BRIEFING

European Parliament

Strategic autonomy and the future of nuclear energy in the EU

Use and availability of high-assay low-enriched uranium and its potential role in securing a clean, safe energy supply

Nuclear energy and the promise of cost-effective small modular reactors (SMRs) is high on the EU's policy agenda, against the backdrop of a difficult global geopolitical context and the Union's energy security and climate ambitions. The EU is building a comprehensive strategy for the development and deployment of SMRs, acknowledging their potential benefits and challenges. Innovative nuclear technologies are of significant strategic value, with major steps being taken to increase the supply of advanced nuclear fuels and research and innovation capacities in this area.

Introduction

Given the scarcity of information on high-assay low-enriched uranium (HALEU), this briefing offers a comprehensive overview of the latest advances in reactors that use this nuclear fuel. It also seeks to contribute to the political discussion in the EU on how this particular fuel could potentially play a role in ensuring a more secure energy supply.

The discourse within the EU regarding nuclear energy encompasses both its potential benefits and its drawbacks. The topic is of high relevance to the European Parliament's work given the ongoing context of the war in Ukraine and the need to reduce dependence on Russian gas, and fossil fuels in general. While nuclear energy is a highly sensitive topic, against the current geopolitical backdrop and in view of the EU's climate ambitions, a comprehensive political discussion on the topic is essential, and this debate must be based on sound scientific evidence.

The Treaty on the European Atomic Energy Community (Euratom Treaty) signed in 1957 laid down common rules and standards on nuclear energy. Common EU rules on nuclear energy also derive from the Nuclear Safety Directive and the Directive for the Management of Radioactive Waste and Spent Fuel. A recent EPRS briefing offers a complete overview of nuclear energy policy in the EU.

HALEU

When mined, natural uranium contains just over 0.7 % of the fissile isotope Uranium-235 (U-235). As this is insufficient to power almost all types of nuclear reactors, the concentration of U-235 needs to be increased before it can be used as fuel, in a process known as enrichment.

Conventional reactors typically require low-enriched uranium (LEU), defined as being enriched to less than 5 % U-235. HALEU is a type of nuclear fuel that is distinguished from LEU by continuing the enrichment process to the range of 5 % to 20 % U-235. This increase, although seemingly modest, paves the way for innovative reactor designs, enhancing efficiency and safety.

It is important to note that HALEU is distinct from highly enriched uranium (HEU), which has an enrichment level above 20 % U-235. HEU is often associated with weapon-grade uranium, which is commonly considered to have been enriched above 90 % U-235.

