the project brings together several Finnish organisations to support the development of SMRs. VTT has already begun the first phase of the project to develop SMRs for district heating.

Fortum and the Massachusetts Institute of Technology (MIT) began cooperation on a techno-economic modelling tool for SMR projects. The three-year cooperation aims to increase understanding of SMR projects and characteristics.

Terrafame, a metal mining company, received a uranium recovery permit for uranium production as a by-product of zinc and nickel production at its Sotkamo mine in Finland. It expects to start operations in 2021.

STUK notified the authorities in charge of radiation safety in the countries that had supplied uranium to Finnish nuclear power plants of Finland's intention to begin final disposal of used nuclear fuel in the mid-2020s. Normal inspections of nuclear materials cannot be performed once the materials have been finally disposed of. So procedures related to such inspections must be specified before the initiation of final disposal.

France

The government published a new version of its Multiannual Energy Programme, outlining its ambition to reduce the share of nuclear energy to 50% by 2035. The decision on nuclear new builds should be taken after the commissioning of the Flamanville EPR, which is expected end of 2022.

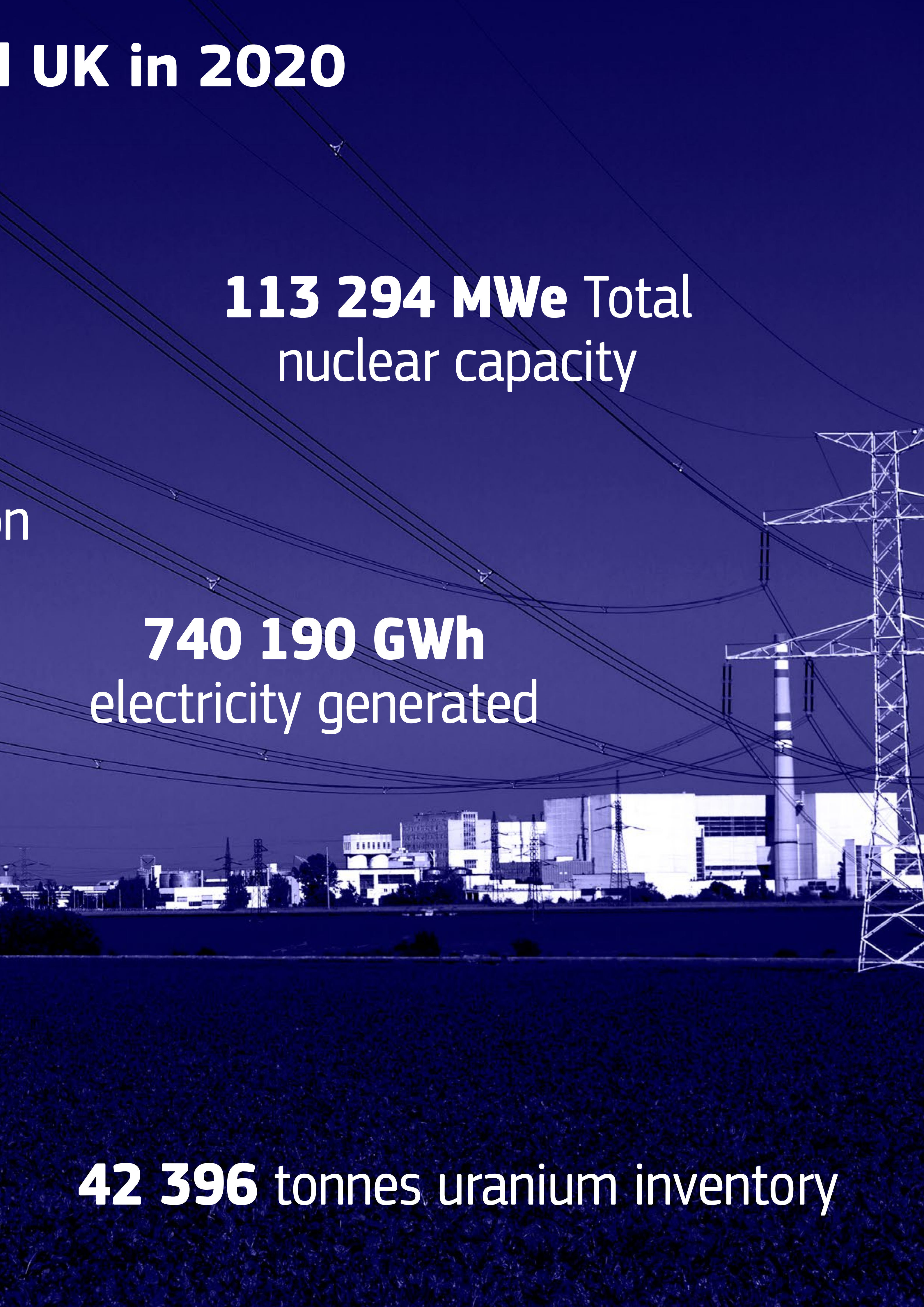
Nuclear Power in the EU27 and

122
operating reactors in
14 States

4 reactors under constructio

12 592 tonnes uranium purchased

I UK in 2020



113 294 MWe Total nuclear capacity

on

740 190 GWh electricity generated

42 396 tonnes uranium inventory

EDF permanently shut down the 920MWe unit of Fessenheim-1 in February and Fessenheim-2 in June 2020. It also put in operation the emergency diesel generators at all of France's reactors, fulfilling the requirement imposed by the nuclear regulator ASN after the Fukushima accident.

ASN authorised the reception and storage of nuclear fuel at EDF's Flamanville EPR. The reception of fuel, which will be stored in the pool of the building intended for this purpose, is another step in the sequence leading to the commissioning of Flamanville EPR. The first fuel assemblies were delivered on the Flamanville EPR site in October 2020.

Orano received an authorisation to start dismantling the Georges Besse gaseous diffusion plant, shut down since 2012.

Germany

The German Federal government, supported by relevant ministries, decided to maintain and further develop competence in the field of nuclear safety. The 'Strategy for Competence Building and the Development of Future Talent for Nuclear Safety' was prepared jointly under the leadership of the Federal Ministry for Economic Affairs and Energy and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Hungary

NPP Paks II submitted an application for a final construction license, and the energy regulatory authority MEKH issued a permit to build the two new VVER1200 units. The authority analysed the security of supply to the electricity grid. The nuclear technology safety assessments are to be conducted by the Hungarian Atomic Energy Authority OAH with a decision expected in the second half of 2021.

The programme of the Budapest University of Technology and Economics became part of the International Nuclear Management Academy and has been endorsed by the International Atomic Energy Agency.

Italy

Società Gestione Impianti Nucleari SpA (Sogin) received an authorisation from the Ministry of Economic Development to decommission the Latina NPP and has begun the work.

Lithuania

Lithuania urged the European Commission to prevent the Astravets NPP in Belarus from starting commercial operations until it has implemented all the recommendations that the European Nuclear Safety Regulators Group (ENSREG) issued on the safety improvement measures the Astravets NPP needs to take as a result of the EU methodology stress tests performed in 2018. Once the plant was connected to the grid, Lithuania stopped importing electricity from the Astravets NPP, which it qualified as unsafe. The new Lithuanian government also said it was committed to a complete blockage of the Astravets NPP, which was the ambition shared by the EU as a whole.

In June 2020, when Belarus accepted a follow-up peer review by ENSREG, the Commission began working to secure constructive technical cooperation according to a mutually agreed ambitious timetable. However, the COVID-19 pandemic adversely affected the review process. The visit of an ENSREG peer review team to the Astravets NPP had to be postponed until February 2021, and the preliminary report was approved by ENSREG in March 2021 [28].

Implementation of the Ignalina decommissioning programme continued and, by the end of 2020, 98% of the spent fuel had been removed from the reactor buildings and transferred to dry safe storage, substantially reducing the hazards at the site. The EU confirmed its commitment to the programme and offered EUR 552 million in financial assistance over 2021-2027.

Netherlands

Nuclear energy is maintained as an option in the energy mix in the Netherlands, based on the policy principle of 'managing on CO2'. Several studies show that by 2050 nuclear energy can be a cost-effective option and that a positive business case can be one of the options in the long term. The Ministry of Economic Affairs and Climate Policy will explore whether the Borssele NPP can continue operating after 2033. In addition, the Dutch Parliament adopted a motion asking the government to hold a market consultation analysing under which conditions market parties are prepared to invest in nuclear power plants in the Netherlands. It also asked the government to investigate what public support is needed for this and to explore in which regions there is interest in building a nuclear power plant.

Poland

In its Energy Policy for the next 20 years, Poland plans to build its first ever six nuclear reactors, with 6-9 GWe of capacity, investing EUR 33.7 billion. The first 1-1.6 GWe facility would be in operation by 2033.

Poland signed a thirty-year cooperation agreement with the United States worth USD 18 billion to develop Poland`s civil nuclear energy programme.

28 http://www.ensreg.eu/document/preliminary-peer-review-report-belarus-stress-test-national-action-plan

Romania

In February 2020, the European Commission decided that the state aid granted to the Compania Națională a Uraniului (CNU) in 2016 was incompatible with the internal market and therefore constitutes illegal state aid. In such case, this aid must be recovered from the beneficiary. In this context, CNU has developed a restructuring / liquidation plan according to which the Crucea-Botusana mine will be closed and certain assets of interest belonging to the Feldioara Branch will be sold to SN Nuclearelectrica SA (SNN). This could allow SNN to concentrate within the company the entire CANDU nuclear fuel manufacturing cycle.

In May 2020, the Romanian Government decided to stop negotiations between SNN and the China General Nuclear Power Corporation for the construction and operation of reactors 3 and 4 of the Cernavoda Nuclear Power Plant, due to unsuccessful negotiation. The government asked SNN to denounce the Memorandum of Understanding signed in this regard.

On 9 December 2020, Romania and the United States concluded the Intergovernmental Agreement on cooperation in connection with the nuclear energy projects in Cernavoda and in the civil nuclear energy sector in Romania. The agreement covers several areas of cooperation, including the Unit 3 and 4 project, the refurbishment of Unit 1 and cooperation in other areas, notably small modular reactors. In October 2020, Romania also signed a declaration of intent on civil nuclear cooperation with France. The US Agency for Trade and Development (USTDA)and SNN announced that the USTDA had awarded a non-reimbursable grant to finance the cost of technical assistance in identifying and conducting a preliminary assessment of potential nuclear sites compatible with SMR technologies in Romania.

Slovakia

The Slovak Nuclear Regulatory Body issued a draft decision in 2020 on fuel loading for Unit 3 of the Mochovce NPP. However, the actual fuel loading date planned in 2021 remained unknown. The process is delayed due to the slowdown in construction activities on site caused by the coronavirus pandemic and the subsequent extension of the decision-making process by the regulator.

Bohunice V1 decommissioning reached an important milestone, with the successful removal and transport of the reactor pressure vessel from Unit 1.

Slovenské Elektrárne planned efficiency upgrades to uprate Mochovce 1 & 2 to a total of 1 000 MWe, expecting to complete the work in 2021.

Slovenia

The goal of Slovenia's new integrated national energy and climate plan is to become carbon neutral by 2050 and improve the country's energy self-sufficiency.

Hydropower plants remain one of the main pillars, but most of the new renewable energy capacity is expected to be photovoltaic. Nuclear energy is supposed to retain its share in the energy mix.

Slovenia signed a Memorandum of Understanding with the United States on civil nuclear cooperation.

Spain

In July 2020, the Spanish Government, by ministerial order, renewed Almaraz-Trillo Nuclear Power Plants' (CNAT) authorisation to operate Unit I of the Almaraz nuclear power plant until November 2027 and Unit II until October 2028.

The government also renewed, by ministerial order, Ascó-Vandellós II Nuclear Association's (ANAV) authorisation to operate Unit II of the Vandellós nuclear power plant until July 2030.

Sweden

Vattenfal shut down Unit 1 at the Ringhals NPP after 44 years of operation.

Sweden decided that the state will become responsible for the safety of the final spent fuel repository in Forsmark once SKB has fulfilled its mission. SKB`s spent fuel and high-level waste storage facility and repository for low and medium-level waste received an authorisation to operate until 2028. The Municipality of Osthammar approved the Swedish final spent fuel repository in Forsmark. The Swedish Government will make the final decision on the construction license, which SKB applied for in 2011.

United Kingdom

The permanent shutdown of the Sellafield Magnox Reprocessing Plant was delayed until 2021 due to COVID-19. EDF Energy announced its plan to close Hinkley Point B no later than July 2022.

