

A photograph of a nuclear power plant at night. Two large, illuminated cooling towers are the central focus, with steam rising from them. The plant's buildings and other structures are also lit up, and their lights reflect on the water in the foreground. The sky is a deep blue, suggesting dusk or dawn. A decorative frame in shades of blue and purple surrounds the text on the left side of the image.

Making investment in the nuclear value chain attractive

Identifying needs, addressing risks, unlocking opportunities

November 2025

■ ■ ■
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Authors

Co-leaders of the Nuclear Excellence Center



Vincent Gautier

EY France Partner, EY Expertises & Transactions, EY Consulting, Project finance France Energy leader



Issam Taleb

EY France Partner, EY Advisory, EY-Parthenon Strategy and Transactions France Energy leader



Pierrick Vaudour

EY France Partner, Assurance France, Financial accounting advisory Services, Nuclear industry

Foreword

To meet the capital demands of deploying substantial new nuclear capacity, the industry must rebuild investor confidence.

The nuclear sector is slated to double its capacity from approximately 420GWe to approximately 820GWe over the next 25 to 50 years to support the wider energy transition, industrial competitiveness and sovereignty of the growing world economy. The expansion will prioritize the life extension of existing facilities as the most cost-effective option for preserving capacity, complemented by new construction projects involving both large-scale and small modular reactors (SMRs). This growth is expected to be primarily driven by China and other advanced economies.

We estimate that US\$3.6 trillion in financing will be required over this period for both generation assets and their supporting front-end and back-end infrastructure. While in recent years, nuclear projects have primarily been financed through utility balance sheets or through government financing, there is now a growing push to involve private investors to leverage their technical and project management expertise and capital, thereby easing the strain of financing capital-intensive projects on debt-laden state budgets.

In deregulated markets, three main challenges currently hinder private investment: political and regulatory risk, construction risk, and revenue uncertainty. Solutions are needed to de-risk investment in nuclear assets by making them predictable and profitable enough to attract private investors. Additionally, private investors typically focus on short investment cycles, which are difficult to reconcile with the long development, construction and operational timelines of nuclear projects. These challenges limit the suitability of traditional metrics, such as the internal rate of return (IRR), to assess whether a project will bring returns commensurate with the risks involved.

Thus, financing schemes and revenue models must cater to both public and private investors, with each playing distinct roles beyond mere financial contributions.

Public support is crucial for long-term technology

development and risk mitigation, while private investors can accelerate the takeoff process once risks are lower by bringing expertise, operational excellence and sufficient capital. Two primary financing models are expected to emerge and evolve over time:

- **Project financing:** Project financing will initially be provided through state funding, including subsidies, equity, debt and guarantees from export agencies, backed by a comprehensive risk-sharing model. This will be followed by an increasing share of private capital as the risks decrease.
- **Supply chain financing:** This will primarily involve private investments to rebuild the industrial capabilities of SMRs and mid-tier companies, which will support the major new developments in the nuclear fuel cycle following decades of limited investment.

Three prerequisites must be met to revitalize the nuclear sector, secure its financing and establish appropriate risk-sharing schemes in accordance with local specifics:

- **Long-term public support:** Support long-term regulatory stability and political sponsorship (e.g., 2025 PINC), a strong financial commitment from the state, broad risk-sharing frameworks, and the inclusion of supportive ESG frameworks (e.g., EU Taxonomy).
- **Operational excellence:** Stabilize construction timelines and costs, increase supply chain readiness and excellence, and deliver on-time and on-budget projects.
- **Revenue security:** Reduce price uncertainty by implementing revenue risk-mitigation mechanisms (e.g., regulated asset-base (RAB), contract for difference (CfD) and power purchase agreement (PPA) to deliver consistent and predictable returns and shield projects from market volatility.

Introduction

The nuclear value chain: a capital-intensive system requiring end-to-end investment

As the world races toward net-zero emissions and reaffirm the importance of **energy sovereignty**, nuclear power is returning to the forefront of the global energy agenda. Amid mounting pressure to **secure clean, reliable, dispatchable and affordable electricity**, as renewable energy penetration increases, the intermittency of wind and solar power creates a growing need for reliable baseload capacity. In this context, **nuclear stands out as a scalable, low-carbon baseload solution.**

Current forecasts indicate substantial growth in electricity demand through 2050. The International Energy Agency estimates that nuclear capacity must double during this period to align with net-zero pathways, while the International Atomic Energy Agency projects **nuclear capacity expansion up to 2 to 2.5 times current levels.** This expansion requirement coincides with technological developments in SMRs, Generation IV systems, fusion and advanced nuclear technologies that promise improved economics and deployment flexibility.¹

What was once a state-dominated, politically sensitive industry has experienced a **remarkable surge in private investor interest** over the past 18 months. This shift reflects both **policy momentum** and **compelling market fundamentals.** Recent developments suggest an evolving investor sentiment toward nuclear assets. From public institutions to private actors, a **growing range of financial stakeholders is showing renewed appetite for nuclear energy.** In 2024 and 2025, a series of high-profile moves marked a turning point in nuclear investment. Politically, both Germany and the US have signaled a shift toward nuclear revival: In Germany, leading parties reopened the debate on extending or relaunching nuclear power as part of their energy security strategy, while in the US, the administration signed an executive order to boost domestic nuclear reactor projects. The World Bank lifted its decades-long ban on nuclear lending, opening the door to multilateral support. Soon after, Apollo Global Management committed funding of up to £4.5 billion to EDF's nuclear expansion at Hinkley Point C, signaling growing confidence from major private capital. In the UK, a tailored financing model brought in CDPQ, Amber Infrastructure and Centrica as investors in

Sizewell C, demonstrating how public-private structures can unlock meaningful private funding. At the European level, the EIB provided a €400 million loan to Orano, supporting additional fuel cycle infrastructure. On the private investment fund side, actors such as Brookfield, Ares and Pelican Energy Partners have expanded into the nuclear supply chain through acquisitions, while venture capital (VC) funds like Breakthrough Energy Ventures, Andreessen Horowitz, DCVC and 92 Capital are backing the next wave of nuclear innovation – SMRs, advanced modular reactors (AMRs) and fusion startups – viewing nuclear as both a climate solution and a frontier technology.

Despite these positive indicators, private capital deployment in nuclear projects faces persistent **structural challenges** that need to be overcome to restore confidence. The nuclear industry must **revitalize and modernize a supply chain that has been dormant for thirty years**, requiring **private sector participation for technical expertise, project discipline, capital and a drive for productivity.** Large-scale nuclear projects remain difficult to evaluate financially due to long development, construction and operational cycles, making traditional metrics such as IRR or payback period often misleading. These **obstacles** can be categorized into three primary risk domains: **long-term public support and regulatory uncertainty, construction and execution risk, and long-term revenue visibility.** To **attract private capital at scale** – beyond restoring operational excellence in construction – these risks must be addressed through **structured financial solutions, innovative market models and public-private partnerships** that share both **risk and reward.**

This white paper examines the **near-term financing needs of the nuclear industry**, analyzes **barriers to private capital participation**, and **evaluates emerging financial structures and risk-sharing mechanisms** in order to overcome these challenges and **unlock nuclear energy's potential** at the right scale and speed required for **global decarbonization and sovereignty.**