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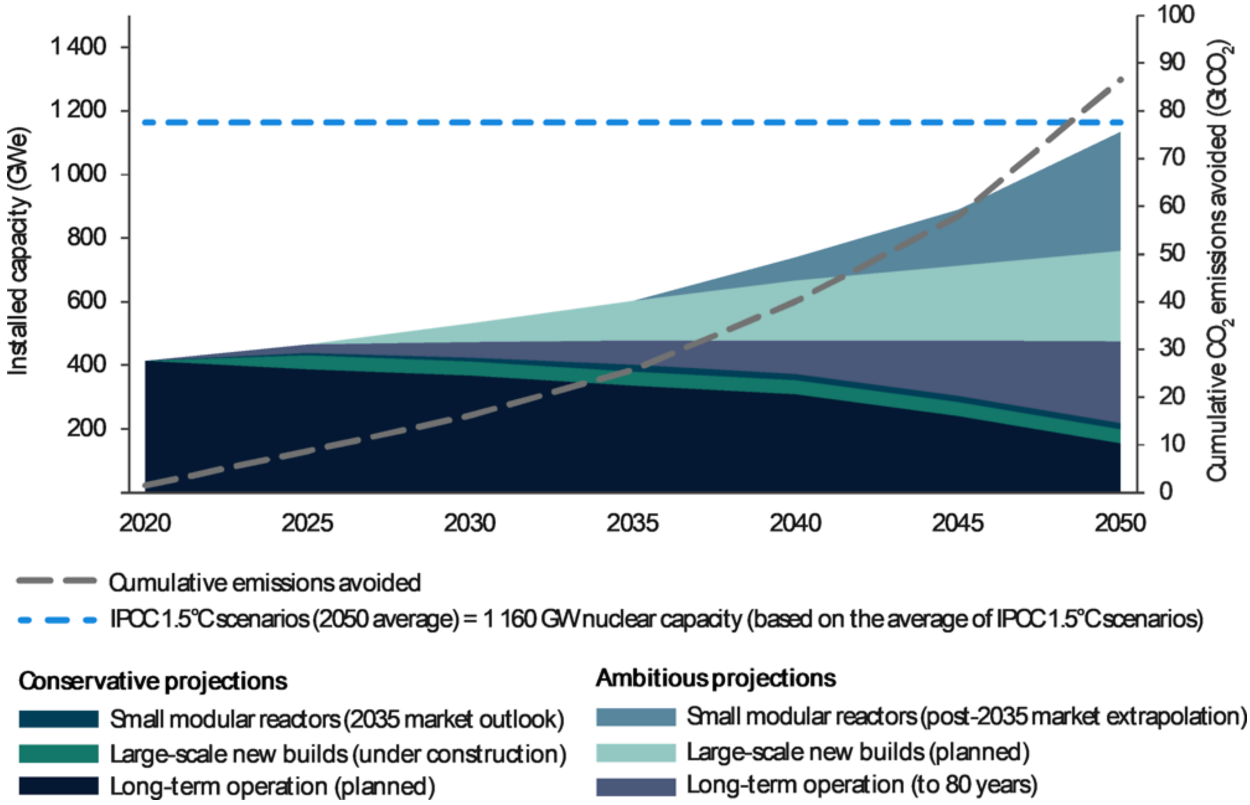
At present, there are nuclear power plants operational in 12 EU Member States. In 2022, nuclear energy was responsible for generating 23 % of the EU's electricity. As the EU moves towards decarbonisation, nuclear energy is expected to play a significant role in several Member States, particularly in the electrification of the economy, as revealed in the modelling work conducted by the European Commission to support the European Climate Law and its legally binding target of net zero greenhouse gas emissions by 2050. At COP28 in late 2023, 20 countries, led by French President Emmanuel Macron and US Special Presidential Envoy for Climate John Kerry, released a joint declaration committing to triple global nuclear energy capacity by 2050, a move seen as an important contribution to achieving a feasible path towards net-zero carbon emissions. This goal is in line with the ambitious projections of the Organisation for Economic Co-operation and Development (OECD) for nuclear power by 2050 (see Figure 1).

Figure 1 – Nuclear power to 2050 in IPCC scenarios



Source: OECD, Meeting Climate Change Targets: The Role of Nuclear Energy, May 2023.

One promising solution when it comes to addressing energy supply issues are SMRs, with commercial viability anticipated by the early 2030s. SMRs hold the potential for diverse applications, including cogeneration, district heating, industrial heat processing, desalination, and (thermo-chemical) hydrogen production. The European Commission has announced that it will be launching a European Industrial Alliance on SMRs as soon as possible.

The European Parliament's recent resolution on small modular reactors highlights the potential of SMRs for power generation in remote areas or where large traditional nuclear power plants may not be feasible. The resolution points out that SMRs offer cost and construction time savings and have reduced fuel requirements, but it acknowledges that there will be challenges in the deployment of SMRs, including design immaturity and the need for a robust supply chain. The resolution calls for a comprehensive EU strategy for the development and deployment of SMRs, including continued research and development, public awareness campaigns, and transparent decision-making processes.

It is very likely that the discussion in the EU around innovative nuclear technologies will be increasingly important, given the global shift towards increased research and innovation capacities in this area, investment in secure fuel supply chains and the development and deployment of SMRs.

Nuclear energy in the world

There are currently 437 operational conventional nuclear power plants worldwide. These typically large power plants (of 1 GWe[1] and above) provide for about 10 % of global electricity generation. Notable examples of countries with operational nuclear power plants include France, whose plants play a pivotal role in the country's energy mix, and the US with its diverse set of reactor designs from different manufacturers.

Around the world, there are approximately 60 power plants under construction, and a further 110 planned. These new projects are concentrated primarily in Asia, with China leading the way in constructing new reactors. India and Russia also have notable developments. A number of EU countries are also pursuing new nuclear power projects. France is building a new nuclear reactor (Flamanville), and has plans for six (or possibly eight) additional new nuclear reactors. Bulgaria and Romania have advanced plans for two new nuclear reactors each. Bulgaria, Czechia and Finland are planning to construct one each. Poland has large-scale plans to start nuclear energy production and build six large pressurised water reactors by 2040. The construction of its first nuclear power plant is due to start in 2026 and be completed by 2033.

