Capital costs challenge: how to overcome the issue in CESA nuclear power projects

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Executive summary

Nuclear power is crucial to safeguarding secure electricity supplies in Central and Southeastern Europe and Central Asia (CESA). Eight countries – Armenia, Bulgaria, the Czech Republic, Hungary, Romania, Slovakia, Slovenia and Ukraine – account for 7% of the global nuclear reactor fleet and generate nuclear power representing 22% of their electricity mix, which is double the global average.

In line with the global goal of tripling nuclear power capacity by 2050, the CESA region is planning its own expansion. Countries with existing nuclear assets are exploring additions and are termed first-in-a-while markets, while newcomers, such as Türkiye, Poland, Kazakhstan, and Uzbekistan are planning to launch their first large nuclear power plants (LNPPs). They are all also considering the possibility of launching small modular reactors (SMRs).

However, the economics of developing viable nuclear power generation are complex and risky. Typically, a long, difficult and capital-intensive design and construction phase is followed by a long economic lifetime of low fuel costs, relatively low operating costs and a high capacity factor. Success in such a venture depends heavily on the cost of capital, influenced by investor risk assessments, legal frameworks, national energy policies, and political contexts. The EY organization estimates the weighted average cost of capital (WACC) for nuclear newbuilds at between 5% and 15%, compared with between 5% and 8% for solar and wind. Changes in WACC significantly impact electricity costs and project competitiveness.

This report provides insights into the financial risks of nuclear newbuild projects in the CESA region and proposes mitigation strategies. Strong governmental commitment is critical to investor confidence and adequate financing of new nuclear power plants relies upon a combination of pricing and revenue guarantees plus de-risking mechanisms. Mechanisms such as power purchase agreements (PPAs), contracts for difference (CfDs) and regulated asset base (RAB) models can ensure stable and adequate cash inflows, while a robust de-risking mechanism can reduce or transfer the risk of unexpected cash outflows related to cost overruns, delays and regulatory changes.

The findings of this report are based on EY CESA Energy Center extensive research, analysis, and EY experience in the nuclear power sector.

Introduction

The global drive toward energy transition is significantly reshaping the geopolitical landscape, as explored in the EY annual Geostrategic Outlook.[1] This transition presents a crucial opportunity for nations to achieve energy security, mitigate climate risks, and enhance economic resilience through the adoption of clean energy solutions. As industries, car fleets, and space heating become increasingly electrified, and as data centers expand across the world, we expect the demand for electricity to rise.

One of the primary challenges in this transition is the inherent intermittency of modern renewable energy sources such as wind and solar power.

These sources can complement technologies that offer flexible dispatch capabilities, meaning they can be activated or deactivated at short notice. While the choice of clean energy sources remains a sovereign decision, tailored to each country's unique needs, the resurgence of nuclear power is gaining recognition as a vital component of a sustainable energy system.

Currently, nuclear power supplies approximately 5% of global primary energy and 9% of electricity. There is increasing acknowledgment of its role in decarbonizing both electricity and non-electric energy production, especially when used in conjunction with renewable energy and other low-carbon solutions. The investment in nuclear power was projected by the International Energy Agency (IEA) to reach US$80 billion in 2024 (9% of total investment in clean energy).[2]

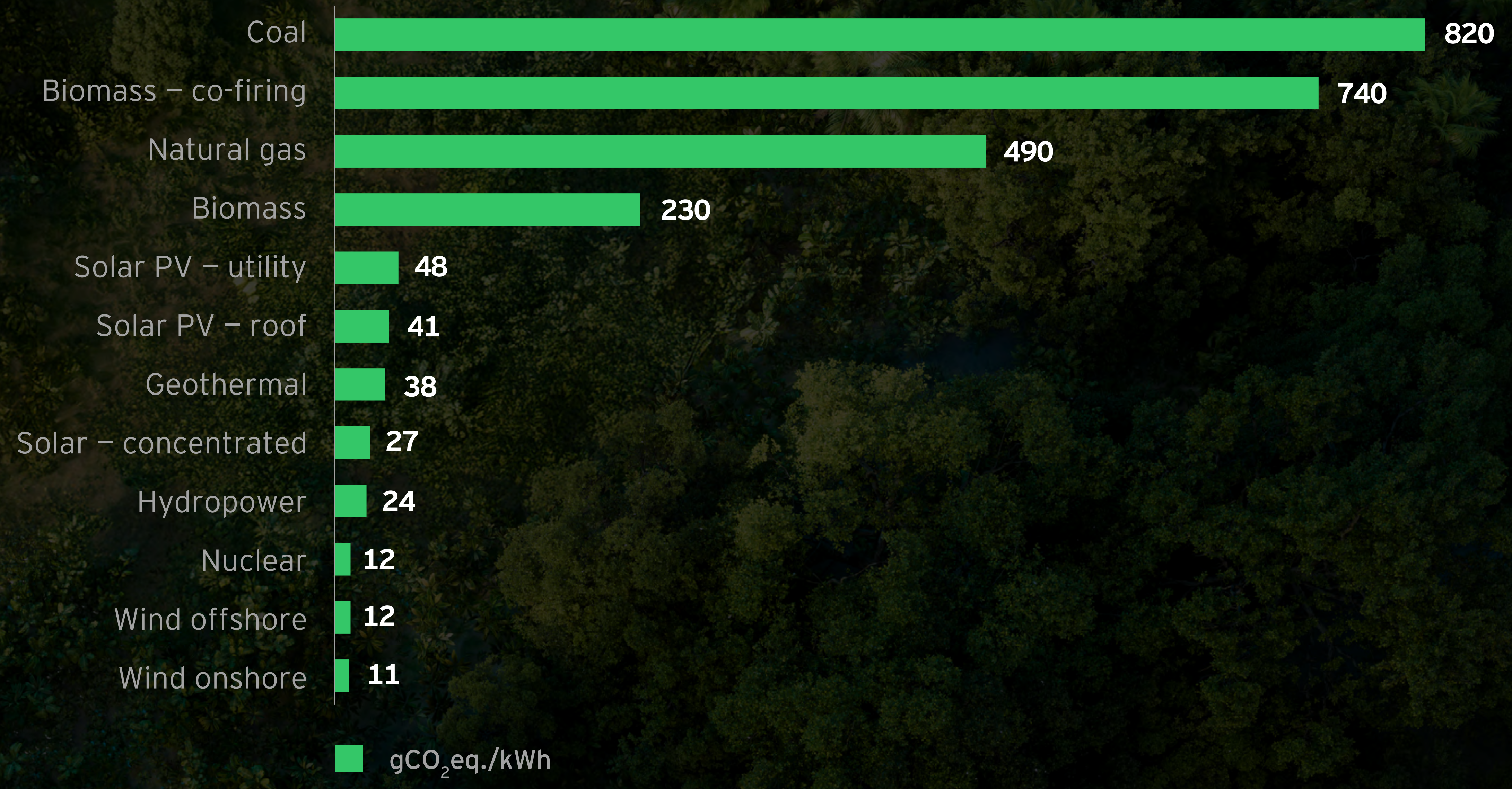
Unlike intermittent renewables, nuclear power has already proven its ability to provide reliable and flexible power around the clock. Additionally, its lifecycle emissions are comparable with those of solar and windenergy.[3]

Global electricity currently supplied by nuclear power:

9%

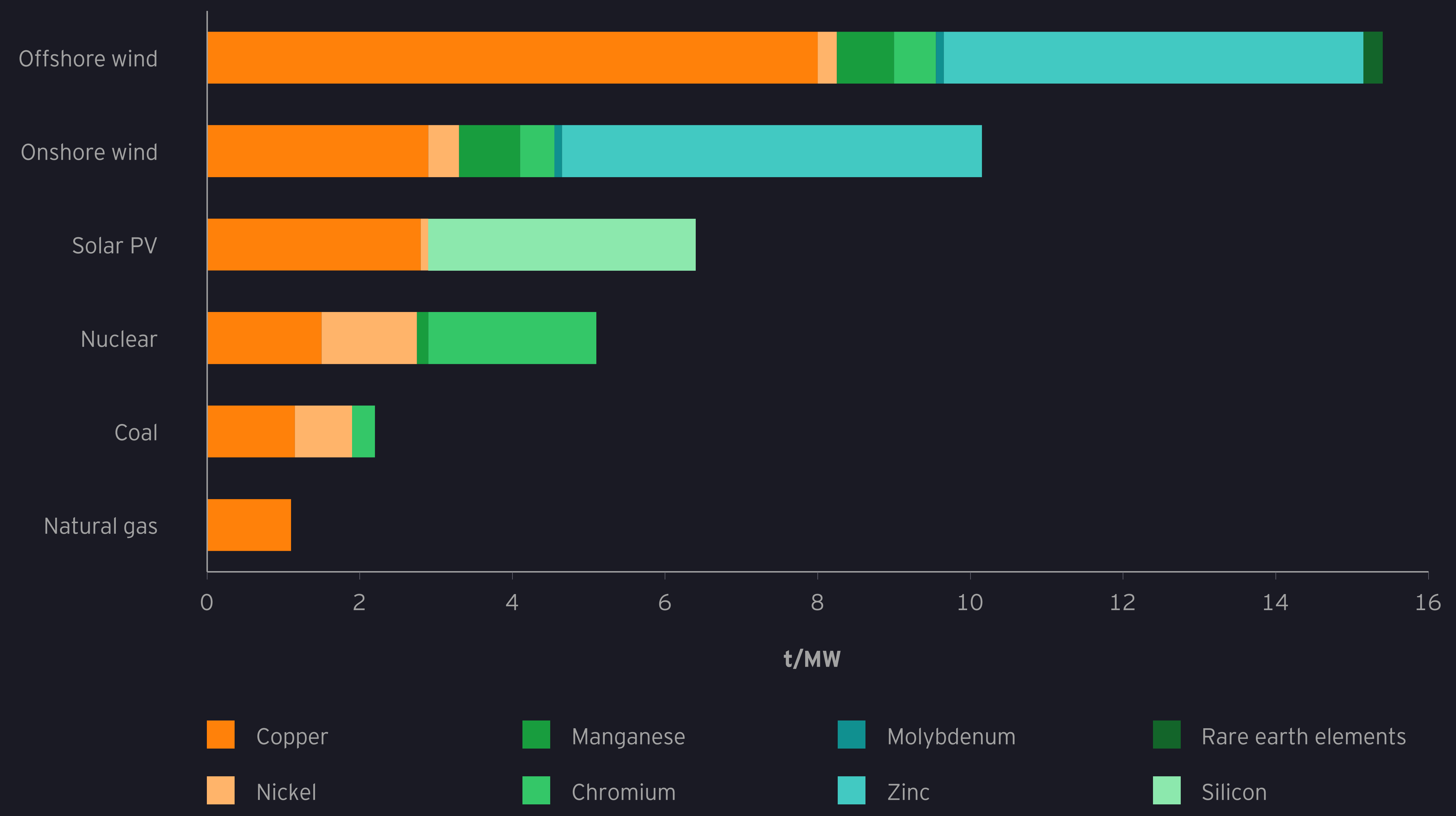
The integration of nuclear power across electricity, heat, and hydrogen production could prevent 90 gigatonnes (Gt) of CO_2 emissions worldwide by 2050[4], averaging 3 Gt annually. This reduction represents 8% of global emissions in 2023, underscoring the significant potential of nuclear power in achieving a sustainable and decarbonized energy future.[5]

Figure 1.
Average lifecycle CO_2 equivalent emissions



Source: IPCC

Figure 2.
Critical minerals required for generating technologies



Note: The IEA's analysis excludes some common metals such as steel and aluminum, as well as concrete, all of which are key bulk materials widely used across many clean energy technologies.
Sources: International Energy Agency, World Nuclear Association

A more mature technology than renewables and carbon capture, nuclear power also requires a lower volume of critical minerals (5.3 tonnes per 1 megawatt (MW) capacity) than renewables such as offshore wind (15.5 tonnes), onshore wind (10.1 tonnes), and solar (6.8 tonnes).[6]

Nuclear power plants also generate more power with less land use – more than 30 times less than solar facilities and over 170 times less than wind farms.[7]

While there are valid concerns about nuclear waste, which can remain radioactive for thousands of years[8], there are also legitimate issues with renewable waste. Wind and solar generate a litany of chemical wastes including toxic heavy metals like cadmium, arsenic, chromium, and lead, which could be dangerous forever.[9] All this waste needs proper management and decommissioning. There is broad agreement on deep long-term geological disposal as the best solution for final disposal of the most radioactive waste produced. For example, Finland recently began a trial run of Onkalo, the world's first geological repository licensed for the disposal of used fuel from civil reactors, which is located at a depth of 400 to 430 meters and designed to accommodate 6,500 tons of spent fuel.[10]

Nuclear power plants require substantial quantities of concrete, averaging 180 tons per MW,[11] as it is a crucial material for both power generation and radioactive waste storage facilities. However, the demand for concrete is also high in renewable energy projects, often in even greater volumes. For example, the foundations of wind turbines use between 243 and 400 tons of concrete per MW installed.[12]

Therefore, nuclear power can complement low and zero-carbon power sources and can drive clean energy directly through energy-intensive sectors. Not only does it have a key role to play in energy transition, but its potential is realizable if the industry can step up to meet this moment of need.

Many nations opt for nuclear energy to meet their climate objectives and commitments by countries are increasing.

Global pledge to triple nuclear power capacity:

FROM
390GW
in 2023

TO ALMOST
1,200GW
by 2050

01

Global commitments to nuclear energy are expanding rapidly

The 28th UN Climate Change Conference in Dubai in late 2023 launched the Declaration to Triple Nuclear Energy[13] from approximately 390GW in 2023[14] to almost 1,200GW by 2050.

It was endorsed by 25 countries, including the US, the UK and France, as well as nations from CESA, such as Armenia, Bulgaria, Croatia, Czech Republic, Hungary, Moldova, Poland, Romania, Slovakia, Slovenia and Ukraine.[15, 16, 17, 18] At the 29th Conference in Baku in 2024, the other six countries, including Kazakhstan, pledged to triple their nuclear power capacity by 2050.[19] Small modular reactors (SMRs) could comprise nearly half of the nuclear expansion.[20]

Fast-increasing data collection combined with the rise of cloud services and artificial intelligence (AI) have resulted in a rapid and significant need for new data centers, which are energy intensive. The needs of data centers worldwide could increase from 460TWh in 2022 (1.5% of global electricity demand) to up to 1,000TWh in 2026, comparable with Japan's total electricity consumption.[21, 22] For example, the US Department of Energy projects growth of data center energy demand from 176TWh in 2023 to between 325TWh and 580TWh by 2028.[23]
In an already tight power market, additional clean energy demand will result in tighter supply. As a result, tech companies are increasingly turning to nuclear power to meet the growing electricity needs. Big tech firms[24, 25, 26, 27] are now exploring collaborations directly with advanced reactor developers and traditional industry players, such as utility companies, to promote new nuclear projects.

