



Nuclear Energy

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Summary

Brief Overview

Nuclear Energy in the World

Nuclear Energy in Latin America

Nuclear Energy in Brazil

Prices and Trading

Brief Overview of Nuclear Energy

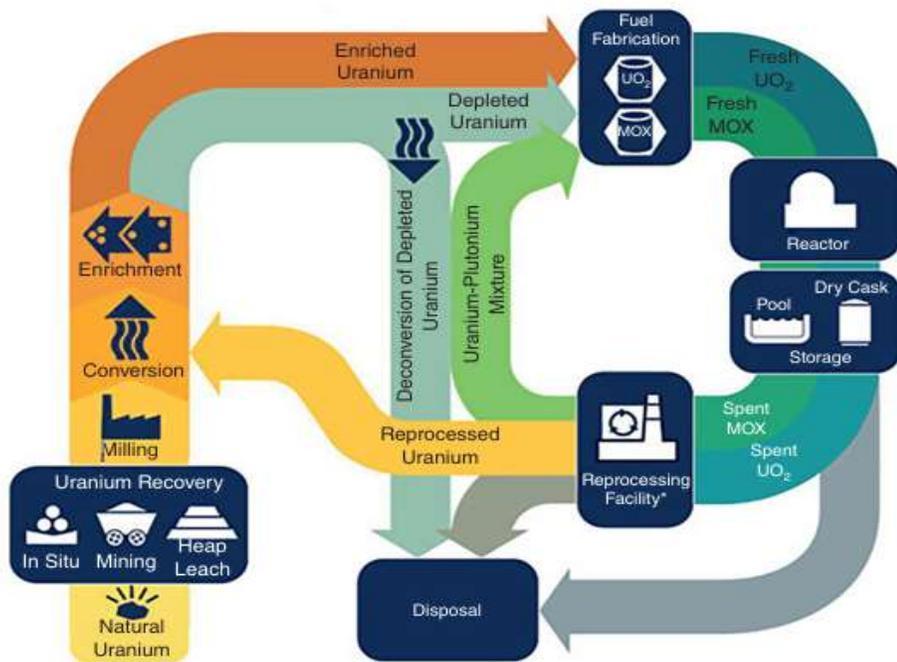
- Nuclear Energy is a form of energy release from the nucleus of an Atom.
- Process of energy release (Fission and Fusion)
- Primary source (Uranium 235)

Merit of Nuclear Energy

- Low emission of GHG
 - High energy density
 - Energy Security
 - Challenges:
 - High cost of Installation
 - Safety Risk
 - Waste Management
-

Uranium Enrichment

Uranium enrichment is the process of increasing the percentage of **Uranium-235 (U-235)** isotope in uranium. Natural uranium contains about 0.7% **U-235**, and enrichment raises this level for use in nuclear reactors or weapons.



Uranium undergoes several chemical transformations before it becomes usable nuclear fuel.

After mining, uranium ore is processed into **uranium oxide (U₃O₈)**, known as yellowcake. This is then refined and converted into **uranium hexafluoride (UF₆)**, a gaseous form used in enrichment processes to increase the proportion of fissile uranium-235. Following enrichment, UF₆ is converted into **uranium dioxide (UO₂)**, a ceramic powder that is fabricated into fuel pellets for use in nuclear reactors.

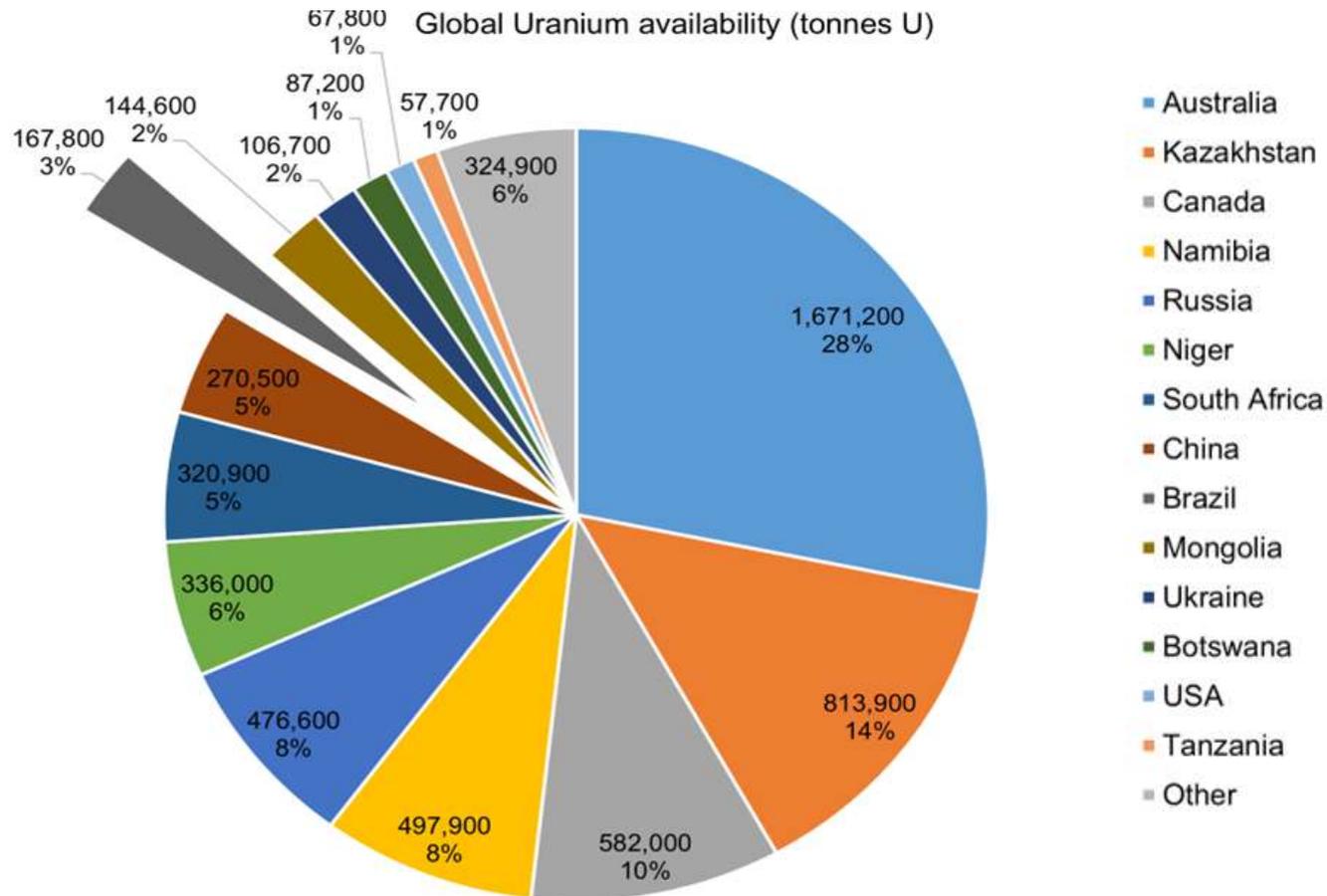


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Nuclear Energy World

Nuclear Energy in World

Global Uranium Availability (tonnes U)