The primary fuel used in nuclear reactors, uranium, is mined in several countries around the world. Uranium is relatively common, with economic concentrations not unusual. Quantities of mineral resources, including uranium, are often greater than commonly perceived and depend on both market prices and the cost of extraction. The world's known uranium resources have increased by at least a quarter in the last decade owing to increased mineral exploration. Australia, Kazakshstan and Canada possess more than half the world's known uranium reserves.

Currently, more than 85 % of uranium is mined in six countries: Kazakhstan, Canada, Australia, Namibia, Niger, and Russia. The mined uranium undergoes a series of processing steps to be converted into a form suitable for use in nuclear reactors. This includes enrichment, which increases the concentration of the U-235 isotope, and fabrication into fuel assemblies or rods.

Russia's Rosatom controls nearly 50 % of global enrichment capacity and can deliver low-enriched uranium products to any world market. This is conventional uranium enriched up to 5 %; it fuels most of the nuclear reactors in operation, and planned, in the world. The other key players in the enriched uranium market are France's Orano, and Urenco, a United Kingdom (UK), German and Dutch consortium. Urenco has several plants in Europe and one in the US. The China National Nuclear Corporation (CNNC) meanwhile produces enriched uranium for Chinese nuclear power plants.

Through the Euratom Supply Agency (ESA), the EU maintains the regular supply of nuclear materials and fuels for all users in the European Atomic Energy Community. Around 62 % of the enriched uranium needed for EU nuclear power plants is produced domestically, about 30 % is imported from Russia, and the remaining 8 % is imported from other countries. Of the 12 Member States generating nuclear energy, four (Bulgaria, Czechia, Hungary and Slovakia) are fully and one (Finland) is partially dependent on Russian nuclear fuel. This is mainly because of reactor design and the use of fuel rods made by Rosatom. Some of these countries are especially vulnerable as nuclear energy represents a large share of their electricity production (up to 54 %).

In close collaboration with Member States and relevant stakeholders, the ESA is pursuing diversification of supply of nuclear fuel, aiming to move towards more reliable, non-Russian, suppliers. The objective is to mitigate the risks in some Member States relating to dependency on Russian nuclear supplies and services, as well as on spare parts and maintenance.

Another important aspect to consider is the fact that the world's nuclear fleet is ageing. The average age of nuclear reactors in the world is 30 years, and in the EU around 83 % of reactors are over 30 years old, with an average age of 37.2 years. Only three new nuclear reactors have gone on line in the EU in the past 20 years.

A recent IEA report discusses the role of nuclear power in advanced economies and the factors that put nuclear power at risk of future decline. It states that nuclear power and hydropower are the backbone of low-carbon electricity generation, providing three-quarters of global low-carbon electricity generation. The report recommends several possible government actions designed to ensure that existing nuclear power plants can operate for as long as they are safe, while supporting the construction of new nuclear power plants. With this report, the IEA highlights the potential contribution of nuclear energy to achieving sustainable energy goals and enhancing energy security. The report also refers to the emergence of new advanced nuclear technologies, such as SMRs, but states that all new projects require significant investment and that these new technologies have still to prove their worth.

In the EU, the European Commission has adopted measures to accommodate the investment environment for long-term operation of and development of new nuclear energy capacities. However, whatever the pathway chosen for the future of nuclear energy in the EU, it must take into account the need for open strategic autonomy, in particular regarding the supply of nuclear fuels, parts and maintenance.

Advanced nuclear technologies and SMRs

Advanced nuclear technologies are new designs of both water-cooled and non-water-cooled reactors, with sizes ranging from a few megawatts to hundreds of megawatts. Some of these new designs use molten salt, high-temperature gas or liquid metal. They also use a variety of fuel types and coolants. Many of the new designs have more inherent safety features than conventional reactors. The main goals of these new reactor designs, however, are lower capital and operational costs.

Technology developers are seeking to cut costs by standardising reactor manufacturing and assembly, making reactors' smaller and also modular – SMRs. A sub-category of SMRs – microreactors – operate with a power output in the range of 1 to 20 MWe, meaning that they can operate as cogeneration plants, producing heat for district heating networks and industrial processes. SMRs in general, and microreactors in particular, can also be used for a wide range of applications, including space propulsion, energy supply to space stations, floating power plants, aircraft carriers, submarines, vessels, etc.