Another significant sectoral candidate for nuclear offtake and investment is the mining industry, which is crucial not only for producing the materials and critical minerals necessary for the clean energy transition but also because it is particularly challenging to decarbonize. For example, a Polish grid-connected copper and silver producer is advancing a project to deploy SMRs to generate over 400MWe of electricity to power its operations by 2029.[28]

Micro SMRs could be vital for companies extracting critical minerals such as rare earth elements, niobium, lithium, cobalt and copper, especially in remote areas. This highlights the importance of off-grid mining to maintain a secure supply chain essential for the clean energy transition.[29]

Tripling global nuclear energy capacity requires a cumulative investment of between US$3 trillion and US$9 trillion[30, 31] by 2050. The EU will need more than US$250 billion.[32]

While capital markets and financing play a critical role in developing and growing nuclear energy projects worldwide, a group of 14 major financial institutions pledged support for the call to triple global nuclear energy capacity by 2050 globally.[33]

Tripling existing nuclear capacity could require over US$150 billion annually (double current investment level), necessitating that nuclear projects demonstrate bankability by effectively managing financial risks. Construction and investment costs account for a substantial proportion of the expenses, making it crucial to mitigate risks associated with cost overruns and delays.[34]

The EY Energy & Resources Transition Acceleration Model also projects growth under the current market environment, albeit lower than committed by market players. In a scenario with a 1.5 x accelerated trajectory, we expect global nuclear capacity to increase by 70% by 2050 and by 91% in a 2 x accelerated scenario. For comparison, the IEA Net Zero Emissions scenario considers approximately 140% growth between 2023 and 2050.[35]

As of mid-2024, there are 64 nuclear reactors under construction (i.e., first concrete pour for the reactor) worldwide, totaling over 70GW, which is 18% of the current operating capacity. China accounts for half of this construction, with other Asian nations such as India, Japan, South Korea and Bangladesh building 19%. This indicates a shift in nuclear development from established to emerging economies.

About 85GW of global nuclear capacity projects have the necessary approvals and 365GW remain proposed (i.e., have specific program or site proposals but lack a definitive timeline for completion).[36] Cumulatively, the pipeline of projects accounts for 130% growth from the current capacity.

The CESA region[37] contributes 10% to global nuclear capacity under construction and 8% to planned and proposed volumes.

However, nuclear is a more difficult investment story to sell than renewables such as solar and wind due to prohibitive costs, deployment timelines, technological hurdles, as well as safety and waste management issues.

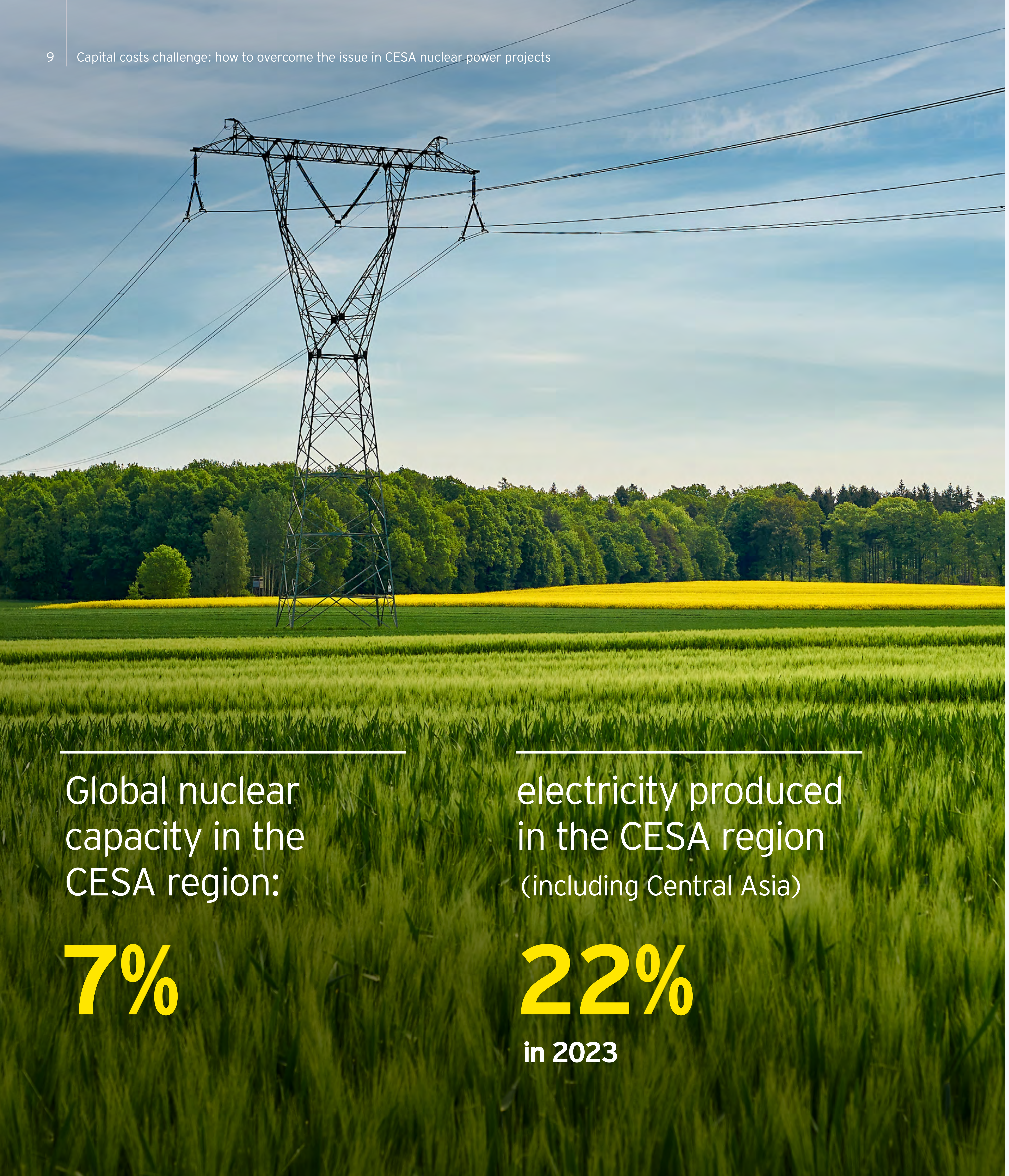
The aim of this report is to identify the role of the CESA region in the global nuclear power renaissance and highlight the key challenges to faster growth.

Figure 3.
Nuclear power capacity growth worldwide, GW

Note: accelerated trajectory – industry and government collaborate to beat the agreed target and commit to make significant changes that prioritize sustainability, limiting global warming to 1.5 degrees by 2050; 2-degree trajectory – industry and government work together to deliver the technology-enabled products and services needed to meet the agreed goal, keeping warming to 2 degrees by 2050.
Source: EY Energy & Resources Transition Acceleration Model

New global nuclear projects:

ABOUT
85GW
have the necessary approvals **of mid-2024**



Global nuclear capacity in the CESA region:

7%

electricity produced in the CESA region (including Central Asia)

22%

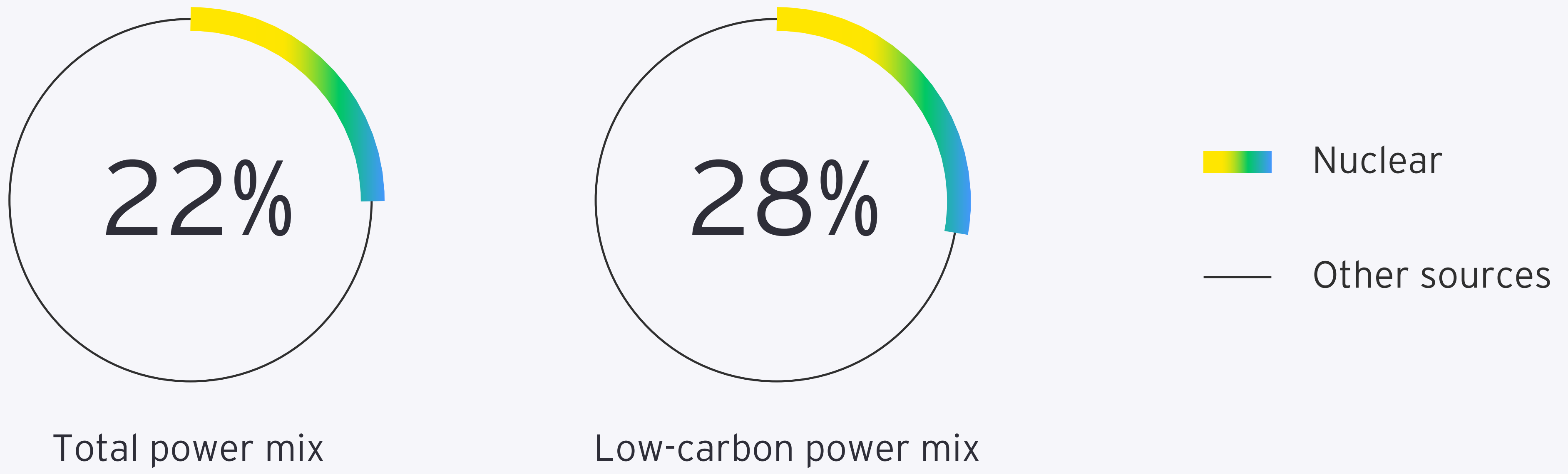
in 2023

02

The CESA region is playing a valuable role in the global nuclear power sector

Nuclear energy, accounting for 22% of the electricity produced in the CESA region (including Central Asia) and representing almost a third of low-carbon electricity, plays a crucial role in delivering low cost, clean, reliable baseload energy.

Figure 4.
Nuclear share in total and low-carbon electricity generation in the CESA region in 2023



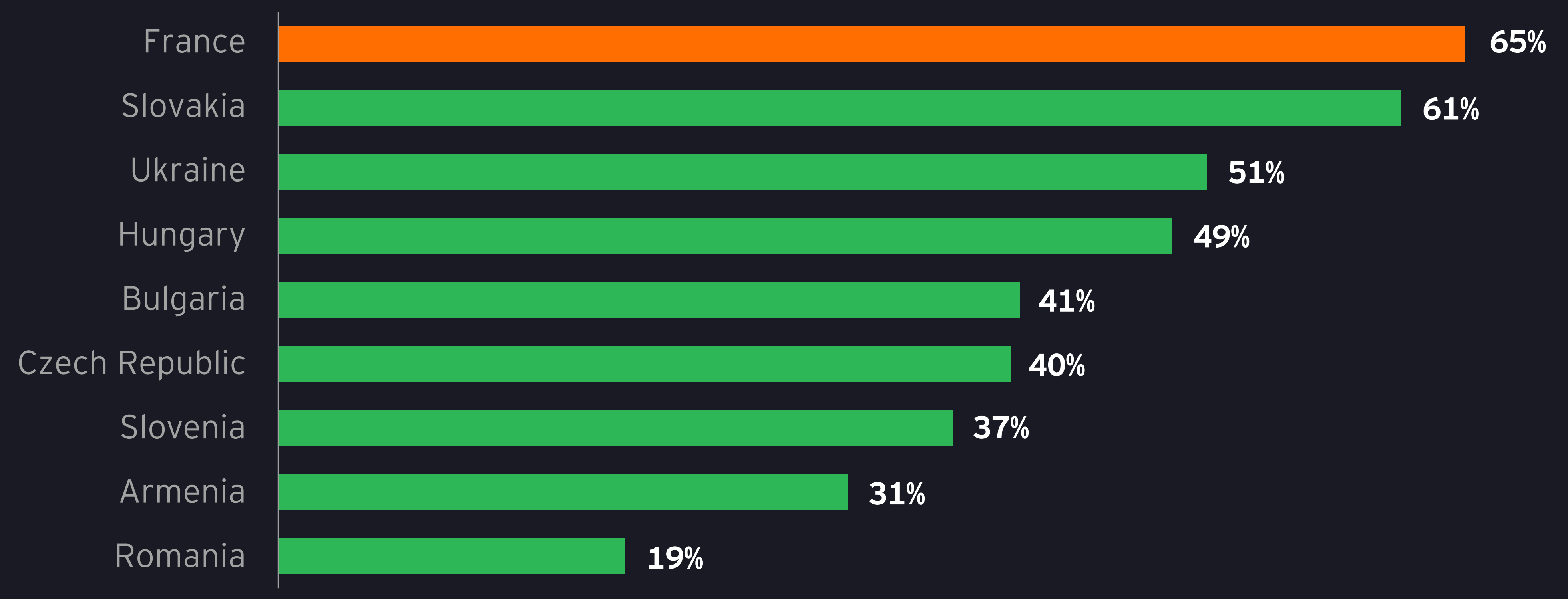
Source: IPCC

The share of nuclear power in the CESA region's energy mix varies from

20% to 60%

Figure 5.

Share of nuclear in the power mix of CESA countries versus France, 2023



Source: Statista, IAEA

Of 29 analyzed countries[38] in the CESA region, eight have active nuclear power generation. The share of nuclear power in the CESA region's energy mix varies from 20% to 60%, depending on the country.

The greatest shares are in Slovakia, Ukraine and Hungary, while the lowest of below 20% is in Romania. Nevertheless, this proportion is still double the global average of approximately 10%, indicating that nuclear power already plays a significant role within the CESA region.

There are 36 nuclear reactors in the CESA region,[39] which account for 7% of global nuclear capacity. In 2023, these reactors were responsible for 6% of the total nuclear power generated worldwide.[40]

All operating assets in the region are pressurized water type (PWR) and Soviet-era design (Vodo-Vodyanoi Energetichesky Reactor or VVER). Only three reactors in the CESA region are based on alternative technologies. In Romania, two units utilize Canadian CANDU 6 pressurized heavy-water reactors. The unit in Slovenia, jointly owned with Croatia, operates the US-designed PWR with the two-loop primary cooling system.[41, 42, 43]

The average age of the active nuclear plants in the CESA region is slightly above the global average – 35.0 vs. 32.2 years – with the oldest reactors located in Armenia and Slovenia.[44]

The older Generation II nuclear reactors are the most common type of nuclear power plant in operation. Their advanced versions (Generation III) with improved efficiency and more safety features are active in Bulgaria, the Czech Republic and Ukraine and use the VVER-1000 design.