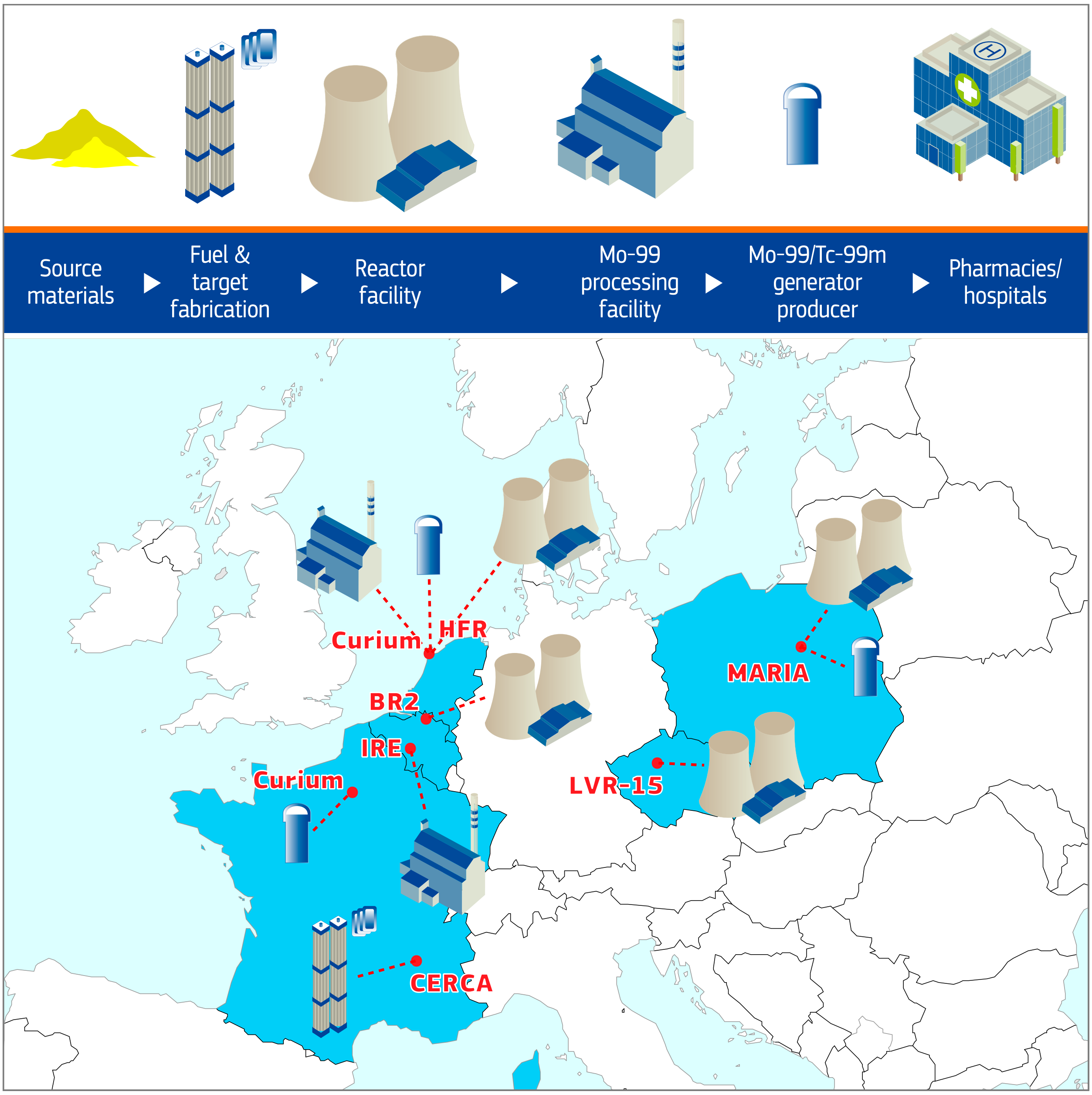
The UK Government awarded GBP 40 million to support advanced nuclear technology development, with a major part of the funding going to advanced modular reactor projects.

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

Radioisotopes are used in medicine to diagnose and treat various diseases, including life-threatening ones like cancer or cardiovascular and brain diseases. Over 10 000 hospitals worldwide use radioisotopes in about 100 different nuclear medicine procedures totalling almost 49 million medical procedures each year. In the EU alone, more than 1 500 nuclear medicine centres deliver about 10 million procedures to patients each year. Nuclear medicine is an important tool for cancer management – depending on the national practices, about 60% of all nuclear medicine procedures are performed in oncology. The therapeutic use of medical radioisotopes in cancer treatment is expanding, with the market for novel radiopharmaceuticals expected to grow massively over the next few years.

Currently, the main source of radioisotopes is nuclear research reactors, with several other non-fission technologies such as cyclotrons and accelerators in use or under development. Radioisotope production technologies mostly rely on highly specialised complex supply chains, which usually stretch across countries and continents and involve 24/7 just-in-time delivery.

Production of medical radioisotopes in the EU



The EU is a leading supplier of medical radioisotopes to the world market, with a share of more than 60% for Mo-99/Tc-99m.

Tc-99m is the most widely used radioisotope. It is used in 80% of all nuclear medicine diagnostic procedures. The production of Tc-99m starts with irradiation of uranium targets in nuclear research reactors to produce Mo-99, then extraction of Mo-99 from targets in specialised processing facilities, production of Tc-99m generators and shipment to hospitals. Any disruption to supply may have negative and sometimes severe consequences for patients.

The EU plays a central role in the nuclear medicine domain. It has a unique complete supply chain network:

- 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 is a leading supplier of medical radioisotopes to the world market, with a share of more than 60% for Mo-99/Tc-99m. Some of the most important pharmaceutical and clinical developments in nuclear medicine also originated in the EU.

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

The NMEu Security of Supply Working Group [29] ensures effective coordination of reactor maintenance schedules to avoid and mitigate disruptions in the supply of Mo-99/Tc-99m. The Emergency Response Team (ERT) created within this Working Group and composed of representatives of research reactors, Mo-99 processors and Mo-99/Tc-99m generator manufacturers monitors production and supply issues. This continuous monitoring makes it possible to identify potential shortages of Mo-99 and draw up mitigation action plans involving all stakeholders.

In 2020, the Observatory was cooperating closely with the NMEu's Security of Supply Working Group, as well as the Transport Working Group for uninterrupted supply of Mo-99/Tc-99m, particularly on COVID-19 pandemic-related concerns and Brexit preparedness and contingency actions. NMEu's ERT support was instrumental in dealing with supply disruption issues. The Joint Communication Team (JCT), created with the Observatory, provided regular information updates received from the ERT to various stakeholder groups, including the Council Working Party on Atomic Questions [30] and the Health Security Committee [31], OECD/NEA and IAEA.

The Observatory, in close cooperation with NMEu, monitored the uninterrupted supply of Mo-99/Tc-99m, particularly in light of COVID-19 pandemic-related concerns and Brexit preparedness and contingency actions.

In the context of the Observatory's work, the Euratom Supply Agency liaised on the COVID-19 response actions with the relevant European Commission services (e.g., Directorate-General for Energy, Directorate-General for Health and Food Safety, Joint Research Centre and Directorate-General for Research and Innovation). At the dedicated meeting of the Commission's Directorate-General for Migration and Home

The Observatory, in close cooperation with NMEu, monitored the uninterrupted supply of Mo-99/Tc-99m, particularly in light of COVID-19 pandemic-related concerns and Brexit preparedness and contingency actions.

29 http://nuclearmedicineeurope.eu/security-of-supply/
30 http://www.consilium.europa.eu/en/council-eu/preparatory-bodies/working-party-atomic-questions/.
31 https://ec.europa.eu/health/preparedness_response/risk_management/hsc_fr

Affairs - COVID-19/Corona Information group, ESA debriefed EU Member States on the NMEu stakeholders' concerns about the effect the pandemic would have on the transport of medical radioisotopes due to the lockdown situation, extended border controls and the curtailment or elimination of many flights.

3.3.2. SAMIRA

Following preparations throughout 2020, the action plan of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) [32] was adopted on 5 February 2021. The action plan contributes to the Commission's flagship initiative 'Europe's Beating Cancer Plan' with new actions on the supply of medical radioisotopes, quality and safety, and research and innovation in medical applications of nuclear and radiation technology. The Agency actively collaborated in preparing SAMIRA, under the leadership of the Directorate-General for Energy and with the involvement of the Directorate-General for Health and Food Safety, the Directorate-General for Research and Innovation and the Joint Research Centre. The action plan will be implemented through instruments and programmes dealing with energy, health and research and innovation. The plan will improve EU coordination, ensure that radiological and nuclear technologies continue to benefit the health of EU citizens, and most importantly contribute to the fight against cancer and other diseases.

The Strategic Agenda for Medical Ionising Radiation Applications is one of the building blocks of the Commission's 'Europe's Beating Cancer Plan'.

Under the SAMIRA umbrella, the Commission will launch a European Radioisotope Valley Initiative (ERVI) to maintain Europe's global leadership in the supply of medical radioisotopes and help accelerate the development and introduction of new radioisotopes and production methods. The Commission will also launch a European Initiative on Quality and Safety of medical applications of ionizing radiation, to ensure that diagnostic and therapeutic uses of ionizing radiation in Member States operate in line with the highest standards. In addition, the Commission will create synergies between the Euratom research and training programme and the 'health' cluster of the EU research programme Horizon Europe through the development and implementation of a research roadmap for medical applications of nuclear and radiation technology.

> The Strategic Agenda for Medical Ionising Radiation Applications is one of the building blocks of the Commission's 'Europe's Beating Cancer Plan'.

3.3.3. Studies and research on the supply chain's back end

In 2020, the Commission's Joint Research Centre continued to assess challenges with the supply of medical radioisotopes to European patients, as well as challenges with research for new radioisotope applications and challenges with developing alternative methods of production. As a follow-up to the 2017-2018 study on the sustainable and resilient supply of medical radioisotopes for imaging in the European market (Sustainable and Resilient Supply of Medical Radioisotopes - SMER 1), another survey (SMER 2) was launched in 2019, in the light of continued interest by the Council of the European Union. This survey focused on the current and emerging radionuclides applied to therapy and was completed end of 2020. The SMER 2 project provided the European Commission with up-to-date information on the radionuclide therapy market in the EU, including forecasting of demand. New research activities on alternative methods for producing radioisotopes of medical interest are on the way at the JRC experimental facilities. All these actions support other EU initiatives, including the European Observatory on the Supply of Medical Radioisotopes, SAMIRA and Europe's Beating Cancer Plan.

3.3.4. HEU to HALEU conversion of targets used for Mo-99 production

In 2020, the five-year Heracles-CP [33] project 'Towards the conversion of high-performance research reactors in Europe' was completed. Thanks to the EUR 6.35 million project, coordinated by the Technical University of Munich and involving five partners, significant progress was made in understanding the behaviour of disperse uranium-molybdenum alloys (U-Mo) fuels under irradiation and in developing a reference concept

32 https://ec.europa.eu/commission/presscorner/detail/en/ip_21_265
33 https://cordis.europa.eu/project/id/661935/fr

that would meet the requirements of high-performance research reactors.

A complementary EUR 6.60 million project, FOREvER [34], kicked off in 2017 to optimise the manufacturing process and will run until 2021. It is coordinated by the French Alternative Energies and Atomic Energy Commission (CEA) and involves nine research partners.

Building on the data of the Heracles-CP and FOREvER, the EU-QUALIFY [35] project started in October 2020 and will last until 2024. The EUR 7.80 million project, coordinated by the Belgian Nuclear Research Centre (SCK-CEN) and involving five partners, will generate data needed for the generic fuel qualification of two main fuel types (U-Mo and 'high-loaded' uranium silicide (U_3Si_2)). The project's main objective is to provide support for further investigation of future needs in terms of volume and fuel design requirements in line with relevant data for each EU research reactor type, and to prepare technical requirements for the safety of manufacturing, storage, transport and reprocessing of such research reactor fuel.

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

In 2020, important projects on non-power applications of nuclear technology were started or continued. The construction of the Jules Horowitz Reactor (JHR) [36] in France advanced. In early 2020, three heat exchangers for the primary circuit of JHR were installed. In November, the main and most voluminous equipment of the pile-block was introduced in the pool and clamped.

The Petten HFR reactor achieved record production in May, supplying 30 000 patients with medical radioisotopes daily. More European producers of radioisotopes are now turning to the Nuclear Research and Consultancy Group for supplies due to transport and logistic issues related to the coronavirus pandemic.

Work on the Pallas [37] research reactor in the Netherlands continued. In 2020, major demolition work was completed on the Energy & Health Campus (EHC) in Petten, on the site where the new Pallas reactor is planned. In March, the Council of State upheld the zoning scheme for the reactor site. In December, the Dutch government announced an EUR 18 million loan to Pallas to continue its activities in the coming months. The additional loan enables Pallas to continue finalising the basic design of the reactor, apply for various permits and prepare for construction. Also in December, the European Commission adopted the Point of View on the construction of this nuclear facility, under Article 43 of the Euratom Treaty.

