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Thematic Insights: Energy Evolution

Uranium – a powerful element in the energy transition

Author:

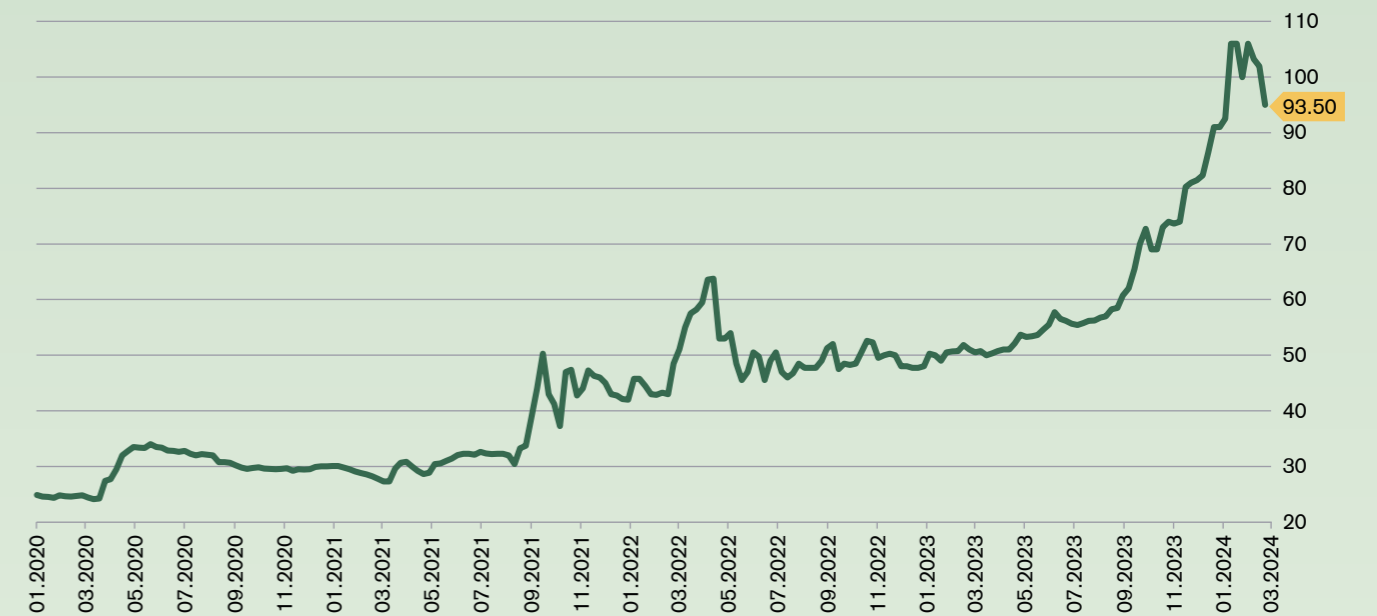
Dirk Hoozemans, CFA
Senior portfolio manager, Thematic Equities

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Uranium – a naturally occurring radioactive element – is one of the critical ingredients in decarbonizing our energy system and providing energy security. Since 2020, uranium prices have more than doubled due to a concentrated and insecure supply.

Weekly uranium price (U308 in USD/pound)



Historical performance indications and financial market scenarios are not reliable indicators of future performance.

Source Bloomberg. Dec 2020–March 2024
Note that 1 imperial pound (lb) is equal to 0.45359237 metric kilograms (kg), or 1 kg = 2.2046 lbs.

Key takeaways

- Generating nuclear power does not cause carbon emissions. Combined with high capacity of nuclear power plants, it makes nuclear power a reliable and stable source of energy.
- Nuclear waste remains the major environmental and safety drawback related to nuclear power.
- Despite some high-profile incidents in the history of nuclear power, it is still one of the safest sources of energy.
- Uranium needs to be enriched to be used in nuclear power reactors.
- Kazakhstan is the world's biggest producer of uranium, but nearly half of enriched uranium exports worldwide comes from Russia.
- Constrained and insecure supply meeting elevated clean energy and energy security demand has driven uranium prices to new highs in recent months.