1. Fusion considered to a minor extent in this paper.

Need for significant capital across the nuclear fuel cycle

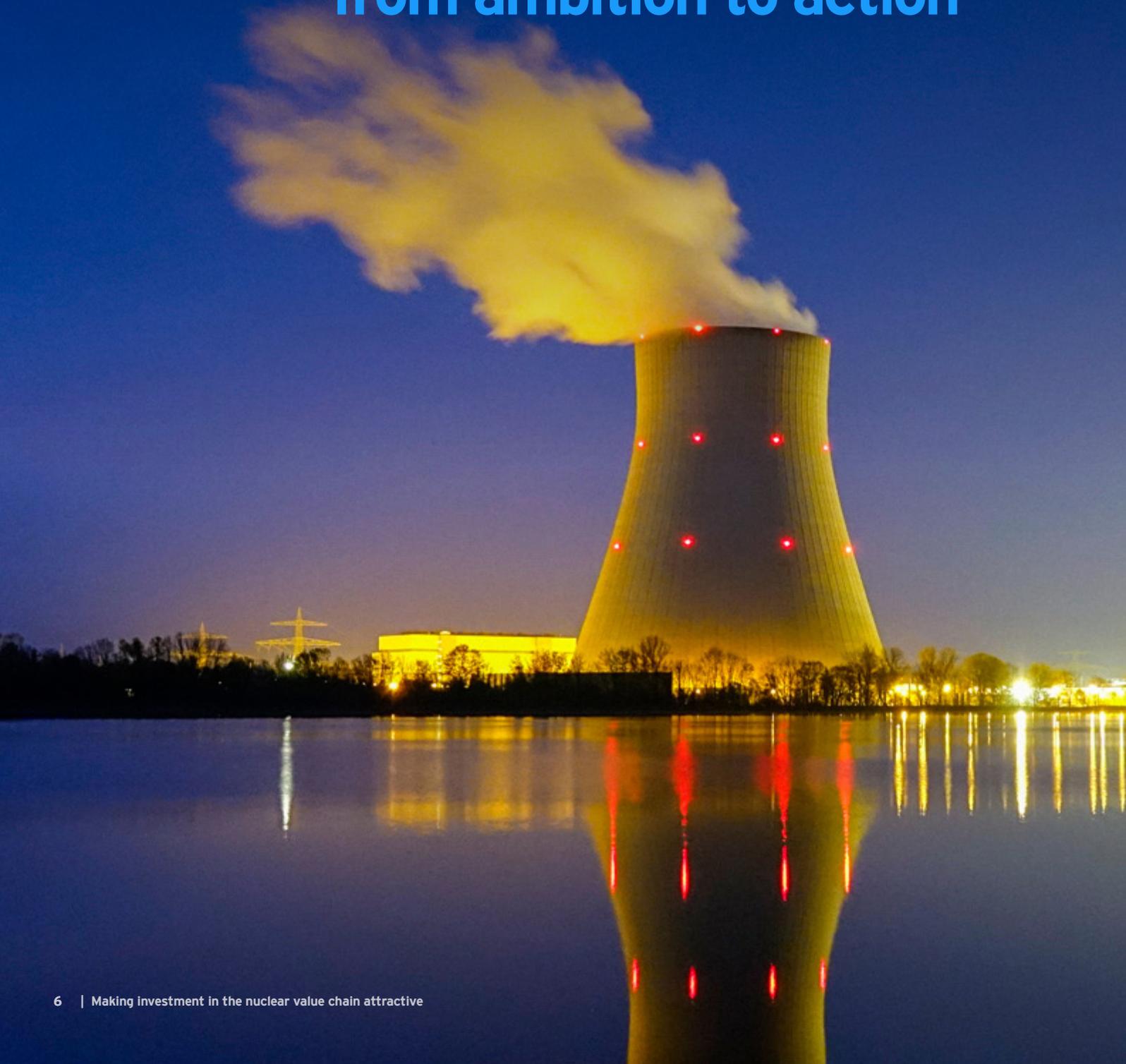
The nuclear value chain spans from uranium mining and fuel fabrication to power plant construction, operations, and eventual waste management and decommissioning. Each stage is highly capital-intensive, with significant investment needs not only for new reactor builds but also across the entire nuclear fuel cycle.

Securing financing for upstream activities (such as enrichment), midstream infrastructure (such as reactor deployment) and downstream obligations (including spent fuel handling and decommissioning) is critical to enable long-term sustainability.

As global interest in nuclear energy grows to meet decarbonization goals, restoring investor confidence and deploying innovative financing models will be essential to mobilize the scale of capital required across this complex value chain.

		Advanced economies	China	Rest of the world
Mining	Annual production (2022) 49,490 tU	Orano, Cameco, Energy Fuels, BHP and General Atomics	GCN and CNNC	TVEL Rosatom, Armz Mining Machinery Rosatom, Uranium One, NMMC, Kazatomprom, UCIL and Maaden
Conversion and enrichment	Annual capacity (2022) 61,500 tSWU	Orano, Cameco, Converdly, Centrus and Urenco	CNNC	Kazatomprom x CGN, TVEL Rosatom, Indústrias Nucleares do Brasil, India Department of Atomic Energy and CNEA
Fuel fabrication	Annual LWR fuel production capacity (2021) 15,500 tons	Westinghouse, Framatome, Global Nuclear Fuel and Icepco	CNNC	Kazatomprom, Rosatom, Indústrias Nucleares do Brasil and India Department of Atomic Energy
NPP construction	Electric generation (2023) 2,600 tWh	(Large or SMR) EDF, Candu, Westinghouse, Toshiba, Mitsubishi Heavy Industries, ICHNP, GE Hitachi, Icepco, Roll Royce and Holtec International	GCN and CNNC	BHEL, Rosatom and Indian Department Of Atomic Energy
		(SMR specialists) Newcleo, Nuward, Xenergy, Nuscale, Thorizon, Oklo, Steady Energy, Kairos Power and Terrestrial Energy	Tsinghua University	Kaeri and Inpav x CNEA
Spent fuel storage	Near-surface storage often directly on the site of the NPP. France, Japan, Spain, the UK and the US	Orano, Holtec international, Westinghouse, Nac International, GNS and Energy Solutions	CNNC	Rosatom
Reprocessing and disposal	Reprocessing capacity (2022) 3,860 tons Deep geological deposit	SKB, Cigéo Andra Project, Japan Nuclear Fuel Limited, Orano and Posiva	CNNC	Rosatom
Decommissioning	Number of decommissioned reactors by 2050 150-200	Orano, Holtec International, Energy solutions, Cyclife, Aecom, Westinghouse, NorthStar Group Services Inc., Jacobs, Sogin and Cavendish Nuclear	CNNC	Rosatom, Javys, Necca and Indian Department of Atomic Energy

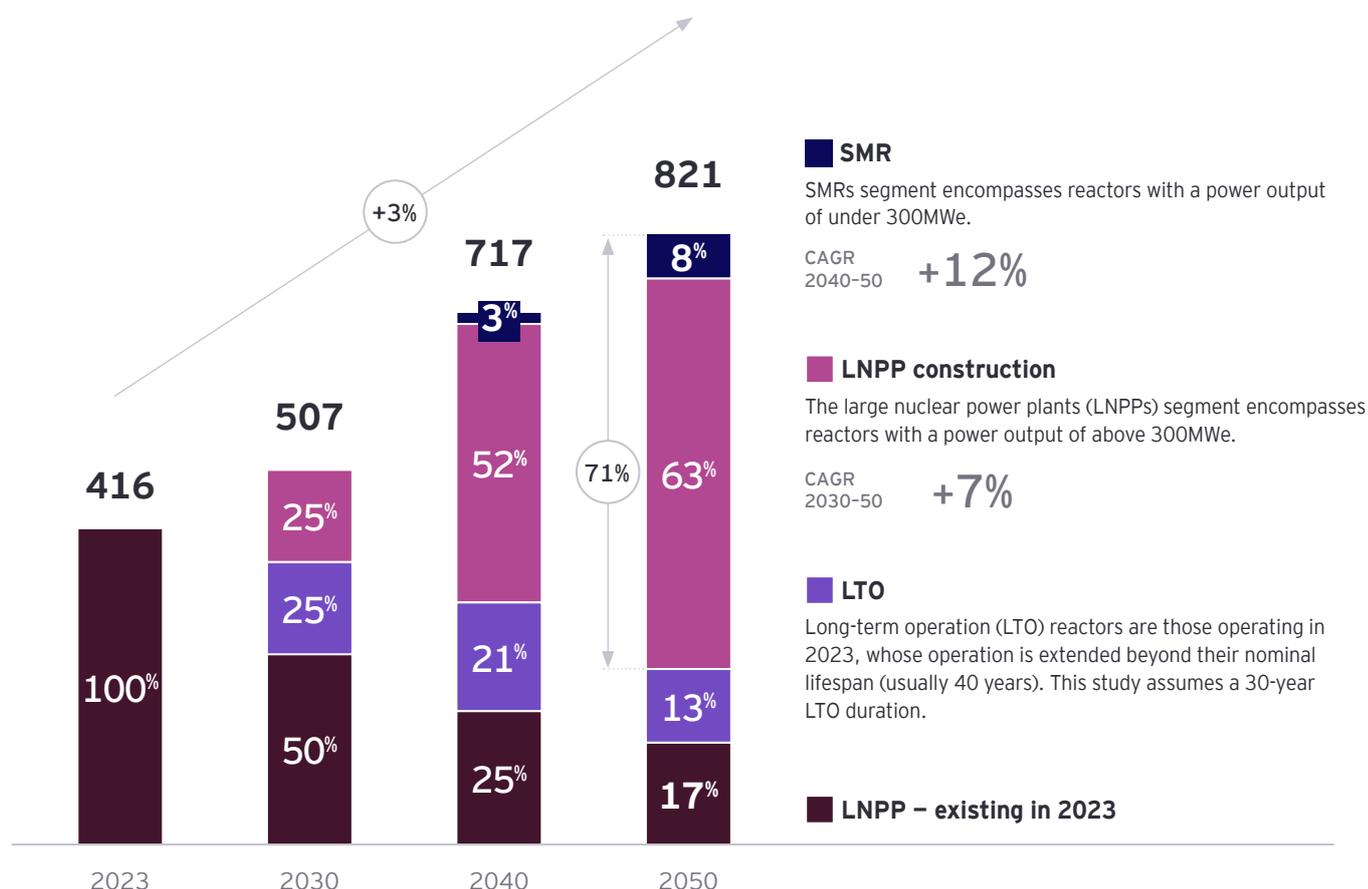
1 Scaling nuclear: from ambition to action