Table 1.
Active nuclear power assets in the CESA region

CESA country	NPP	Active reactors	Capacity (gross), MWe	Total nameplate capacity in the country, GWe	Type	Design (model)	Generation	Mean age of reactor fleet, years
Armenia	Metsamor 2	1	448	0.4	PWR	VVER-440 (V-270)	II	44.0
Bulgaria	Kozloduy 5-6	2	2,080	2.0	PWR	VVER-1000 (V-320)	III	35.4
Czech Republic	Dukovany 1-4	4	2,000	4.2	PWR	VVER-440 (V-213)	II	33.7
	Temelin 1-2	2	2,164		PWR	VVER-1000 (V-320)	III	
Hungary	Paks 1-4	4	2,027	2.0	PWR	VVER-440 (V-213)	II	39.6
Romania	Cernavodă 1-2	2	1,411	1.3	PHWR	CANDU 6	II	23.1
Slovakia	Bohunice 3-4	2	1,000	2.4	PWR	VVER-440 (V-213)	II	26.8
	Mochovce 1-3	3	1,471					
Slovenia	Krško 1	1	727	0.7	PWR	WH 2LP	II	43.4
Ukraine	Zaporizhzhia 1-6	6	6,000	13.1	PWR	VVER-1000 (V-320)	III	35.7
	Rivne 1-2	2	835		PWR	VVER-440 (V-213)	II	
	Rivne 3-4	2	2,000		PWR	VVER-1000 (V-320)	III	
	South Ukraine 1-3	3	3,000		PWR	VVER-1000 (V-302, V-338 and V-320)	III	
	Khmelnytsky 1-2	2	2,000		PWR	VVER-1000 (V-320)	III	
CESA region, total		**36**		**26.1**				
Share of global		**9%**		**7%**				

Note:
1) Pressurized water reactor (PWR) uses light water as both coolant and neutron moderator, operating under high pressure to prevent boiling and transferring heat to a secondary circuit to generate steam for electricity production. In contrast, a pressurized heavy-water reactor (PHWR) utilizes heavy water as its coolant and moderator, allowing it to efficiently use natural uranium as fuel while maintaining similar high-pressure conditions to avoid boiling.
1) VVER (Water-Water Energetic Reactor or Vodo-Vodyanoi Energetichesky Reactor) – a series of pressurized water reactor designs originally developed in the Soviet Union and now Russia.
2) CANDU (CANada Deuterium Uranium) – a Canadian PHWR design of the reactors.
3) WH 2LP (Westinghouse two-loop primary cooling) – a type of PWR developed by the US, characterized by its two-loop primary cooling system, which enhances efficiency and reliability.
4) Six reactors of Zaporizhzhia NPP in Ukraine are in shutdown condition after September 2022 due to security measures.
Sources: World Nuclear Association, IAEA, EY CESA Energy Center

12,540 MWe

in additional capacity could be achieved by first-in-a-while countries with the potential completion of projects currently under construction and those in the planning stages.

Armenia, Bulgaria, the Czech Republic, Hungary, Romania, Slovakia, Slovenia and Ukraine plan to expand or replace existing nuclear power capacity.

03

Countries in the CESA region with active nuclear facilities are now planning to expand their projects (first-in-a-while)

All eight countries in the CESA region that currently have operational nuclear power assets are exploring additions to their nuclear power fleets, including Generation III+ reactors. These reactors are "evolutionary designs" and incorporate enhanced safety features to prevent disasters such as that at Fukushima in 2011. The classification of these nuclear power markets could be first-in-a-while.

The historical foundation of such markets and their ability to scale suggest that mobilizing for new build projects will be more efficient, thereby shortening the lead time compared with first-in-kind initiatives. A local supply chain benefits from operating according to current industry practices (power producers, nuclear competency), and an existing legislative framework and regulations approved by the International Atomic Energy Agency (IAEA) and other international regulators. Experienced personnel for operation also contribute positively. However, consideration of the current environment requires update of the established infrastructure.

Moreover, a first-in-a-while country that has not built new capacity for 20 or more years is likely to have lost construction knowledge and capacities, while technology suppliers are usually located elsewhere.

Some first-in-a-while countries in the CESA region have already decided on their vendor, while others are still selecting from technology providers, limited to the US, France, South Korea, China and Russia.

Table 2.
The plans of LNPPs development in the CESA region's countries with existing active reactors

Country	Site	Capacity (gross), MWe	Type	Technology	Generation	Commissioning	Estimated capex, US$ billion (price estimate year)	Status
Armenia	Armenia 3[45]	n/a	n/a	n/a	n/a	2040	n/a	Proposed
Bulgaria	Kozloduy 7[46]	1,250	PWR	AP-1000	III+	2035	14.0[47] (2024)	Planned
	Kozloduy 8[48]	1,250				2037		Planned
Czech Republic	Dukovany 5[49, 50]	1,050	PWR	APR-1000	III+	2036	17.3[51] (2024)	Planned
	Dukovany 6	1,050				n/a		Proposed
	Temelin 3[52]	1,200	n/a	n/a	n/a	2040	n/a	Proposed
	Temelin 4	1,200	n/a	n/a	n/a	n/a		Proposed
Hungary	Paks 5[53]	1,200	PWR	VVER-1200	III+	2032	13.6[54, 55] (2024)	Planned
	Paks 6[56]	1,200				2032		Planned
Romania	Cernavodă 3[57, 58]	720	PHWR	CANDU 6	III	2030	7.4[59] (2024)	Planned
	Cernavodă 4[60]	720	PHWR	CANDU 6	III	2031		Planned
Slovakia	Mochovce 4	471	PWR	VVER-440 (V-213)	II	2025	n/a	Construction
	Bohunice[61]	1,200 (with the potential expansion to 1,700)	n/a	n/a	n/a	2038–40	n/a	Proposed
Slovenia	Krško 2 (JEK2)[62]	1,300	n/a	n/a	n/a	2040	13.1[63, 64, 65] (2024)	Proposed
Ukraine	Khmelnitsky 3[66, 67, 68]	1,089	PWR	VVER-1000	III	2026–27	n/a	Construction
	Khmelnitsky 4	1,089	PWR			n/a	n/a	Construction
	Khmelnitsky 5[69, 70]	1,250	PWR	AP-1000	III+	2030	n/a	Construction
	Khmelnitski 6	1,250				n/a	n/a	Construction
	Additional 7 reactors (incl. new in Chyhyryn and in western Ukraine)[71, 72]	8,750	PWR	AP-1000	III+	n/a	n/a	Proposed

Note:
1) Under construction: the first concrete has been poured for the reactor, indicating a more advanced stage. Planned: the project has the necessary approvals, funding, or commitment in place and is expected to begin operations within the next 15 years. Proposed: the project has a specific program or site proposals but lack a definitive timeline for completion.
2) The AP1000 – a US-designed evolutionary two-loop 1,000 MWe-class Generation III+ PWR.
3) The APR-1000 (Advanced Power Reactor 1000) – a South Korean-designed evolutionary two-loop 1,000 MWe-class Generation III+ PWR.
Source: EY CESA Energy Center's analysis

The plans of LNPPs development in the CESA region's countries with existing active reactors

01 Armenia

Armenia, home of the oldest nuclear plant in the region, the lifespan of which will be extended until decommissioning in 2036,[73] intends to build a new nuclear unit to take the place of its existing NPP. The government is negotiating with the US, Russia and South Korea on the matter.[74] However, most contractors offer reactors with capacities as high as 1,000MWe, while Armenia's current energy demand stands at 1,200MWe. To keep its energy sources diversified, the country may consider constructing a modular plant.[75]

While Armenia plans to replace the Soviet-era reactor, other countries from the region are actively seeking to increase the role of nuclear power within their energy portfolios.

02 Bulgaria

The Bulgarian Parliament has given its approval for the construction of two new reactors using the US Westinghouse's AP-1000 technology,[76, 77] paving the way for an expansion of nuclear power in Bulgaria by 115% from current capacity. The government also announced a red line for the Bulgarian side of US$14 billion in terms of investments.[78] The Bulgarian government canceled another proposed nuclear project, the Belene NPP with two VVER-1000 reactors.[79]

03 Czech Republic

The Czech Republic has selected South Korea's APR-1000 technology for the construction of two new reactors (fifth and sixth units) in the active Dukovany NPP with an estimated cost of US$8.65 billion each, if built together.[80] Two more units at the Temelin NPP are also under consideration with the implementation of the same technology.[81] If all these projects are completed, nuclear capacity in the Czech Republic will increase by almost 110%. If only the Dukovany NPP expansion comes to fruition, capacity will grow by 50% from existing volumes.

04 Hungary

The construction of two new reactors (1,200MWe capacity each) based on Russian VVER-1200 technology[82] at the Paks NPP in Hungary is projected to increase the country's nuclear power capacity by 120% securing supply of between 60% and 70% of the country's long-term electricity needs.[83, 84] Moreover, the country has informed the EU of its intention to extend the operational lifespan of its four operating VVER-440 units, aiming for a service period into the 2050s.[85]

05 Romania

Romania plans to double its existing nuclear capacity at the Cernavodă NPP with two 720MWe reactors using the Canadian CANDU 6 technology. Recently, the project received a favorable opinion from the European Commission on its technical and nuclear safety aspects.[86]

06 Slovakia

Slovakia could add approximately 70% to its nuclear capacity, if it completes a 471MWe VVER reactor at the Mochovce NPP[87] (scheduled to start in 2025)[88] and deploy a new 1,200MWe reactor at the existing Jaslovske Bohunice site with the potential expansion to 1,700MWe,[89, 90] the plan for which has been approved by the government.

07 Slovenia

Slovenia plans to increase the capacity of the Krško NPP, co-owned by neighboring Croatia, by at least 190% with an addition of up to 1,300MWe,[91] but no earlier than 2040.[92]

Unlike their CESA region peers, Slovakia and Slovenia have not decided on their technology vendors yet, with the selection process considering companies from France, the US and South Korea.

08 Ukraine

Ukraine, which has the largest fleet of NPPs in the CESA region, also plans a two-fold expansion from its existing capacity. Khmelnitsky NPP with two operating units can become Europe's most powerful nuclear plant after the launch of an additional four reactors with total capacity of almost 4,700Mwe, compensating for the Zaporizhzhia NPP. The third and fourth reactors, based on Soviet-designed VVER-1000 technology, construction of which stalled in the 1990s, are partially completed (75% and 28%, respectively).[93, 94] There are negotiations on equipment imports from the canceled Belene project in Bulgaria for these two units. The other two reactors (units fifth and sixth) will use US-designed AP-1000 units.[95]

8,550 MWe

in additional capacity could be achieved by the newcomers with the potential completion of projects currently under construction and those in the planning stages.

04

The CESA region also includes nations launching their inaugural nuclear power projects (newcomers)

The CESA region's potential LNPP newcomers could introduce up to 28.3GWe of nuclear power capacity to the global electricity market, which would account for approximately 6% of current global nuclear capacity (equivalent to CESA's current operating capacity), provided that all projects under construction, planned and proposed are realized. If there is completion of only the projects currently under construction and planned, the newcomers would contribute an additional 8,550MWe.

Türkiye, Poland, Kazakhstan and Uzbekistan are to be the newcomers in nuclear power in the CESA region.

Table 3.
Plans for LNPPs development in CESA region's countries without active reactors

Country	Site	Capacity (gross), MWe	Type	Technology	Generation	Commissioning	Estimated capex, US$ billion (price estimate year)	Status
Türkiye	Akkuyu 1	1,200	PWR	VVER-1200	III+	2025	24.0–25.0[96] (2024)	Construction
	Akkuyu 2	1,200	PWR	VVER-1200	III+	2026		Construction
	Akkuyu 3	1,200	PWR	VVER-1200	III+	2027		Construction
	Akkuyu 4	1,200	PWR	VVER-1200	III+	2028		Construction
	Sinop 1-4[97, 98]	Up to 5,200	PWR	APR-1400/VER-1200	III+	n/a	32.6[99] (2023)	Proposed
	Igneada 1-4[100, 101, 102, 103]	5,300	n/a	n/a	n/a	n/a	n/a	Proposed
Poland	Lubiatowo-Kopalino 1[104]	1,250	PWR	AP-1000	III+	2036	50.1[105, 106] (2025)	Planned
	Lubiatowo-Kopalino 2	1,250				2037		
	Lubiatowo-Kopalino 3	1,250				2038		
	Patnow 1[107]	1,400	PWR	APR-1400	III+	n/a	n/a	Proposed
	Patnow 2[108]	1,400						
	Unit 1	1,250	PWR	AP-1000	III+	n/a	n/a	Proposed
	Unit 2	1,250						
	Unit 3	1,250						
Kazakhstan	Ulken, Lake Balkhash 1[109]	1,200	PWR	VVER-1200/ HPR-1000/ APR-1000/ APR-1400/ EPR-1200	III+	2035[110]	6.7[111] –25.0[112] (2024)	Proposed
	Ulken, Lake Balkhash 2[113]	1,200						
Uzbekistan	Lake Tuzkan 1	1,200	PWR	VVER-1200	III+	2033	11.0[114] (2018)	Proposed
	Lake Tuzkan 2	1,200						

Source: EY CESA Energy Center's analysis

Türkiye

Türkiye aims to produce just over 11% of its electricity from nuclear energy by 2035 and 29% by 2053.[115] The nation is on the verge of joining the ranks of nuclear power-producing countries with its first nuclear power plant, the Akkuyu NPP, located in the southern province of Mersin. The plant will feature four VVER-1200 reactors with a capacity of 1,200 MWe, each capable of generating 20% more electricity than the older VVER-1000 models.[116] Russia's Rosatom is constructing these reactors at Akkuyu using a build-own-operate model.[117] Once fully operational, Akkuyu is projected to supply 10% of Türkiye's electricity needs by 2028.[118]

Two additional proposed sites in Türkiye – Sinop (four reactors on the Black Sea coast) and İğneada (four reactors in Kirklareli province near the Bulgarian border) – are of less mature status. The construction has not yet commenced at these sites, although Turkish officials continue to express their intention to begin work there.

Central and Eastern Europe

In Central Europe, **Poland** is the only newcomer, with ambitious plans announced. The nation is working to raise its nuclear power share from the current zero to 20% of its electricity mix by 2045. The updated 2020 Nuclear Power Program aims to build nuclear plants totaling between 6 GW and 9 GW using Generation III+ reactors.[119] The Polish government has approved plans for the first plant Lubiatowo-Kopalino, featuring three US designed AP-1000 reactors, to be located in Pomerania, a region in northern Poland, which to date lacks nuclear generating capacity.[120, 121] Geological surveys began in 2024, and construction is planned for 2026.[122] Recently, the government approved financing of up to US$15 billion for this project, which is still awaiting EU approval.[123] It aims to cover 30% of project costs with this equity injection.[124] The Polish government approved another site in the Patnów-Konin region in central Poland in late 2023, with two South Korean APR-1400 reactors of 1,400MWe each (equivalent to 12% of current electricity demand in the country).[125, 126]

Serbia, currently deriving over 60% of its electricity from coal [127] and aiming to phase it out by 2050, is at the very emerging stage of nuclear power development. It is moving to end the country's decades-old policy banning the construction of nuclear power plants on its territory. In July 2024, Serbia gathered experts to establish a nuclear energy program.[128] In autumn 2024, the nation signed agreements on cooperation in the peaceful use of nuclear energy with France.[129]

Central Asia

Central Asia, rich with uranium fuel, is also likely to contribute to the growth of new nuclear power capacity.