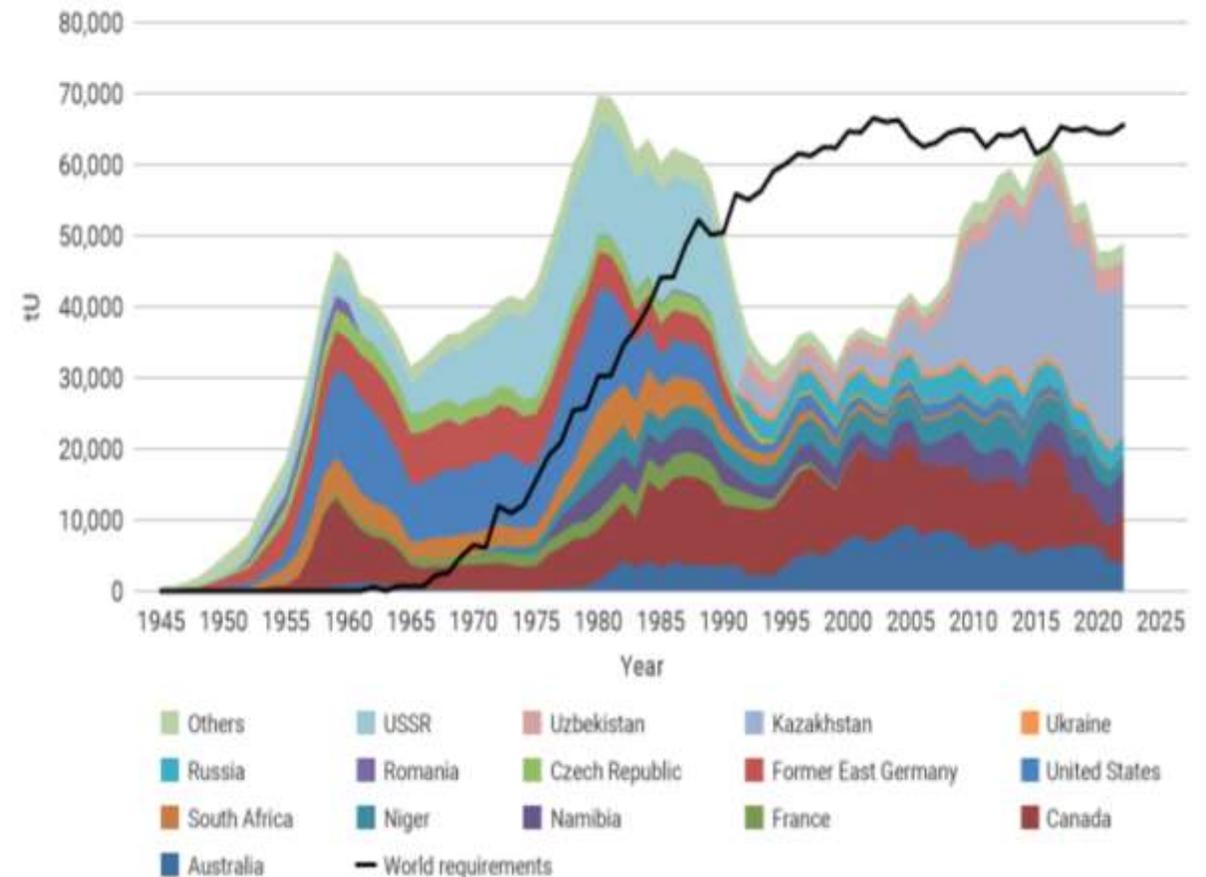
- Measure of long-term security of supply is the known reserves in the ground capable of being mined.
- Australia is the country with Largest Available reserve Globally
- Brazil Have the 9TH Largest Available Reserve.

Nuclear Energy in World

World Uranium Production (tonnes U)

- Despite Australia has the largest availability, the main country that produced uranium through history was Canada
- The collapse of the soviet union disrupted production in east Europe and Central Asia
- Kazakhstan declared its independence from the Soviet Union on December 1991.
- 1950s–60s: rapid build-up, then a mid-60s drop.
- Late 1970s to early 1980s, major peak with strong output from the US, Canada, USSR, France
- 2000s–2010s: recovery and shift Kazakhstan becomes the top producer, with Canada and Australia.
- Dependence of secondary supply ie stockpile and reprocessing.
- Chernobyl(1986) and Fukushima (2011) incident

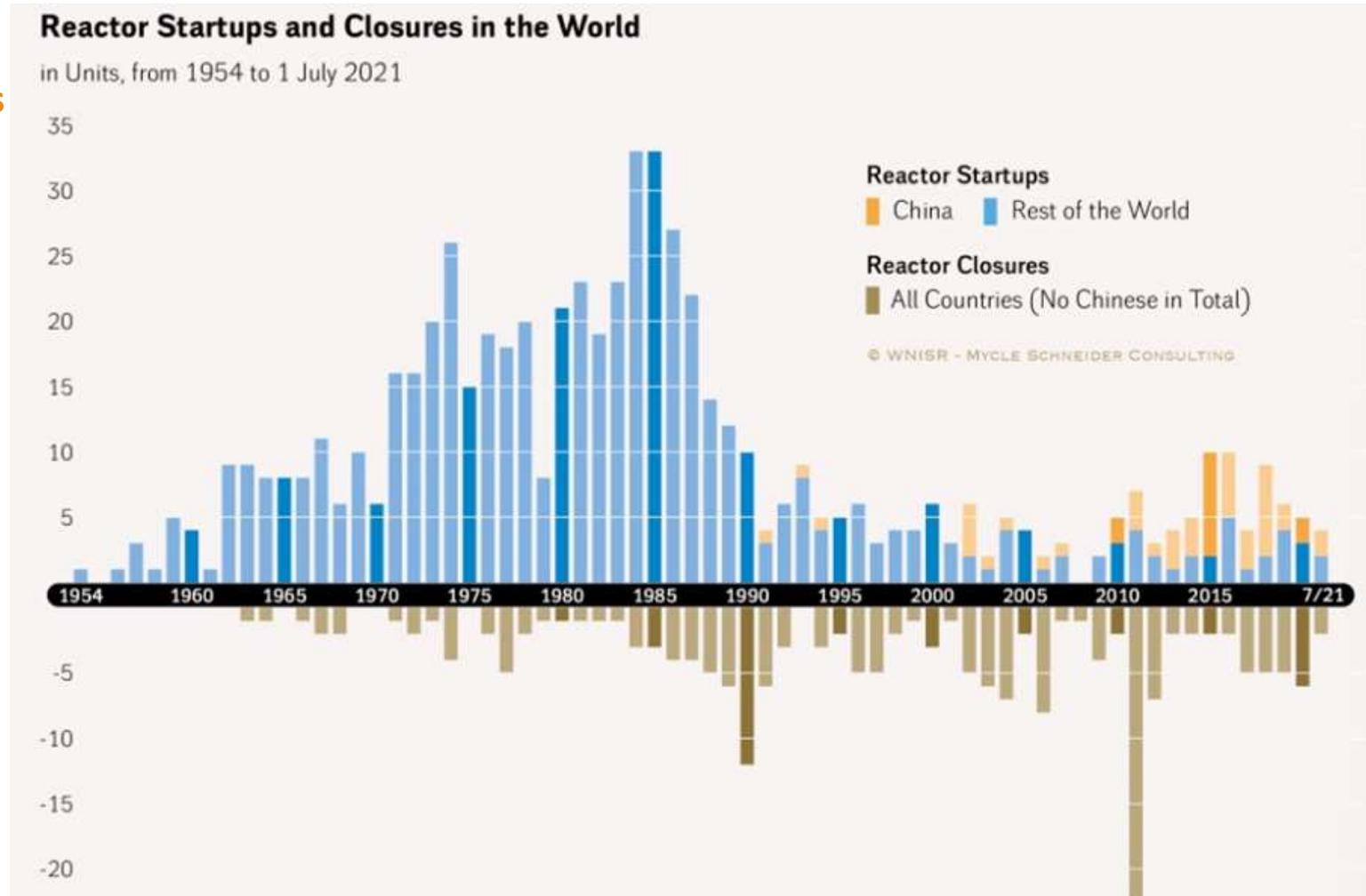
World uranium production and reactor requirements (tonnes U)



Nuclear Energy in World

Commissioned and deCommissioned Reactors

- The recent trend shows china investing more because of its desire to move to clean energy.
- The early growth was because of great demand energy.
- There were less startup because some countries could not afford to invest in new nuclear plant without international financial assistance.
- No major increase in electricity energy demand



Nuclear Energy in World

Number of reactors by type

Reactor type	Main countries	Number	GWe	Fuel	Coolant	Moderator
Pressurized water reactor (PWR)	USA, France, Japan, Russia, China, South Korea	311	299	enriched UO_2	water	water
Boiling water reactor (BWR)	USA, Japan, Sweden	60	61.0	enriched UO_2	water	water
Pressurized heavy water reactor (PHWR)	Canada, India	47	24.0	natural UO_2	heavy water	heavy water
Light water graphite reactor (LWGR)	Russia	10	6.5	enriched UO_2	water	graphite