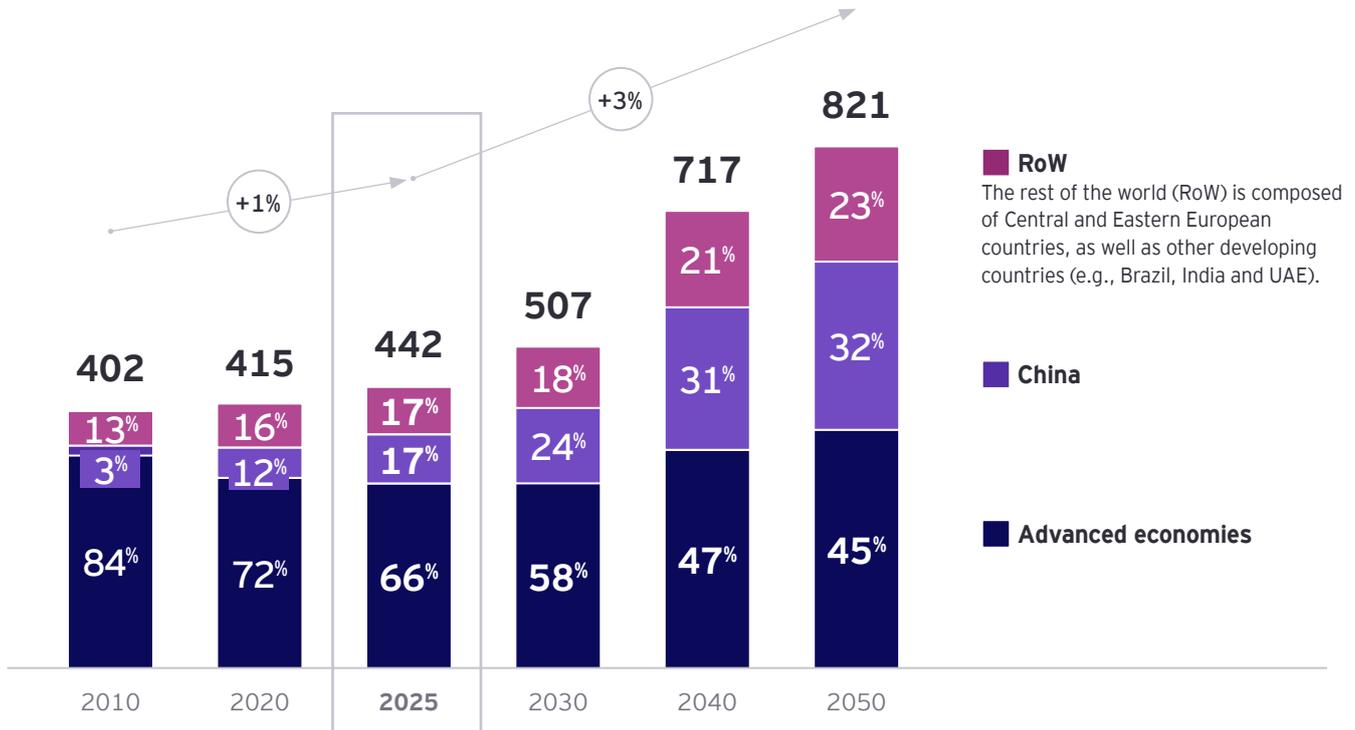
Unlocking market potential as IEA scenarios take shape

Nuclear capacity is expected to reach approximately 821GWe by 2050, of which approximately 71% is yet to be built. In advanced economies, it is expected to grow moderately, while market share for China and the rest of the world is projected to increase from approximately 30% in 2020-25 to approximately 55% in 2050.

Nuclear capacity forecast by type of plant (GWe installed base)



Unlocking market potential as IEA scenarios take shape

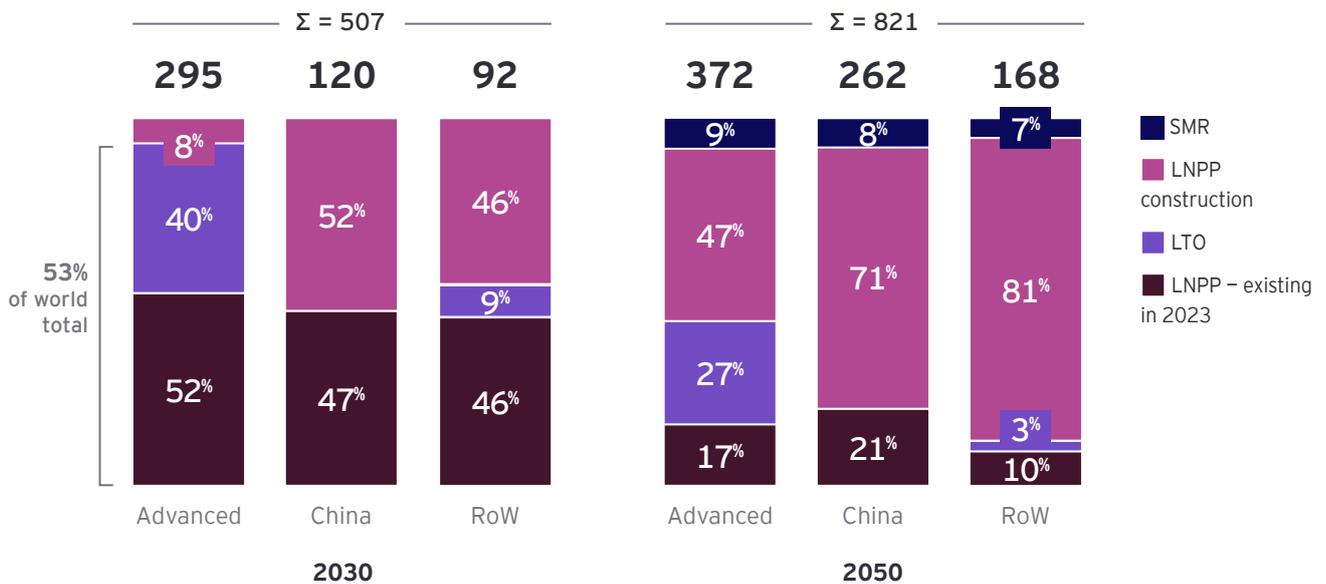


Regional outlook for nuclear growth

- Advanced economies experienced a slowdown in nuclear capacity between 2010 and 2025, largely due to the Fukushima accident in 2011, which led to nuclear phase-outs in countries like Japan and Germany, as well as a general decline in new investments across the OECD.
- A recovery in nuclear capacity is expected in advanced economies between 2025 and 2040, driven by renewed commitments in countries, such as:
 - France, with the EPR2 program aiming to add 10GW to 23GWe
 - The UK, through projects like Hinkley Point C and Sizewell C
 - Poland, Czech Republic and Sweden, which are launching or expanding national nuclear programs
- China will remain the primary engine of global nuclear growth, building on a long-term strategic roadmap initiated with its 10th five-year plan in 2007. The country is targeting 200GWe of nuclear capacity by 2035, according to CGNPG's 2019 projection.