Kazakhstan, a leading uranium producer accounting for 43% of the world's supply, is suffering from power shortages. As a result, it is considering two nuclear reactors with a 1,200 MWe capacity each, backed by the positive results of a national referendum, with a potential expansion to three units.[130, 131, 132] The shortlist of potential technology suppliers includes Russia's VVER-1200 and VVER-1000, China's HPR-1000 reactor, Korea's APR-1400 and France's EPR-1200.[133]

Uzbekistan, ranked among the top five uranium producers globally,[134] has been in talks with Russia since 2018 to build two Generation III+ VVER-1200 reactors.[135] The nuclear power plant is slated for construction near Lake Tuzkan, 55 km from the Kazakhstan border, with Russia's Rosatom as the main contractor.[136, 137] The reactors could provide between 5% and 18% of Uzbekistan's energy needs.[138] However, the country decided to start with small modular reactors to gain experience in the new industry.[139, 140]

Azerbaijan is also revisiting the idea of a nuclear power plant, driven by the need to replace the aging and environmentally adverse Mingachevir power plant with a new, modern and eco-friendly facility, but has not yet proposed any projects.[141, 142]

Unlike first-in-a-while markets, countries embarking on nuclear energy programs for the first time will need to establish a governing body responsible for the control and regulation of the nuclear sector and the handling of nuclear materials.

Additionally, it is necessary to train local specialists to work at the plants, develop plans for emergency response and physical protection of the nuclear facility, and more. The creation of such nuclear infrastructure is a lengthy and labor-intensive process that incurs additional costs.

05

The CESA region is also exploring opportunities for SMRs

SMRs represent about one-third of the generating capacity of traditional nuclear power reactors. They bring flexibility, scalability and access to remote areas. Among their advantages are construction time (between two and five years compared with five to 10 years for LNPPs)[143, 144, 145] and wider refueling intervals (between three and seven years versus one to two years required by standard nuclear facilities).[146]

However, the technology is still largely unproven. There are only two active SMRs in China and Russia. Only four projects are under construction with planned launches in 2026–27, one of which is located in Argentina and has been under construction since 2014.[147]

There are several projects around the world, including in the CESA region, but all of them are at the pre-investment stage. Uzbekistan is in the active phase of preparatory work at the construction site, the development of design and licensing documentation.[148]

Nations such as Poland, Slovakia, the Czech Republic and Slovenia are engaged in Project Phoenix, which garners financial and technical assistance from the US for feasibility studies on transitioning from coal to SMR technology.[149]

Countries that have not yet decided on SMR technology have a wider array of options, as the variety of SMR designs is more extensive compared with LNPPs.[150]

Table 4.
Suggested implementation of SMRs in selected nations within the CESA region (continues)

Country	Site/location	Type	Technology	The origin of design	Capacity (gross), MWe	Status	Comments
Türkiye	At least 16 individual SMRs	n/a	n/a	n/a	5,000	n/a	The initiation of the SMR fleet is targeted for completion by 2050.[151] Türkiye is actively engaging with companies from the US, the UK and France regarding SMR technology.
Poland	Dąbrowa Górnicza	BWR	BWRX-300	US, Japan	4 x 300	Pre-investment	The Ministry of Climate and Environment has issued decisions-in-principle for Orlen Synthos Green Energy to construct 24 SMRs.[152] Orlen aspires to establish a network of 76 SMRs across 26 locations by 2038.[153]
	Nowa Huta	BWR			4 x 300		
	Ostrołęka	BWR			4 x 300		
	Stawy Monowskie	BWR			4 x 300		
	Tarnobrzeg SEZ	BWR			4 x 300		
	Włocławek	BWR			4 x 300		
	Greater Poland Voivodeship	BWR	NuScale	US	6 x 77	Cooperation agreement	A decision-in-principle has been granted to KGHM Polska Miedź SA, a producer of copper and silver.[154, 155]
Romania	Doicești	PWR	NuScale	US	6 x 77	Pre-investment	The project backed by US funding is anticipated to be operational by 2029.[156, 157] FID is expected in 2025.[158]

Note: BWRX-300 is a boiling water reactor (BWR) with the capacity of 300 MWe.
Source: EY CESA Energy Center's analysis

Table 4.
Suggested implementation of SMRs in selected nations within the CESA region (continued)

Country	Site/location	Type	Technology	The origin of design	Capacity (gross), MWe	Status	Comments
Hungary	At least one SMR with no locations identified	n/a	n/a		n/a	n/a	Hungary may contemplate the procurement of SMRs as soon as 2029–30 at the earliest.[159, 160]
Czech Republic	Several proposed locations (incl. Temelin site, coal-fired power plants at Dětmarovice and Tušimice)	PWR	Rolls-Royce	UK	3,000	Pre-investment	Czech Republic unveiled its SMR Roadmap. ČEZ aims to operate a collection of SMRs with a total capacity reaching 3,000 MWe by the close of 2045.[161, 162]
Bulgaria	Replacing five coal plants	PWR	NuScale	US	4 or 6 or 12 x 77	Cooperation agreement	The pact to investigate the potential installation of SMRs at the Kozloduy site is intended to assess the practicability of implementing NuScale's technology.[163]
Estonia	Toila/Kunda/Loksa/Varbla	BWR	BWRX-300	US, Japan	4 x 300	n/a	The inaugural unit of the proposed SMRs is projected to become operational 2035.[164, 165, 166]
Slovakia	n/a	n/a	n/a	n/a	n/a	n/a	Slovakia was granted US$2 million under the Phoenix project to fund a feasibility study of SMRs and received an additional US$5 million under the NEXT project from the US government to support the selection of the best site for their construction.[167, 168]
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	Despite favoring large nuclear plants, Slovenia has included SMR development in its Spatial Development Strategy 2050.[169]
Uzbekistan	Jizzakh [170, 171]	PWR	RITM-200N	Russia	6 x 55	Active phase of preparatory work at the construction site, the development of design and licensing documentation[172]	The first SMR unit is scheduled to begin operation in late 2029 with the other units commissioned consecutively by 2033.[173, 174]
Kyrgyzstan	n/a	PWR	RITM-200N		110-330	n/a	In 2022, the Ministry of Energy of Kyrgyzstan signed the terms of reference for a preliminary study for the construction of a low-power NPP.[175, 176, 177]

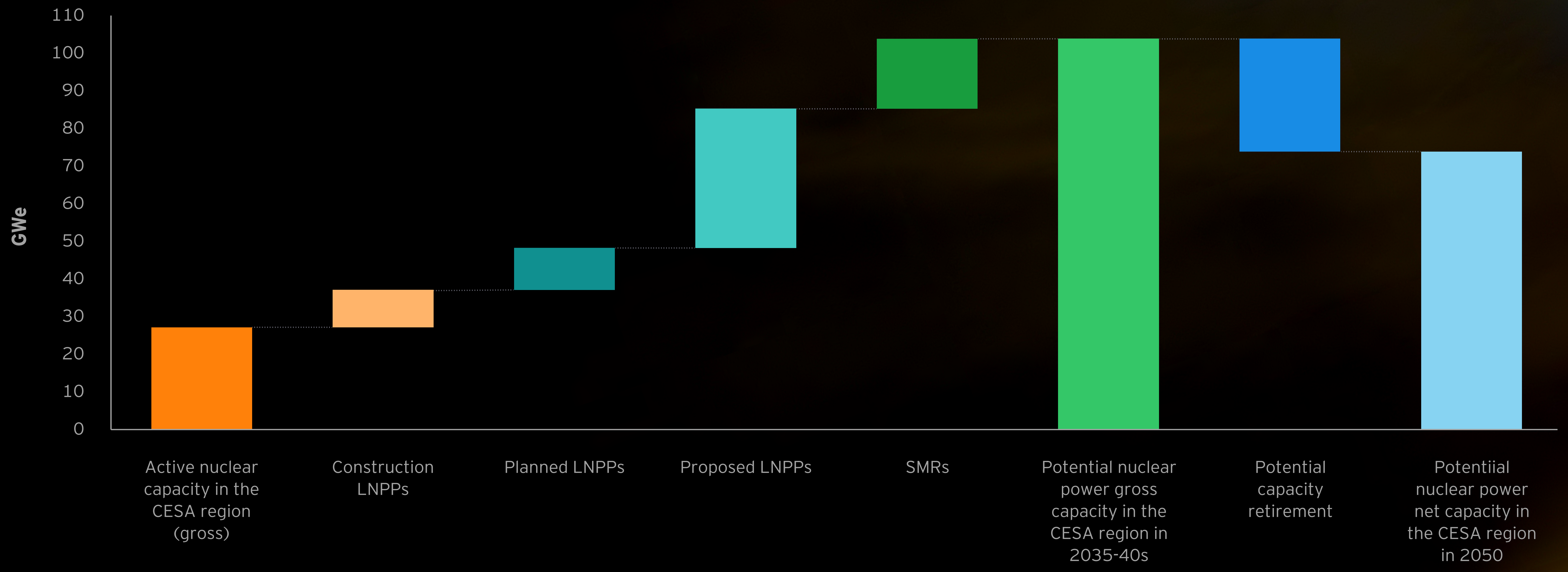
Note: BWRX-300 is a boiling water reactor (BWR) with the capacity of 300 MWe.
Source: EY CESA Energy Center's analysis

Should all the CESA region projects (both LNPPs and SMRs) come to fruition, nuclear capacity could more than triple compared with the existing reactor fleet. However, existing plants schedule to decommission by 2040-50. By 2030, approximately 2GWe of capacity could be retired in the region, with an additional retirement of about 27GWe expected between 2030 and 2050.[178] Replacing these reactors in time is critical to avoiding a shortfall in electricity supply, particularly as energy demand rises.

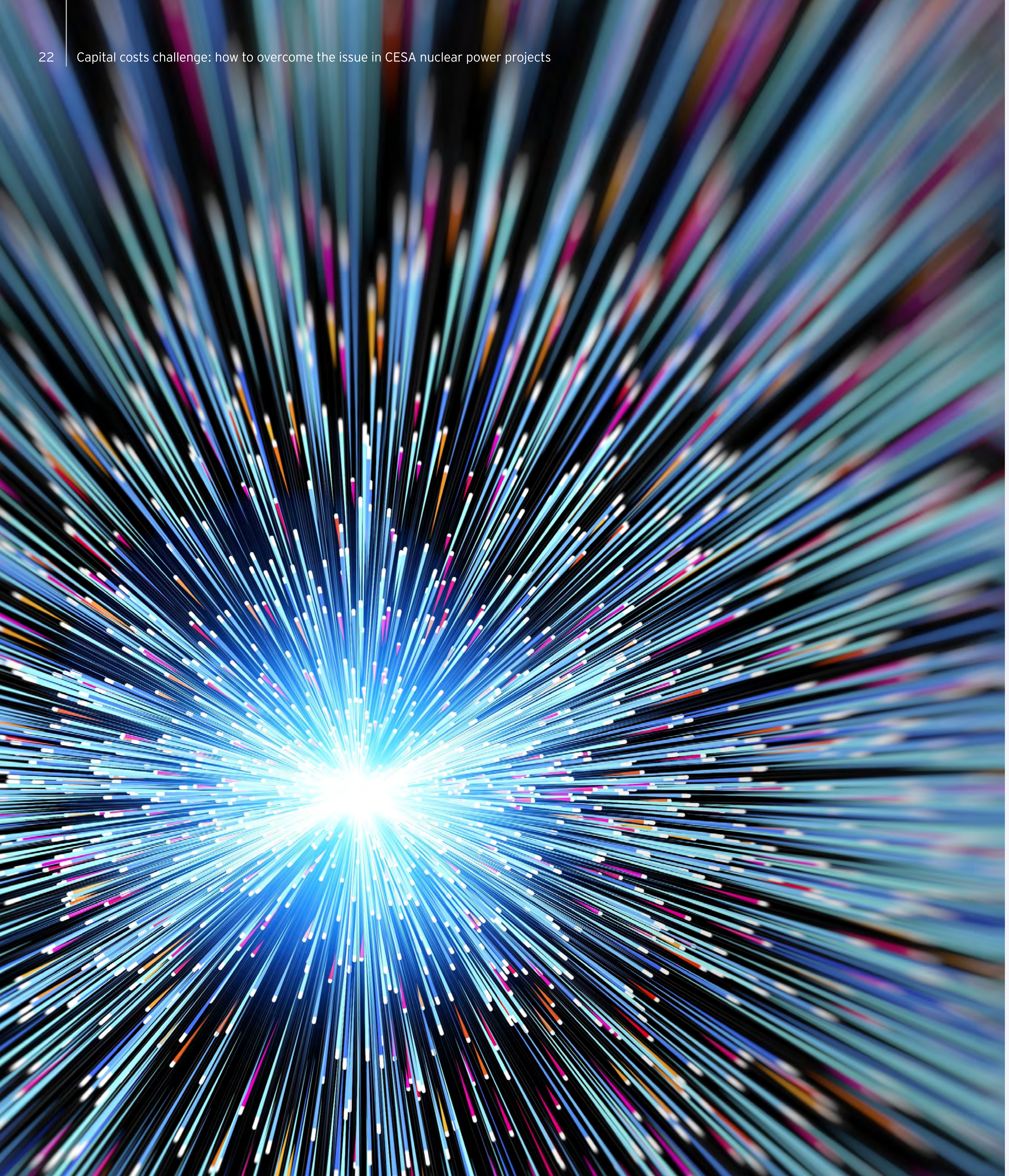
However, not all announced capacity could reach completion or be online in time due to ongoing risks and historically explored barriers, including financing.

The CESA region can more than triple its existing reactor fleet, but decommissioning of the oldest reactors is expected by 2050.