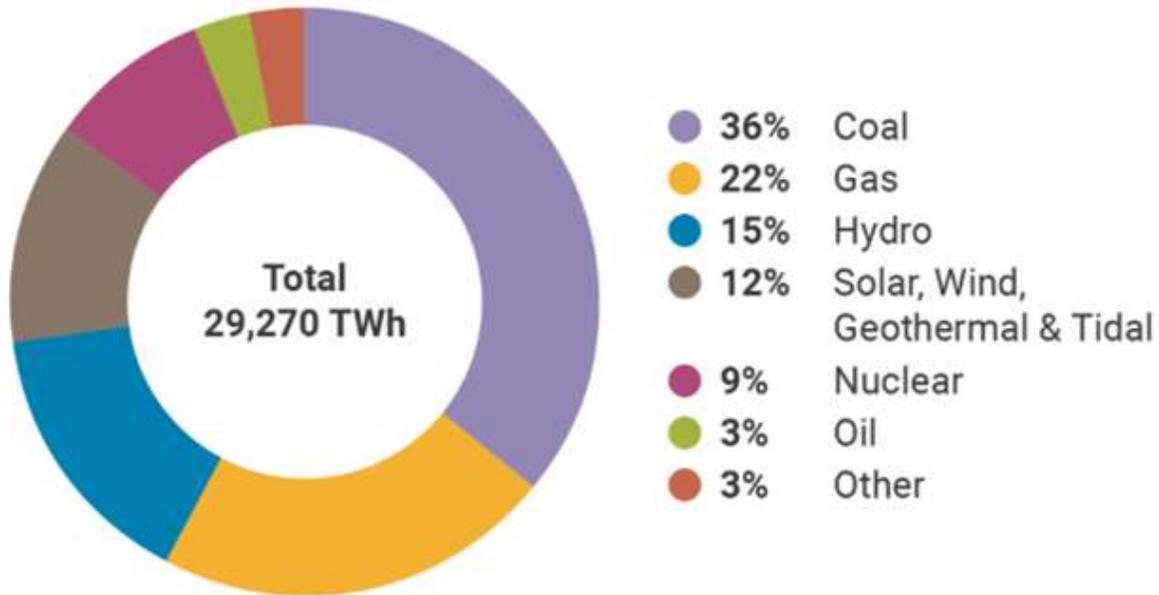
Nuclear Energy in World

Number of reactors by type

Advanced gas-cooled reactor (AGR)	UK	8	4.7	natural U (metal), enriched UO ₂	CO ₂	graphite
Fast neutron reactor (FNR)	Russia	2	1.4	PuO ₂ and UO ₂	liquid sodium	none
High temperature gas-cooled reactor (HTGR)	China	1	0.2	enriched UO	helium	graphite

Nuclear Energy in World

Total electricity production by source (2022)



416 NUCLEAR POWER REACTORS
IN OPERATION

376 261 MW_e TOTAL NET INSTALLED
CAPACITY

23 NUCLEAR POWER REACTORS
IN SUSPENDED OPERATION

19 687 MW_e TOTAL NET INSTALLED
CAPACITY

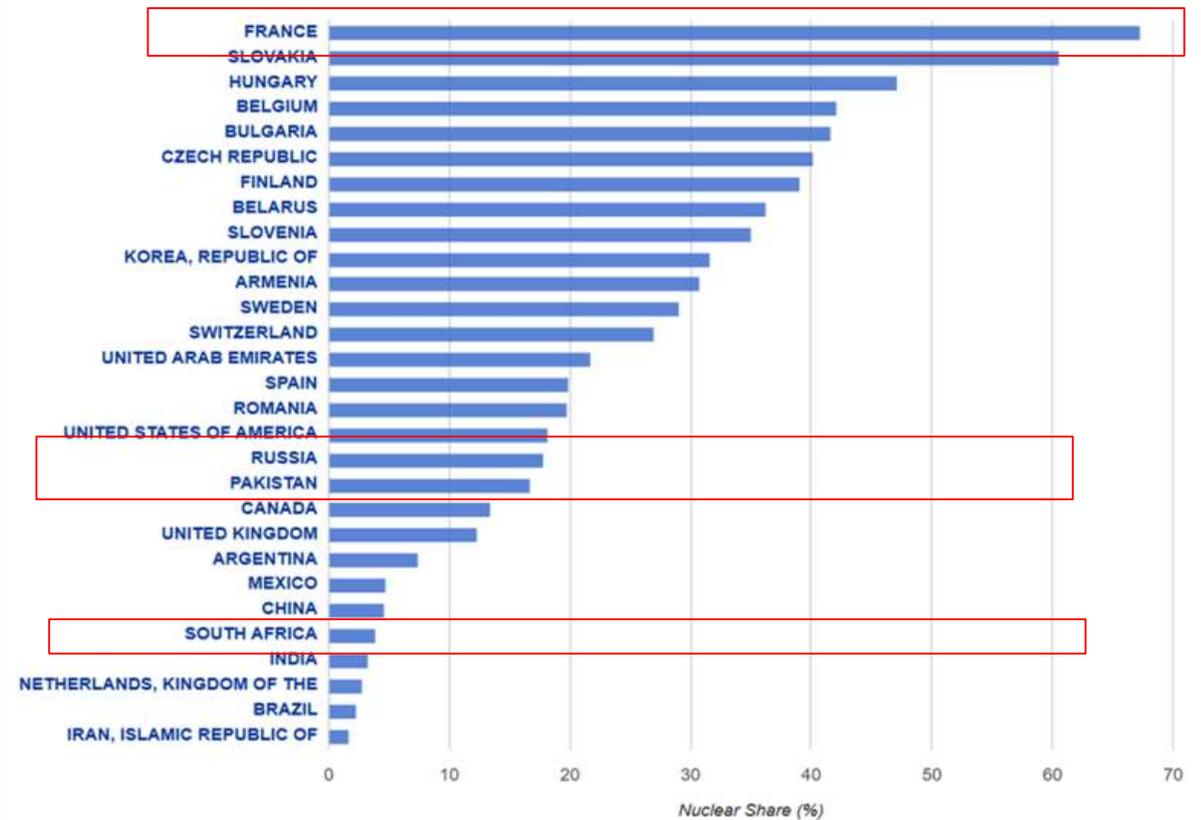
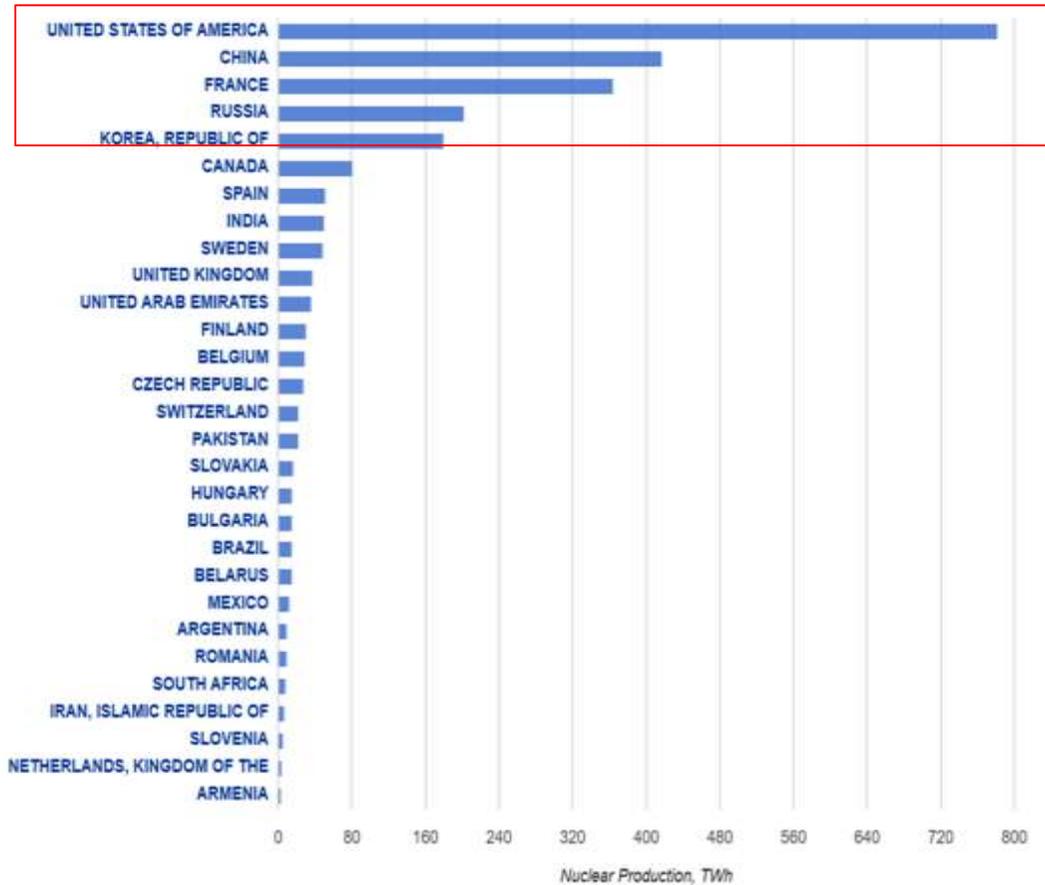
62 NUCLEAR POWER REACTORS
UNDER CONSTRUCTION