While advanced economies will perform LTO on their existing plants, China will build new large NPPs

Nuclear capacity breakdown by region x type of plant (GWe installed base)



How will global nuclear capacity evolve between now and 2050?

- **SMRs** new builds will contribute from the next decade (technological breakthrough) to approximately **+2 to 5 net GWe per year**.
- **New LNPP builds** add, on average, **+14 to 24 net GWe per year** over the whole period.

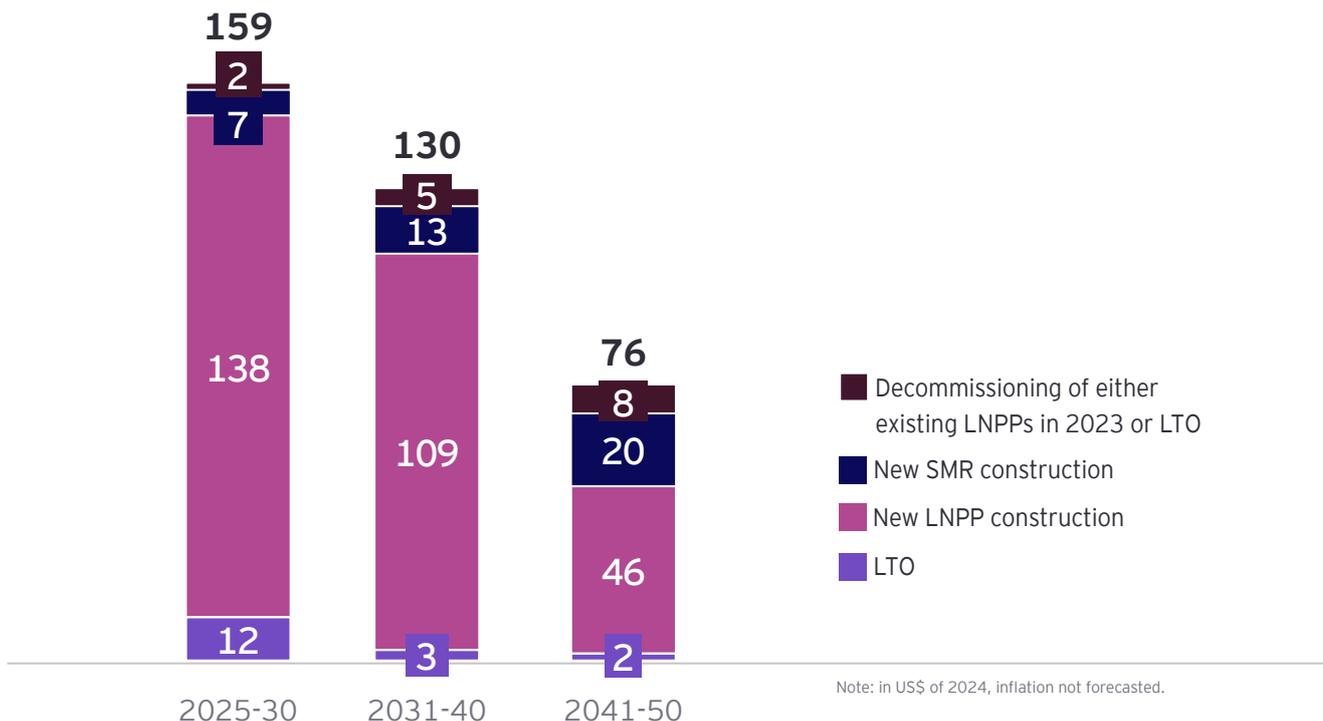
- **LTO** will play a major **role in power plant status change** from **2024 to 2030**, as most **existing capacities** will go through **retrofitting and be considered LTO**.
- **Decommissioning** will account for **-7GWe per year** from 2024 to 2030, primarily in RoW and advanced economies. In **2041 to 2050, advanced economies will strongly drive the decommissioning at -9GWe per year**.

2

The economics of nuclear expansion

Estimated **NPP investments** needs will reach their **peak in 2025-30**. Total annual NPP investments are expected to reach approximately US\$159 billion by the year 2025-30, driven by LNPP construction. **Most of the required investments need to be deployed rapidly to reignite momentum and revitalize the nuclear industry.**

Yearly nuclear investment need by type (US\$ billion per year)

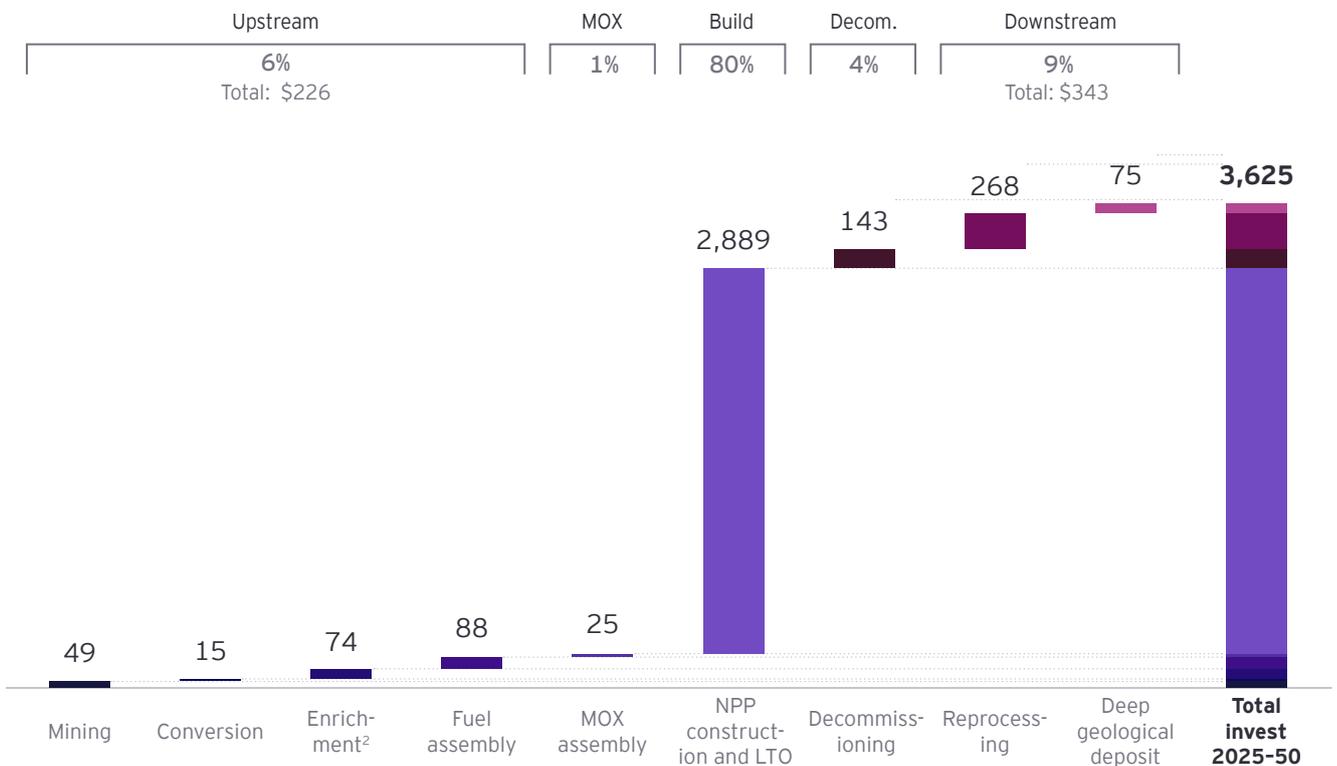




The nuclear investment need from 2025 to 2050 is approximately US\$3,600 billion, with about 90% allocated for NPP construction and LTO.