However, despite all the potential advantages, SMR technologies still need to prove that they can deliver on their promises, and that they can compete with conventional electricity production, and in particular with renewable electricity and storage. SMRs are a new technology and as with all new technologies their first-of-a-kind deployments are costly and take time to overcome regulatory scrutiny. There are several SMR designs at different stages of development and first-of-a-kind power plants being deployed. It is expected that some designs will be more successful than others. Overall, it is clear that there are uncertainties in terms of development costs, precise

Small modular reactors (SMRs)

SMRs are a class of advanced nuclear reactors with a power capacity of up to 300 MWe per unit, which is about one third of the generating capacity of traditional nuclear power reactors. They are physically smaller than conventional reactors and the fact they are modular is a key characteristic because they can be factory-assembled and transported to a location for installation.

SMRs can be deployed incrementally to match increasing energy demand and can be installed into an existing heat network and/or electricity grid, or work remotely off-grid.

Source: International Atomic Energy Agency (IAEA).

licensing requirements and the final cost per MWh generated. For example, one of the leading US nuclear SMR developers, NuScale, suffered a serious setback in October 2023, when it reported that it had cancelled plans for its first SMR project, in Idaho. The reason was apparently the cost increase, from the initially agreed U$55 to US$89 per MWh. Nevertheless, Nuscale still plans to go ahead with its other ongoing projects.

The International Atomic Energy Agency (IAEA) is promoting the safe and secure worldwide deployment of advanced nuclear power plants, particularly SMRs, through its Platform on Small Modular Reactors and their Applications and its Nuclear Harmonization and Standardization Initiative. According to the IAEA there has been increased investment in SMRs and microreactors. Their compatibility with smaller electricity grids and their modular design could potentially allow for easier integration with renewable energy sources.

Over 80 SMR designs are currently being developed in 18 countries, with two SMR units already operational in China and Russia. The Russian operating SMR is the floating nuclear power station Akademik Lomonosov. The pressurised water reactor (PWR) KLT-40 produces 150 MWt and about 52 MWe. It uses HALEU (averaging 14.1 % enrichment) and it is refuelled every 3 years. The Chinese operating SMR (HTR-PM) includes a high-temperature gas-cooled reactor pebble-bed module reactor that produces 250 MWt. Two reactors are connected to a single steam turbine to generate 210 MWe, and it also uses HALEU (8.6 % enrichment). The main goal of this type of system is for them to replace coal-fired power plants. There are other SMR units at different stages of development and deployment in Argentina, Canada, China, the EU, Japan, South Korea, Russia, the UK and the US. Across the Atlantic in the US, the development and deployment of SMRs is booming, and start-ups are fighting to secure funding and regulatory approval.

According to the IAEA's advanced reactors information system, there are several SMRs in design phase in the EU: ALFRED, ALLEGRO, ELFR, ASTRID, NUWARD, ELETRA, LFR-AS-200, MSTW, MYRRHA and SEALER. Most of these are research/demonstration reactors, and only NUWARD, LFR-AS-200, MSTW and SEALER are being developed for commercial purposes.

In November 2023, the 'France 2030' investment programme awarded funding to six innovative nuclear reactor projects (GTA, RF01, CALOGENA, HEXANA, Otrera, and BLUE CAPSULE). Two projects had already been awarded funding by the same programme in June 2023 (XAMR and Newcleo-LFR-30). These projects go beyond the development of SMRs. Each of the eight projects involves diverse reactor designs, from high-temperature microreactors for heat supply, to sodium-cooled fast neutron reactors, including reactors that use reprocessed waste from older nuclear power plants, fuelled by depleted uranium and plutonium, helping to reduce radioactive waste.

Coming back specifically to the development of SMRs in the EU, one of the best-known projects is EDF's NUWARD expected to be deployed in 2030, according to the developers. This is a 340 MWe power output SMR with two independent 170 MWe reactors within a single building. It is said to be designed for flexibility, load following, and non-electric applications, serving as a complementary solution to renewable energy and replacing aging coal-fired plants in the 300 to 400 MWe range.