The Myrrha [38] - Multi-purpose hYbrid Research Reactor for High-tech Applications (the world's first prototype of a subcritical lead-bismuth cooled reactor driven by a particle accelerator) - reached important development milestones in 2020. For the first time at the Belgian Nuclear Research Centre (SCK-CEN), researchers succeeded in accelerating a proton beam through the connected radio frequency quadrupole (RFQ). The RFQ is a component of the particle accelerator that will drive the Myrrha sub-critical research reactor. Moreover, in 2020 for the first time, the RFQ produced a proton beam at the exact requirements to drive the particle accelerator. It is a milestone the SCK-CEN has been working towards for 6 years - a breakthrough that is the result of international collaboration. In addition, a cryomodule prototype - an important element needed for the Myrrha project - was developed.

The SCK-CEN and the Institut National des Radioéléments (IRE) [39] signed a public-public partnership in 2020 to produce Lutetium-177 (Lu-177), which is used to treat prostate cancer.

In April, IRE started production of the medical radioisotope Mo-99 using a low-enriched uranium (LEU) target instead of a high-enriched uranium one. The LEU target was irradiated in the Belgian Research Reactor 2, operated by SCK-CEN in Mol. The conversion from the HEU target to the LEU target is expected to be fully completed by 2022. The production of Iodine-131 (I-131), an isotope that is used to treat thyroid cancer, will also eventually be based on LEU. This demonstrated IRE's capacity to carry out advanced R&D activities while maintaining its highest production output during temporary or unplanned outages of some alternative suppliers of medical radioisotopes.

In September, IRE and Ion Beam Applications S.A. (IBA) announced a contract for the installation of a cyclotron with an energy of 30 MeV on an IRE site. Commissioning is scheduled for 2023. These two Belgian entities joined forces to install the new cyclotron, which will enable IRE to produce Germanium-68 (Ge-68), the raw material for the Germanium-68/ Gallium-68 generators. These generators are manufactured on the Fleurus site by its pharmaceutical subsidiary IRE ELiT to serve hospitals around the world. Gallium-68 (Ga-68), the end product extracted from these generators, is in growing demand, as it can provide an accurate

34 https://cordis.europa.eu/project/rcn/210823_en.html.
35 https://cordis.europa.eu/project/id/945009/fr
36 http://www-rjh.cea.fr/index.html
37 https://www.pallasreactor.com/en/
38 https://myrrha.be
39 https://www.ire.eu

and earlier diagnosis of many cancers through the use of PET (positron emission tomography) camera technology.

ITM Isotopen Technologien Munchen AG (ITM) [40], a biotechnology and radiopharmaceutical group of companies, announced in 2020 an expansion of a long-term agreement for the supply of highly pure no-carrier-added (n.c.a.) Lu-177, which was originally concluded in 2018 between ITM AG and Endocyte, Inc., a Novartis company. Under the agreement, ITM will supply Endocyte with n.c.a Lu-177 for its investigational Lu-177-PSMA-617 radioligand therapy for patients with metastatic castration-resistant prostate cancer.

In 2020, ITM Medical Isotopes GmbH, a subsidiary of the ITM, Bruce Power, an electricity company, and IsoGen, a joint venture between the two nuclear energy companies Framatome and Kinectrics, announced that Bruce Power and IsoGen had set the first milestone for a consistent irradiation service which will be provided to ITM exclusively for 15 years. Lu-177 will be obtained by irradiating Ytterbium-176 at the Bruce Power reactors. The construction of the radioisotope production system at Bruce Power by IsoGen is scheduled to start in early 2021 and production of Lu-177 is expected to start in 2022. N.c.a. Lu-177 is used as a therapeutic radiopharmaceutical precursor for targeted radionuclide therapy of cancers such as neuroendocrine tumors, prostate cancer, non-Hodgkin's lymphoma, bone metastases and several further indications.

In October, the IAEA agreed to work with the University of Coimbra's Institute for Nuclear Sciences Applied to Health in Portugal (POR-ICNAS) on radioisotopes and radiopharmaceuticals production. POR-ICNAS will be the first IAEA Collaborating Centre working on cyclotron radiopharmaceutical production and the first one dedicated entirely to radio pharmacy [41]. Valid until 2024, the agreement focuses on a number of areas, including: new production routes of nuclides, new and improved radiopharmaceuticals, new scanner technology and pre-clinical development and translation of new tracers into clinical trials.

In January 2020, US-based SHINE Medical Technologies [42] announced that, together with the Institute of Organic Chemistry and Biochemistry (IOCB Prague) and GE Healthcare, it had produced patient dose quantities of the therapeutic radioisotope n.c.a Lu-177 - a major step toward commercial production using the IOCB technology for Lu-177. In early 2021, SHINE announced they had selected a site in Groningen (The Netherlands) as their preferred location for the European production facility. There they plan to use a low-energy, accelerator-based neutron source to fission an LEU target dissolved in an aqueous solution to produce Mo-99. According to SHINE, their system can produce medical radioisotopes also via activation. This includes Lu-177. SHINE expects to start construction of their facility in Europe in 2023, with commercial production starting in 2025.

40 https://itm-radiopharma.com
41 https://www.iaea.org/newscenter/news/new-iaea-collaborating-centre-in-radioisotope-and-radiopharmaceutical-production
42 https://shinemed.com/

4. World market for nuclear fuels in 2020

At the end of 2020, 444 nuclear power reactors are reported [43] in operation by the IAEA, with 394.1 GWe total net installed capacity, and another 50 reactors in construction representing an additional 53.3 GWe. As in the previous year, both expansion and short to long-term growth prospects remain centred in Asia, home to 31 of the 50 reactors under construction.

According to the IAEA data on power reactors worldwide [44], 2020 saw 5 new connections to the grid reported (1 for Belarus, 2 for China, 1 for Russia and 1 for the United Arab Emirates), 6 permanent shutdowns (2 for France, 2 for the United States, 1 for Russia, and 1 for Sweden) and 4 construction starts (1 for Turkey, and 3 for China).

In the time of search for zero and low-emission technologies that contribute to climate neutrality while supporting common energy policy objectives, the nuclear has both its supporters and opponents.

The ongoing COVID-19 pandemic is a reminder of the importance of resilience in the energy system. A commentary in June from the IEA's chief economist underlined concerns about the possible impact of the COVID-19 crisis in 'nuclear power's important role in clean energy transitions' [45].

In its annual projections [46], the IAEA sees nuclear power continuing to play a key role in the world's low-carbon energy mix worldwide, with global nuclear electrical capacity to nearly double by 2050 in a high case scenario, making climate change mitigation a key potential driver for maintaining and expanding the use of nuclear power.

The IAEA's Director General [47] spoke of 'a common cause, which is the decarbonization of our economies,' [48] and underscored the belief that nuclear power remains 'part of the solution to the climate crisis' [49]. Such views were also echoed by the IEA's Executive Director who noted that, alongside renewables, savings and innovation, 'nuclear can make a significant contribution to achieving sustainable energy goals and enhancing energy security' [50].

Metallic uranium

© *iStock.com RHJ*

In the European Union, the approach seems to be clear: each Member State is free to develop nuclear power or refrain from it in mutual respect and observance of the goals of the Communities. Therefore many EU countries continue to see potential for nuclear energy as part of their energy portfolio, and recent reports point to how the utilisation of local or regional uranium resources can provide a platform for sustainable development [51]. In particular, interest is growing in small modular nuclear reactors (SMRs), which reduce the financial risk thanks to the incremental investment aspect of such technologies [52].

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43 IAEA PRIS data.
44 New connections to the grid: BARAKAH-1 (1345 MW(e), PWR, UAE) on 19 August, BELARUSIAN-1 (1110 MW(e), PWR, BELARUS) on 3 November, FUQING-5 (1000 MW(e), PWR, CHINA) on 27 November, LENINGRAD 2-2 (1066 MW(e), PWR, RUSSIA) on 22 October, TIANWAN-5 (1000 MW(e), PWR, CHINA) on 8 August. Permanent shutdowns: DUANE ARNOLD-1 (601 MW(e), BWR, USA) on 12 October, FESSENHEIM-1 (880 MW(e), PWR, FRANCE) on 22 February, FESSENHEIM-2 (880 MW(e), PWR, FRANCE) on 30 June, INDIAN POINT-2 (998 MW(e), PWR, USA) on 30 April, LENINGRAD-2 (925 MW(e), LWGR, RUSSIA) on 10 November, RINGHALS-1 (881 MW(e), BWR, SWEDEN) on 31 December (IAEA PRIS).
45 IEA Varro.
46 IAEA DG Grossi's statement to the 2020 IAEA General Conference.
47 IAEA DG Grossi's Statement to the IAEA General Conference.
48 16.3.2021, IAEA Director General Highlights Global Impact of Cooperation with European Union, Calls for Closer Partnership.
49 IAEA DG Grossi's statement to the 2020 IAEA General Conference.
50 Birol, IEA.
51 UNECE report.
52 Mignacca & Locatelli : Economics and Finance of Small Modular Reactors : A systematic review and research agenda. in Ren. and Sust. Energy Reviews 118 (2020) 109519.

> Expansion and short to long-term growth prospects remain centred in Asia, home to 31 of the 50 reactors under construction.

Now, looking at the world situation on nuclear energy country-by-country, Asia remains a key region in the world where electricity generating capacity and specifically nuclear power are growing significantly, with the greatest growth in nuclear generation expected by the WNA in China [53].

Australia

Australia is known for its uranium resources, the world's largest. The country exports all its production and ranks third among the world's producers of uranium concentrates, behind Kazakhstan and Canada.

While Australia remains a key primary producer of uranium, national authorities report [54] the Ranger uranium mine as due for closure in 2021.

Though Australia uses no nuclear power, it operates research reactors and has been active in developing and producing radioisotopes.

The country is also active in other technologies of nuclear interest. Australian Silex Systems Limited, for example, owns technologies to develop innovative uranium enrichment processes. There has also been talk in recent years, of an international high-level nuclear repository.

Canada

Canada remains a world leader in nuclear research and technology [55] and one of the largest sources of primary uranium supplies [56].

The country continued its lead in SMR development, with NuScale submitting its 60MW SMR design for regulatory review. GE Hitachi did the same, applying for a pre-licensing review for its BWRX-300 and micro modular reactor and creating a joint venture at Chalk River. Global First Power, Ultra Safe Nuclear Corporation and Ontario Power Generation joined forces towards a 5MWe (15MWt) SMR for industrial heat and electricity.

In response to the coronavirus pandemic, production in Saskatchewan at Orano Canada's McClean Lake mill and Cameco's Cigar Lake mine was suspended both in March and December. Bruce Power, which is operating eight CANDU reactors in Ontario, reduced staff by two thirds as a preventive measure but ensured supply of Cobalt-60.

Meanwhile, Canada and the United States reached an agreement on cooperating to improve security of supply chains and industrial competitiveness in critical minerals, which include uranium.

The year saw news about various forward-looking projects, awaiting developments in uranium prices. Orano's proposed Midwest mine received environmental approval. Various projects in the Athabasca Basin have potential for development, including NexGen Energy's Arrow Deposit (world's second largest high-grade uranium deposit at 130 900 tU) [57]. During the year, Denison announced an assessment of Waterbury Lake for in-situ recovery (ISR) mining to produce 3 730 tU over 6 years [58].

China

China remains one of the most important growing markets for nuclear power in the world. The country intends to reach peak emissions before 2030 and become carbon neutral before 2060. A recent draft of the Five-Year Plan (2021-2025) shows plans to reach 70 GWe gross of nuclear capacity by the end of 2025.

The Chinese Government reassured the industry that the COVID-19 pandemic had not affected its ongoing nuclear power plant constructions (15 reactors). Ongoing builds that saw progress include CNNC's HTR-PM project, and the Changjiang SMR project - ACP-100 (Linglong One), scheduled to begin operating in 2025. Meanwhile, State Power Investment Corporation of China officially launched the CAP1400 reactor design, a 1 400 MWe enlarged version of Westinghouse's AP1000 PWR. At the same time, China also announced stricter 'dual-use' export controls on its Generation III & IV nuclear reactor technologies.

Endowed with varied geology, the country has uranium inventories that remain undisclosed - though domestic

53 WNA, Asia's nuclear energy growth.
54 DFAT website, retrieved Apr 2021.
55 WNA review, retrieved April 2021.
56 WNA Canada uranium review, retrieved April 2021.
57 OECD/NEA Red book 2020, p. 169.
58 WNA review, retrieved April 2021.

prospection continues. It has immense reserves of rare earth elements and very likely additional uranium resources – though possibly in remote locations. Meanwhile, Chinese companies have been active abroad, notably in Namibia, Niger, Kazakhstan and Australia. Uranium imports are reported from Australia, Russia, African and central Asian countries, and other sources [59].

China admittedly is aiming for a closed nuclear cycle, with solutions for the recycling of spent fuel. This means that cooperation with European nuclear industries is a strong prospect. In December 2020, a report from a French government agency quoted ongoing negotiations for a 800 t/year reprocessing plant [60].

India

India is home to one of the world's largest thorium reserves, often in the form of monazite sands together with other heavy minerals [61]. It is a pioneer in the thorium fuel cycle and has several advanced facilities in that field [62]. Cooperation is also high on the agenda, with various international nuclear cooperation agreements signed in 2020, including with Russia [63].

