Glowing Prospects? The Future of Polish Nuclear Power

Aurora Polish Power and Renewables Public Webinar

3rd June 2025

Introducing the team

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Sources: Aurora Energy Research

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Agenda

The energy crisis of 2022 highlighted Europe's exposure to external shocks

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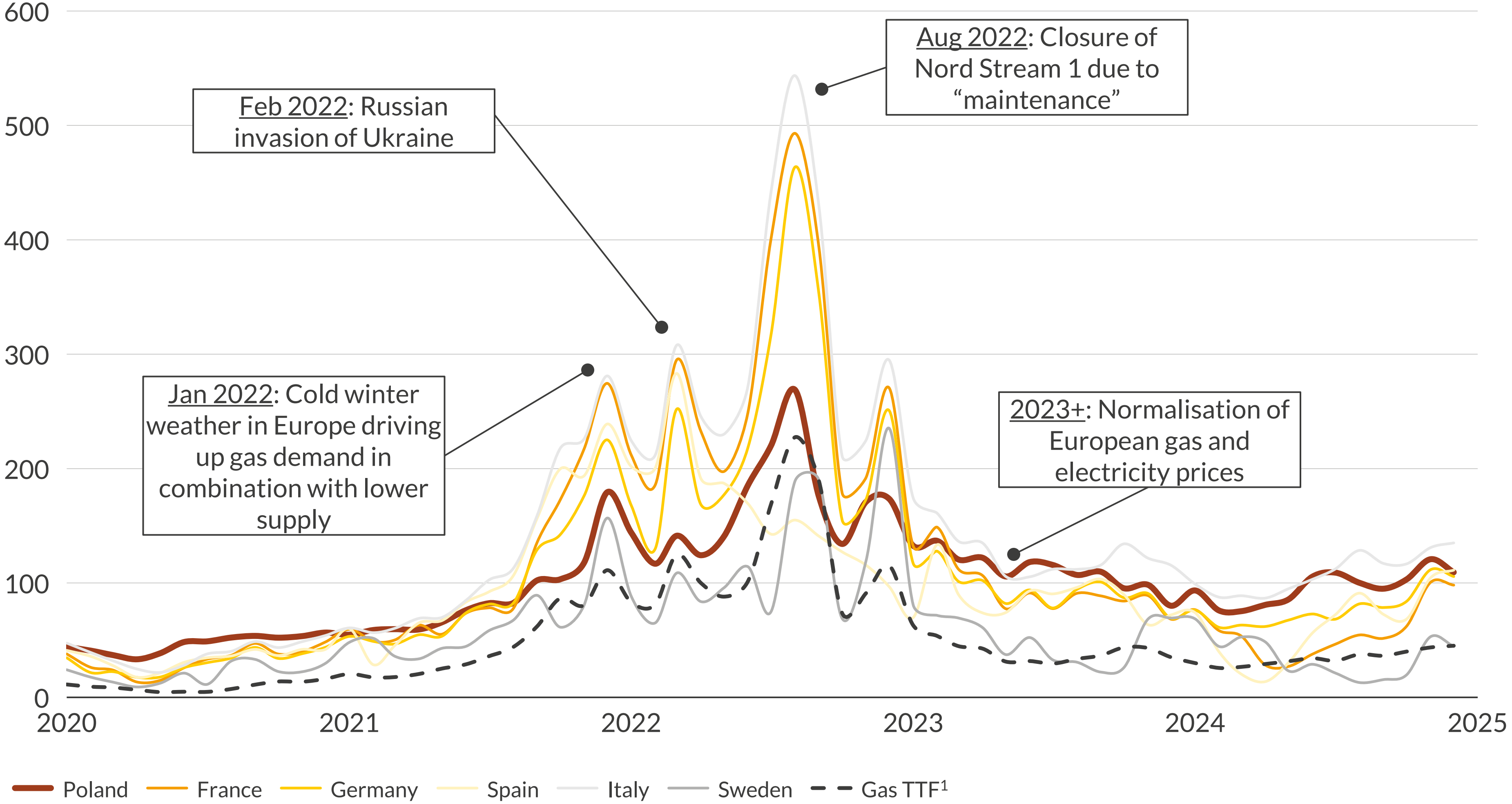
Wholesale gas and baseload electricity prices
€/MWh (nominal)



1) Average Natural Gas price at the key trading hub – Dutch TTF (Title Transfer Facility).