65 040 MW_e TOTAL NET INSTALLED
CAPACITY

20 363 REACTOR-YEARS OF
OPERATION

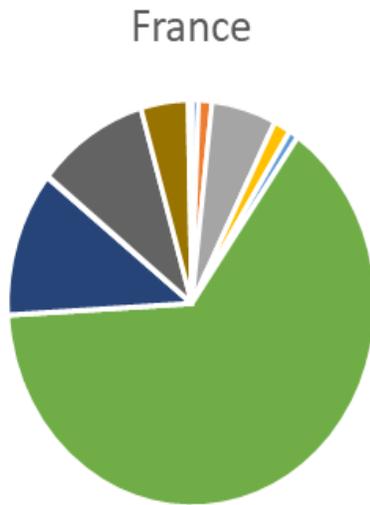
Nuclear Energy in World

Nuclear energy share in electricity per country

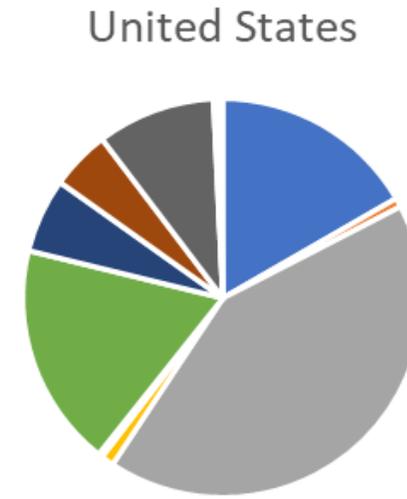


Nuclear Energy in World

Electricity Generation by source - France and US



■ Coal ■ Oil ■ Natural gas ■ Biofuels
 ■ Waste ■ Nuclear ■ Hydro ■ Tide
 ■ Wind ■ Solar PV ■ Other sources ■ Geothermal

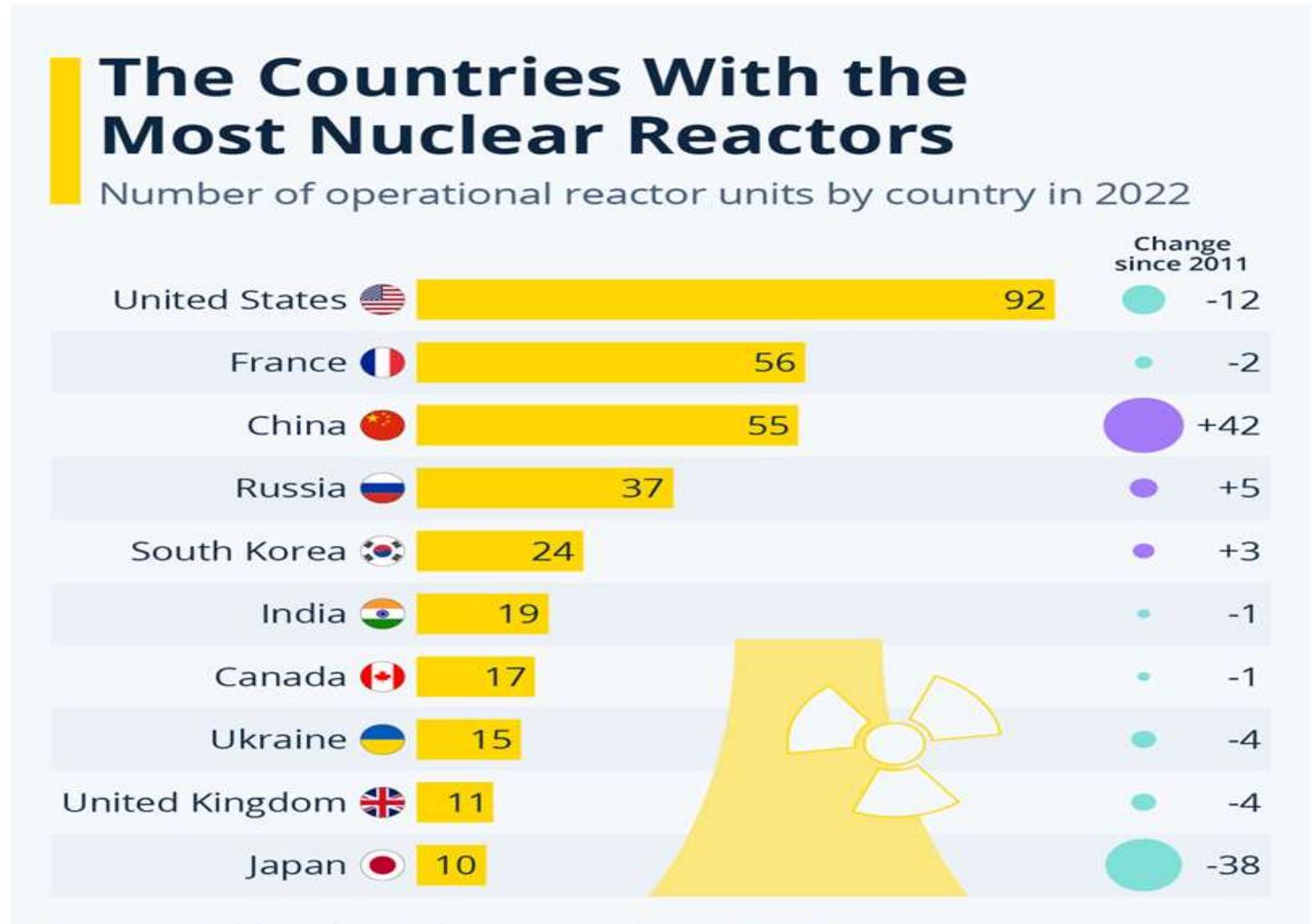


■ Coal ■ Oil ■ Natural gas ■ Biofuels
 ■ Waste ■ Nuclear ■ Hydro ■ Solar PV
 ■ Wind ■ Solar thermal ■ Geothermal ■ Other sources

Nuclear Energy in World

Change in the number of reactors per country (2011)

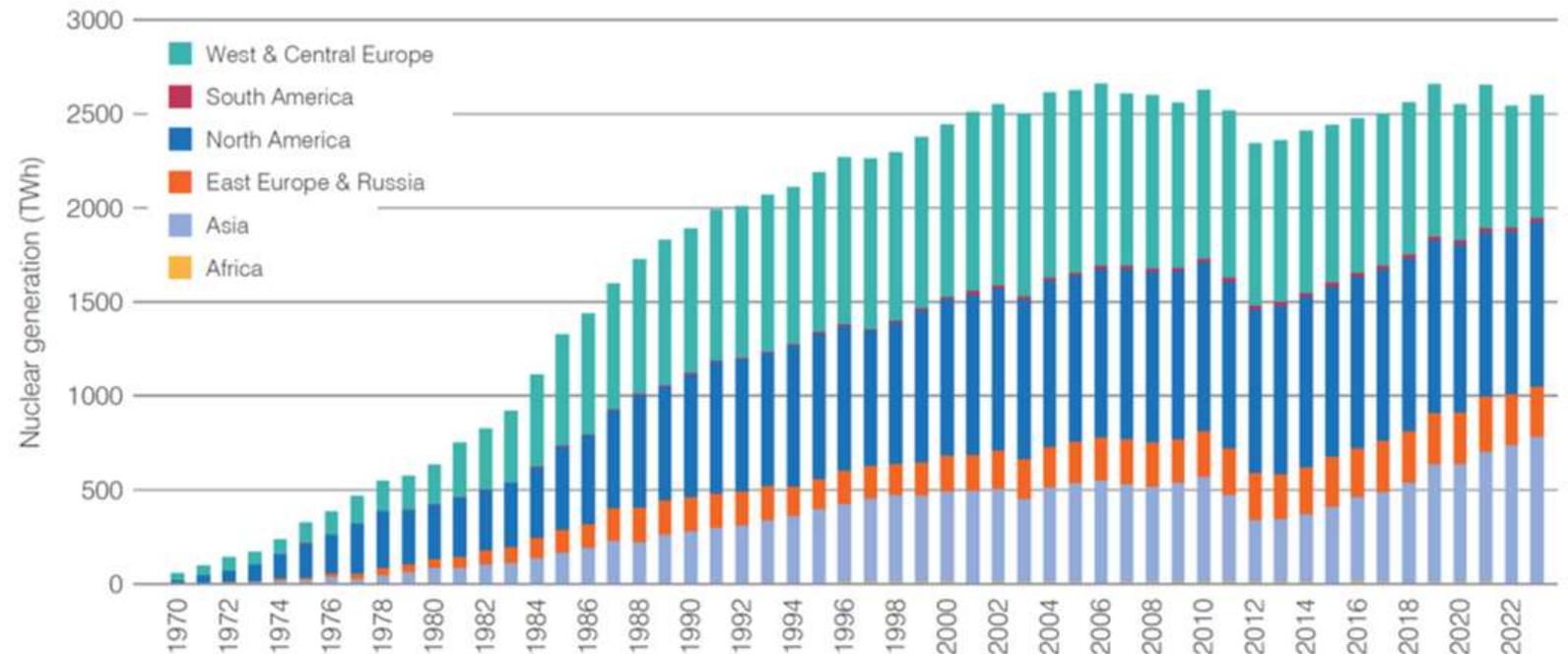
- China had significant increase while most country were shutting down their reactors after Fukushima accident. Japan was the country that made most closures