Comparatively, India's uranium resources are reportedly modest (and in a high-cost category). The country therefore is expected to import an increasing proportion of its uranium fuel needs [64] for the indigenous PHWR reactors being built. Despite the schedule having slipped by several years, Kakrapar 3 became the first of four projected plants to achieve criticality in July 2020.

India had expected to have 20 GWe of nuclear capacity online by 2020 and about 22.5 GWe by 2031 and aims to supply 25% of electricity from nuclear power by 2050 [65] [66].

Japan

With a complete, closed fuel cycle, Japan is a major industrial and commercial player worldwide. It also leads in various fields of nuclear R&D, such as with fast reactors. However, following the Fukushima accident, activity has been slowed down, as the country's regulatory structure was completely overhauled. The year saw safety checks in Rokkasho's reprocessing plant approved, and the Mutsu storage project, scheduled to be operational in 2021/2022, was also approved [67].

Onagawa 2 in Japan expects to receive approval to restart operations, given that Japan's Nuclear Regulation Authority approved a report finding the unit in compliance with the safety standards needed to begin operating again, provided the necessary repairs are performed. The reactor has been offline since the March 2011 tsunami and earthquake. However, before it can restart in 2021, a 29-meter high seawall running 800 meters in length must be completed.

Japan Atomic Energy Agency (JAEA) received permission to restart the graphite-moderated helium gas-cooled (HTTR) reactor in Oarai, a small prototype 30 MWt reactor now planned to be used to produce hydrogen.

Kazakhstan

The world's leading uranium producer since 2009, accounting for over 40% of global production in 2019, Kazatomprom announced production of only 19,477 tU in 2020, down from previous totals due to the impact of COVID-19 [68].

The United States and Kazakhstan completed a joint effort to down blend Kazakh HEU fuel from the IGR research reactor by removal and down blending of the last 2.9 kilograms of unirradiated HEU fuel.

Kazatomprom reported in March that it had completed the sale of its interest in the Uranium Enrichment Center JSC (UEC) to its partner in the joint venture, TVEL.

The year also saw completion of the Ulba-FA fuel fabrication plant, a joint project of Kazatomprom and China's CGN started in 2016 [69].

Russia

With potential for a significant increase in uranium mine production, Russia has seen increasing international involvement in parts of its fuel cycle. The country admittedly aims to increase exports, not only of nuclear power plants but also front-end fuel cycle services thanks to the export agent

59 IAEA Uranium geology report 2020.
60 Trésor bulletin 12/2020
61 https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1877web.pdf
62 WNA review, retrieved April 2021.
63 https://www.world-nuclear-news.org/Articles/Russia-and-India-strengthen-cooperation
64 WNA review, retrieved April 2021.
65 WNA review, retrieved April 2021.
66 https://www.world-nuclear-news.org/Articles/Russia-and-India-strengthen-cooperation
67 https://www.world-nuclear.org/focus/fukushima-daiichi-accident/japan-nuclear-fuel-cycle.aspx
68 https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/kazakhstan.aspx
69 https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/kazakhstan.aspx

Tenex and the fuel fabricator TVEL, including new Accident Tolerant (ATF) fuels [70 71 72 73].

Rosenergoatom reported in January that the nuclear power share in the Russian energy sector exceeded 20% [74] in 2020 after 19% in 2019.

The Russian floating NPP entered commercial operation in May. Consisting of 2 KLT-40S reactors with an electricity capacity of 35 MWe each, the plant aboard the Akademik Lomonosov is the northernmost one in the world.

Rosatom announced conversion of its fast Beloyarsk-4 NPP to MOX by 2022, while Rosenergoatom announced plans for new reactors in the Leningrad and Smolensk regions, with the new VVER-1200 and/or VVER-TOI units replacing obsolescent RBMK-1000s.

While TVEL/NCCP presently ensure Rosatom's position in the global market for fuel rod/assemblies primarily thanks to the captive VVER market [75 76], future developments may depend on how related security of supply questions are addressed. The potential to export Western designs has also not gone unnoticed, and the 2020 US NFWG report called for the NRC authority to deny imports of fuel assembled in Russia or China [77 78].

Turkey

Turkey currently operates no nuclear power plant. However, the Akkuyu NPP project to build four VVER-1200 reactors has generated considerable interest, being a first for the build-own-operate model. Turkey aims to bring unit 1 online in 2023. The regulatory authority issued a construction license in 2020 to the prime contractor JSC Akkuyu (99.2% held by Rosatom) [79 80].

Turkish companies also have cooperation agreements with Rolls-Royce (possible joint production of SMRr) and GE Steam Power (turbine islands), pointing to an international future for nuclear power in the country [81].

Ukraine

Following safety upgrades funded by the EBRD and EURATOM, lifetime extension for some of Ukraine's fifteen reactors has been under consideration. Three units (two VVER-440s and one VVER-1000) at Rovno saw their lifetime extended by 20 years, two units at South Ukraine for 10 years, and four units at Zaporozhye for 10 years [82].

Meanwhile, South Ukraine's nuclear power plant became the third Ukrainian VVER-1000 reactor fully loaded with TVZ-WR fuel supplied by Westinghouse, Energoatom reported. The companies inked agreements to supply two 440MWe Rovno NPP units and a letter of intent to explore local production of assembly components.

Ukraine has also announced plans to focus on SMRs, noting how they would better integrate with increasing renewable power projects, such as solar and wind.

United Arab Emirates

An emerging customer for nuclear power, UAE has made significant developments in recent years. UAE announced in 2020 the successful startup and grid connection of the 1 400MW Barakah-1 unit, a first of its kind in the region [83]. Before going into full operation, the plant will undergo several months of testing. Following the assessment by the World Association of Nuclear Operators, this APR-1400 unit was licensed to operate for 60 years.

The CEO of Emirates Nuclear Energy Corp. stressed the company's goal of supplying up to one quarter of UAE's electricity needs with 'safe, reliable, and emissions-free electricity'. Three other identical units are being constructed.

USA

The year was marked by the publication of the US Nuclear Fuel Working Group's strategy paper 'Restoring America's Competitive Nuclear Advantage', recommending 'immediate and bold action' to strengthen the domestic uranium mining and conversion industries and 'restore the viability' of the entire front-end of the nuclear fuel cycle. Domestic uranium production has been steeply decreasing, having hit in 2019

70 https://www.energy.gov/sites/default/files/2021/01/f82/DOE-NE%20Strategic%20Vision%20-Web%20-%2001.08.2021.pdf
71 https://rosatom.ru/en/press-centre/news/rosatom-completes-new-stages-in-atf-development-program/
72 https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-fuel-cycle.aspx
73 https://www.defense.gouv.fr/content/download/602824/10148102/file/202009-strat%C3%A9gies_nucl%C3%A9aires_civiles_Energie-Rapport-5.pdf
74 https://www.nucnet.org/news/2020-nuclear-share-increases-to-more-than-20-says-rosenergoatom-1-1-2021
75 https://www.diw.de/documents/publikationen/73/diw_01.c.793995.de/dp1883.pdf
76 https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/fuel-fabrication.aspx
77 https://www.defense.gouv.fr/content/download/602824/10148102/file/202009-strat%C3%A9gies_nucl%C3%A9aires_civiles_Energie-Rapport-5.pdf
78 https://www.energy.gov/sites/prod/files/2020/04/f74/Restoring%20America%27s%20Competitive%20Nuclear%20Advantage-Blue%20version%5B1%5D.pdf
79 https://world-nuclear-news.org/Articles/Turkey-grants-construction-permit-for-Akkuyu-unithttps:/world-nuclear-news.org/Articles/Turkey-grants-construction-permit-for-Akkuyu-unit
80 http://www.akkunpp.com/index.php?lang=en
81 https://www.powermag.com/first-turbine-module-delivered-for-turkish-nuclear-plant/
82 https://eu.boell.org/sites/default/files/2020-09/wnisr2020_lr.pdf
83 https://www.cnbc.com/2020/08/03/uae-becomes-first-arab-country-to-launch-local-nuclear-energy-program.html

the lowest output since 1949, according to data by the US Energy Information Administration.

By November 2020, the US Senate Committee on Appropriations included a USD 150 million budget line to initiate a uranium reserve programme to stimulate domestic production [84] and to 'ensure there is a backup supply of uranium in the event of a significant market disruption'. Meanwhile, an amendment was concluded in October 2020, extending the Suspension Agreement with Russia through to 2040 [85].

Recent years have seen a growing interest in the potential of micro-reactors. The year saw the US Department of Defense award contracts for the Project Pele mobile prototype, while the Oklo company applied for a US NRC license for its 4 MWth HALEU-fuelled and heat-pipe-cooled fast reactor design (Aurora), a first for privately-funded projects of this kind [86]. GE Hitachi Nuclear Energy and TerraPower have plans for a versatile sodium fast test reactor, and a first topical report on GE Hitachi's BWRX-300 SMR was submitted to the NRC.

Plans for HALEU production continue, as Centrus Energy Corp.'s 16 C-100M centrifuges are being used to demonstrate production of HALEU through a three-year contract with the US Department of Energy. The demonstration programme is scheduled to last until 2022, when Centrus should have a licensed and operable HALEU production capability. See also section on enrichment below.

Also during 2020, the Indian Point 2 nuclear power plant was stopped definitively, after 45 years of operation. Low revenues were one of the various factors that influenced the decision to close both Indian Point reactors in 2021.

4.1. Primary uranium supply

Following a period of contraction that began in 2016 (a fall of 5% in 2017 and 10% in 2018), the expected stabilization of uranium concentrate production levels was significantly disrupted, among various reasons, by the pandemic crisis in 2020. Various key players in the global primary production market reported lower-than-expected results in their yearly financial reports [87].

Nonetheless, industry observers caution that forecasts of future demand for uranium remain very uncertain and that secondary and other sources of uranium need to be considered as alternative feedstock for nuclear fuel. In the medium and long term, demand for natural uranium could very well increase due to the projected commissioning of new power plants in China, for example.

The year saw the OECD-NEA/IAEA publish a new edition of its 'Redbook', covering all aspects of global uranium supply and demand. The Paris-based agency noted a modest rise in global uranium resource estimates, mainly from newly identified resources at known deposits and re-evaluation of previously identified resources, but also from new discoveries (e.g. in Canada).

Regarding identified resources in the upper cost category, Australia is reported to continue in the lead with 28% of the total, in large part due to the Olympic Dam site, with Kazakhstan having the lead for lower cost categories with as much as 49% of the world total. Ongoing assessments of resources brought about noteworthy changes in resource assessments for major producing countries such as Australia, Canada and Namibia, but also increases for Mongolia, Kazakhstan and Niger in the upper inferred resources category [88].

At almost 39 million tU, unconventional resources are seen as another source of potential future supply [89]. As noted by the NEA, in some cases, including those of major producing countries with large identified resource inventories, estimates of undiscovered

> Forecasts of future demand for uranium remain very uncertain and secondary, and other sources of uranium need to be considered as alternative feedstock for nuclear fuel.

84 WNN news.
85 WNN news.
86 UNECE report.
87 E.g. Orano group report.
88 OECD/NEA Redbook 2020.
89 Unconventional sources should not be confused with secondary sources mentioned later in this report.

resources and unconventional resources are either not reported or have not been updated for several years [90].

Some recent reports [91] optimistically note changes in the attitude towards uranium mining, for example in Australia. However, the Paris-based body emphasised the downward trend observed in recent years in worldwide domestic exploration and mine development expenditures, which decreased to approximately USD 0.5 billion in 2018 from USD 2 billion in 2014 [92].

The COVID-19 pandemic has significantly influenced the uranium market, as several companies announced in the second quarter the measures leading to a significant decrease of uranium production and related services

The pandemic has also resulted in suppliers seeing their inventories rapidly go down. In the meantime, utilities may be trying to revise their supply contracts or to build up the stock to ensure the security of their supplies and protect themselves from future price increases.

Illustrating the events, Cameco temporarily suspended production at its Cigar Lake facility in Canada, and then again later in the year. Cameco stated expecting to buy more U_3O_8 than it delivers in 2020 due to such mine shutdowns. Likewise, Kazatomprom foresaw output falling by 15.5% in 2020, though not impacting sales obligations [93] amid healthy inventories. Kazatomprom also reported its intention to produce 20% less uranium in 2021 and 2022 (between 22 000 mtU and 22 500 mtU), as a consequence of an oversupplied market [94].

Meanwhile, Ranger mine in Australia is expected to cease production in 2021. In Niger, while Cominak production at the Akouta mine is due to close, Orano reported France's intentions to continue uranium production in the north of the country. Orano's subsidiary SOMAIR expects to operate for as long as possible, with visibility of 10 years, or at least until the Imouraren project starts production.

Table 8. Natural uranium production in 2020 (compared to 2019, in tonnes of uranium equivalent).