Sources: Aurora Energy Research, ENTSO-e, TTF

- Gas and power prices across Europe have risen to unprecedented levels following the Russian invasion of Ukraine.
- Reductions in the supply of gas by Russia have significantly increased gas prices, and in turn, power prices, as gas generators are often price setting in power markets.
- **Poland was less exposed to gas-induced shock** as its dispatchable fleet operates on coal, which is largely domestically supplied.
- Spain and Sweden benefited from a large RES fleet, lower reliance on gas and limited interconnection, making them less prone to external shocks.

Concerns over power price volatility have driven a renewed interest in nuclear across the EU

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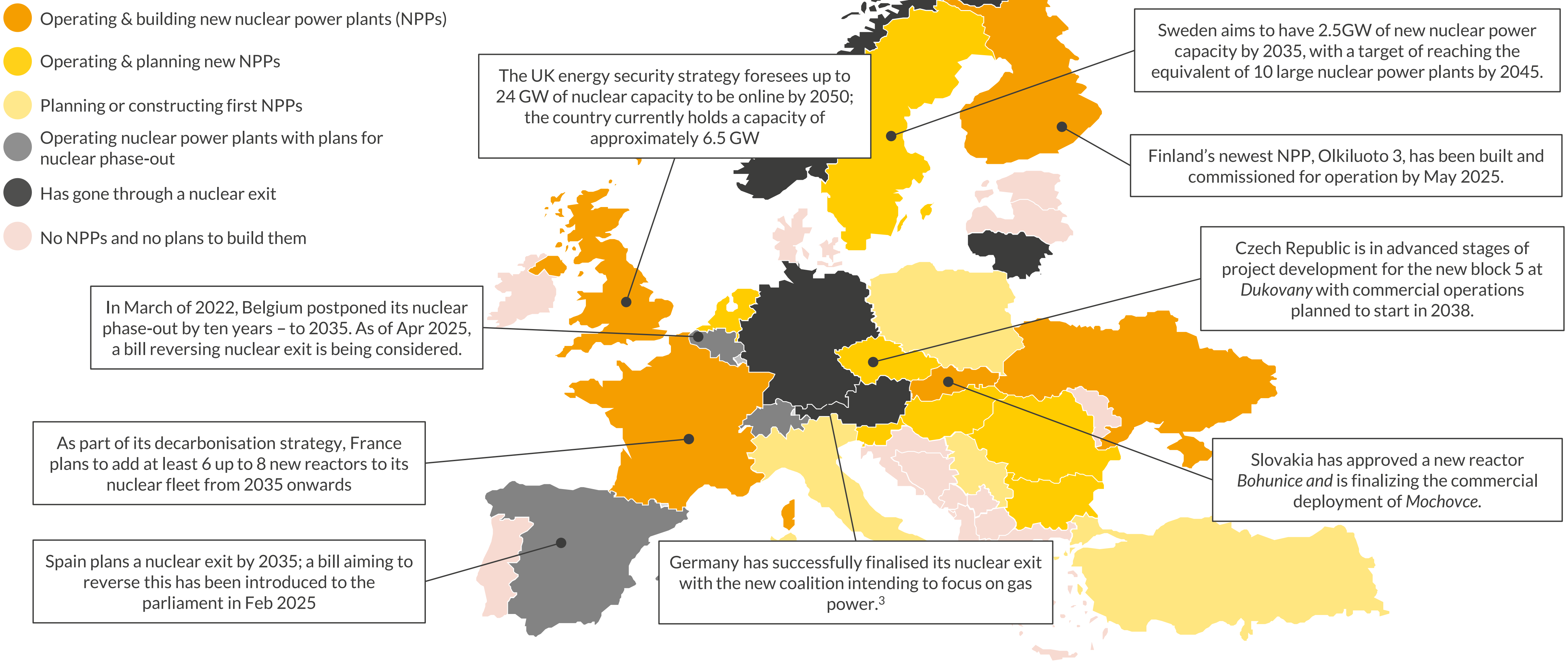
Nuclear energy policy and planning[1], 2025[2]



1) Encompasses expressed interest in and sustained political discussion about building nuclear power plants, excluding small modular reactors, and announced plans to do so. 2) As recorded in April 2025. 3) According to the Coalition Agreement from April 2025.