Nuclear Energy in World

Total nuclear generation by region (1970-2023)

- Latin America is the smallest nuclear energy producing region after Africa
- The largest nuclear energy-producing region is North America.
- There is a drop from 2010 to 2012 because of Fukushima accident
- There is a decrease on generation from 2018 onwards in West & Central Europe because of the closing of power plants in Germany





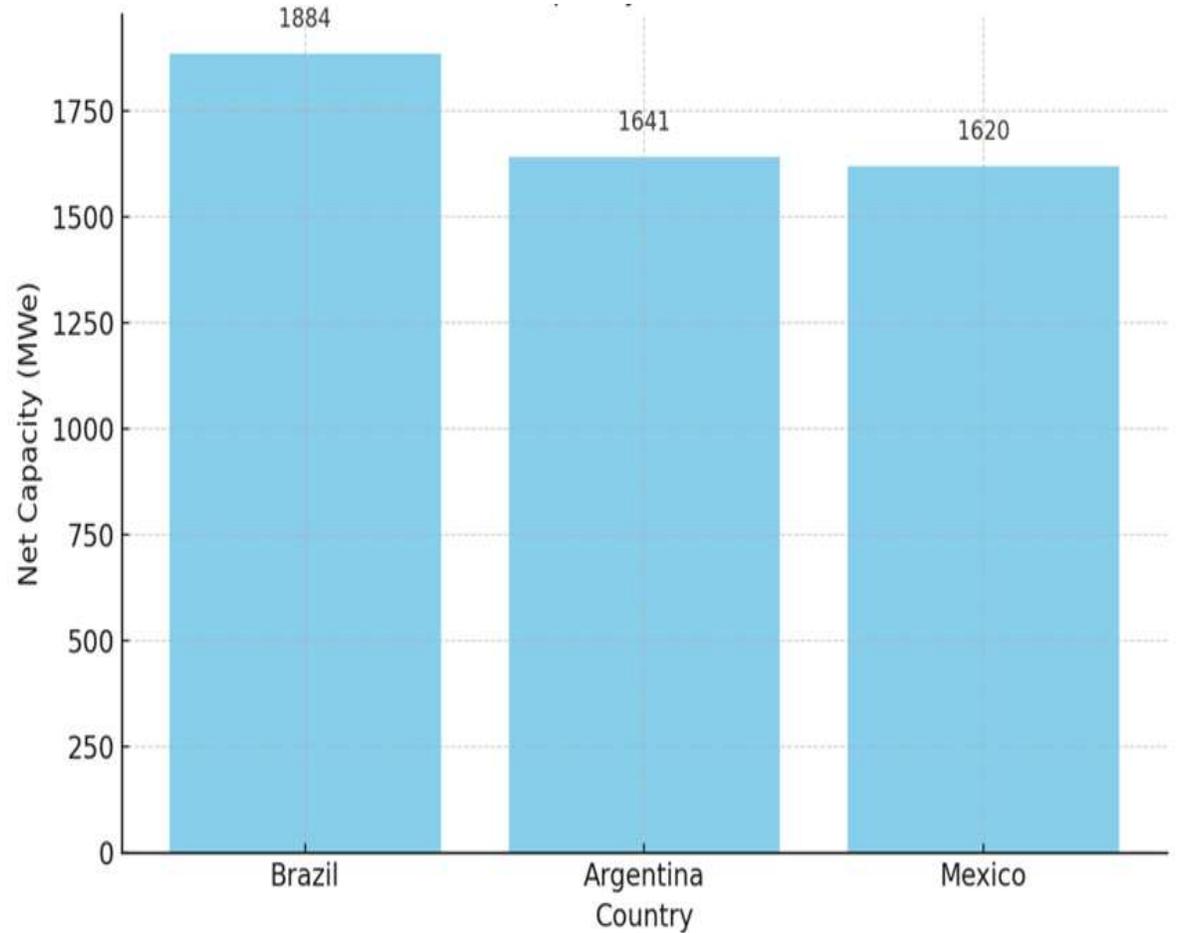
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Nuclear Energy Latin America

Nuclear Energy in Latin America

Power Capacity in 2025

- Only 3 countries have a significant amount of nuclear capacity in Latin America
- Argentina is the country with higher share of nuclear energy in electricity capacity

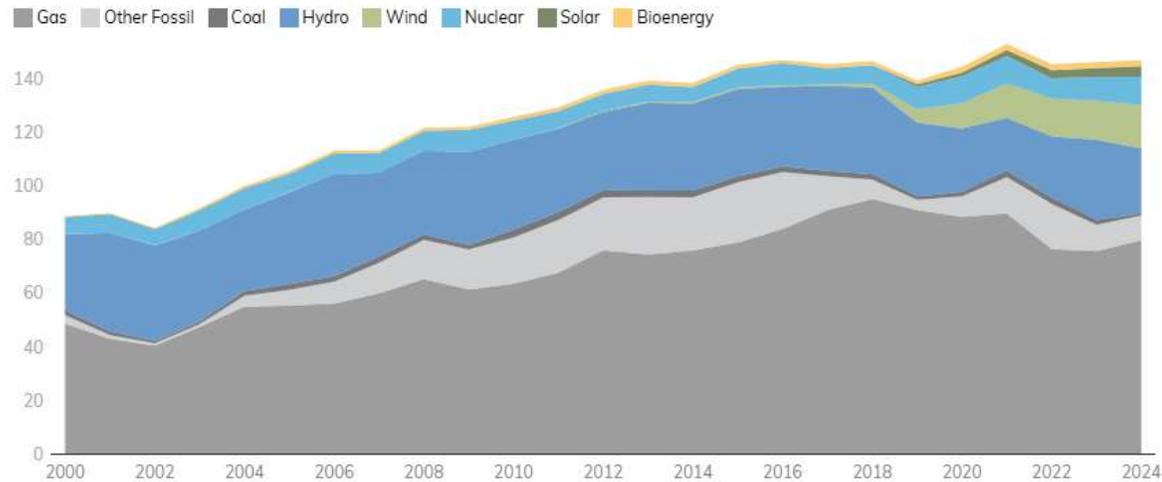


Nuclear Energy in Latin America

Argentina

- Gas is the dominant source of power in Argentina. In 2024 it provided about 55% of the country's electricity
- Nuclear energy corresponded for about 7% of electricity generated in 2024

Argentina electricity generation by source (TWh)



3 

OPERABLE
REACTORS
1,641 MWe

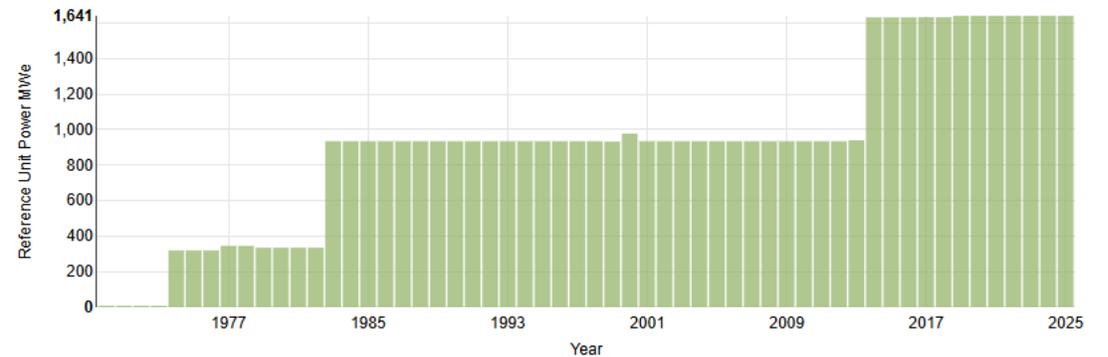
1 

REACTORS UNDER
CONSTRUCTION
25 MWe

0 

REACTORS
SHUTDOWN
0 MWe

Operable nuclear power capacity



Nuclear Energy in Latin America

Mexico

- Mexico is increasingly reliant on natural gas, particularly from the USA
- Nuclear energy corresponded for about 3.3% of electricity generated in 2024