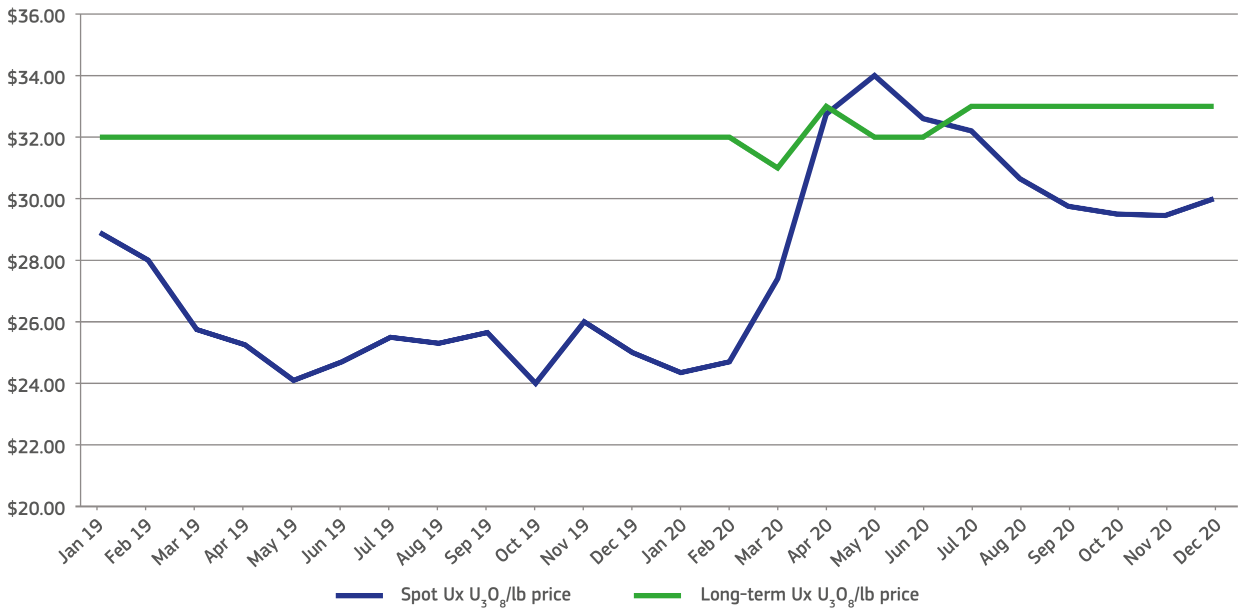
Region/country	Production 2020 (estimate)	Share in 2020 (%)	Production 2019 (final)	Share in 2019 (%)	Change 2020/2019 (%)
Kazakhstan	19 521	40.6	22 808	41.7	-14.4
Australia	6 154	12.8	6 613	12.1	-6.9
Namibia	5 433	11.3	5 476	10.0	-0.8
Canada	3 895	8.1	6 938	12.7	-43.9
Niger	3 654	7.6	2 983	5.4	22.5
Uzbekistan	3 414	7.1	3 500	6.4	-2.5
Russia	2 837	5.9	2 911	5.3	-2.5
China	1 587	3.3	1 885	3.4	-15.8
Ukraine	769	1.6	801	1.5	-4.0
Others	673	1.4	424	0.8	58.8
United States	81	0.2	67	0.1	20.6
South Africa	77	0.2	346	0.6	-77.8
Total	**48 094**	**100**	**54 752**	**100**	**-12.2**

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

Early estimates suggest leading uranium producers have failed to meet their 2020 production targets. This confirms the latest reports from the IAEA and NEA that point to a crisis in uranium production, with mines mothballed, production reduced and exploration rolled back, all compounded by the COVID-19 pandemic,.

90 OECD/NEA Redbook 2020
91 Baker McKenzie Global mining guide 2020, p. 11.
92 OECD/NEA Redbook 2020.
93 S&P report
94 OECD/NEA Redbook 2020.

Figure 11. Monthly spot and term U_3O_8/lb prices (in USD)



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Industry observers note [95] that despite being USD 21 short of the USD 50 threshold often cited as the level that will incentivise projects, the U_3O_8 spot price has added 21 percent to its value year-to-date, and 37 percent from its January low to its May high. The start of the year saw depressed prices sitting at the USD 24 mark. But transport-related supply constraints began to emerge in March, pushing prices to USD 27.

COVID-19 lockdowns forced leading producers to curtail output, affecting global supply. Partly as a result, the U_3O_8 spot price was pushed above USD 30 for the first time since 2016. Cameco's temporary shuttering of the Cigar Lake mine in Saskatchewan was just one of the catalysts that helped send U_3O_8 values to a four-year high. Moves from Kazakhstan's Kazatomprom were also a catalyst. Kazatomprom is the largest uranium producer globally, and it has reduced its 2020 guidance and halted development into 2021.

According to market observers, other uranium projects in Namibia and South Africa experienced COVID-19 pandemic-related production declines, albeit to a lesser extent. Looking to 2021, the market is reportedly also preparing for an imminent loss of production of two longstanding mines in Australia (Ranger) and Niger (Arlit).

To summarise, sufficient uranium resources are believed to exist to support the long-term use of nuclear energy for low-carbon electricity generation as well as for other uses such as industrial heat applications and hydrogen production. However, the impact of the ongoing COVID-19 pandemic on the industry and recent reductions in uranium production and exploration could affect available supplies. Timely investment in innovative mining and processing techniques would help assure that uranium resources are brought to market when they are needed [96].

Sufficient uranium resources are believed to exist to support the long-term, sustainable use of nuclear energy for low-carbon electricity generation as well as for other uses such as industrial heat applications and hydrogen production.

95 Williams (2020).
96 IAEA press release

4.2. Secondary sources

In 2020, world primary uranium production continued to provide the bulk of world reactor requirements, complemented by secondary supply sources [97], which included government-held or commercial inventories of natural uranium, enriched uranium, fabricated fresh fuel assemblies, down-blended uranium, reprocessed uranium and plutonium recovered from spent fuel, depleted uranium, and uranium saved through underfeeding [98].

With potential for a significant impact on the market, plans to re-enrich part of the US Department of Energy's depleted uranium stocks have been confirmed, further to an agreement between Silex, Cameco and GE-Hitachi [99]. The proposed Paducah Laser Enrichment Facility (PLEF) is to re-enrich depleted UF_6, with commercial operations to begin in the medium to long term [100].

Several countries, including the US and Russia, also hold HEU stockpiles, part of which is available for down-blending. Such inventories are relevant for HALEU (19.75% assay) products, particularly for research reactors and ongoing development projects [101]. In 2020, reports emerged of the US and Kazakhstan having completed a joint effort to down-blend Kazakh HEU fuel from the IGR research reactor by removal and down-blending of the last 2.9 kilograms of unirradiated HEU fuel.

The post-Fukushima period has seen excess SWU capacity being used to underfeed enrichment plants and/or re-enrich depleted tails to natural uranium, leading to higher uranium inventories also at the enrichers' stores.

> The post-Fukushima period has seen excess SWU capacity being used to underfeed enrichment plants and/or re-enrich depleted tails to natural uranium.

> In 2021 and beyond, the inventory of secondary sources of supply could be expected to continue offsetting primary uranium production and depressing the price of concentrates, unless a significant change occurs in demand.

Russian underfeeding has been estimated at more than 4 500 tU/year. Since the end of the US-Russia agreement on HEU down- blending, the importance of secondary supplies has dwindled but still remains significant and is estimated at about 18-25% of the total. Currently, the global enrichment capacity used for underfeeding and tails re-enrichment is estimated in the region of 5 000-7 000 tonnes of natural uranium equivalent, depending on the scenario, declining steeply by the end of the 2020s [102].

Recycling spent fuel to produce uranium oxides or mixed uranium-plutonium oxides may also be considered a secondary source of supply. The WNA estimates the inventory of separated, recyclable materials worldwide to be in the range of 110-195 thousand tU, depending on whether uranium and plutonium from non-civilian stocks is also included.

Besides reprocessed materials, including 32 tonnes of reactor-grade reprocessed plutonium, Russia reportedly has as much as 34 tonnes of plutonium available for MOX fuel fabrication for fast neutron reactors [103]. Another significant part of the inventory is in the form of depleted uranium. Tails for re-enrichment have low assays, but given Russia's reportedly large excess enrichment capacity, the volume of re-enriched tails could remain high over 2021-2028.

97 See also WNA report
98 NEA, p. 98
99 Silex press release
100 WNN news
101 INL report
102 WNA report, p. 31
103 WNA Russia review, retrieved April 2021

IAEA experts generally consider that, on average, commercial inventories are driven by utilities (about 2 years of forward requirements), fuel producers (about 0.5 years of forward requirements), and around 10% of annual requirements for brokers, traders and other investors.

Due to the post-Fukushima slowdown, Japanese utility inventories of uranium concentrates remain significant and are reported to hold enough fuel to last through most of the next decade and some utilities even beyond 2030 [104]. However, the NEA suggests that worldwide commercial inventories have been generally decreasing [105].

In 2021 and beyond, the inventory of secondary sources of supply could be expected to continue offsetting primary uranium production and depressing the price of concentrates, unless a significant change occurs in demand. However, towards the end of the decade, the situation might change, particularly if sources of secondary supplies draw down. In anticipation, various observers and analysis have underlined the need to substantially invest over the coming decade in uranium mining, prospecting and development.

4.3. Uranium exploration

Global expenditure on uranium mineral exploration and development has decreased in recent years. The future development in uranium exploration will depend on multiple factors, such as energy demand in a mid-term perspective, the share of nuclear in the energy mix, actual uranium production or the results of efforts to develop safe mining practices and new exploration technologies with less environmental impact. Future development will also be affected by wider trends, as it is expected that new energy technologies and the expansion of renewable energies will prompt a new growth in expenditure on energy minerals exploration in the coming decade.

According to the NEA, reported non-domestic exploration expenditures steeply declined from USD 420 million in 2016 to USD 54 million in 2019. Available data also suggest a notable decline in total expenditures on domestic exploration compared to previous reporting periods. This is consistent with the trend of generally declining expenditures since 2012, with the exception of 2014 when increased expenditures were mainly due to China's development of the Husab mine in Namibia [106].

In the near future, the list of mining sites closing down or being placed in care and maintenance should continue to grow. The closing down of the Akouta (Niger) and Ranger (Australia) mining sites in 2021 added to the list of mines placed in care and maintenance in recent years, which includes Rabbit Lake and McArthur River (Canada), and Langer Heinrich (Namibia). Pre-feasibility studies on the reopening of such sites suggest it will be uneconomical to do so unless uranium prices rise significantly above 2019 levels.

In spite of depressed prices, some uranium exploration and development is ongoing, both in less explored regions such as Pakistan and Brazil and in mature sites such as Canada and the United States.

After announcing in late 2019 a joint venture for mining projects in Uzbekistan, Orano Mining has been awarded exploration permits for Greenland, effective in 2021 [107]. Other projects on the horizon, such as the Arrow deposit in Canada, could significantly alter the global uranium market cost structure in the medium term.

4.4. Conversion

It is expected that in the short-medium term, the global nuclear fuel market will continue to be served by the current five primary converters: Orano (France), CNNC (China), Rosatom (Russia), Cameco (Canada) and ConverDyn (USA). World requirements for conversion are estimated to have risen to approximately 65 000 tU by 2020 and are projected to reach 72 000 tU by 2025.

The world's primary nameplate conversion capacity is estimated at 62 000 tU. In the EU, new capacity is provided by Orano's Comurhex, operating between two sites in France. At the French Malvési site, a new unit for the production of 300 tU/y of high purity UO_2 from UNH is being constructed [108] and is due to start operating in 2022.

> World requirements for conversion are estimated to have risen to approximately 65 000 tU by 2020 and are projected to reach 72 000 tU by 2025.

104 IAEA Symposium, contrib. 82.
105 WNA Nuclear fuel report.
106 NEA Uranium 2020 report.
107 ORANO release.
108 Orano report , p. 13.

China's capacity is expected to grow considerably through to 2025 and beyond to keep pace with domestic requirements. Reportedly, a 9 000 tU/y plant is under construction at Lanzhou, and another 3 000 tU/y plant is under construction at Hengyang [109].

US Honeywell is reportedly planning to restart its Metropolis facility towards 2023 [110]. In March, NRC renewed the operating license for the plant for an additional 40 years – until 2060.

The COVID-19 pandemic influenced Cameco's conversion operations. The company was forced to temporarily suspend the UF_6 plant at the Port Hope Conversion Facility and the Blind River Refinery throughout the month of April. Anti-COVID-19 measures were put in place and some maintenance works planned for late-2020 were advanced. Both facilities were reopened in May.

TVEL plans to extend its DUF_6 capacity and build a new facility at the Urals Electro-chemical Plant. The facility would utilise DUF_6 technology provided by France's Orano to convert the DUF_6 into more stable uranium oxide through a defluorination process.