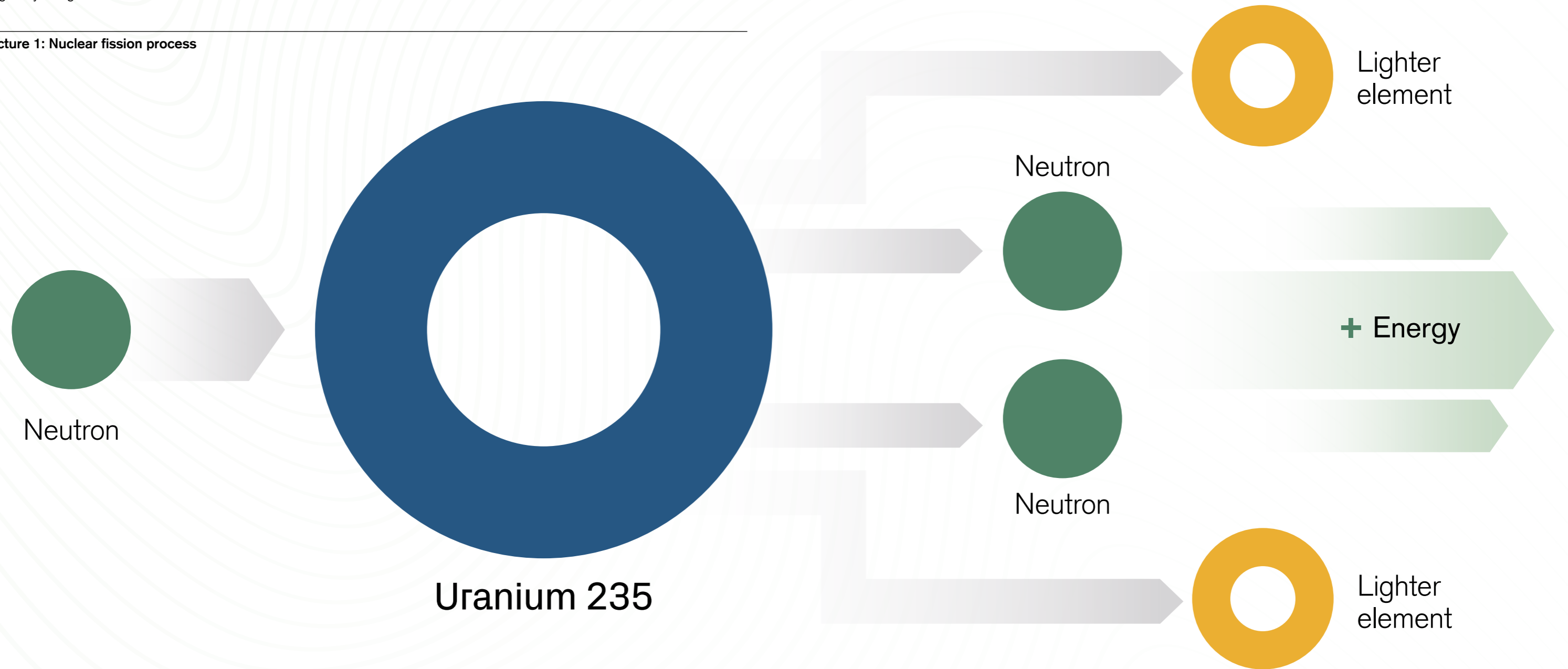


A quick history of uranium

Uranium was discovered in 1789 by the German chemist Martin Heinrich Klaproth and was named after the then-recently discovered planet Uranus. It occurs as a naturally radioactive silvery-white metal and is one of the more common chemical elements in the Earth's crust. Denoted by the symbol U, it has atomic number 92 in the periodic table of elements, meaning its nucleus contains 92 positively charged protons, orbited by 92 negatively charged electrons.¹