2 

OPERABLE
REACTORS
1,552 MWe

0 

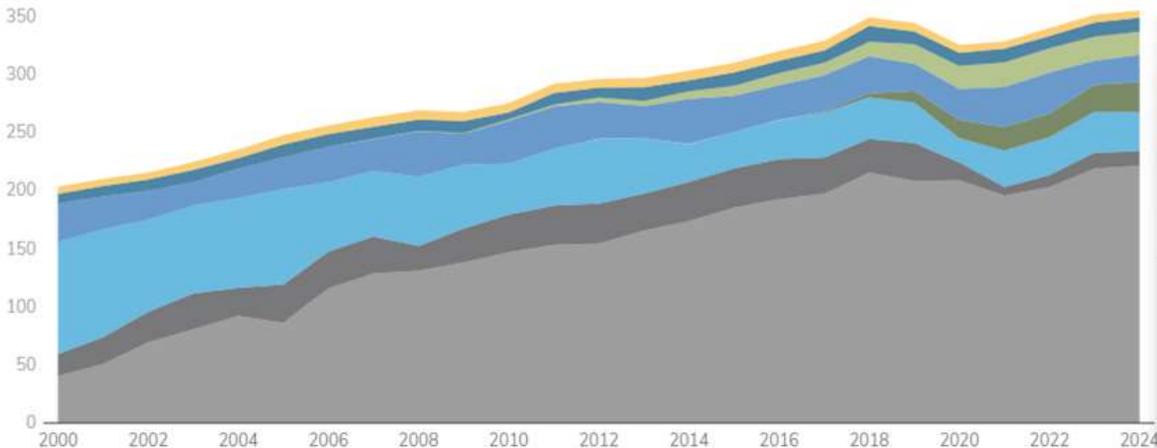
REACTORS UNDER
CONSTRUCTION
0 MWe

0 

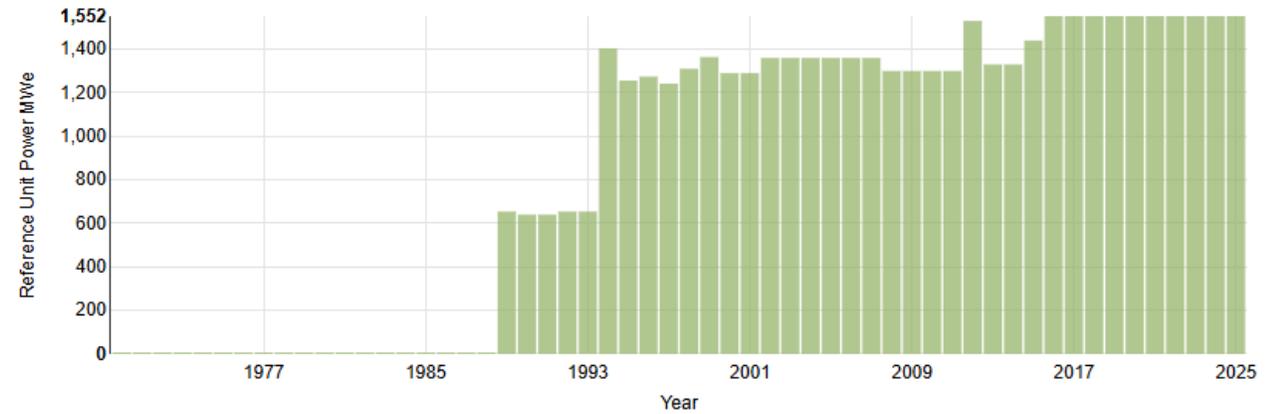
REACTORS
SHUTDOWN
0 MWe

México electricity generation by source (TWh)

Gas Coal Other fossil Solar Hydro Wind Nuclear Bioenergy



Operable nuclear power capacity





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Nuclear Energy Brazil

Nuclear Energy in Brazil

Domestic Energy Supply

- Operational Reactors: 2 reactors (**Angra 1 and Angra 2**) with 1,990 MWe capacity
- **Angra 3**: Under construction, with multiple delays, expected to be operational by 2031, adding 1,405 MW.
- Government exercises control over other activities associated with the industry

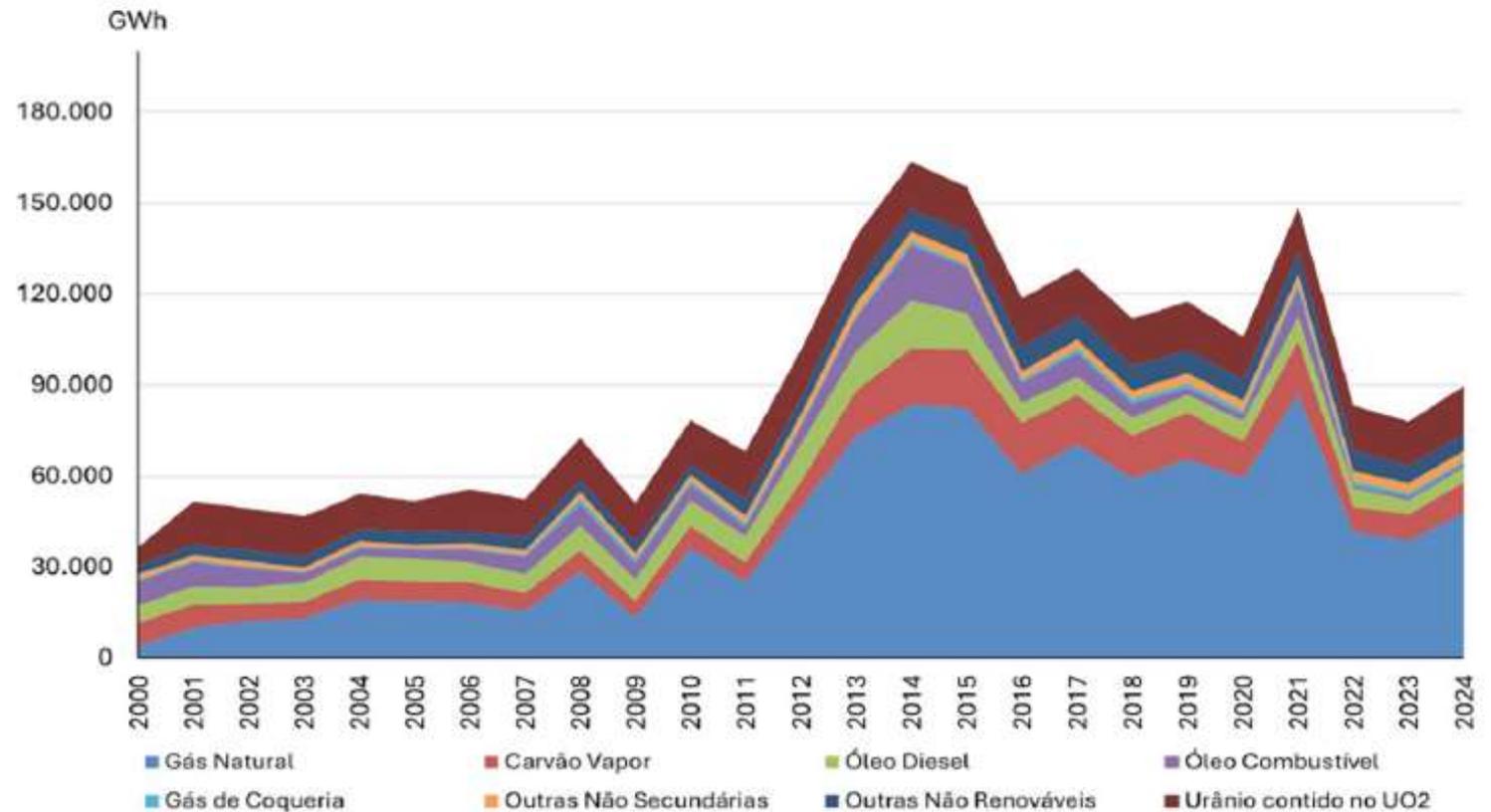
IDENTIFICAÇÃO	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	10 ³ tep (toe)	IDENTIFICATION
ENERGIA NÃO RENOVÁVEL	175.879	162.787	166.827	157.768	158.316	148.591	166.527	160.383	160.143	160.979		NON-RENEWABLE ENERGY
PETRÓLEO E DERIVADOS	111.602	105.170	106.075	99.407	100.898	95.247	103.625	108.873	110.476	109.586		PETROLEUM AND OIL PRODUCTS
GÁS NATURAL	40.971	35.569	37.938	35.905	35.909	33.824	40.049	31.739	30.223	30.970		NATURAL GAS
CARVÃO MINERAL E COQUE	17.625	15.916	16.790	16.421	15.435	13.955	16.945	13.995	13.720	14.431		COAL AND COKE
URÂNIO (U₃O₈)	3.855	4.211	4.193	4.174	4.292	3.727	3.900	3.861	3.850	4.156		URANIUM - U₃O₈
OUTRAS NÃO RENOVÁVEIS	1.826	1.921	1.831	1.860	1.780	1.838	2.007	1.914	1.674	1.836		OTHER NON-RENEWABLE
ENERGIA RENOVÁVEL	124.521	126.488	127.826	133.407	137.141	140.923	137.218	143.577	154.330	161.012		RENEWABLE ENERGY
HIDRÁULICA ¹	33.898	36.267	35.024	36.460	36.364	36.215	33.189	37.842	37.935	37.271		HYDRAULIC ¹
LENHA E CARVÃO VEGETAL	25.075	23.502	24.864	26.350	26.411	26.457	27.407	27.265	27.265	27.372		FIREWOOD AND CHARCOAL
DERIVADOS DA CANA-DE-AÇÚCAR	50.623	50.318	49.758	50.090	52.841	54.933	50.105	46.732	52.851	53.715		SUGAR CANE PRODUCTS
EÓLICA	1.860	2.880	3.644	4.169	4.815	4.906	6.217	7.020	8.239	9.258		WIND
SOLAR	605	667	785	1.060	1.385	1.791	2.371	3.591	5.428	7.229		SOLAR
OUTRAS RENOVÁVEIS	12.460	12.855	13.751	15.378	15.325	16.421	17.929	21.126	22.612	26.167		OTHER RENEWABLE
TOTAL	300.400	289.276	294.654	291.175	295.456	289.514	303.744	303.960	314.472	321.991		TOTAL