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.*

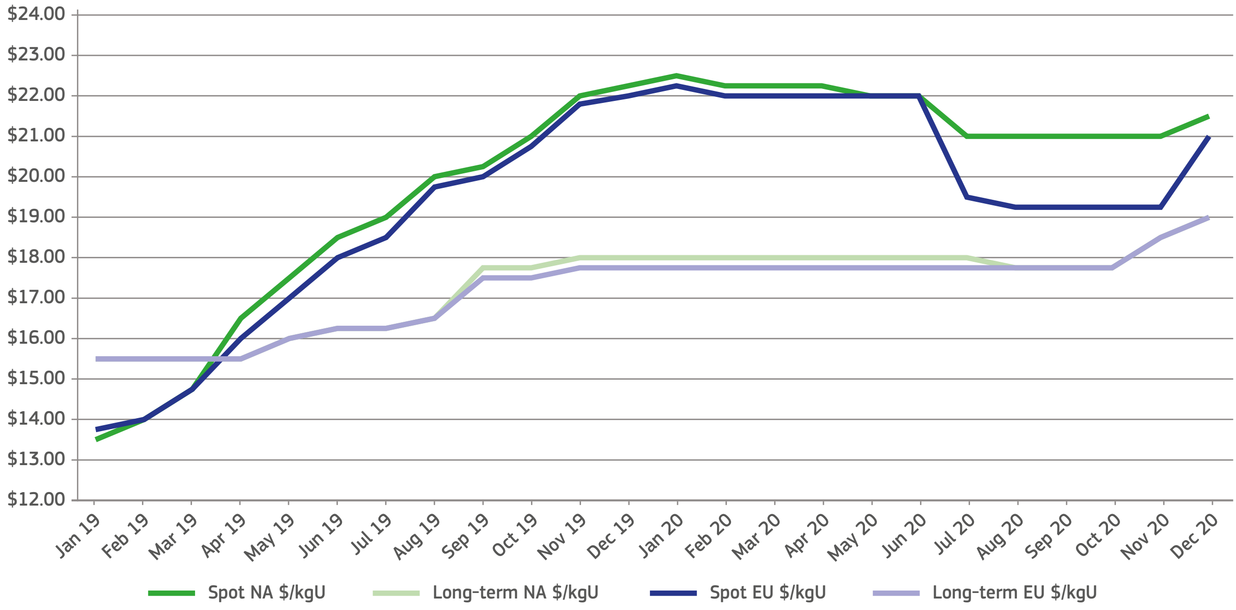
**** Activity suspended since end of 2017.*

Supply in the conversion market has continued to tighten since 2017, mainly due to the halt in production at the US conversion production facility (maintained since then in an idle state). In Europe, the shift from Comurhex I to the new Philippe Coste plant had been anticipated through the building and then consumption of a UF_6 stockpile. The announced reopening of the Metropolis plant could ease the situation after 2023.

Price recovery into 2020 was accentuated by some outsourcing of conversion services. The European and North American spot conversion prices started the year 2020 at USD 22.25 and USD 22.50 per kgU, respectively, which was 66% higher than January 2019. January was the month when the highest prices were observed, while both indicators slipped USD 0.25 at the end of February and experienced their minimum levels for the European indicator in August, as the price fell to USD 19.25 per kgU and for the North American indicator in July as the price declined to USD 21.00. Prices climbed to end the year at USD 21.00 and USD 21.50 per kgU respectively.

109 WNN review.
110 WNN news.

Figure 12. Uranium conversion price trends (in USD)



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4.5. Enrichment

In addition to the technological developments in Russia's centrifuges, the year saw the prospect of laser enrichment of US tails and the renewal of the Russia Suspension agreement all pointing to possible changes in the later part of this decade.

As another batch of generation 9+ gas centrifuges were installed at JSC Electrochemical Plant (ECP) in Zelenogorsk, Russia, Rosatom published a 2030 strategy document, announcing its commitment to further develop the gas centrifuge technology [111].

As mentioned in Section 4.2., the Paducah Laser Enrichment Facility (PLEF) is to begin re-enriching depleted UF_6 [112] towards the end of this decade [113].

Russian enriched uranium that could be sold to US utilities in 2019-2020 under the US-Russian Suspension Agreement had been limited by the US Department of Commerce to 6.1 million separative work units, with a 2019 quota raised to 3.12 million SWU and in 2020 to 3.02 million SWU [114]. The agreement, limiting the annual volume of Russian uranium imported fuel requirements, was renewed in late 2020 and extended through 2040. Prior to the amendment, the agreement allowed Russian uranium exports to meet about 20% of US enrichment demand, but now this figure will drop gradually over the next 20 years.

The US Nuclear Regulatory Commission accepted to review Centrus Energy Corp's application to produce HALEU. Once licensed, Centrus could enrich uranium up to 20%.

Meanwhile, the transportation of high-assay low-enriched uranium packages has received attention. In 2021 Daher Nuclear Technologies is planning to apply for a license for a new UF_6 transportation cylinder for HALEU. The company is developing a safety analysis report for the transportation cylinder, the DN-30X. The analysis will assess a cylinder for enrichment up to 10% U-235 and another one for enrichment up to 20% U-235.

The spot price started 2020 at USD 47.00 per SWU and held that level through the end of February, then slipped to USD 46.50 at the end of March and remained there through April. The price started to go back up in May and continued to increase, ending the year at USD 51.50 per SWU.

The term price indicator followed a similar pattern, starting the year at the level of USD 49.00 per SWU and holding at that level through the end of May. Then it started to gain, ending the year at a higher level of USD 55.50 per SWU.

111 NEI magazine.
112 Silex press release.
113 WNN news.
114 WNN news.

Figure 13. Monthly spot and long-term SWU prices (in USD)

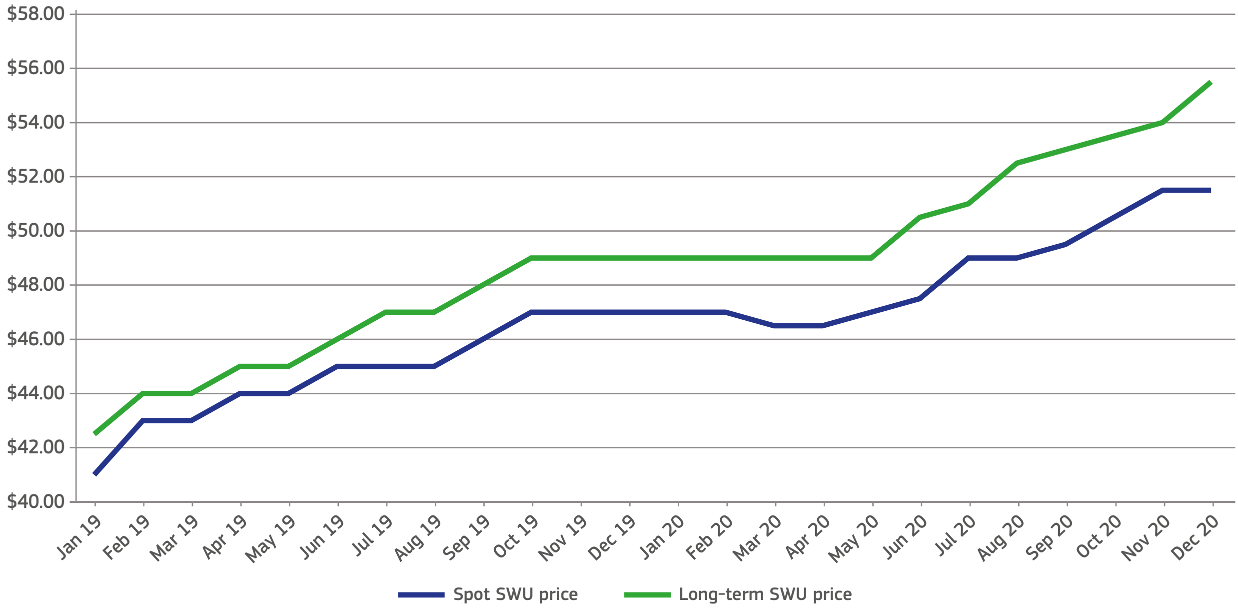

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Table 10 Operating commercial uranium enrichment facilities, with approximate 2020 capacity

Company	Nameplate capacity (tSW)	Share of global capacity (%)
Rosatom (Russia)	27 933	46
Urenco (UK/Germany/Netherlands/ United States)	18 414	30
Orano (France)	7 500	12
CNNC (China)	6 750	11
Others * (INB, JNFL)	55	0
Total nameplate capacity	**60 652**	**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

Around the world, several fuel manufacturers reported intensified efforts towards producing innovative fuels.

The Tennessee Valley Authority awarded Framatome several contracts for work on the company's reactor fleet. The contracts include fuel for the Browns Ferry nuclear plant, fuel handling equipment upgrades across the fleet and steam generator replacements at the Watts Bar plant. The contract to provide Framatome's Atrium 11 fuel for the three boiling water reactors at Browns Ferry will allow operators to run their plants with more flexibility and also help use the uranium in nuclear fuel more efficiently.

Around the world, several fuel manufacturers reported intensified efforts towards producing innovative fuels.

In September, Westinghouse Electric and ENUSA Industrias Avanzadas announced the insertion of EnCore Fuel at the Doel Unit 4 nuclear power plant in Belgium. This installation is the first insertion of accident-tolerant EnCore Fuel rod assemblies in Europe, and the second insertion into a commercial nuclear power plant worldwide.

In February, BWX Technologies Inc. (BWXT) reported that the US Department of Energy's National Nuclear Security Administration (NNSA) had awarded its subsidiary BWXT Nuclear Operations Inc. a USD 3.6 million contract to manufacture uranium-molybdenum alloy high-assay low-enriched uranium fuel. This will make it easier to convert high-performance US research reactors from the current use of high-enriched uranium.

X-Energy reported that it signed an agreement with the Massachusetts Institute of Technology (MIT) to irradiate its TRISO-X fuel in MIT's research reactor. The gathered data will be used for licensing X-energy's Xe-100 and other reactors.

In December, TVEL reported that it produced the first accident-tolerant fuel assemblies (ATF) for the VVER-1000 reactor. According to the company, the fuel and energy divisions of Rosatom are planning to load the ATFs into one of the Rostov NPP reactors. In January, TVEL also reported that acceptance tests were completed for experimental fuel assemblies manufactured at the Siberian Chemical Combine in Seversk, Russia. The assemblies were fabricated with mixed uranium nitride-plutonium fuel for use in a fast neutron reactor.

TVEL announced the start of tests of its 3rd generation fuel intended for VVER-440 reactors. The new fuel, which will be loaded in Dukovany, Czechia in reload batch quantity in 2023, allows the reactor to operate with increased thermal capacity and to extend the fuel cycle at the plant, leading to better economic efficiency.

Unit 2 of the South Ukraine nuclear power plant became the third Ukrainian VVER-1000 reactor fully loaded with fuel supplied by Westinghouse after the core was loaded with TVZ-WR assemblies, Energoatom reported in June.

Westinghouse and Energoatom signed a contract for the supply of fuel assemblies for the two 440MWe units of Rovno NPP. The parties also signed a letter of intent to explore the localisation of fuel assembly component production.

Rosatom reported that Siberian Chemical Combine, which belongs to TVEL, will develop a new uranium-plutonium REMIX (regenerated mixture) fuel fabrication facility for VVER-1000 reactors. REMIX fuel fabrication will be done in cooperation with the Mining and Chemical Combine in Zheleznogorsk. The project is to be completed by 2023. TVEL also started preparatory works to fabricate MOX fuel for its demonstration fast neutron reactor Brest-300.

France's Orano reported that it had signed a contract with Japan`s Nuclear Fuel Industries Ltd. for the fabrication of MOX fuel assemblies, to be used in Kansai Electric Power Co.'s Takahama-3 and -4.

4.7. Reprocessing and recycling

The remaining uranium still present in the spent fuel can be recovered through reprocessing, becoming reprocessed uranium. During the irradiation of uranium fuel, some plutonium is also generated, and this is recovered as well at the reprocessing stage. By using reprocessed uranium and recovered plutonium, the utilities can significantly reduce their need for fresh uranium. Governments can also use this material as a strategic stockpile.

The year also saw news emerge of EDF's plans to license new 1 300 MW reactors for MOX fuel use, with more details expected in 2021. Presently 22 EDF reactors use MOX fuel. Also, EDF is re-envisaging the use of reprocessed uranium fuel as of 2023 [115] [116].

The generation of spent fuel worldwide is estimated to be around 10 000 – 13 000 tHM/y. Global commercial reprocessing capacity is just over 2 000 tHM/y. Reprocessing is mainly carried out in La Hague, France, which has a capacity of 1 700 tHM/y, and in Chelyabinsk, Russia, which has a capacity of 400 tHM/y. There are plans to increase capacity in Russia to 600 tHM/y by 2022. The Japanese Rokkasho plant, whose operation has for now been postponed, would add 800 tHM/y to global commercial capacity [117] [118].

Mixed oxide (MOX) fuel is manufactured from plutonium recovered from used reactor fuel, mixed with depleted uranium. In Europe, MOX fuel is produced in the Melox plant in Marcoule, France. It has an authorised production capacity of 195 tHM/y. The EU Member States in possession of nuclear power plants in 2020 using MOX fuel were France, the Netherlands, Belgium and Germany. The UK was also using MOX fuel.