Figure 6.
Nuclear power capacity expansion plans in the CESA region



Source: EY CESA Energy Center's analysis



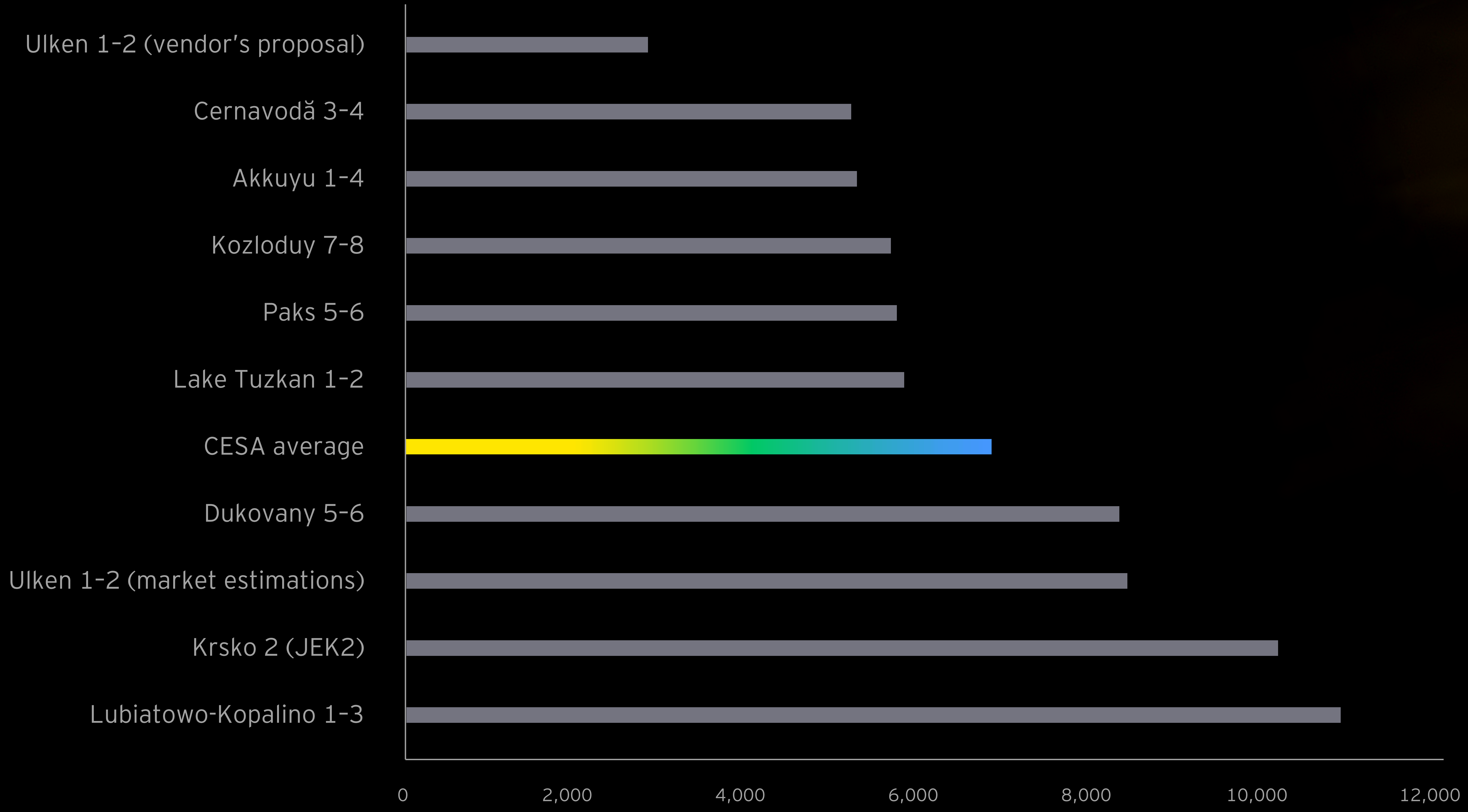
06

Technical complexity of nuclear projects translates into massive construction costs

Beyond noneconomic barriers such as public acceptance, the nuclear industry faces significant economic challenges to investment. The foremost economic hurdle is the cost competitiveness relative to other low-emission energy sources.

In our costing analysis, we concentrate exclusively on new LNPPs, excluding lifetime extensions, which are undeniably more cost-effective than new constructions. The construction expenses for recent nuclear reactors in Europe and the US remain substantial, with unit prices potentially escalating if not constructed in pairs. China and India demonstrate lower construction costs and shorter build times (five to seven years), whereas Europe's costs are double those of China.[179]

Figure 7.
Overnight construction costs for announced nuclear power projects in the CESA region (2024 prices)



Note: Includes projects with announced or estimated construction costs. Calculated as announced costs (minimum in case of the range) divided by announced gross capacity.
Source: EY CESA Energy Center's analysis

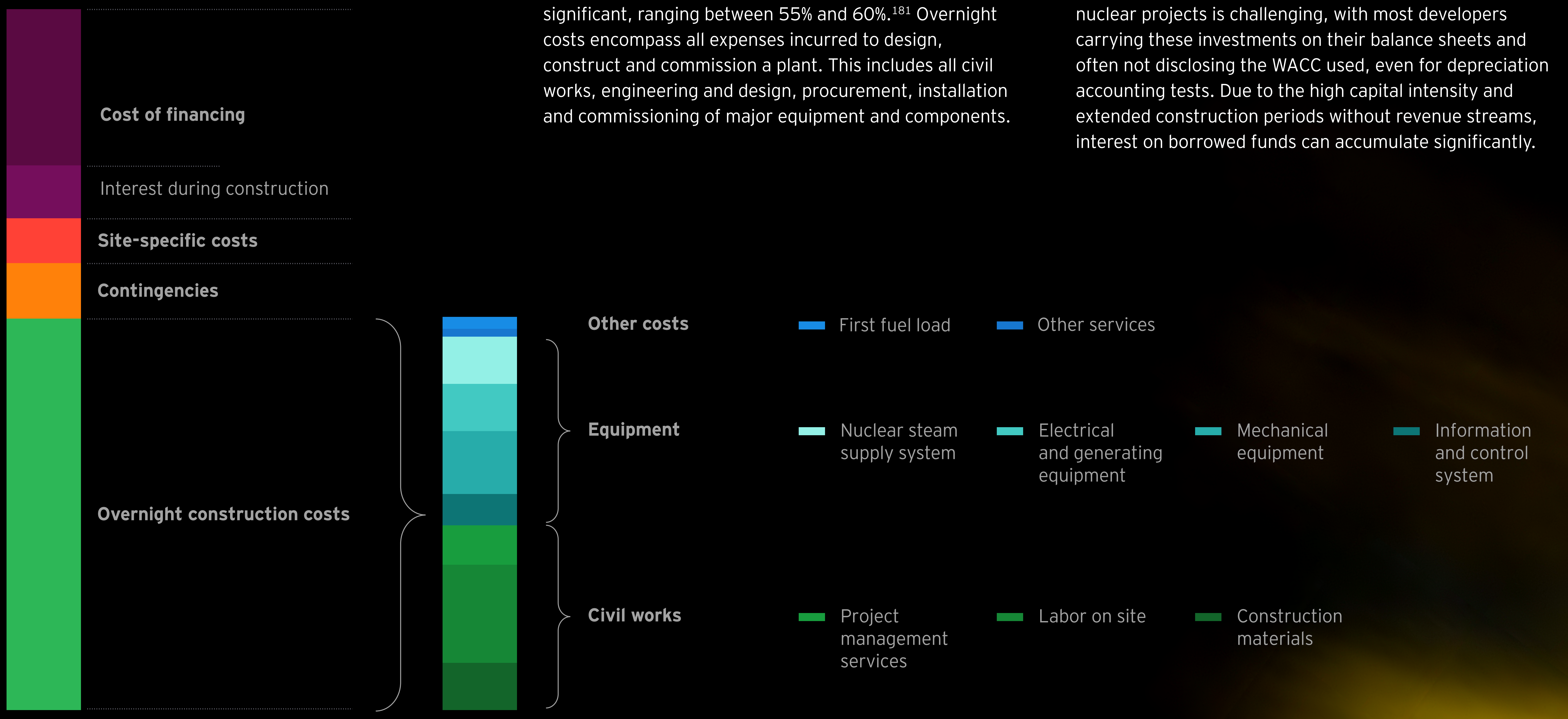
In the CESA region, the overnight construction costs for announced nuclear projects range from US$3 to US$10 per MWe of gross capacity in 2024 terms, without future inflation impact.[180] The average CESA region new nuclear built overnight construction cost is estimated at US$7 million per MWe in the same terms, but as soon as all announced projects reach their promised commercial operations date, the average cost in the region could increase by 22% in real terms due to the impact of inflation.

The average overnight construction cost in the CESA region is

US$7 million

per MWe in 2024 terms.

Figure 8.
Breakdown of NPP capital costs



Source: Independent Review of Economic Analysis Input Data of the JEK2 Project, EY

According to a recent EY independent economic analysis for a nuclear project developer in the CESA region, which focused on capital and operating costs in the industry, the share of overnight construction costs in capex is significant, ranging between 55% and 60%.[181] Overnight costs encompass all expenses incurred to design, construct and commission a plant. This includes all civil works, engineering and design, procurement, installation and commissioning of major equipment and components.

Financing costs significantly influence overall capex, particularly the weighted average cost of capital. Assigning WACC is inherently complex, especially for projects such as new nuclear builds. Financing large nuclear projects is challenging, with most developers carrying these investments on their balance sheets and often not disclosing the WACC used, even for depreciation accounting tests. Due to the high capital intensity and extended construction periods without revenue streams, interest on borrowed funds can accumulate significantly.

According to a recent EY analysis,[182] the WACC from 5% to 15% for nuclear energy projects and from 5% to 8% for renewables, with greater government support potentially lowering the discount rate. The IEA estimates a WACC of 8% to 9% for nuclear projects and 4% to 7% for utility-scale solar PV and onshore wind projects.[183]

The WACC range for nuclear energy projects:

5%–15%

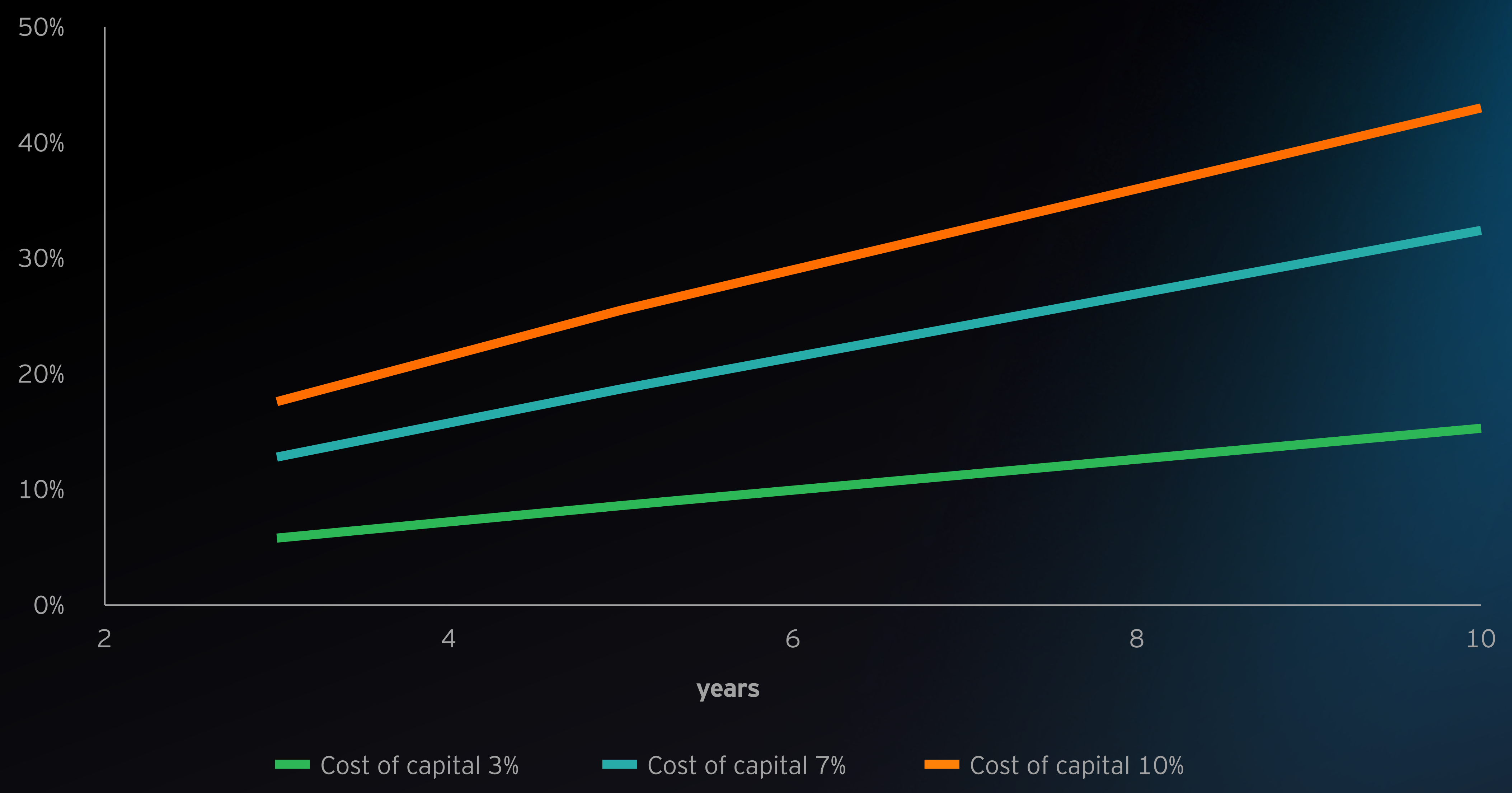
Substantial capital intensity of a new nuclear build renders the project extremely sensitive to fluctuations in the cost of capital, overnight costs and the construction schedule. For example, applying a 3% real-term WACC and a seven-year average construction period (a standard project execution) to a US$10 million/MWe overnight cost results in an additional cost of US$2.3 million/MWe. Increasing the real-term WACC to 6% over seven years for the same US$10 million/MWe overnight cost and construction period raises the WACC-loaded cost to US$5 million/MWe. Delays in the planned schedule incur further increases to the WACC-loaded costs.[184]

Effectively managing these costs requires minimizing or transferring project and technology-specific risks to other parties.

Achievement of lower WACC is only through adequate risk sharing between parties to the project and a government support package.

Figure 9.

Portion of the interest paid to investors during the construction period in total investment costs per kWe as a function of costs and construction period [185]



Note: calculations based on overnight construction costs of US$4,500/kWe
Sources: OECD

Effective cost management requires minimizing or transferring project and technology-specific risks to other parties.

When measured by LCOE, solar PV is the most affordable new electricity source in most markets, followed by onshore wind. However, nuclear power can be competitive when considering its broader benefits to the electricity system.