1. Inclui importação de eletricidade oriunda de fonte hidráulica. 1 kWh = 860 kcal (equivalente térmico teórico - primeiro princípio da termodinâmica). Ver Anexo VI.6 - Tratamento das Informações. / Includes electricity imports originated from hydraulic sources. 1 kWh = 860 kcal (physical equivalent - First Principle of Thermodynamics). Look Appendix VI.6.

Nuclear Energy in Brazil

Electricity Generation: non-renewable sources

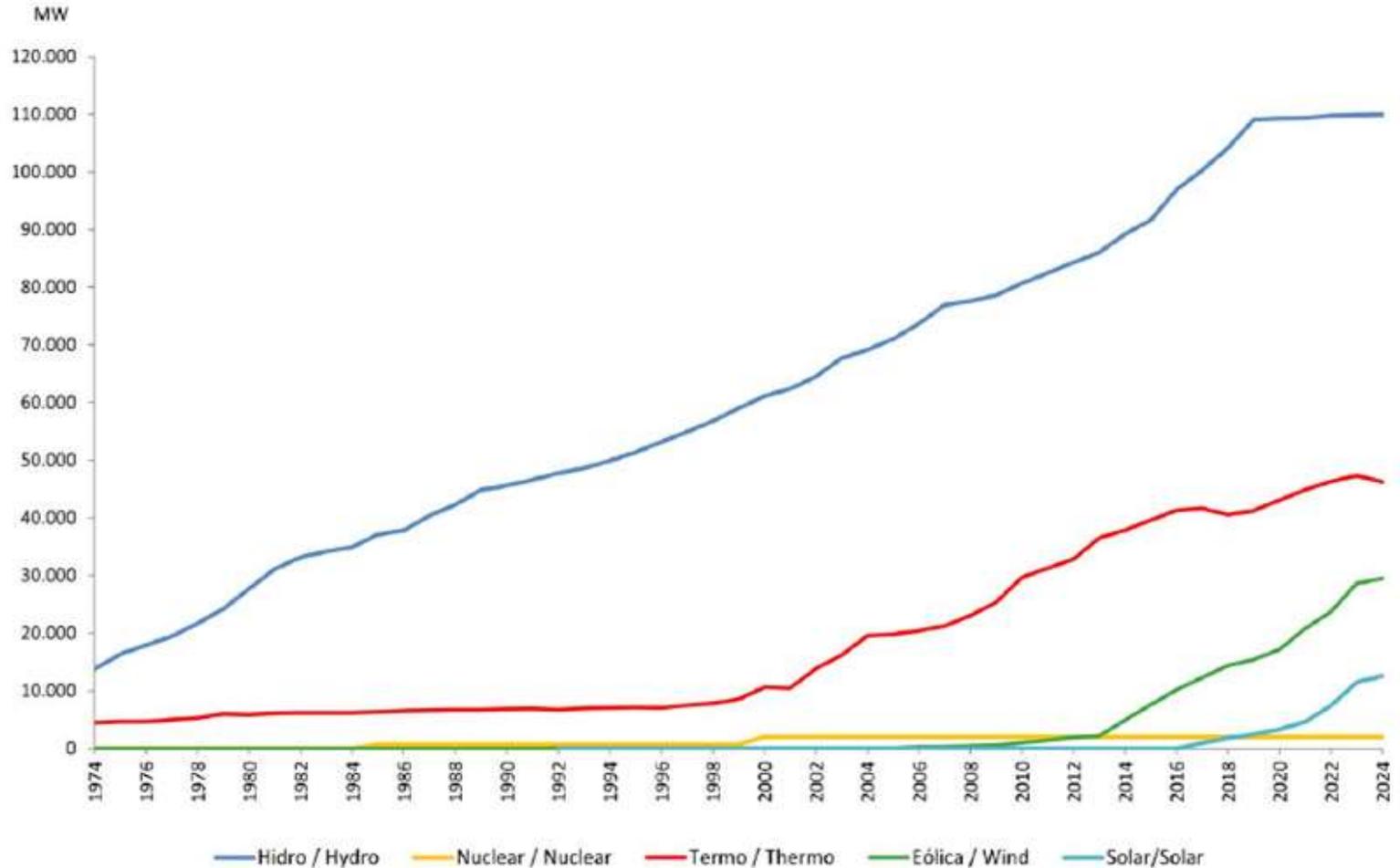
- Remains roughly constant between 2015 and 2014 - between 1.2% and 1.5% of domestic energy supply
- Remains constant mainly because of the increase interest on renewables (economically competitive)



Nuclear Energy in Brazil

Installed Capacity Of Electric Energy Gener.