The developer Blykalla meanwhile is planning to start construction of the Swedish Advanced Lead Reactor (SEALER), a 55 MWe demonstration SMR, in Sweden in 2024, to enter operation in 2029. The UK-Italy Newcleo project will be deploying its first-of-a-kind 30 MWe SMR in France in 2030 and its 200 MWe lead-cooled fast reactor SMR (LFR-AS-200) in 2032. Finally, Danish Seaborg technologies is developing a floating SMR 'power barge' with a compact molten salt reactor (CMSR) that can deliver from 200 MWe up to 800 MWe of electricity. Construction of prototype 'power barges' is expected to start in 2026.

There are also plans to deploy SMRs in the EU from non-EU technology developers. For example the Polish chemical company Synthos plans to deploy a Hitachi BWRX-300 boiling water reactor (BWR) with 300 MWe power capacity, in Poland by 2030, fuelled by average 3.81 % (up to maximum 4.95 %) enriched uranium. A feasibility study was completed in December 2020 and licensing started with the Polish National Atomic Energy Agency. Hitachi has also signed agreements to deploy its SMR design in Sweden, Czechia and Estonia.

In February 2022, US NuScale Power and the large mining Polish conglomerate KGHM Polska Miedź announced signing of contract to construct first operational reactor in Poland by 2029. In 2021, NuScale had already signed an agreement with the state-owned Romanian nuclear energy company Nuclearelectrica, to build a power plant with six small-scale modular nuclear reactors on the site of a former coal power plant. The project is estimated to be completed by 2026 to 2027, which will make the power plant the first of its kind in Europe. The power plant is expected to generate 462 MWe.

One of the key differences in SMR designs is the type of nuclear fuel used. While some SMR designs, such as NUWARD and Hitachi SMRs, use low-enriched (3 to 5 %) uranium – LEU, other designs, such as Blykalla's SEALER and Newcleo's LFR-AS-200 aim to use 5 to 20 % high-assay low enriched uranium – HALEU. Several US SMRs under development plan to use HALEU (for example the US-Japan TerraPower and GE Hitachi Natrium reactor. This is also the fuel used in the two operational Russian and Chinese SMRs mentioned above. Interestingly, Seaborg technologies were initially planning to use HALEU, but opted for LEU for fear that the limited availability of the fuel would delay their deployment timeline.

LEU and HALEU are both viable options for SMRs; but what are the implications of using HALEU?

High-assay low-enriched uranium – HALEU

The current fleet of nuclear power plants runs primarily on LEU. This is largely for economic reasons linked to the fact that in the early development of the nuclear industry the process used to enrich uranium was energy intensive and costly.

Potential benefits and costs of using HALEU

Potential benefits

- Increased capacity factor
- Smaller reactor cores and reactors
- Longer core lives / refuelling cycles
- Reduced waste volumes

Potential costs

- Higher fuel costs
- Potential for accelerated corrosion and embrittlement of pressure vessels – potentially life-limiting reactor component
- Potentially more onerous regulatory requirements and transport standards

The balance of these considerations will change depending on the cost of uranium and fuel cycle services, and technological and regulatory considerations.

Source: World Nuclear Association.

Nuclear engineers are now looking at HALEU fuels as a way to make SMRs and microreactors more cost-effective. HALEU has more fissile material compared to the LEU fuel currently used in most conventional nuclear power plants, and can therefore potentially make nuclear reactors more efficient, produce more energy, increase the time before refuelling and reduce costs in the long run. Many of the small modular reactor (SMR) designs in development and ready for near term deployment use HALEU.

Table 1 – SMRs using HALEU in near-term deployment, whose development is well advanced

Name	Power output	Developer	Country
ARC-100	100 MWe	ARC with GE Hitachi	US
Aurora	15 MWe	Oklo	US
Hermes prototype	35 MWt	Kairos	US
LFR-AS-30	30 MWe	Newcleo	UK/Italy
Natrium	345 MWe	TerraPower + GE Hitachi	US
PRISM	311 MWe	GE Hitachi	US
RITM-200M	50 MWe	OKBM	Russia
RITM-200N	55 MWe	OKBM	Russia
Seaborg CMSR	100 MWe	Seaborg	Denmark*
SEALER	55 MWe	Blykalla AB	Sweden
Xe-100	80 MWe	X-energy	US

* recently decided to make a fuel change from HALEU to LEU

Data source: WNA, updated February 2024.