07

Europe's nuclear construction faces cost competitiveness issues

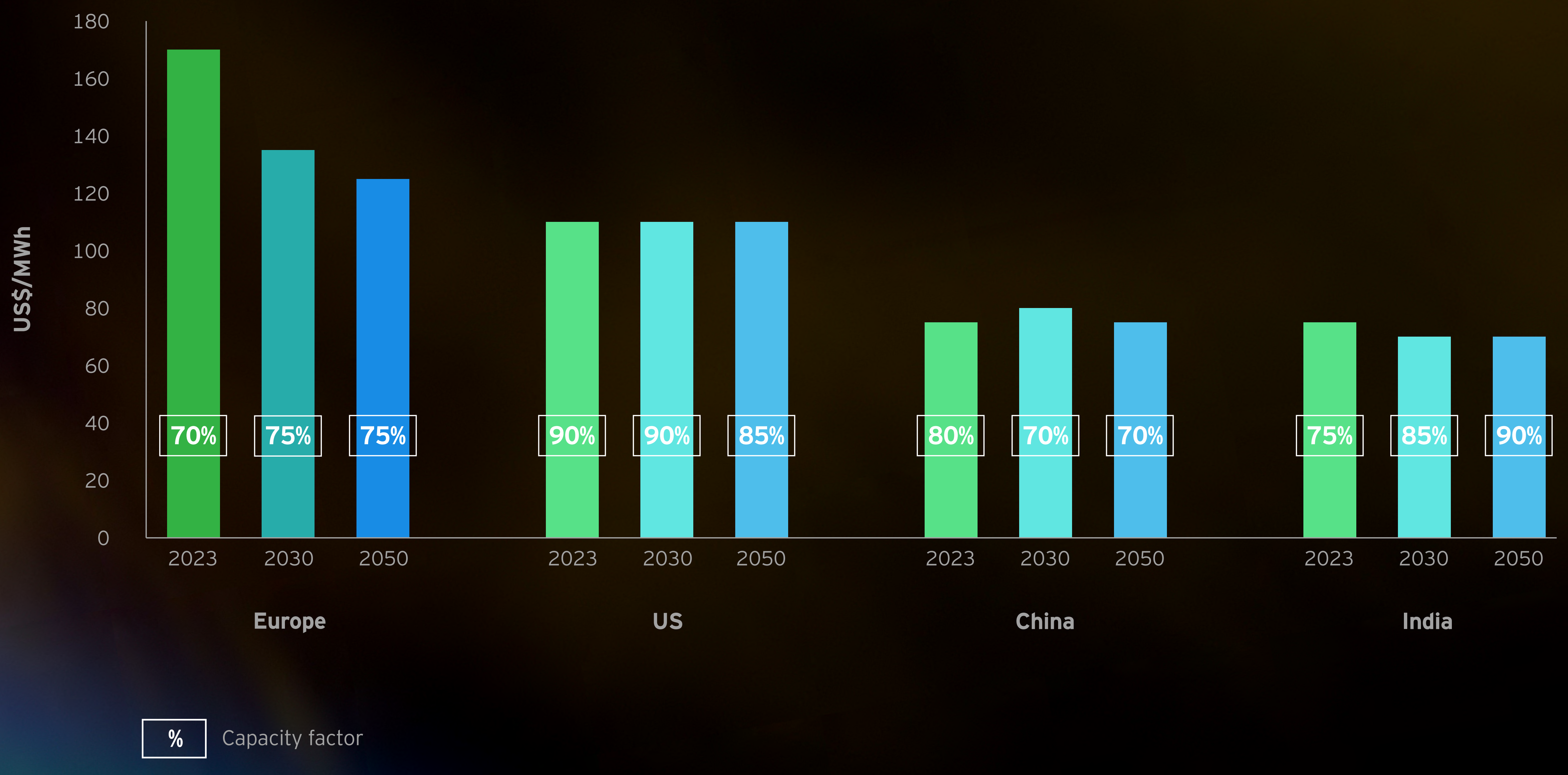
The construction and operation costs of nuclear power plants significantly influence the closing price of electricity, known as the levelized cost of electricity (LCOE).

While the LCOE metric does not capture all benefits of nuclear technology (it represents firm decarbonized power with relatively lower grid connections than renewable sources), it could still be a helpful tool for to comparison with other technologies.

LCOE estimates can vary widely based on underlying assumptions and the perspective of the forecaster. Key factors such as the reactor's economic lifespan, WACC and load factor affect LCOE results.

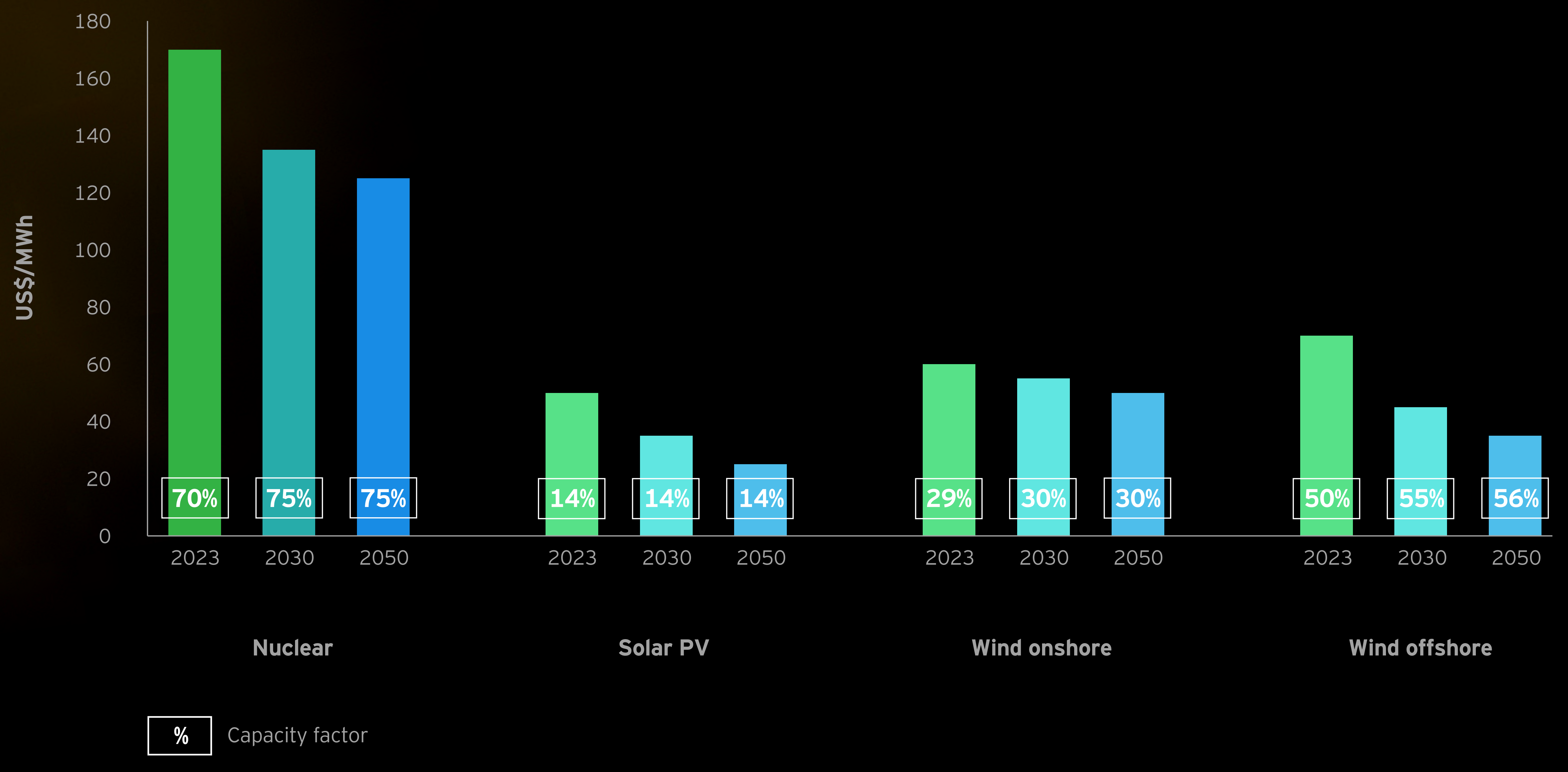
The LCOE for nuclear energy in Europe is higher than in other regions, and higher than for renewable energy sources.

Figure 10.
Nuclear LCOE across the world



Note: Capacity factor describes the average output over the year relative to the maximum rated capacity.
All costs are in 2023 market exchange rate US$.
Source: International Energy Agency, World Energy Outlook 2024 – Stated Policies Scenario, October 2024

Figure 11.
LCOE by technology in Europe



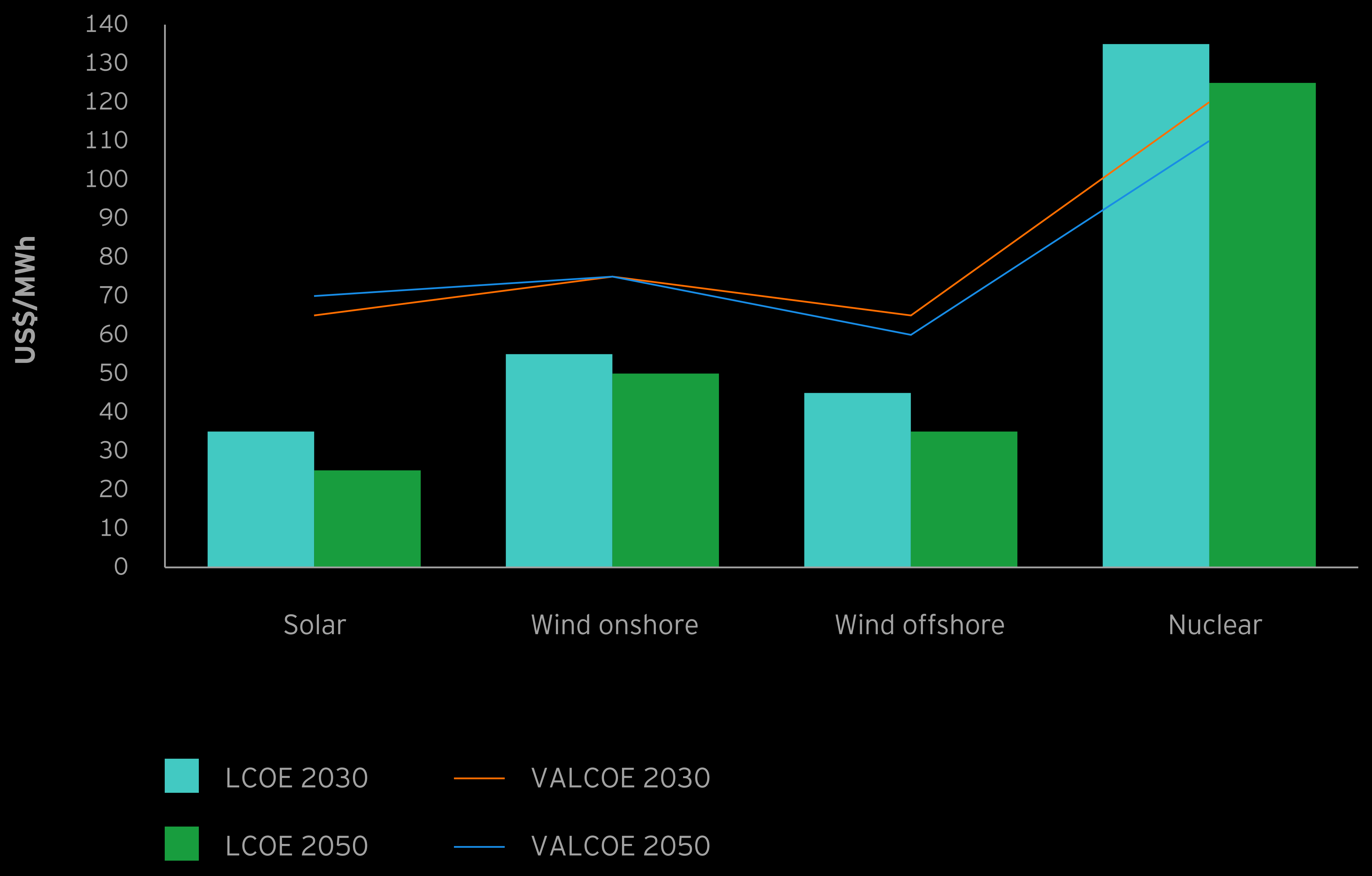
Note: Capacity factor describes the average output over the year relative to the maximum rated capacity.
All costs are in 2023 market exchange rate US$.
Source: International Energy Agency, World Energy Outlook 2024 – Stated Policies Scenario, October 2024

LCOE

When measured by LCOE, solar PV is the most affordable new electricity source in most markets, followed by onshore wind. However, nuclear power can be competitive when considering its broader benefits to the electricity system. While LCOE is a common metric for comparing low-emission generation options, it does not account for operational differences such as dispatchability or the weather dependency of solar and wind energy.

The IEA's value-adjusted LCOE (VALCOE) offers a more comprehensive assessment by considering electricity system value contributions.[186] It has a similar scope to the levelized avoided cost of electricity, a metric created for the US Energy Information Administration.[187, 188]

Figure 12.
LCOE vs. VALCOE of low-carbon electricity in the EU in 2030 and 2050



Source: International Energy Agency, World Energy Outlook 2024 – Stated Policies Scenario, October 2024

VALCOE captures the value of three system services as additional elements to the traditional LCOE:

- **Energy value** – the worth of the electricity produced, considering the time and market conditions
- **Flexibility value** – the ability of a technology to respond to demand fluctuations and provide grid stability
- **Capacity value** – the contribution to meeting peak demand and ensuring reliable supply

Thus, a technology that provides more flexibility than the system average will have a negative adjustment component, thereby reducing its VALCOE and increasing its competitiveness. In its World Energy Outlook 2024,[189] the IEA indicates that the VALCOE for nuclear power, which remains the most dispatchable low-carbon technology, decreases compared with LCOE, while the VALCOE for solar and wind increases in the EU in 2030 and 2050 under the Stated Policies Scenario.

The LCOE and VALCOE for new nuclear power plants are particularly sensitive to the cost of capital owing to the importance of fixed investment costs relative to variable costs and the long construction period. For instance, financial costs can represent two-thirds of the costs of nuclear electricity when the cost of capital reaches 9% but fall to less than one-third if it is at 3%. At a 5% rate, a standard new-build project could produce electricity at around US$65/MWh, versus US$170/MWh at a 15% rate.[190] Delays in construction result in further increases in electricity generation costs.

A standard new-build project could produce electricity at around US$65/MWh at a 5% WACC, versus US$170 MWh at a 15% rate.