EY-Parthenon assessed investment needs across the entire nuclear value chain – from upstream activities (mining, conversion and enrichment) to generation, and downstream processes (pool storage, reprocessing and long-term disposal).¹

Total nuclear investment need for each value chain step (world, cumulative US\$ billion 2025-50)



Note: in US\$ of 2024, inflation not forecasted.

1. NB: Both upstream and downstream capacities were scaled to match projected generation volumes by 2050, ensuring a balanced and realistic view of system-wide requirements. The sizing is grounded in real-world benchmarks, drawing on data from existing infrastructure and planned industrial projects across each segment.

2. Including Enrichment of RepU into REU2.

Significant investment needs across the nuclear value chain from 2025 to 2050

Worldwide upstream and downstream cost hypotheses (cumulative US\$ billion 2025-50)

The **downstream industry** requires the **largest share of investment** in the fuel cycle, driven by the **critical importance of safe, efficient recycling** to improve uranium recovery rates. On the other hand, highly technical phases such as **enrichment and fuel assembly** also demand substantial capital to sustain future reactor builds.

	Upstream				Downstream	
	Mining	Conversion	Enrichment	Fuel assembly	Spent fuel reprocessing and storage	Deep burying
Yearly world capacity (2022)	49,490 Tons U3O8 per entire work	62,000 Tons UF6 per year	61,500 Thousand SWU per year	20,952 Tons of enrU transformed into assembly per year	3,860 Tons of spent fuel reprocessing per year	400 Tons of HAVL per year
Total investment sized (2025-50)	US\$49 billion	US\$15 billion	US\$74 billion	US\$88 billion	US\$268 billion	US\$75 billion

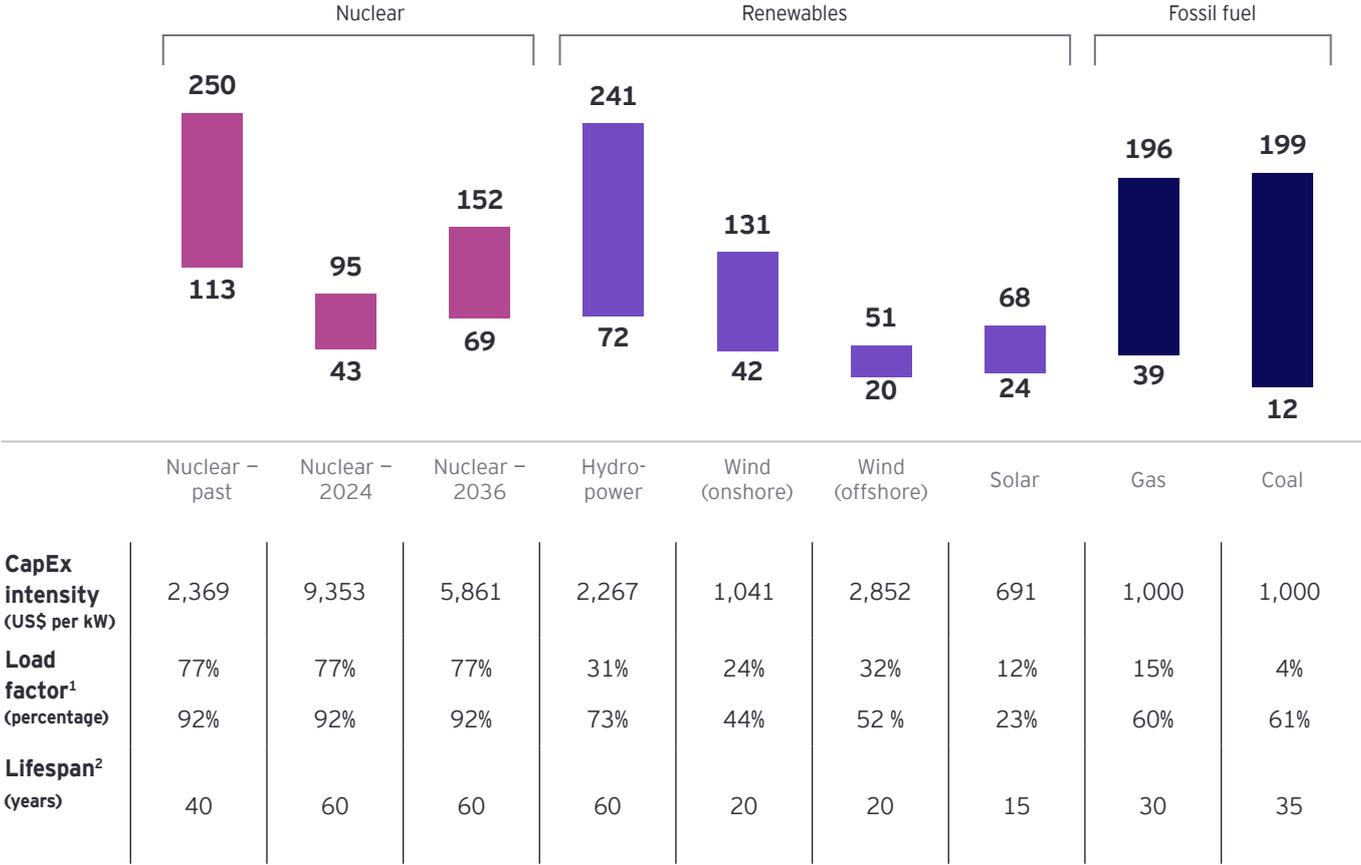
Methodology Bottom-up approach based on internal case studies

Note: in US\$ of 2024, inflation not forecasted.
 Note: MOX addressed separately. New fuels for AMRs were not considered in this study but could require significant investments for new plants.

New nuclear delivers competitive output per dollar invested

Global lifetime electricity generation measured by kWh per US\$ invested

This chart compares the **potential kilowatt-hours generated per unit of investment** across energy sources, which is key to **assessing their relative quality, value and economical attractiveness**. Nuclear plants, though capital-intensive, stand out as **long-term assets** with the **highest load factors**, positioning them **alongside other major energy sources** when deciding for future energy investment. Renewables tend to remain more agile and flexible in their deployment yet being less centralized for grid connection.