HALEU is also particularly relevant for small-scale maritime and space applications. Marine-based SMRs can cover offshore barge-mounted floating power units, vessel propulsion, production of hydrogen, ammonia and synthetic fuels for transport, and seawater desalination. While marine-based nuclear power plants have been around since the mid-1950s, the development of marine-based SMRs for different applications has been gaining momentum in recent years. Research and development is focusing on space nuclear energy microreactors to increase significantly power outputs, specifically for applications such as nuclear electric propulsion and fission surface power (above 1 MWe). Owing to non-proliferation concerns, the focus has turned towards the use of HALEU for these applications. This is a shift from past designs, which were predominantly low power (0.1 MWe) applications using highly enriched uranium – HEU. Few nuclear power systems with low power output have been deployed into space as yet. Several low and higher nuclear power systems are under development, mainly in Russia and the US, but major research efforts are still needed to enable future deployment.

Non-energy uses of HALEU

Currently, the most important use of HALEU is for medical isotope production. The EU is central to global production of Technetium-99m (Tc-99m), with 60 % of the worldwide market. Tc-99m is a vital isotope used in the vast majority of nuclear medicine diagnostic procedures. This and other radionuclides used for therapy, such as for example the increasingly needed Lutetium-177, are produced in research reactors, like the one on the European Commission Joint Research Centre site in Petten, the Netherlands. Most of the research reactors used for production of radioisotopes are fuelled with HEU and HALEU.

Strategic autonomy: HALEU availability and use

Producing HALEU involves existing centrifuge technology and a unique nuclear fuel cycle infrastructure, along with new regulations and licensing regimes. Additionally, new transport containers are needed for the large-scale movement of HALEU for SMRs and advanced reactor deployment. The necessary centrifuge technology is available in the EU, but currently the demand for HALEU is too low to justify private investment in scaling up production domestically.

At present, the Russian Federation is the only viable commercial supplier of HALEU. Tenex, a subsidiary of Rosatom, is currently the only company in the world offering commercial sales of HALEU. However, other countries are also seeking to build the capability to provide HALEU for SMRs, to avoid this excessive reliance on a single supplier.

China has achieved self-sufficiency across various facets of the fuel cycle, outlining a strategic vision for uranium production and procurement. It is also looking to expand its nuclear fuel supply chain, in the coming years, including its HALEU production capacities. China aspires to produce one third of its uranium domestically, secure another third through foreign equity in mines and joint ventures abroad, and acquire the remaining third from the open market. While initial agreements with Russia led to the construction of two major enrichment plants, China has significantly bolstered its capacity through indigenous efforts. This commitment to self-reliance is mirrored in substantial research and development investments, particularly in advanced nuclear technologies such as high-temperature gas-cooled and molten salt-cooled reactors, some of which use HALEU and thorium.

The US is preparing strategically for the production of HALEU as part of the Department of Energy (DoE) HALEU availability program authorised by the US Energy Act of 2020. The main goal is to address HALEU needs for civilian domestic research, development, demonstration, and commercial use. The Inflation Reduction Act allocated US$700 million to support the development of a domestic supply chain for HALEU.

The UK is investing GB£300 million to launch a HALEU programme to produce the fuel needed for advanced nuclear reactors. The investment is part of a plan to deliver up to 24 GW of clean, reliable nuclear power by 2050, meeting a quarter of the UK's electricity needs. An additional £10 million will be provided to develop skills and sites for producing other advanced nuclear fuels in the UK. This initiative will boost the north-west of England's nuclear fuel production hub, supporting local industry and jobs, and helping to expand the UK's nuclear revival domestically and overseas. The first plant is scheduled to be operational in the early 2030s.

In the EU, HALEU is currently needed for research reactors, not only for nuclear medicine, but also for materials research, nuclear physics and the life sciences. Traditionally, these reactors and radioisotope production have used HEU, largely supplied by the US and Russia. However, EU Member States have committed to reduce HEU use, aiming to convert research reactors to HALEU to mitigate proliferation risk. While several EU research reactors have successfully transitioned to HALEU, there is growing dependency on Russia for its supply. As laid down in the Euratom Treaty, the ESA is in charge of ensuring the security of supply of the HEU and HALEU required to feed the production of medical radioisotopes and to fuel research reactors. At the moment, these strategic materials are not produced in the EU and must be imported from the US (HEU) and the Russian Federation (HALEU). The supply of HEU involves specific bilateral intergovernmental agreements and commercial contracts, co-signed by the ESA. The supply of HALEU requires only commercial contracts co-signed by the ESA, with fewer constraints on international and national transport.