Sources: Aurora Energy Research, International Atomic Energy Agency, National Governments, European Commission, World Nuclear Association

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In 2024, as much as 86% of Polish energy demand was met based on domestic resources

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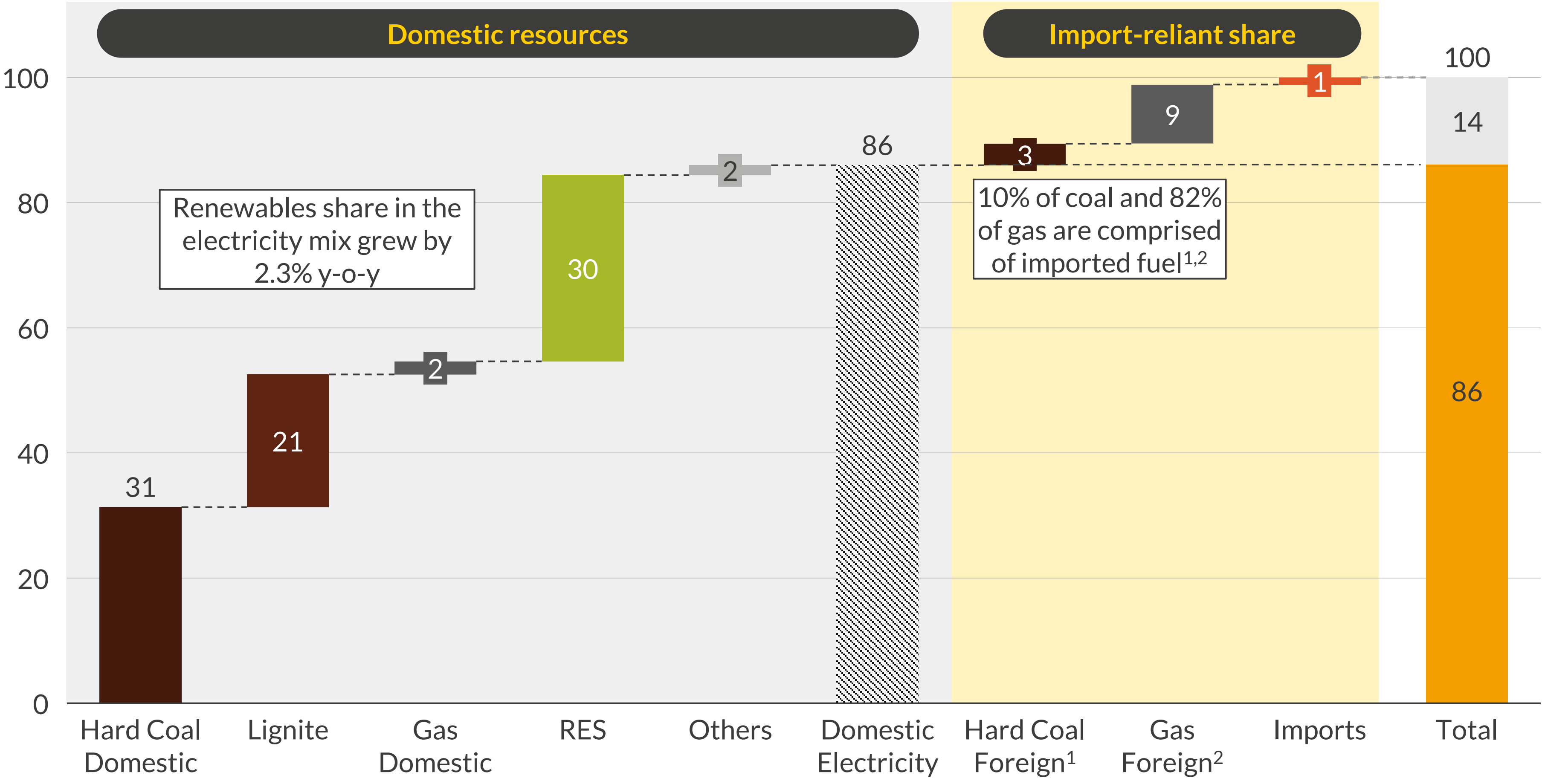
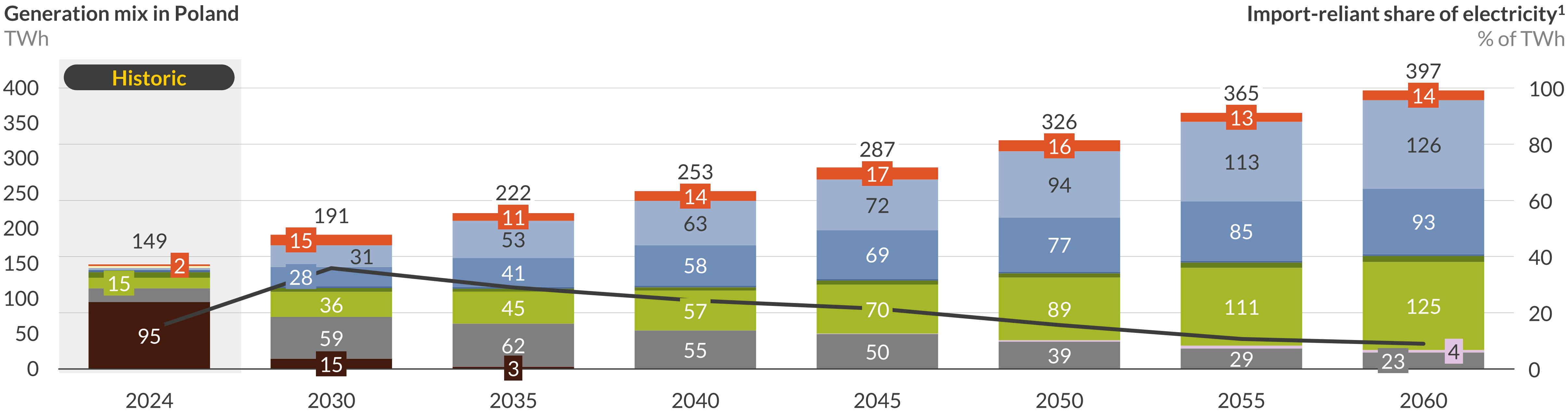
Origin of electricity in 2024
% of electricity mix