The UK stockpile of recovered plutonium is stored at the Sellafield site in the north of England. Studies have been ongoing at Orano's Melox facility in order to determine the usability of the material in MOX fuels. This will make it easier to choose an option for recycling the material at the Sellafield site as, to date, there is no clear option for final disposal in the UK. Outside the EU, MOX fuel is produced in Zheleznogorsk, Russia.

115 news-36486-avis-asn-matieres-radioactives.pdf (actu-environnement.com)
116 https://www2.assemblee-nationale.fr/content/download/336354/3292365/version/1/file/Note+Covid+CNE2+.pdf
117 https://www-pub.iaea.org/MTCD/Publications/PDF/P1905_web.pdf
118 https://unece.org/sites/default/files/2021-03/UNECE Use of nuclear fuel resources for sustainable development_ Final_0.pdf

5. ESA management, administration and finances

Legal status

The Supply Agency was established directly by the Euratom Treaty [119]. It is endowed with legal personality and financial autonomy [120] and operates under the supervision of the European Commission on a non-profit-making basis. The statutes [121] address in more detail the governance of the Agency.

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.

Financing

ESA derives revenue from a contribution from the EU general budget [122].

The European Commission adopts ESA's budget, transfers the contribution, and directly covers some of its administrative needs.

For its financial operations, the Euratom Supply Agency applies the relevant provisions of its statutes and of the EU Financial Regulation [123] as well as the accounting rules and methods established by the European Commission.

ESA is 100% financed by the EU general budget.

Financial accounts

In 2020, the assets owned by the Agency totalled EUR 963 505.

They were financed by EUR 71 933 (7%) in liabilities and EUR 891 572 (93%) in equity.

E-meeting during COVID-19

© Euratom Supply Agency

At EUR 191 937, the fixed assets have increased significantly (from EUR 18 879 in 2019) since the development of the IT project, NOEMI.

The Supply Agency has EUR 5 856 000 in capital. An instalment of 10% of the capital is paid at the time of a Member State's accession to the EU. On 31 December 2020, the amount of the instalments called up and reflected in ESA's accounts stood at EUR 585 600.

119 Article 52 of the Euratom Treaty.
120 Article 54 of the Euratom Treaty.
121 Council Decision (2008/114/EC, Euratom) of 12 February 2008 establishing Statutes for the Euratom Supply Agency.
122 ESA's present financial situation results from the 1960 Council decision to postpone indefinitely the introduction of a charge on transactions (contracts for the purchase of nuclear materials by EU utilities), which had been intended to cover ESA's operating costs.
123 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.

Budget

The Euratom Supply Agency's 2020 adopted budget [124] amounted to EUR 230 000 in 2020 (a 3% increase compared to 2019). Its revenue and expenditure were in balance.

On 31 December 2020, ESA's accounts showed a budget execution of EUR 228 949, or 99.54% of commitment appropriations. The budget and final annual accounts are published on ESA's website (http://ec.europa.eu/euratom).

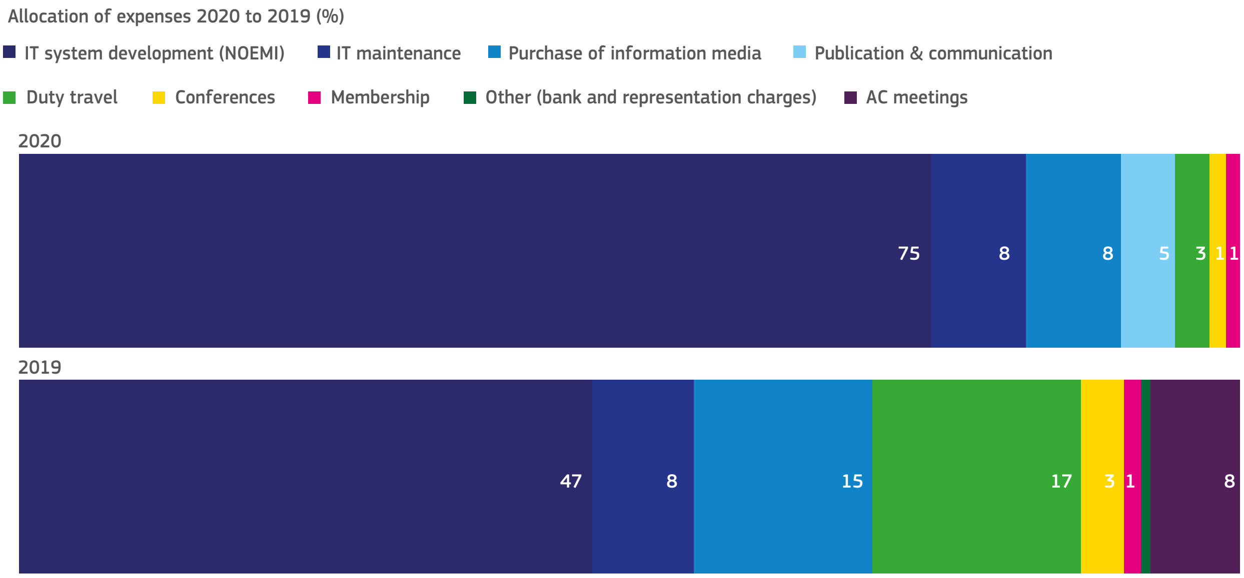
A part of ESA's administrative expenses, including salaries [125], premises, infrastructure, training, and some IT equipment, is covered directly by the European Commission budget, and is not acknowledged in ESA's accounts. According to an internal estimate, the salaries of the Agency's staff, covered by the Commission, were calculated at EUR 2 024 000. This off-budget expenditure and the underlying transactions are included in the Commission section of the EU annual accounts. ESA is also exempt from the charge-back of any services provided to it by the Commission [126].

The other part of ESA's operating costs is covered by its own budget; this includes duty travel, the IT system and its stand-alone computer centre, media subscriptions and communication activities.

Budget implementation

The in-kind contribution and charge-back exemption has had a positive impact on ESA's administrative capacity.

Figure 14. Budget execution by expenditure type



124 Commission Decision C(2020) 2.
125 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.
126 Commission Decision C(2018) 5120, Annex 21.

Table 11. Budget execution by expenditure type

Budget item	2020	%	2019	%
IT system development (NOEMI system)	170 759	75	104 337	47
Information media	17 386	8	18 279	8
IT maintenance	17 241	8	32 861	15
Publications & communication activities	10 701	5	0	0
Duty travel	6 500	3	37 600	17
Conferences (participation & organisation)	3 000	1	7 783	3
Membership in nuclear organisations	2 862	1	2 980	1
Bank and representation charges	500	0	1 397	1
Advisory Committee & working groups	0	0	17 452	8
TOTAL	228 949	100	222 689	100

Table 12. Overview of expenditure financed directly by the European Commission

STAFF	Salaries & allowances
	Socio-medical infrastructure
	Training
INFRASTRUCTURE & OPERATING EXPENDITURE	Rental of buildings and associated costs
	— Buildings, infrastructure and associated costs
	Information and communication technology
	— EC software applications
	Movable property and associated costs
	Current administrative expenditure
	— Stationery and office supplies
	Postage/Telecommunications
	— Computer hardware (servers, PCs and equipment)
	— Telecommunications
	Information and publishing
	— Publication - Official Journal

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 follows carefully the observations of a cross-cutting nature accompanying the annual report on the EU agencies [127].

In 2020, ECA signed off the 2019 accounts and issued a clean opinion [128], as they present fairly the financial situation, operations, and cash flows in line with the accounting rules. In addition, ECA provided a clean opinion on the legality and regularity of ESA's revenue and payment operations. Building on the audit outcome, ESA took further steps to more closely monitoring its budget execution in 2020.

127 https://www.eca.europa.eu/en/Pages/DocItem.aspx?did={A61C7E9C-312D-4D33-9686-3C8DB2231D7F}.
128 https://www.eca.europa.eu/en/Pages/DocItem.aspx?did={5204F722-91A9-44A7-96CA-3607AC53AE53}

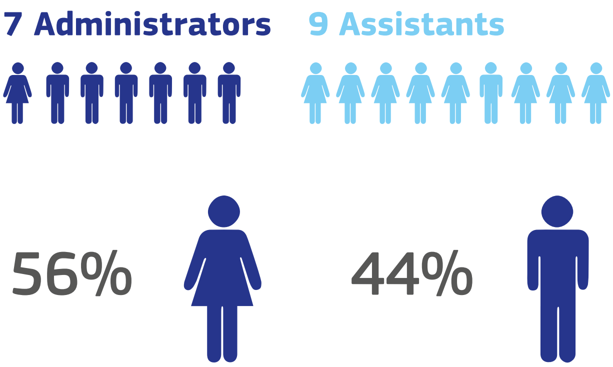
Discharge

The European Parliament, acting on a Council recommendation, is the discharge authority for ESA. On 13 May 2020, the European Parliament granted ESA's Director General discharge for the implementation of the budget for the 2018 financial year [129].

Staff allocation

ESA staff are European Commission officials and ESA's establishment plan is incorporated in the global staff numbers of the European Commission. For 2020, the number of authorised posts was 17 (7 administrators and 10 assistants). At year end, 16 permanent posts were occupied, one assistant post being vacant.

Figure 15. Staff distribution



Equal opportunities

ESA provides equal career opportunities for staff at all levels and promotes a gender-balanced workplace. Women make up 56% of ESA staff and men 44%. The equal opportunities policy is also reflected in management positions, which are also equally distributed.

Information system innovation in NOEMI

Initiated in 2019, the IT project NOEMI ('Nuclear Observatory and ESA Management of Information') consists of designing a new technological platform that will securely host sensitive nuclear contracts' data and will reinforce monitoring capabilities of the nuclear materials and fuel market.

The project will be implemented during 2020-2021, at an estimated cost of EUR 355 000.

A functional prototype, including the key features, was delivered in June 2020. In addition, the worldwide lockdown measures have accelerated the deployment of secure digital solutions resulting in an overall increase of the digital knowledge and maturity of stakeholders. In 2021 ESA is planning to carry out a feasibility and security requirements study on the possibility of a fully digital processing of nuclear supply contracts and notification of nuclear service contracts.

> NOEMI will reinforce ESA's monitoring capabilities of the nuclear materials and fuel market whilst securely hosting sensitive nuclear contracts' data.

Communication and visibility

In 2020, ESA engaged in a highly focused outreach to stakeholders in industry, research, and national administrations. This particular focus was deemed necessary in the light of the COVID-19 pandemic and ESA's assurance of business continuity. ESA was able to guide its stakeholders in the submission and remote completion of contracts, by using specific secure IT tools. Outreach continued with the successful organisation of the Advisory Committee's e-meeting in October.

In June 2020, ESA commemorated its 60th anniversary of operations with a press release that was published on all main platforms.

Work, already commenced in 2019 on ESA's visual identity, continued in 2020, with the launch of the newly approved ESA logo. A complete restructuring of the website was initiated. By mid-2021, it will have an updated look and feel and will operate from a more efficient platform.

129 European Parliament decision of 13/5/2020 (P9_TA-PROV(2020)0104: Decision 2019/2087(DEC), P9_TA-PROV(2020)0121: Decision 2019/2098(DEC)), internal reference Ares(2019)3499364 - 3/7/2020.

Internal control and risk management

In 2020, the Agency adopted its internal control framework, designed to provide reasonable assurance in achieving five objectives set in Article 36 of the Financial Regulation:

a) effectiveness, efficiency, and economy of operations,

b) reliability of reporting,

c) safeguarding of assets and information,

d) prevention, detection, correction and follow-up of fraud and irregularities, and

e) adequate management of the risks relating to the legality and regularity of the underlying transactions.

This framework supplements the EU's Financial Regulation and other applicable rules and regulations relevant in this context [130], the aim being to align Euratom Supply Agency standards with the highest international standards as set by the COSO [131] principle-based system. A set of indicators was defined, which will be used to assess the effectiveness of the framework's implementation.

In January 2020, ESA performed a full-scale risk assessment workshop covering all areas of the Agency's work and its operational and administrative processes. ESA reviewed the controls in place and identified areas that required monitoring.

Management assurance

In order to assess the effectiveness of internal controls, ESA uses the baseline requirements adapted to its environment. The annual assessment for 2020 did not reveal any risks that could lead to a reservation in the Annual Declaration of Assurance.

On the basis of 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 Annual Report.

The United Kingdom's withdrawal from the European Union and Euratom

As a Member State, the UK had subscribed a EUR 672 000 share in the capital of the Euratom Supply Agency. It paid 10% of its share, i.e., EUR 67 200, at the time of its accession to Euratom. Since then, this latter sum of money has been held with the Agency's bank account. In connection to the paid-off part of the UK's share, nothing is provided for in the Withdrawal Agreement (or in any other agreement or arrangement or legal act).