The ESA Advisory Committee has established a working group to evaluate methods of securing the European supply of HALEU. The working group's current priority is to identify viable schemes for a sustainable EU supply of HALEU. The objective is to maintain sovereign know-how and rebuild strategic capabilities in HALEU production, involving European industry and the customers using the material. This includes exploring necessary conditions, involving the public and private sectors in the EU, and assessing specific industrial and commercial options.

The ESA HALEU working group report presents the future needs for HALEU for the period from 2035 to 2050. The minimal scenario assumes the conversion of all EU research reactors to HALEU by 2035, and projections are based on conservative assumptions, offering a safe scenario. Overall, the estimates indicate that the EU will need between 0.7 and 1.2 tonnes of HALEU per year. A limited amount of HALEU (255 to 120 kg) might also be needed to supply South African and Australian research reactors. The working group is confident that the technology for producing HALEU exists in the EU because both Urenco and ORANO are world leaders in LEU enrichment technology. They can use the same technology to produce HALEU without major technical challenges. However, both companies have stated that the required investments are not viable, given the €20 000 per kg price of HALEU. These companies suggest that demand for HALEU of between 3 to 8 tonnes per year would be required for commercial production in the EU.

After analysing different options for meeting needs for HALEU in the EU, the ESA working group concludes that it is necessary to build domestic capacity for HALEU production in the EU to ensure the production of medical supplies and other uses of research reactors. To achieve this goal, the Euratom research and training programme under Horizon Europe recently launched a call for proposals on preparing for a European production capability to secure a supply of HALEU fuel. The deadline was 8 November 2023.

Federal authorities in the US are also planning to secure domestic HALEU supplies, but mainly for an expected significant expansion of nuclear power production. The US Department of Energy (DoE) analysis indicates that nuclear energy will reach approximately 250 GW installed capacity by 2050, with a diverse mix of reactor types. This would correspond to an estimated cumulative need for HALEU of about 40 tonnes in 2030. In November 2023, the DoE announced that Centrus Energy Corp had produced the first HALEU in the US in over 70 years, as part of the HALEU availability program. This private company is expected to produce 900 kilograms of HALEU by 2030. It followed the announcement of the production of commercial-grade HALEU fuel pellets by researchers at Idaho National Laboratory. These high-density HALEU pellets contain fuel enriched to 15 % uranium-235 and are to be used in the advanced reactor design program, in which 9 out of the 10 reactors use HALEU.

Conclusion

A global race is well under way to secure the HALEU supplies needed for various purposes, including research, radiosotopes for cancer treatments, and fuel for a new generation of nuclear reactors, including SMRs. In the US and elsewhere, the focus is on securing HALEU for advanced microreactors and SMRs, and providing public support, as the expected demand for this nuclear fuel for SMRs is not yet driving private investment into new production capacity.

In the EU, from an open strategic autonomy point of view, it is undoubtedly important to ensure HALEU supply for the production of radioisotopes, and this is the objective the EU is currently pursuing through the ESA. However, it might also be important to consider the HALEU supplies needed for the next generation of microreactors and SMRs currently being developed in the EU, such as the Swedish SEALER project, and for those whose deployment in the EU is planned for the coming years.

In parallel to securing HALEU supplies, another area worth close attention is opportunities to re-use spent fuel from existing nuclear power plants. Used nuclear fuel has long been reprocessed to extract fissile materials for recycling and to reduce the volume of high-level waste. However, new reprocessing technologies are being developed to be deployed in conjunction with fast neutron reactors, and work needs to be done to derive optimal solutions to problems such as safeguards, economics, and waste management.

Finally, the critically important matter of nuclear safety and safeguards at international level needs to be addressed. With the move towards more advanced nuclear technologies, it is important to consider the materials used carefully and how they might impact nuclear safety and security globally. It is therefore vital to foster the international efforts facilitated by the IAEA to address these concerns and, potentially, to support the IAEA in developing specific safeguards, in particular addressing security, reprocessing of fuel, and material accounting measures for HALEU and other nuclear fuels in advanced reactors.

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ENDNOTE

1 Nuclear reactors are usually rated for thermal power in megawatt thermal (MWt) or gigawatt thermal (GWt), which is a measure of the heat generated by the nuclear reaction, and for electrical power in megawatt electrical (MWe) or gigawatt electrical (GWe), which is the electrical power delivered by a nuclear power plant. The latter will always be lower than the former, as the heat to electricity conversion process cannot be perfectly efficient.

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