Which uranium isotope is key in generating nuclear energy?
Uranium has three different naturally occurring isotopes: U234, U235 and U238.² The most common isotope is U238, which accounts for over 99% of natural uranium. The important nuclear energy carrier U235 used in power generation makes up for around 0.7% of all uranium, while U234 occurs only in very small quantities.³

Picture 1: Nuclear fission process



Sources Credit Suisse, U.S. Energy Information Administration. Based on: U.S. Energy Information Administration (n.d.). [Nuclear Explained](#). Retrieved on 19.03.2024.

¹ Britannica (2024). periodic table. [Link](#). Accessed on 26.03.2024

² Atoms with the same number of protons but different numbers of neutrons are called isotopes. U234 has 92 protons and 142 neutrons (and its mass number is $92+142=234$), whereas U235 and U238 have 143 and 146 neutrons, respectively.

³ United States Nuclear Regulatory Commission (2023). Natural uranium. [Link](#). Accessed on 21.03.2024

Splitting atoms to create nuclear power

All nuclear power plants currently in operation are based on the principle of fission. In nuclear fission, a neutron is made to collide with a uranium atom, thereby splitting the atom. This releases both radiation and the energy that holds the atom together in the form of heat. The split also causes more neutrons to be released and bump into more uranium atoms, creating a nuclear chain reaction that generates significant amounts of heat. That heat is then used to fire a steam turbine, generating electricity. Most nuclear reactors use fuels containing U235, which is nature's most fissile isotope.

Nuclear fuel needs a higher concentration of U235 than found in nature. Hence after mining, uranium needs to be "enriched": the content of U235 needs to be taken up to 3%–5% (for LEU or low-enriched uranium, fuel for most reactor designs), or as high as 20% (HEU or highly enriched uranium, used in e.g. submarine propulsion).⁴ Uranium is considered weapons-grade when it has been enriched to 90%.⁵

Enriched uranium has a super-high energy density: one single uranium fuel pellet, the size of a gummy bear, can create the amount of energy of a ton of coal, 149 gallons of oil, or 17,000 cubic feet of natural gas.⁶

Nuclear energy: a clean and reliable force in the net-zero economy

Contrary to traditional fossil-fuel-based electricity generation, nuclear power generation is carbon emissions free and contributes to net zero outcomes^{7,8}. Also, nuclear power plants operate at high round-the-clock capacity factors, making nuclear power a reliable and stable source of baseload power generation. The major environmental and safety drawback related to nuclear power is nuclear waste, especially used nuclear fuel, which can remain radioactive for many years.

There have been headline-grabbing and serious disasters related to nuclear power plants in the past: the 1979 Three Mile Island partial meltdown,⁹ the 1986 Chernobyl accident¹⁰, and the 2011 Fukushima disaster¹¹ caused by a tsunami spring to mind immediately. While these incidents have caused public concern and anxiety around nuclear power, and have led to NIMBY-ism¹² in the past, it should be noted that the track record of nuclear power versus other sources of energy¹³ tells a compelling story about the safety of nuclear energy. Note also that accidents and near-accidents have led to improved safety designs in existing and new reactors.

In the International Energy Agency's (IEA) World Energy Outlook 2023, the role of nuclear energy increases in all three scenarios outlined, whereas in Bloomberg New Energy Finance's (BNEF) so-called red scenario (economic transition to nuclear energy and nuclear-produced hydrogen), the role of nuclear energy becomes even more significant. The growth outlook for nuclear energy was bolstered in 2023 as the 28th United Nations Conference of Parties (COP28) called for accelerated deployment of nuclear technology.¹⁴