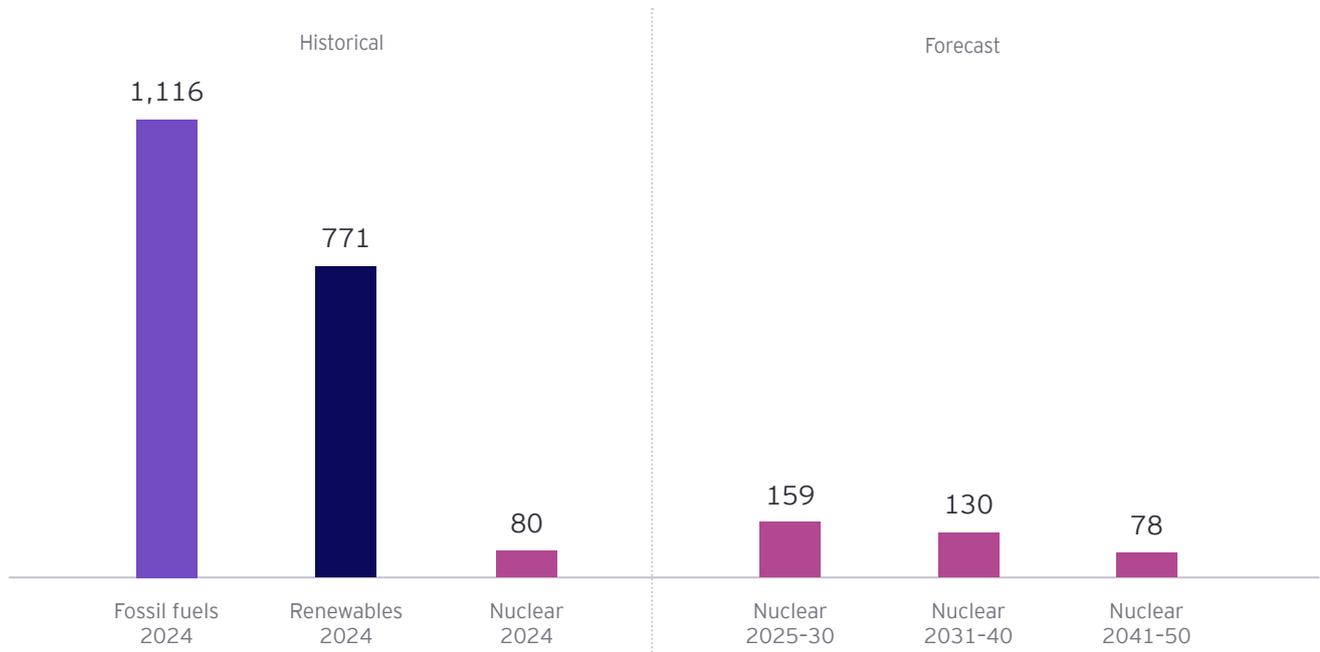


Note: in US\$ 2024, inflation not forecasted, worldwide average. Nuclear - 2024 in China reaches a 115 to 139 range. The costs of storage and grid reinforcement works for renewables are not taken into account, which could negatively affect their kWh per unit of investment.

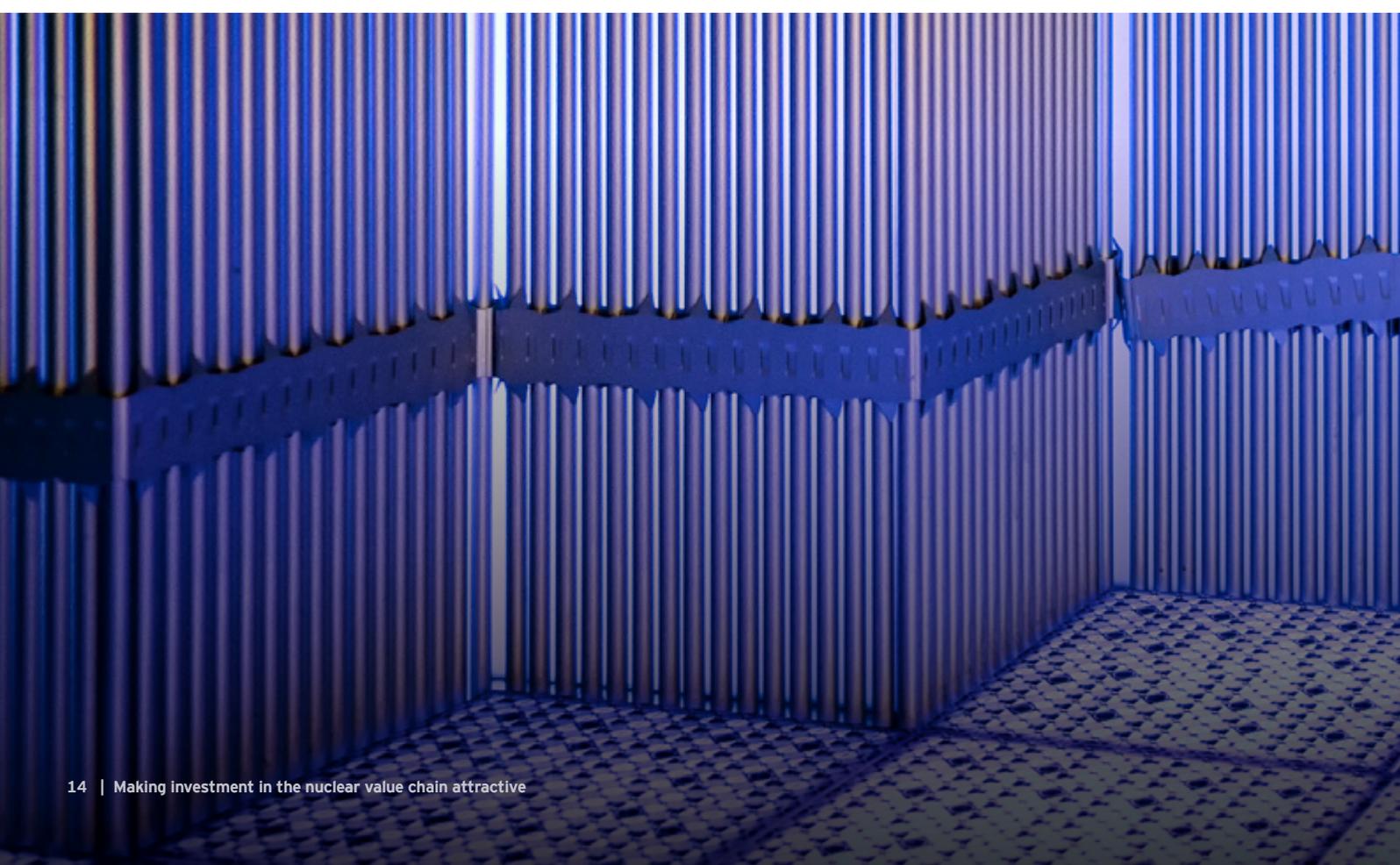
1. Minimum / maximum rate observed in countries, depending on the preferred energy mix (i.e. meteorological for renewables, and political choices for fossil fuels and nuclear energy).
 2. Lifespan not taking into account repair work and lifespan extension, requiring additional CapEx.

Annual investment by technology (US\$ billion per year)

Despite perceptions of nuclear investments as massive, a **broader view** shows that **renewables** and **fossil fuels** attract **five to 10 times more funding worldwide**.