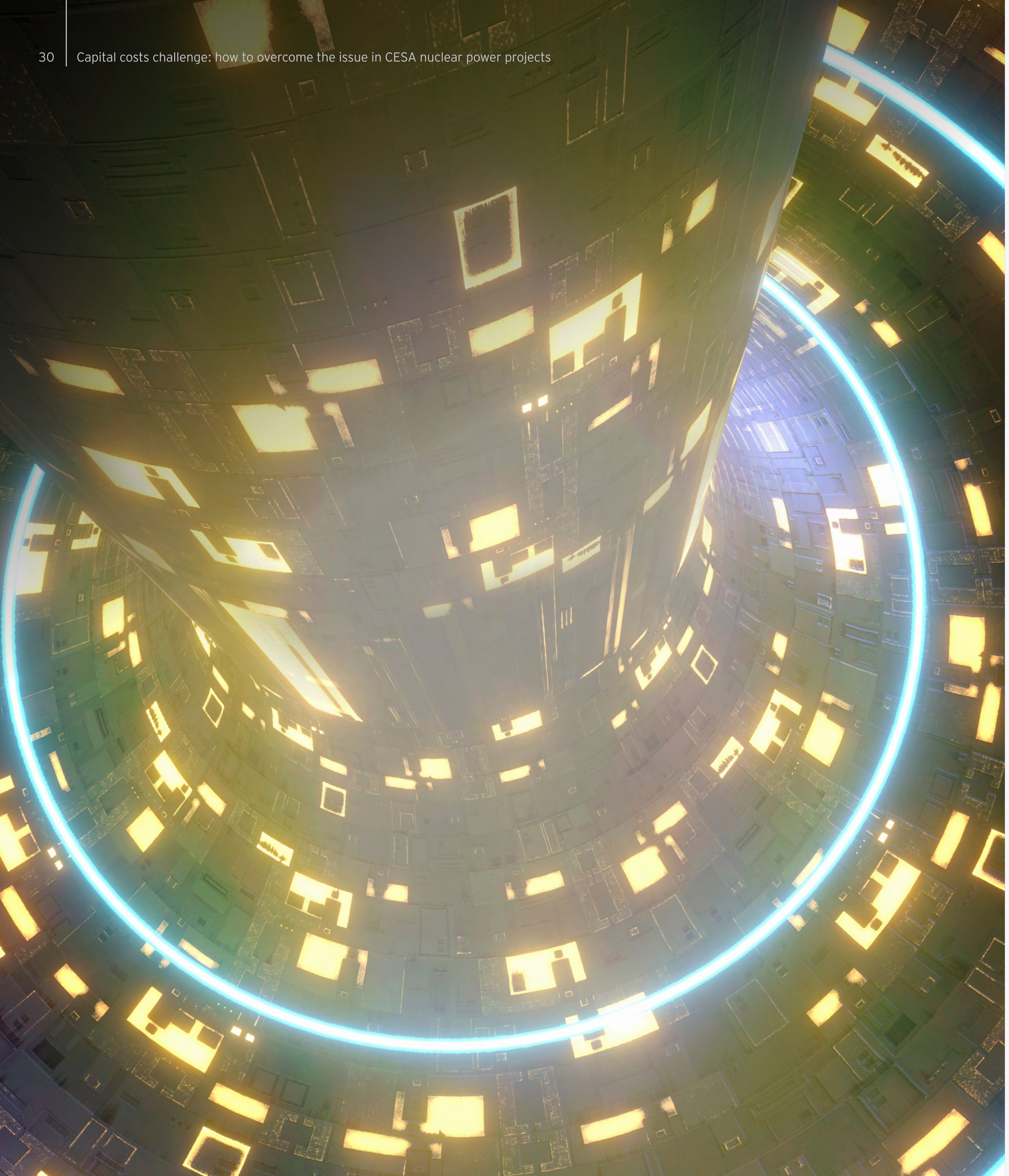
Figure 13.
Impact of WACC on the LCOE for new nuclear power plants

Source: NEA (2020)

To compete with renewables, the VALCOE for nuclear power in the EU needs to fall within the range of between US$65/MWh and US$80/MWh.[191]

To achieve cost reductions and to reduce risks, the nuclear industry will need to deliver projects on time to begin receiving a revenue stream on budget. For instance, shorter construction periods and higher projected capacity factors result in a lower LCOE in China.

Consequently, the investment community places great emphasis on the predictability of costs and schedules.



08

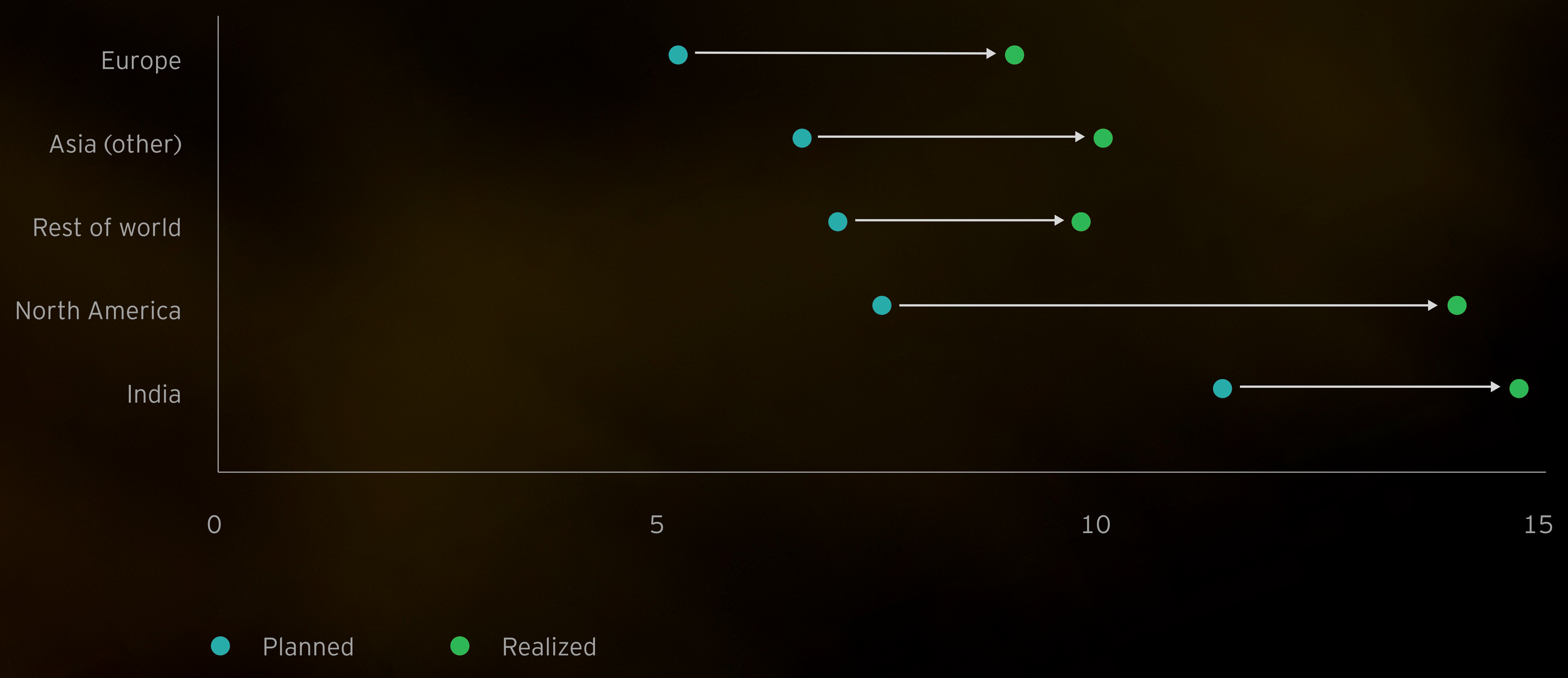
Complexity often leads to delays, cost overruns, or abandonment, affecting the predictability and financing of nuclear projects

Historically, nuclear projects worldwide have encountered persistent delays and financial excesses, attributable to their intricate and safety-sensitive characteristics.

Nuclear projects initiated between 2010 and 2020 have experienced delays of three years on average.

Nuclear projects initiated between 2010 and 2020 have experienced delays of three years on average.

Figure 14.
Average planned vs. realized construction time of NPPs, years



Source: IEA (projects with construction started after 2007)

During the decade 2014–23, construction began on 61 reactors worldwide. As of mid-2024, only 13 units had started up, while the remainder remained under construction. Many of them are still far from completion and of the 23 reactors documented as behind schedule, at least 10 have reported increased delays and two reported delays for the first time over the past year.[192]

For instance, in Slovakia, the grid connection of the third Mochovce unit, initially planned for 2012, finally commissioned after an 11-year delay. Unit 4 (VVER-440 (V-213) type reactor) has been delayed by at least another 12 years with its currently planned connection in this year.[193] At the time of project relaunch in 2007, costs for the total project were estimated at €2.8 billion (or €3.5 billion in real 2020 value), but in December 2020 estimates put total project costs at €6.2 billion.[194]

Similarly, the expansion of the Vogtle NPP with units 3 and 4 (AP-1000 reactors) in the US was seven years overdue, culminating in expenditures of US$35 billion, a marked increase from the preliminary US$14 billion projection.[195, 196]

In the UK, the Hinkley Point C nuclear power station (two EPR-1750 reactors), proposed in 2007 and under construction since 2016, is also facing construction delays. Latest estimates suggest that at final completion in 2031, the project will have cost as much as £34 billion in 2015 figures or up to £46 billion (US$58 billion) in today's money.[197, 198] Notably, in 2017, costs were revised upward by £1.5 billion to £19.6 billion, while the initial completion date was set for 2025.[199]

The newest first EPR reactor in Europe, Finland's Olkiluoto 3 nuclear power plant, which has been under construction since 2005, started generating electricity only in 2023 rather than in the initially planned 2009.[200] As a result, the final price tag was estimated at €11 billion (including €5.5 billion of accumulated losses) compared with the target of €3 billion.[201, 202]

In some cases, developers decide to abandon nuclear power projects.

Having an order for a reactor, or even having a nuclear plant at an advanced stage of construction, is no guarantee of ultimate grid connection and power production. Of the 807 reactor constructions launched since 1951, at least 93 units in 19 countries (including 13 in the CESA region) were abandoned or suspended, as of 1 July 2024. This represents an abandonment rate of 11.5% – or one in nine – nuclear constructions.[203]

This sad fate has also affected the nascent SMR sector. In late 2023, the US producer canceled its flagship project, proposed in 2015 and planned to be operable by 2029. Its cost had jumped from US$4.2 billion for 12-unit facility of 720MWe in 2018 to US$9.3 billion for a downsized plant of six units with total capacity of 462MWe in January 2023. The target price increased to US$89/MWh, up from a previous estimate of US$58/MWh, and only few customers signed up to receive its power amid rising costs.[204,205]

09

Projects need a clear revenue stream, greater than operating and capital costs, to attract private capital

Companies raise private capital for nuclear projects through debt and equity. Most commonly the corporate entity is a large utility, which arranges credit from lenders and takes on the risk related to the project. In some cases, groups of investors may choose to cooperatively finance a project, an approach largely found in France, South Korea, the UK and the US.

Regardless of market design, a project needs to be economically viable (revenues above operating and capital costs and provision of an acceptable return on investment) to attract finance and pass a final investment decision (FID). In competitive wholesale markets with volatile prices, there may not be a clear funding stream that is satisfactory to investors.

However, neither banks nor private equity, which call for proven business cases, are willing to assume the full scale of NPP construction risks. It is hard for any investor to think about market design more than 60 to 80 years into the future. Therefore, investors in new nuclear power demand a significant risk premium, which in practice makes investment in nuclear power projects difficult on commercial terms.

Potential project participants have expressed strong interest in mechanisms to share the risk of cost overruns (e.g., sharing among an "order book" consisting of many projects of the same design) and in additional government support to address cost-overrun risk.

10

Long-term governmental commitment to nuclear power and support remains critical

In countries that plan for nuclear power to play a part in their energy transition, governments should intervene to help overcome the economic barriers.

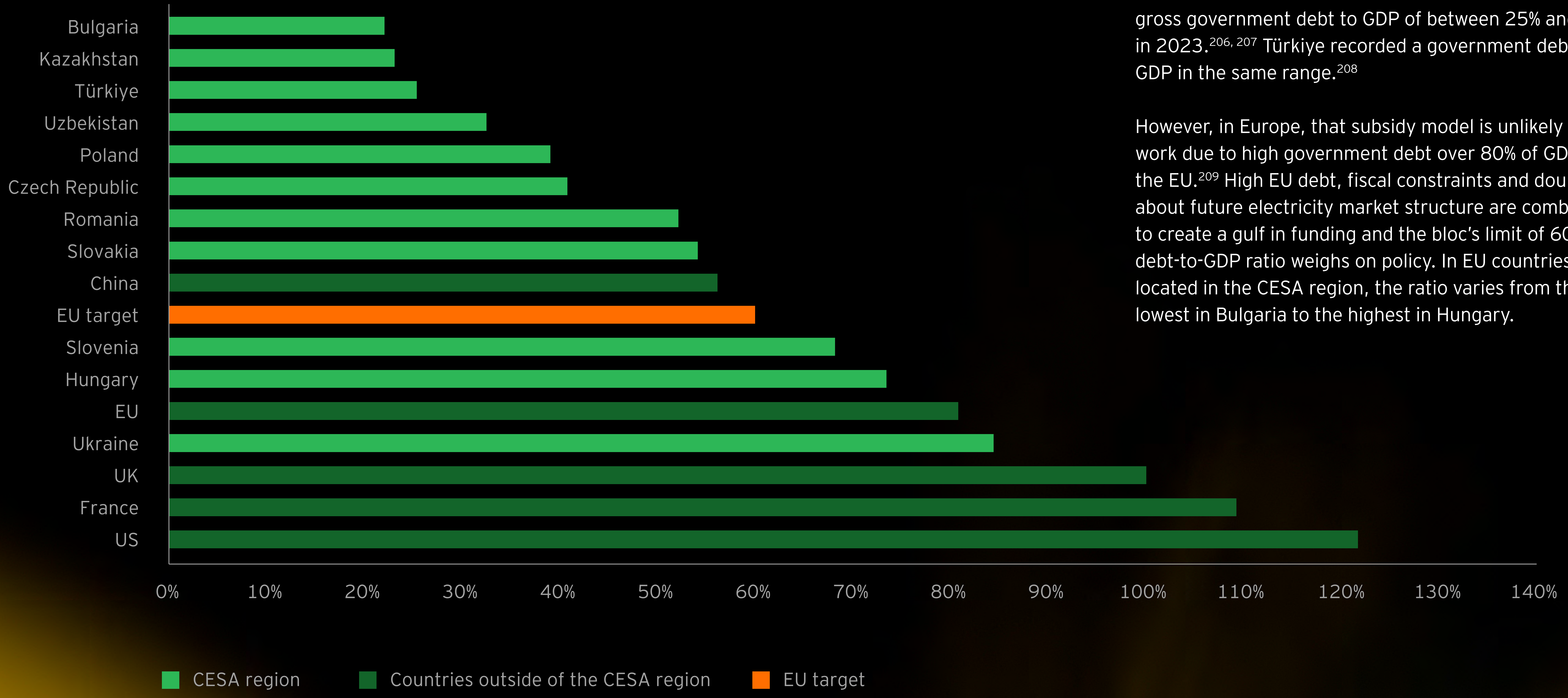
Regulated utility markets financed and built most NPPs operating today, with guaranteed offtake and high enough electricity prices to ensure a profitable rate of return. Under these conditions higher electricity prices covered cost overruns and project delays. In addition, governments provided much of the financing for these plants, such as government backing or guarantees.