Table 1: Nuclear energy share in IEA and BNEF scenarios

Total Energy Supply	IEA Stated Energy Policies Scenario STEPS				IEA Announced Pledges Scenario APS				IEA Net Zero Emissions Scenario NZE				BNEF Green Scenario				BNEF Grey Scenario				BNEF Red Scenario						
	2010	2021	2022	2030E	2035E	2040E	2050E	2030E	2035E	2040E	2050E	2030E	2035E	2040E	2050E	2030E	2035E	2040E	2050E	2030E	2035E	2040E	2050E	2030E	2035E	2040E	2050E
Coal	28%	27%	27%	22%	19%	17%	14%	20%	15%	12%	7%	17%	9%	5%	3%	15%	10%	6%	1%	18%	18%	19%	18%	15%	9%	5%	0%
Gas	21%	23%	23%	22%	22%	21%	20%	21%	19%	17%	14%	21%	14%	10%	6%	21%	15%	11%	4%	23%	24%	24%	26%	20%	14%	10%	3%
Oil	32%	29%	30%	29%	28%	27%	26%	28%	25%	22%	16%	26%	21%	15%	8%	30%	22%	14%	5%	30%	22%	15%	8%	28%	20%	12%	4%
Nuclear	6%	5%	5%	6%	6%	6%	7%	6%	7%	9%	9%	8%	10%	12%	12%	6%	7%	7%	5%	6%	7%	7%	5%	15%	30%	44%	66%
Bioenergy	5%	4%	4%	3%	3%	3%	2%	1%	1%	1%	1%	0%	0%	0%	0%	9%	11%	11%	11%	9%	11%	12%	12%	9%	9%	9%	7%
Solar	0%	1%	1%	3%	5%	7%	10%	4%	8%	11%	17%	6%	12%	18%	26%	5%	9%	12%	18%	4%	5%	7%	9%	3%	5%	5%	6%
Wind	0%	1%	1%	3%	4%	5%	6%	4%	6%	7%	11%	4%	8%	11%	16%	11%	23%	34%	52%	6%	10%	13%	17%	6%	10%	12%	12%
Other renewables	8%	9%	10%	12%	13%	14%	16%	15%	18%	21%	25%	18%	25%	28%	30%	3%	3%	4%	4%	3%	3%	4%	4%	3%	3%	3%	2%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Sources World Energy Outlook 2023 Free Dataset - Data product - IEA; Bloomberg New Energy Finance New Energy Outlook 2021: Data Viewer (1.0.3); Credit Suisse. Latest data point: December 2022 (E: Estimates)

⁴ United States Nuclear Regulatory Commission (2020). Uranium Enrichment. [Link](#). Accessed on 22.03.2024; International Atomic Energy Agency (2023). What is Uranium?. [Link](#). Published on 16.08.2023. Accessed on 28.03.2024

⁵ World Nuclear Association (2022). Uranium Enrichment. [Link](#). Accessed on 20.03.2024

⁶ encore energy (n.d.). Nuclear Energy: The Future. [Link](#). Accessed on 28.03.2024; Note that 149 gallons corresponds to ~3.55 barrels or 564 liters of oil, and 17000 cubic feet of gas is equal to ~481 cubic meters.

⁷ Credit Suisse (2022). Net Zero Asset Managers Initiative. [Link](#). Published on 22.03.2022. Accessed on 28.03.2024

⁸ World Nuclear Association (n.d.). How can nuclear combat climate change. [Link](#). Accessed on 28.03.2024

⁹ Office of NUCLEAR ENERGY (2022). 5 Facts to Know About Three Mile Island. [Link](#). Published on 04.05.2022. Accessed on 27.03.2024

¹⁰ World Nuclear Association (2022). Chernobyl Accident 1986. [Link](#). Accessed on 28.03.2024

¹¹ World Nuclear Association (2023). Fukushima Daiichi Accident. [Link](#). Accessed on 26.03.2024

¹² Britannica (2024). NIMBY. [Link](#). Accessed on 28.03.2024 [NIMBY | Meaning, Examples, & Facts | Britannica](#)