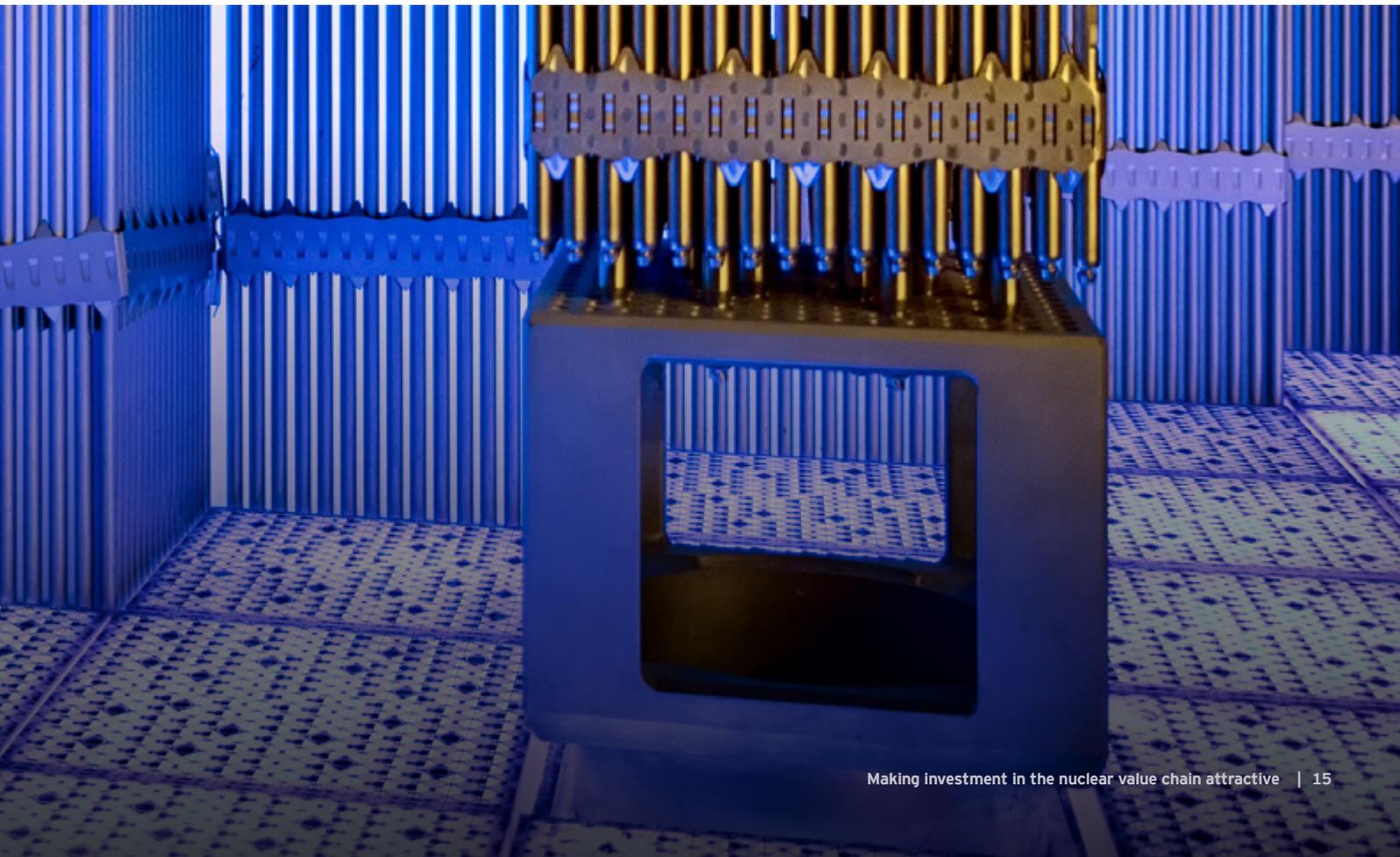
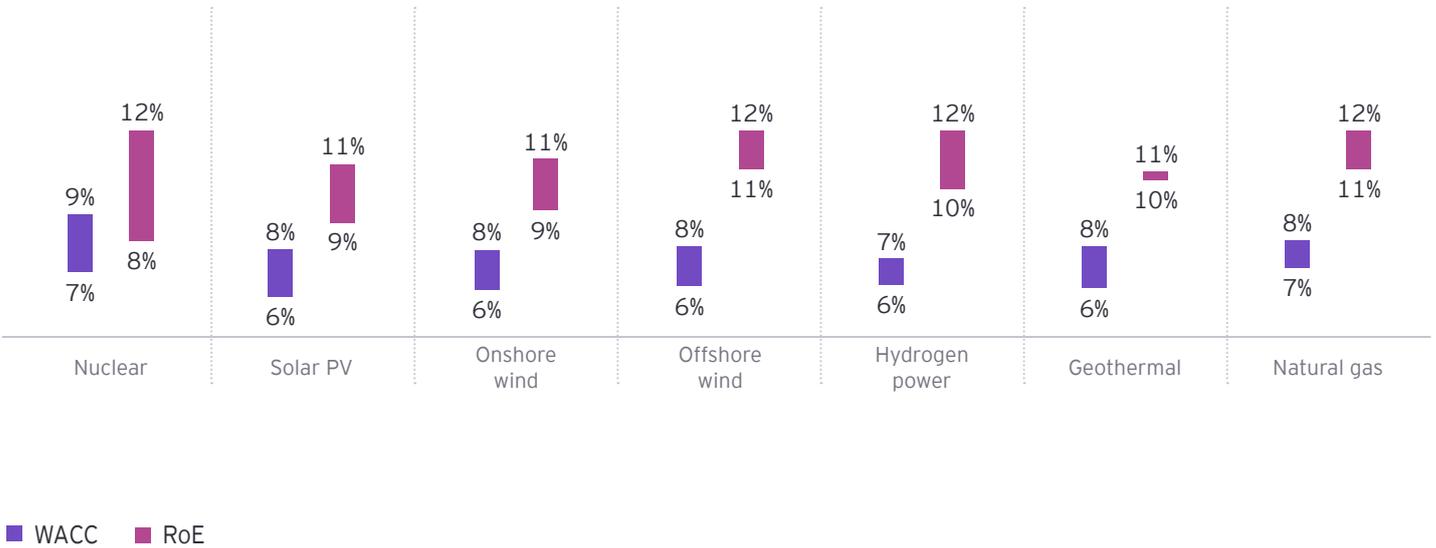


Note: in US\$ of 2024, inflation not forecasted.



Comparison of expected weighted average cost of capital (WACC) and return on equity (ROE) by technologies (2020s)

Solar PV, wind farms and geothermal benefit from **low WACC** because their **risks are well understood** and regulators are familiar with their **technical and economic fundamentals**. For nuclear, the ROE can reach lower levels driven by strong regulatory frameworks and forms of state supports often put in place; but is **still playing in the same league**.



3 | Challenges and barriers to financing



Why does private capital remain limited in nuclear build financing, and what are the structural challenges that must be addressed to unlock it?

While **nuclear energy** is **gaining traction in policy and investment circles**, its **financing** remains overwhelmingly **dependent on the state**. Today, **governments** are often the **only actors** capable of **managing the scale, complexity and risk profile** of nuclear projects – either directly through funding or indirectly through guarantees – to build good value-for-money, long-lasting and sovereign assets. Yet achieving the level of deployment required for **climate and energy security goals** will demand the mobilization of a much broader range of investors. This remains elusive. Nuclear financing continues to face **three structural barriers** that **prevent projects from being assessed** through **conventional investment metrics**, such as **IRR**, and from **attracting the volume of capital required**.

As a result, private investors remain largely on the sidelines, unlike in sectors such as renewables or oil and gas, unless the **state assumes nearly all the project risks**. To change this dynamic, **tailored risk-sharing mechanisms** must be designed to enable private actors' participation. While **strong public backing remains necessary**, it is no longer sufficient on its own. Unlocking private capital at scale will require **rethinking how risk is allocated, mitigated** and ultimately turned into **bankable opportunities**.

Main financing deterrents

Explanation

Political and regulatory uncertainty	Long-term support and inclusion in energy planning	There is no long-term inclusion of nuclear in the energy mix and a lack of stable scaling up of competitive programs instead of one-off projects.
	Licensing, permitting and regulatory uncertainty	Inconsistent or protracted regulatory processes undermine investor confidence and financing prior to license delivery for large builds, as well as for SMRs and AMRs.
	Fuel cycle	Unresolved downstream liabilities , such as long-term waste storage and decommissioning liabilities, trigger public backlash and political delays.
Construction risk (delays and overruns)	Delays and overruns	Chronic delays (10-year average construction time) and cost inflation (increased by three to four times) erode financial viability and political goodwill.
	Incomplete design	Partially developed designs constitute a key first-of-a-kind (FOAK) risk by increasing the likelihood of rework, delays and cost escalation.
	Limited supply chain development	A weak or underprepared supply chain constrains delivery schedules and quality assurance.
	Program learning curve	Steep learning curves for countries without recent development experience raise execution and coordination risks.
Revenue risk	Exposure to market price volatility	Merchant or volatile electricity prices mean that nuclear plants, as baseload, high-capacity, high-CapEx assets, are highly vulnerable to unclear signals for long-term power pricing. Furthermore, nuclear has no fuel-price linkage to electricity prices.

“

We hardly see private investors for large builds due to construction risks.

UK investment bank

“

The nuclear industry is exposed to massive cost overruns. It is a risk that we do not want to be exposed to.

Global investment bank

Level of exposure of each stakeholder to key risk factors for new-build nuclear

States	Equity	Debt	Operator and vendor	Consumers and taxpayers	Deep dive
High	Low	Low	Moderate	Low	Deep dive
High	High	Low	High	Low	Deep dive
High Long-term hazardous waste programs	Low	No exposure	High Overflowing storage capacity	No exposure	Deep dive
High	High	Moderate	High	Moderate	Deep dive
High	High	No exposure	High	No exposure	
Moderate	Moderate	Low	Moderate	No exposure	
High	Moderate	Low	High	Low	
High Via state guarantees	High	High Revenues needed to pay debt interests	High	High Via taxpaying	Deep dive

High Moderate Low No exposure Deep dive

The state, and operators with sufficiently large balance sheets, remain the only actors able and willing to finance and underwrite nuclear programs, assuming full exposure to project risks while private players stay on the sidelines.