Until 31 December 2020 (i.e., the end of the transition period) the legal situation was not affected by the exit of the United Kingdom from the EU and Euratom. Therefore, there was no financial impact to be reported in the 2020 annual accounts.

The COVID-19 outbreak

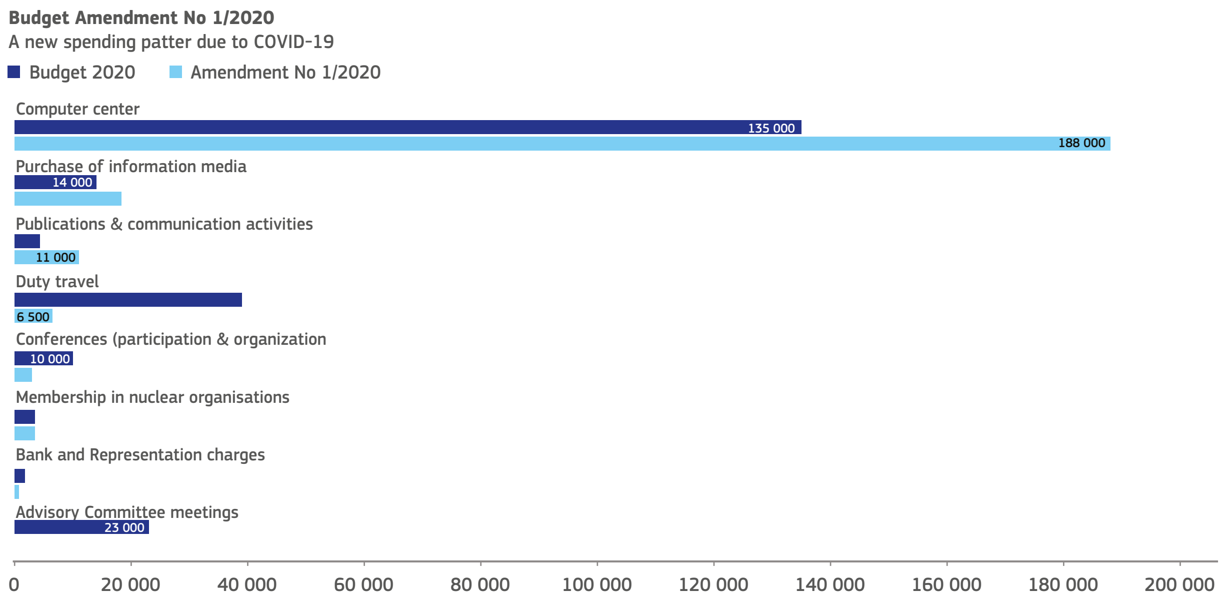
During 2020, the COVID-19 pandemic greatly affected the EU. The Agency has made every effort to reduce the effect on its staff and stakeholders. ESA stayed fully operational and demonstrated it can respond swiftly to challenges arising from the COVID-19 crisis.

In line with the Commission guidance and in order to minimise the risk to staff and to their families, ESA pursued teleworking as the default option. However, critical and essential staff who needed to access resources and work on the premises were able to do so on a rotational basis.

In parallel, ESA introduced changes in its spending pattern through a budget amendment to reduce expenses related to the organisation of meetings, participation in conferences and statutory missions. Instead, it invested in upgrading its core IT application.

130 such as the Staff Regulations, governance arrangements and decisions relating to anti-fraud measures.
131 Committee of Sponsoring Organizations of the Treadway Commission (COSO)

Figure 16. Budget amendment in 2020 due to COVID-19



For subsequent periods, where appropriate, ESA re-scoped its ongoing tasks and adjusted the approach and timeline to take account of changing circumstances in its new 2021 work programme.

ITER at night

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

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

Further information
Additional information can be found on the EUROPA website:
http://europa.eu

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

More information on the Commission’s Directorate-General for Energy can be found at:
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-28 gross and net requirements (quantities in tU and tSW)

(A) 2021-2030

Year	Natural uranium		Separative work	
	Gross requirements	Net requirements	Gross requirements	Net requirements
2021	13 611	12 360	11 301	10 263
2022	13 513	12 793	11 445	10 798
2023	13 164	11 730	11 224	10 195
2024	12 093	10 229	10 306	9 140
2025	14 580	12 999	12 615	11 236
2026	13 682	12 130	11 659	10 311
2027	12 073	10 318	10 240	8 734
2028	12 359	10 651	10 492	9 027
2029	12 245	10 117	10 268	8 451
2030	11 850	9 829	9 857	8 118
Total	**129 171**	**113 155**	**109 407**	**96 273**
Average	**12 917**	**11 316**	**10 941**	**9 627**

(B) Extended forecast 2031-2040

Year	Natural uranium		Separative work	
	Gross requirements	Net requirements	Gross requirements	Net requirements
2031	11 261	8 910	9 290	7 265
2032	11 841	9 528	9 777	7 781
2033	10 270	7 788	8 371	6 230
2034	10 668	7 879	8 741	6 328
2035	10 274	7 313	8 335	5 776
2036	10 216	7 429	8 328	5 917
2037	9 789	6 831	7 946	5 388
2038	10 483	7 695	8 613	6 201
2039	9 492	6 705	7 762	5 350
2040	10 310	7 523	8 418	6 007
Total	**104 604**	**77 602**	**85 580**	**62 244**
Average	**10 460**	**7 760**	**8 558**	**6 224**

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

Year	Fuel loaded			Deliveries		
	LEU (tU)	Feed equivalent (tU)	Enrichment equivalent (tSW)	Natural U (tU)	% spot	Enrichment (tSW)
2011 (**)	2 583	17 465	13 091	17 832	3.7	12 507
2012 (**)	2 271	15 767	11 803	18 639	3.8	12 724
2013 (**)	2 343	17 175	12 617	17 023	7.1	11 559
2014 (**)	2 165	15 355	11 434	14 751	3.5	12 524
2015 (**)	2 231	16 235	11 851	15 990	5.0	12 493
2016 (**)	2 086	14 856	11 120	14 325	3.1	10 775
2017 (**)	2 232	16 084	12 101	14 312	3.8	10 862
2018 (**)	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**

(*) 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

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
2010	61.68	31.45	79.48	40.53	78.11	39.83	1.33
2011	83.45	44.68	107.43	57.52	100.02	53.55	1.39
2012	90.03	44.49	97.80	48.33	103.42	51.11	1.28
2013	85.19	43.52	78.24	39.97	84.66	43.25	1.33
2014	78.31	40.02	74.65	38.15	93.68	47.87	1.33
2015	94.30	40.24	88.73	37.87	88.53	37.78	1.11
2016	86.62	36.88	88.56	37.71	87.11	37.09	1.11
2017	80.55	35.00	55.16	23.97	80.50	34.98	1.13
2018	73.74	33.50	44.34	20.14	74.19	33.70	1.18
2019	79.43	34.20	55.61	23.94	80.00	34.45	1.12
2020	**71.37**	**31.36**	**(***)**	**(***)**	**75.51**	**33.17**	**1.14**

(*) 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, 2011-2020 (tU)

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Niger	1 726	2 376	2 235	2 171	2 077	3 152	2 151	2 067	1 962	2 555
Russia	4 524	5 102	3 084	2 649	4 097	2 765	2 192	1 759	2 543	2 545
Kazakhstan	2 659	2 254	3 612	3 941	2 949	2 261	2 064	1 754	2 518	2 414
Canada	3 318	3 212	3 156	1 855	2 845	2 946	4 099	3 630	1 485	2 312
Australia	1 777	2 280	2 011	1 994	1 910	1 896	2 091	1 909	1 851	1 671
Namibia	1 011	1 350	716	325	385	504	923	1 046	1 234	481
Uzbekistan	929	159	653	365	526	115	348	166	612	329
Re-enriched tails	0	0	0	0	212	212	171	161	161	196
EU	455	421	421	397	412	220	0	18	251	64
South Africa	113	412	17	20	1	0	0	118	115	21
Other	128	256	621	299	229	130	80	80	103	4
United States	180	241	381	586	343	125	193	110	0	0
Ukraine	284	0	0	23	0	0	0	19	0	0
HEU feed	731	395	0	0	0	0	0	0	0	0
Malawi	0	180	115	125	2	0	0	0	0	0
Total	**17 832**	**18 639**	**17 023**	**14 751**	**15 990**	**14 325**	**14 312**	**12 835**	**12 835**	**12 592**

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**
Total	**233 356**	**25 483**	**17 277**

Annex 6
EU nuclear utilities that contributed to this report

ČEZ, a.s.
EDF and EDF Energy
EnBW Kernkraft GmbH
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)
RWE Power AG
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

Orano Cycle
Orano Mining
BHP Billiton
Cameco Inc. USA
Cameco Marketing INC.
CNU-SA
Cominak
EnBW
Internexco
Itochu International Inc
KazAtomProm
Macquarie Bank Limited, London Branch
NUKEM GmbH
Rio Tinto Marketing Pte Ltd
Tenex (JSC Techsnabexport)
TVEL
Uranium One
Urenco Ltd
USEC

Annex 8
Calculation method for ESA's average U_3O_8 prices

ESA price definitions

In order 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 2018 and 31 December 2020) 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 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 ensured by appropriate measures.

Annex 9
Declaration of assurance

I, the undersigned, Agnieszka Kaźmierczak

Director-General of Euratom Supply Agency in 2020

In my capacity as authorising officer

Declare that the information contained in this report gives a true and fair view [132]

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 concerning 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 learnt from the reports of the Court of Auditors for years prior to the year of this declaration.

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

Luxembourg, 22 March 2021

Agnieszka Kaźmierczak

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

Annex 10
Work Programme 2021

Mission and Objectives

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

ESA's strategic objective is the short, medium and long-term 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 objectives have been defined:

Specific policy objectives

1. ensure continuous supply of nuclear materials for users in the Community;
2. facilitate the future supply and encourage the diversification and emergence of reliable alternative sources of supply;
3. facilitate the continued and equitable supply of medical radioisotopes, notably Technetium-99m;
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. improve the effectiveness and efficiency of ESA's organisation and operations.

This work programme sets out the main activities to be pursued in 2021.

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

Contract management

Since its inception, ESA's main task has been 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 monitors 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. acknowledge notifications of transactions involving small quantities, pursuant to Article 74 of the Euratom Treaty;
3. acknowledge notifications of transactions relating to the provision of services in the nuclear fuel cycle, pursuant to Article 75 of the Euratom Treaty, in line with the common supply policy, taking due account of the European Energy Security Strategy;
4. support the European Commission's nuclear materials accountancy, on request, in verifying contract data contained in prior notifications of movements of nuclear materials;
5. 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, when the revised Rules enter into force;
6. contribute, on request, for matters within its purview, to the assessment of international agreements communicated to the Commission under Article 103 of the Treaty;
7. provide information and support to stakeholders on contract issues related to the nuclear common supply policy and/or the Agency's Rules.

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, in line with relevant decisions at political level.

To facilitate future supply, ESA will:

1. undertake measures to provide clarity to market actors on the common supply policy pursued by ESA;

2. facilitate emergence of alternative sources of nuclear fuel/services supply where such sources are presently not available, in particular for VVER reactors;

3. monitor the chapter 'energy security' of the national energy and climate plans (NECP).

Facilitating the continued and equitable supply of medical radioisotopes

In order to enhance the security of supply of Mo-99/Tc-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.

In line with the conclusions of the report 'Securing the European Supply of 19.75% enriched Uranium Fuel', ESA will also strive to facilitate the future supply of HALEU for production of medical radioisotopes and as fuel for research reactors.

ESA will:

1. lead and coordinate the activities of the European Observatory on the Supply of Medical Radioisotopes;

2. undertake measures that facilitate future supply of high-enriched uranium (HEU) and high-assay low-enriched uranium (HALEU);

3. contribute to the European Commission's SAMIRA initiative (Strategic Agenda for Medical Ionising Radiation Applications of nuclear and radiation technology);

4. 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.

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 Supply Agency's ambition is to retain its position as a reliable and well-respected source of high-quality and neutral analyses of the Euratom nuclear fuel cycle market.

To deliver on its market monitoring responsibilities, ESA will:

1. monitor and analyse market conditions and technological developments which are likely to have an impact on the nuclear fuel market;

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. continue monitoring the needs for HEU and HALEU which are required to produce medical radioisotopes and to fuel research reactors;

5. 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.

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 European 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 and seek renewal of the 2014 MoU with the US Department of Energy - National Nuclear Security Administration, in order to facilitate HEU supply until full conversion and advance towards the minimisation of HEU;

4. engage with interested parties in and outside EU, both suppliers and users, to facilitate the continued supply of medical radioisotopes and meet the need of HALEU;

5. monitor the implementation of the Euratom cooperation agreements with non-EU countries as regards trade in nuclear materials;

6. 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 and the World Nuclear Fuel Market;

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

Making ESA's internal organisation and operations more effective

The Supply Agency 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. keeping ESA's work practices under review and updating them where appropriate;

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

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

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