¹³ Our World in Data (2020). What are the safest and cleanest sources of energy. Retrieved from [link](#) on 19.03.2024

¹⁴ International Atomic Energy Agency (2023). Nuclear Energy Makes History as Final COP28 Agreement Calls for Faster Deployment. [Link](#). Published on 13.12.2023. Accessed on 26.03.2024

Table 2: Uranium supply–demand balance (million pounds)

	2017	2018	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E	2028E	2029E	2030E
Primary Supply Forecast														
Australia	14.0	16.7	16.9	16.1	10.8	11.8	12.0	13.3	13.7	14.1	14.1	14.1	14.1	13.1
Canada	34.2	18.1	18.0	10.3	12.2	19.5	28.5	34.5	36.9	36.7	36.9	56.6	67.2	76.0
Kazakhstan	60.6	56.4	59.3	50.6	56.7	56.3	54.9	57.0	66.1	73.3	78.5	80.0	76.7	77.3
Nambia	11.2	15.2	14.2	14.1	15.0	14.6	13.7	14.9	18.5	19.7	19.8	19.8	19.8	19.8
Niger	9.0	7.6	7.8	7.8	5.0	5.2	3.9	3.9	5.0	6.0	8.0	7.5	6.7	6.1
Russia	7.7	7.6	7.0	6.8	6.8	6.5	6.9	9.9	10.9	11.7	11.7	11.7	11.7	11.7
Other	18.8	19.5	17.9	18.5	17.1	16.7	12.5	12.4	13.3	14.9	14.8	14.4	14.3	13.9
Primary supply total	155.4	141.1	141.1	124.2	123.6	130.7	132.4	146.0	164.4	176.3	183.9	204.2	210.5	217.8
Inventory and secondary supply total	30.5	32.4	31.5	28.5	29.4	28.9	22.6	21.1	23.2	24.2	22.5	22.0	21.6	23.2
Total supply	185.9	173.5	172.5	152.7	153.0	159.6	155.0	167.2	187.6	200.5	206.4	226.1	232.1	241.0
Demand Forecast Ex Buffer Inventories														
USA and the Americas	54.9	53.4	52.8	48.3	50.7	54.6	53.2	52.6	53.2	55.3	54.0	55.3	55.4	57.2
Europe	55.4	51.0	53.2	46.7	47.5	48.7	53.6	48.9	48.9	49.7	51.6	51.9	50.6	52.1
China	25.1	23.0	25.5	22.7	23.1	27.5	29.8	35.0	38.8	42.0	48.9	57.7	58.6	59.0
India	2.6	2.6	2.6	4.2	5.9	5.2	5.3	4.6	4.6	7.0	7.8	9.5	8.9	10.5
Japan	1.2	2.2	5.8	4.3	6.5	9.3	8.1	8.6	9.5	12.4	9.8	9.6	9.6	9.6
Russia	16.5	14.0	14.0	14.2	15.8	13.1	12.9	12.7	12.5	14.4	13.5	15.8	17.0	14.4
Rest of Asia	12.2	12.7	11.8	11.5	16.2	12.6	14.1	12.5	11.5	12.3	14.0	14.1	13.0	13.0
Other countries	2.2	2.5	5.8	8.0	7.4	6.2	5.1	5.1	5.1	6.3	7.0	6.0	12.9	13.3
Reactor Demand subtotal	170.0	161.4	171.6	160.0	173.3	177.3	182.1	180.0	184.1	199.4	206.6	219.9	226.0	229.0
Financials	0.0	8.4	1.2	-0.3	30.7	21.4	10.0	10.0	10.0	5.0	5.0	0.0	0.0	0.0
BMO Demand Forecast Excluding Buffer Inventories	170.0	169.8	172.8	159.7	204.0	198.7	192.1	190.0	194.1	204.4	211.6	219.9	226.0	229.0
Supply/Demand Imbalance	15.9	3.7	-0.2	-7.0	-50.9	-39.1	-37.1	-22.8	-6.5	-3.9	-5.2	6.2	6.1	12.0