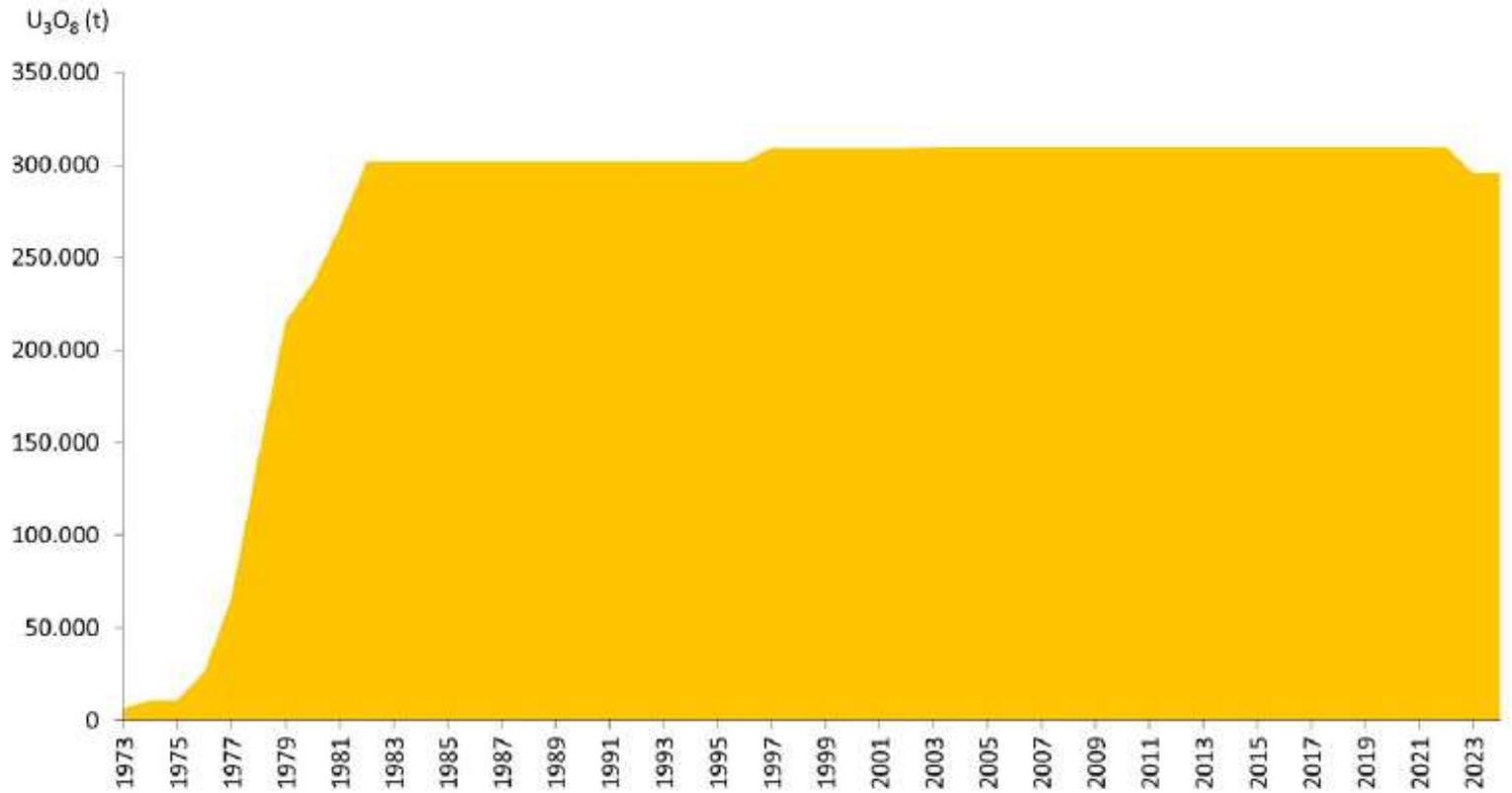
- Remained between 1% to 2% of installed capacity from 1974 to 2024
- Achieved a peak on 2010, which corresponded to 1,7%
- In 2025 was responsible for 1%



Nuclear Energy in Brazil

Reserves of Uranium in Brazil (tonnes)

- Remain roughly constant since 1982
- 3 main reserves:
 - Poços de Caldas (deactivated)
 - Lagoa Real (Bahia; operating since 1999)
 - Santa Quitéria (Ceará state; planned)



Nuclear Energy in Brazil

Reserves of Uranium in Brazil (tep)

- Assumption that there are up to 30% losses in mining and beneficiation
- 38,3% of reserves are inferred, equivalent to additional reserves in the AIEA convention

Convencional (Brasil) <i>Conventional (Brazil)</i>	AIEA IAEA
Reservas Medidas + Reservas Indicadas <i>Measured Reserves + Indicated Reserves</i>	Razoavelmente Asseguradas <i>Reasonably Assured</i>
Reservas Inferidas <i>Inferred Reserves</i>	Reservas Adicionais <i>Additional Reserves</i>

	UNIDADES/UNITS	MEASURED/ INDICATED/INVENTORIED	INFERRED/ ESTIMATED	TOTAL	OIL EQUIVALENT ³ - 10 ³ toe	
CARVÃO MINERAL ²	10 ⁶ t	25.689	6.535	32.224	7.013.099	COAL ²
HIDRÁULICA ³	GW	111,4	24,0	135,4	83.956	HYDRAULIC ³
ENERGIA NUCLEAR ⁴	t U ₃ O ₈	182.220	113.169	295.389	2.056.667	NUCLEAR ENERGY ⁴

Nuclear Energy in Brazil

Energy Imports of Uranium (tep)

	10 ⁸ tep (toe)										
FONTES	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	SOURCES
PETRÓLEO	15.377	8.009	7.491	9.627	8.885	8.684	7.247	12.724	11.721	13.375	OIL
GÁS NATURAL	16.198	10.320	9.434	9.324	8.628	8.458	14.833	7.722	5.692	7.105	NATURAL GAS
CARVÃO METALÚRGICO / VAPOR	13.263	12.909	14.033	13.808	12.437	10.712	13.266	10.703	9.980	11.921	METALLURGICAL COAL / STEAM COAL
COQUE DE CARVÃO MINERAL	1.584	764	1.061	1.269	902	937	1.153	1.082	1.562	1.200	COAL COKE
URÂNIO	4.888	6.353	8.269	6.267	6.342	7.293	7.852	5.940	7.367	3.962	URANIUM



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Nuclear Energy Trading and Prices

Nuclear Energy

Trading

- There's no open public commodity exchange for uranium (like NYMEX for oil)
- Deals are bilateral contracts or handled via a small number of brokers

Types of contracts:

- Spot contracts: Immediate or near-term delivery (small share of the market).
- Long-term contracts: Multi-year supply agreements (dominant in nuclear industry).

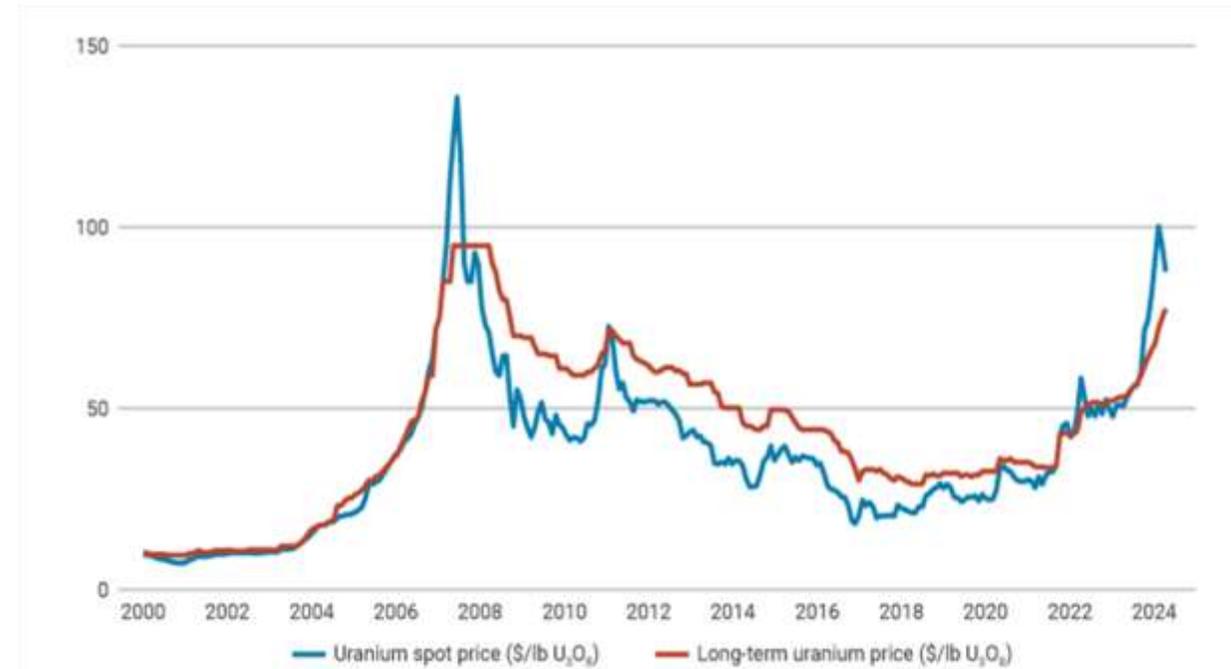
Trade is regulated by:

- IAEA (International Atomic Energy Agency) safeguard
 - Nuclear Non-Proliferation Treaty (NPT) obligation
 - Bilateral nuclear cooperation agreements
-

Nuclear Energy

Uranium Prices (2000-2023)

- Most trade is via 3-15 year term contracts with producers selling directly to utilities at a higher price than the spot market, reflecting the security of supply
- In 2000, primary market participants – utilities and producers – accounted for 95% of the spot market. That share decreased to two-thirds by 2005 and one-third by 2011 and it has remained at 30-40% since. The rest comes from the financial community, namely traders and financiers who have moved in on the market, bringing greater liquidity and efficiency.



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Thanks!

**Bruna Seixas
Fidel Castro**