Political and regulatory uncertainty

Long-term support and inclusion in energy planning

- Long-term support is significantly hindered by nuclear incidents and political decisions (e.g., early shutdowns post-Fukushima, bans in Belgium and Italy, and Germany's phase-out). Although, for nuclear incidents, insurance or other risk-sharing and transferring mechanisms can be a mitigating factor.
- By contrast, China has maintained uninterrupted state planning and investment; while new countries have placed nuclear firmly on their agenda (e.g., Poland, Czech Republic).

Licensing, permitting and regulatory uncertainty

“

Licensing and permitting requirements are a significant risk driver for investors. For SMRs, such requirements are still uncertain, as the technology is not mature yet and may be as high as for large nuclear plants. On the contrary, if these requirements are lighter, it could drive more opportunities for private capital investment.

European utility

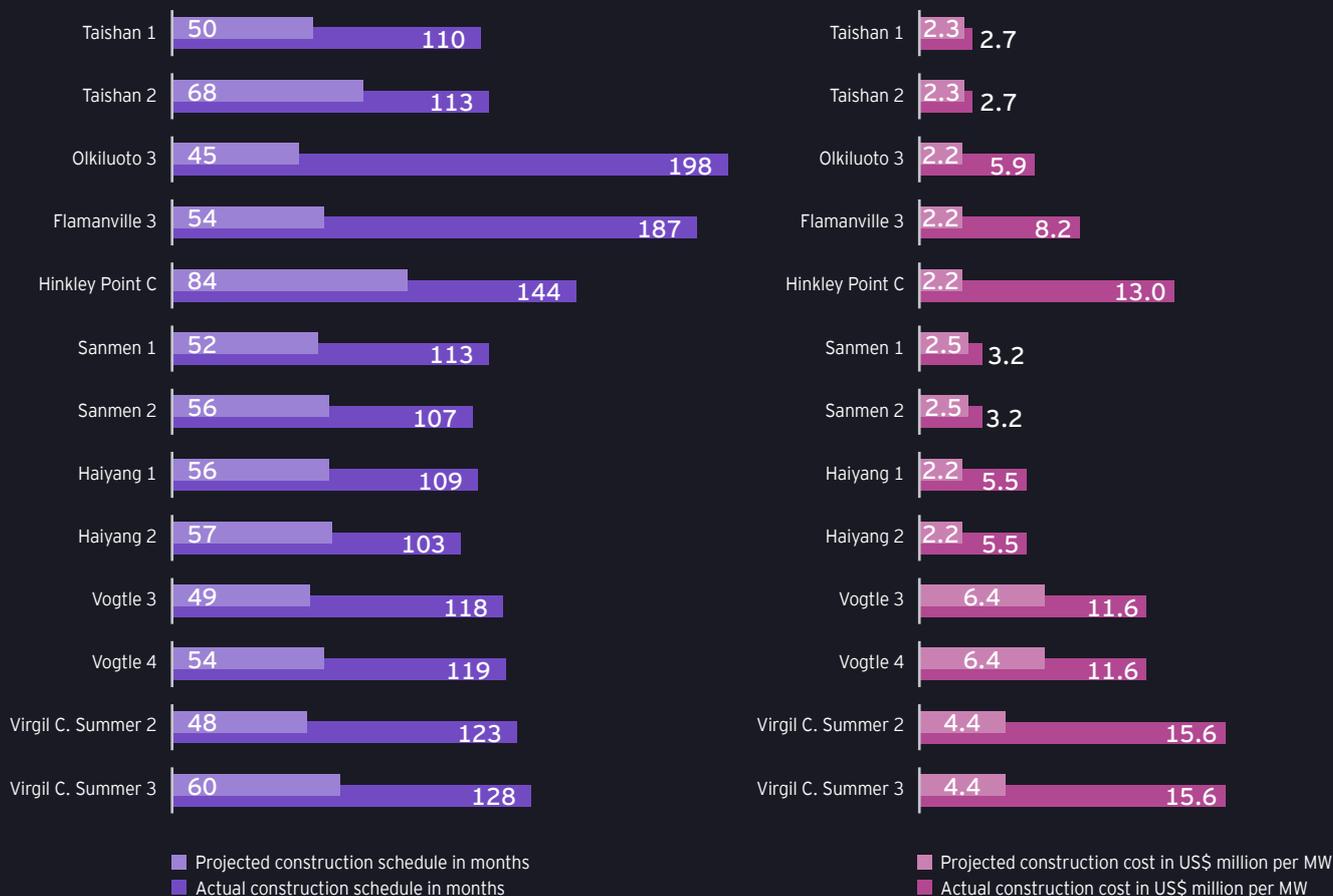
Fuel cycle

“

The fact that nuclear fuel is excluded from the taxonomy is a major obstacle; it deters investors from engaging in a sector already under scrutiny. These projects are long, risky and potentially very costly, making it difficult to raise capital in the markets. For one of the two The Hague plants, full funding came from foreign customer advances and state financing for the first project in the 1980s. With low margins compared with the committed CapEx, strong guarantees are essential on the future revenues.

Up and downstream utility

Construction risk (delays and overruns)



“

The fundamental bankability issue for nuclear projects remains the construction risk. There is a high likelihood of funding shortfalls due to delays or cost overruns. Until this risk is properly managed, non-recourse financing of nuclear projects under project finance principles seems unlikely. The EIB is however considering providing venture debt product to support early-stage nuclear developers and supply chain providers or corporate loans to established corporates in the sector.

European investment bank

Nuclear power plant construction costs have surged due to three main factors:

- The tightening of safety standards, reflected in new features in new designs (e.g., core catchers and diesel redundancies).
- The loss of the “series effect” observed in specific designs (AP1000 or EPR program) or in large unit scaling (e.g., Barakah case) could target altogether up to 25% in cost saving.
- The progressive erosion of industry expertise and skilled labor over decades (e.g., NPP design and welding).

Of these factors, tighter safety standards are structural, whereas scale effects and skill capabilities can be regained.

Revenue risk

The electricity market is subject to fluctuations, while nuclear plants require defined thresholds to remain financially viable. Clear breakeven points are therefore essential to secure a revenue safety net and support stability.



“

The second risk after construction, in liberalized markets, is revenue risk. No investor would invest in capital-intensive technologies such as nuclear facilities (or renewables) without some form of price certainty. This becomes particularly challenging in systems with a high penetration of variable renewables, where significant price volatility can occur and is already observed.

IAEA

“

A critical issue with nuclear projects is investors' patience regarding the extended timeline for receiving initial dividends. This extended timeline is likely to exclude many investors until Europe, specific countries or specific technologies can demonstrate a reliable track record.

European utility

Against those barriers, traditional metrics like IRR do not suit nuclear projects; alternative KPIs are needed to assess project value

“

We ask ourselves: Could the project be phased into distinct stages, each with its own IRR and WACC structure?

Finance manager, European utility

Nuclear IRR versus other KPIs for private investors



Payback ratio

- **Payback** becomes the **threshold** – everything beyond is upside
- Payback **ignores discounted cash flows, unlike IRR**
- **Payback is pushed back significantly due to the long construction and development timeline**

IRR generation on fixed margin

- Utilities typically **operate at EBITDA margins of over 60%, which allows for a very high debt quantum in the financial plan**
- However, due to **heavy discounting** of the cash flows and long payback periods, **IRR generation is significantly reduced**
- **To avoid “rent-seeking”** dynamics, as seen in other public infrastructures (e.g., highway concessions in France), the state is often keen to regulate the potential returns of nuclear assets

Economical, social and environmental impact

- **x2 to x2.5 economical multiplier** (direct, indirect and induced value)
- **x3 social multiplier** (direct, indirect and induced jobs) for 3,000 to 9,000 construction jobs created (SMR-LNPP)
- **Lowest mortality rate** (90 deaths per PWh compared with over 100 and over 4,000 for renewables and oil and gas)
- **Low direct and indirect CO2 emissions**
- Strong impact on **energy sovereignty**

Declining financing risk in nuclear power with risk mitigation and support

Evolution of WACC and RoE for nuclear power