China and Russia, the countries actively building the new nuclear reactors worldwide, rely on state financing to support these projects.

Policymakers look to taxes and debt as the main sources of public money.

In countries that plan for nuclear power to play a part in their energy transition, governments should intervene to help overcome the economic barriers.

Figure 15.
Gross government debt-to-GDP ratio in CESA countries compared with selected nations interested in nuclear power, 2023



Source: OxfordEconomics

Central Asian countries are backed more by public finance and have access to the feedstock, therefore they are more resilient to such challenges. Countries like Kazakhstan and Uzbekistan had a comfortable level of gross government debt to GDP of between 25% and 35% in 2023.[206, 207] Türkiye recorded a government debt to GDP in the same range.[208]

However, in Europe, that subsidy model is unlikely to work due to high government debt over 80% of GDP in the EU.[209] High EU debt, fiscal constraints and doubts about future electricity market structure are combining to create a gulf in funding and the bloc's limit of 60%[210] debt-to-GDP ratio weighs on policy. In EU countries located in the CESA region, the ratio varies from the lowest in Bulgaria to the highest in Hungary.

Furthermore, when comparing Central Asia with Western countries, obtaining approvals in the EU can take longer due to the necessity of receiving permissions from the European Commission, which extends the construction period.

Nevertheless, the objective is to establish a new financial framework that facilitates industry investment in new-build nuclear projects and attracts private investment by mitigating risks through targeted support measures.

Minimizing these risks required substantial support throughout various stages of the project lifecycle, including the design and research phase, development, construction, operations, back-end and end-of-life activities.

Additionally, governments in competitive markets have often underestimated the workload and timelines necessary to create a conducive environment for nuclear FID. This includes updating legislation, regulations, permitting procedures and criteria, grid requirements, site selection, power market design and nuclear infrastructure, such as facilities for long-term storage or disposal, including decommissioning.

11

The role of government varies depending on investment model

To advance nuclear energy development, innovative financing methods and support policies were explored in the EY Financing new nuclear in Sweden report,[211] including public investment in equity and debt, as well as sovereign guarantees.

An investment model forms the foundation for FID, bankability and attractiveness for investors, comprising various project components that together must achieve economic balance. A lack of confidence indicates that investors are uncertain about their return on investment.

Even if a government is not a direct sponsor of a project, it can still play a crucial role in mitigating risk for investors. State support can be multifaceted, addressing the financing gap through five main avenues, as outlined in Table 5, to support the revenue and mitigate WACC.

However, no single measure can fully support the development of new-build plants, and some countries implement a combination of measures.

Figure 16.
Overview of key investment models

Investment model

01 Delivery model

Pre-conditions for financial close

EPC turnkey model
Single contractor/consortium assumes full responsibility with price guarantees.

Split package
Responsibility shared among various contractors.

Multi-contract
Owner manages overall interface with multiple contracts for different categories.

02 Ownership model

The asset owner and ultimate client or counterparty of the delivery partners, regulatory authorities, offtakers and external financiers

Sovereign ownership
Reliance on governments directly owning either the plant, or through special project vehicle (SPV) that is issued to fund the plant.

Corporate ownership
Reliance on private sector to own the plant or SPV.

SPV ownership
Plant's capacity to raise external finance with limited-recourse facilities, project intrinsic cash flow generation, and risk profile.

03 Operations model

Plant operator and operational risk exposure

Integrated owner and operator
Full operational control of the plant by the existing owner.

Separated owner and operator
Emerging model enables plant ownership and financial structures asymmetrical with operator ownership.

04 Back-end model

Nuclear liability funding requirements (e.g., spent fuel management/disposal, decommissioning)

State-managed decommissioning fund
Investments to assets with upcoming liabilities by the state through dedicated fund, which collects payments from the plant; the state risk of cost overruns.

Owner-based liabilities management
Investments by the owner of the NPP as a share of its revenue to face long-term decommissioning obligations; the owner's risk in case of cost overruns.

Existing nuclear waste fund
The fees paid by NPPs to finance the future costs of managing and disposing spent fuel and waste products (e.g., KAF in Sweden); the owner's and operator's risk of cost overruns.

05 Revenue model

The remuneration mechanism for nuclear generation, monetizing the full-cycle benefits for the generator

Contract for difference (CfD)
Public law contract, where the state and the owner agree upon a fixed price for power.

Power purchase agreement (PPA)
Private contract between the owner and the state/offtakers.

Regulated asset base (RAB)
Public contract, where the state agrees to reimburse capital costs incurred during the project construction and operation, with an additional fee to compensate capital providers for the risk taken.

Mankala
The offtaker of the plant is its owner; low revenue volatility risk from the project and cost of capital.

Emissions-avoidance certificates
A premium paid to generators of low-emission power such as nuclear.

06 Financing model

The sources of capital that will reasonably be deployed for the project to achieve FID and successful commercial operation date

Government led
Support for financing as part of the ownership structure through an equity stake or public loans, led by a dedicated government unit.

Vendor led
Funding by the technology vendor through either direct equity stake in the projects or by mobilizing the export credit agencies (ECAs) from various countries to provide a part of debt financing.

Owner led
Sufficient resources at disposal of the owner of the plant, ability to provide a joint debt and equity support.

Source: EY, "Financing new nuclear in Sweden"

Table 5.
Main pillar of support by governments for new-build nuclear power projects (continues)

Main axes of government support	Risks covered	Potential remedy	Examples of plans/proposals (project, country)
Direct equity contributions, either by the project owner or special project vehicle	Prohibitive cost of capital Low project bankability (First-of-a-kind (FOAK) projects) Political risks (potential of reaching FID)	Equity contribution from the government or that a government-related entity will ensure strong project buy-in and tangible involvement	98% of the equity commitment to the project, with the rest cover by utility company (Dukovany 5, Czech Republic) [212] 100% special project vehicle exposure through the state-owned utility company (Paks 5 and 6, Hungary) [213] 30% of the total costs covered by the Polish government (60 billion zloty or €14 billion between 2025 and 2030 as a grant to the state-owned company), with the remainder coming from foreign borrowing (Lubiatowo-Kopalino, Poland) [214] Implementation entirely on public funds with 25-30% self-financing and the rest loan-financed, partly with state guarantees (Kozloduy 7 and 8, Bulgaria) [215] 80% from Russia to a US$0.5 billion Uzbekistan-Russia joint venture fund (Jizzakh SMR, Uzbekistan) [216]
Lender support	Prohibitive cost of capital Low project bankability (FOAK stage)	Government underwriting the debt (either through direct loans, sovereign debt issuances, or full guarantees), at preferential rates	Sovereign debt for 98% of outstanding project costs with 0% interest on the loan (Dukovany 5, Czech Republic) [217] Intergovernmental agreement with Russia, which secures financing of 80% of project costs (Paks 5 and 6, Hungary) [218] Intergovernmental agreement with Russia, which indirectly underpins the financing of the plant's development (Akkuyu, Türkiye) [219] Up to US$12 billion in loan guarantees by the Department of Energy (Vogtle 3 and 4, US) [220] Debt guarantee of £2 billion of bonds that a project company issues to finance construction, subject to some conditions (Hinkley Point C, UK) [221] Potential provision of 30% of a nuclear project's investment by sovereign wealth fund and the rest from foreign loans[222] (Ulken, Lake Balkhash, Kazakhstan)

Source: EY CESA Energy Center's analysis

Table 5.

Main pillar of support by governments for new-build nuclear power projects (continued)

Main axes of government support	Risks covered	Potential remedy	Examples of plans/proposals (project, country)
Revenue support to provide visibility of long-term cash flows	Market risk (uncertainty surrounding long-run revenue estimates)	Long-term predictable support through contracts for difference (CfDs), power purchase agreements (PPAs), regulated asset base (RAB), etc.	The plan of the government to provide a RAB structure to cover all project costs and a target fee to compensate capital providers (Sizewell C, UK) [223] CfD to mitigate electricity market risks by providing price certainty over the first 35 years of operation (Hinkley Point C, UK)[224] The government's plan to provide a long-term contract with CfD principles which removes volume and price risk from the plant owner (Dukovany 5, Czech Republic) [225] PPA with a wholesaler with for 15 years covering 70% of production from units 1 and 2 and 30% from units 3 and 4 [226] (Akkuyu, Türkiye) Discussion on CfD scheme to fund the inaugural NPP in the northern Pomerania province [227] (Lubiatowo-Kopalino, Poland)
Tax incentives	Prohibitive costs	Reduced tax burden	Production tax credit of US$18/MWh for the first 8 years (Vogtle 3 and 4, US) [228] Strategic Investment certificate, which can provide tax reductions and exemptions, including from income tax and value added tax, as well as custom duties exemption (Akkuyu, Türkiye) [229]
Project risk allocation	Unpredictable licensing, regulatory and legal framework Unknown funder of last report of last resort (i.e., exposure to overrun costs and delays)	Clear allocation of risks between the state, the owner and nuclear vendor when it comes to the supporting framework Distribution of liabilities in case of overruns and delays	The government's intention to provide an extensive protection to plant owners in case of overruns with a RAB model and a clear framework for overruns funding with multiple tranches of exposure (Sizewell C, UK) [230]
Investor insurance	Political risk (i.e., uncertainty regarding the long-term government position on nuclear)	Insulating project completion risk from political inference	Provision of a compensation clause through Secretary of State Investor Agreement to protect the utility from future government's policy changes, such as early plant shutdowns or program cancellation (Hinkley Point C, UK) [231] Cost recovery protection against changes in the national agenda, including changes in the national nuclear energy policy, failure to uphold the commitment to grant the policy support measures outlined above, or delays to the project due to the rejection of bids from prospective vendors (Dukovany 5, Czech Republic) [232]

Source: EY CESA Energy Center's analysis

Concluding remarks

The IEA projects global electricity demand to double by 2050, according to its Stated Policies Scenario.[233] This surge necessitates strategies that can curb emissions while accommodating the increased demand. Nuclear energy emerges as a pivotal solution, providing dependable, continuous, low-carbon electrical and thermal energy. Its ability to deliver consistent baseload power makes it a valuable complement to variable renewable energy sources. Without nuclear power, achieving net-zero ambitions would be more challenging and costly.

As numerous nations pursue their energy independence, nuclear energy can enhance energy security by decreasing reliance on fossil fuels and imported energy.

Three core channels can assess the economic benefits of nuclear power:

- **Direct impact:** economic activity and employment generated directly by firms in the nuclear power sector, and the generated taxation
- **Indirect impact:** economic activity and employment supported in the supply chain of the civil nuclear industry, because of procurement of goods and services from firms in other sectors
- **Induced impact:** wider economic benefits that arise when employees within the nuclear power industry, and its supply chain, spend their earnings

Together these channels represent nuclear power's impact on national economies.

The global commitment to triple nuclear power generation by mid-century is a positive indicator for economic development. We expect the **CESA region to play a significant role in these plans**. If all announced LNPP and SMR projects in the region come to fruition, nuclear capacity is set to more than triple compared with the existing reactor fleet, excluding decommissioning assumptions.

The region includes established nuclear markets classified as first-in-a-while such as Bulgaria, Czech Republic, Hungary, Romania, Slovakia, Slovenia and Ukraine, which have operational nuclear power plants and expansion plans. Additionally, newcomer countries such as Türkiye, Poland and Central Asian nations are entering the nuclear energy sector. The latter are benefiting from their access to uranium mines.

Countries within the EU may face challenges and delays due to the need for approvals from the European Commission, while non-EU countries can make decisions on nuclear development at the national level.

Securing capital for nuclear new-build projects can be a challenge, particularly in CESA countries, where infrastructure development has traditionally relied on multilateral development banks, which may not be readily available for nuclear, at least in the short to medium term.[234] Beyond availability, the **high cost of capital**, driven by a "nuclear risk premium" resulting from concerns around policy, project completion (delays and cost overruns) and market price risks, remains a critical driver of project economics, impacting LCOE and VALCOE figures.

Despite positive signals from 14 financial institutions expressing support for efforts to triple nuclear power, they still need to achieve risk-adjusted returns on the capital entrusted to them.

Nuclear energy emerges as a pivotal solution, providing dependable, continuous, low-carbon electrical and thermal energy.

Therefore, government intervention will be essential to ensuring bankability. **Governments will need to play a pivotal role in supporting** both large and small modular reactor projects by facilitating access to capital and reducing the weighted average cost of capital through de-risking measures. investors as well as establishing clear frameworks, stakeholders can effectively harness the potential of nuclear power to meet future energy needs while combating climate change.

Countries need to focus on innovative financing and funding mechanisms to overcome these hurdles:

01.

Additional measures and sources of funding to reduce development-phase risks, as nuclear projects take between six and seven years to reach financial close compared with between six and eight months for renewables.

02.

Patient capital provision during construction to extend the return timeline beyond the current 20-year payback period, better aligning with the typical 60-year design life of nuclear plants.

03.

Innovative policies and financing tools to incentivize diverse stakeholders (investors, developers, contractors and consumers) by lowering short-term risks and sharing long-term rewards through:

- **Government financing** (e.g., direct equity contribution, sovereign debt with reduced interest rates, loan guarantees, intergovernmental agreements)
- **Fiscal policy** (e.g., tax incentives),
- **Revenue stabilization mechanisms** (e.g., long-term PPAs, CfDs)
- **Public-private partnerships**
- **RAB model, sharing construction and operational risks between investors and consumers, enhancing project viability**
- **Regulatory and legal framework stability**
- **Export Credit Agencies (ECAs) debt and financing**

Conclusion

These measures can reduce the nuclear risk premium, making nuclear investments more appealing to the market, and securing future revenue streams.

Each program and project must adopt a tailored approach to financing, selecting solutions best suited to its specific circumstances. However, one thing is clear: political commitment at the national level will be a critical success factor in enabling the nuclear industry to develop and mature across the CESA region. For countries subject to EU regulations, government support must carefully balance alignment of budgetary constraints and compliance with State aid competition rules and requirements.

Public funding is crucial for developing regulatory frameworks, safety protocols and waste management systems. Establishing a robust legal framework will help mitigate risks for private investors. Simplifying licensing processes and ensuring regulatory harmonization can facilitate faster project development, including pre-approval of standardized designs to reduce bureaucratic delays.

By fostering collaboration between governments and investors as well as establishing clear frameworks, stakeholders can effectively harness the potential of nuclear power to meet future energy needs while combating climate change.

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