Sources BMO Capital Markets (Research, 09.02.2024, p.3); World Nuclear Association; Credit Suisse. Latest data point: December 2022 (E: Estimates)

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¹⁵ World Nuclear Association (2023). Uranium Production Figures, 2013-2022. [Link](#). Accessed on 26.03.2024

¹⁶ World Nuclear Association (2022). Uranium Enrichment. [Link](#). Accessed on 22.03.2024

¹⁷ CONGRESS.GOV (n.d.). H.R.1042 - Prohibiting Russian Uranium Imports Act. [Link](#). Accessed on 28.03.2024

¹⁸ Finnish Institute of International Affairs (2023). Russia and Kazakhstan in the global nuclear sector: From uranium mining to energy diplomacy. [Link](#). Published on 05.10.2023. Accessed on 27.03.2024

¹⁹ Bloomberg (2023). The Manhattan Project to Wean the World Off Russian Uranium. [Link](#). Published on 23.08.2023. Accessed on 28.03.2024

²⁰ Kazatomprom (2024). KAP expects adjustments to its 2024 Production. [Link](#). Published on 12.01.2024. Accessed on 27.03.2024

²¹ World nuclear news (2024). Cameco looks to increase production as net earnings double. [Link](#). Published on 08.02.2024. Accessed on 26.03.2024

²² Sprott (n.d.). Sprott Physical Uranium Trust. [Link](#). Accessed on 28.03.2024

²³ BBC (2022). Breakthrough in nuclear fusion energy announced. [Link](#). Published on 13.12.2022. Accessed on 28.03.2024

²⁴ IEA (n.d.) Nuclear Power and Secure Energy Transitions. [Link](#). Accessed on 27.03.2024

²⁵ United States Nuclear Regulatory Commission (2022). Licensing Activities for Small Modular Reactors. [Link](#). Accessed on 27.03.2024

Kazakhstan and Russia – key players in uranium production and enrichment

While uranium is mined in only a few countries globally, enrichment is even more concentrated: there is only a handful of fuel enrichment companies operating in a limited number of countries. Russia makes up only 5% of global uranium production,¹⁵ but the country accounts for almost half of the world's enrichment capacity,¹⁶ mainly supplied from Kazakhstan.

Russia-Ukraine war impacts uranium imports

Prior to passing a bill banning Russian nuclear fuel imports in the wake of the Russia-Ukraine war,¹⁷ the US imported nearly half of its nuclear fuel from Russia.¹⁸ Europe relies on Russia for 40% of its nuclear fuel supply. Sanctions on Russia have increased demand for non-Russian nuclear fuel, which has led to increased demand for uranium to be enriched outside of Russia.¹⁹

On top of this, Kazakhstan's state-owned uranium miner Kazatomprom is experiencing production problems due to shortages in process chemicals,²⁰ and Canadian producer Cameco is also struggling to meet production targets.²¹

Another market tightening factor has been financial buying of uranium, especially by [Sprott Physical Uranium Trust](#)²², which bought around 20 million pounds of uranium in 2022, and another 4 million in 2023; the trust currently holds approximately 64 million pounds of physical uranium, or about 1/3 of annual global demand.

Constrained and insecure supply meeting elevated clean energy and energy security demand has driven prices to new highs in recent months.

The future of nuclear energy

Research into nuclear energy is ongoing, especially into nuclear fusion: nuclear energy can also be released in a reaction that combines two atoms to form a larger atom. However, this reaction is much less controllable than a fission reaction.²³

Other advancements are being made in reactor design. Especially the so-called SMRs (small modular reactors) look promising due to their lower projected cost and safety attributes.²⁴ The first SMR design was approved by the US Nuclear Regulatory Commission in 2020,²⁵ with construction planned in the coming years.

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