- **A large share of the Polish energy mix depends on domestic energy sources**, with 95TWh generated from coal and lignite, and an additional 50TWh based on renewables, totalling 86%.
- **Poland produced and imported 170TWh of electricity in 2024**, with fossil-based generation accounting for 67%.
- Poland's net imports stood at 2TWh, with an additional 22TWh of power generated domestically, but based on imported gas and coal. **The import-reliant share totals 14% of domestic power consumption.**

1) We assume the share of coal imports in the energy sector to be in line with the cross-sectoral average, which arrives at 10%. 2) Poland had an increase of available gas by 18.24 bm2 in 2024, with 3.3 bm2 coming from local production. 82% of gas came from abroad. 3) Dispatchable sources include: coal, lignite, gas and biomass.
Sources: Aurora Energy Research, ENTSO-G, ARE, Eurostat, ARP

Polish foreign electricity dependence is expected to increase as coal assets are replaced; long-term reliance declines due to increased RES



Foreign reliance peak

- Highest reliance on imported electricity is observed in 2030 at 36% and gradually decreases over the horizon.[2]
- The peak results from
  - The closure of existing coal plants, which are powered by largely domestic fuel production.
  - Higher reliance on gas in baseload, as wind and battery fleets are yet to reach full potential.

The shift towards gas

- Poland's switch to gas comes as a measure to substitute coal capacity, which proves to be both increasingly uneconomical and is based on an ageing fleet of low-efficiency plants.
- The majority of gas utilised for electricity production in Poland needs to be imported, due to insufficient domestic production.
- Historically, gas imports were reliant on supplies from Russia, but after 2022, Poland has shifted towards supplies from the US and Europe.

Coal and lignite | Gas | Hydrogen | Solar | Other RES | Hydro | Offshore wind | Onshore wind | Other | Interconnectors | Import reliant share[3]

1) Interconnectors and gas generation. 2) Under the Aurora Central April 2025 scenario. 3) Imports reliance calculated in the same way as the previous slide, considering imported gas, hydrogen, coal and direct electricity imports. Gas based on forecast, coal assumed the same ratio as 2024.

Sources: Aurora Energy Research, PGNiG

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I. Introduction – European pathways

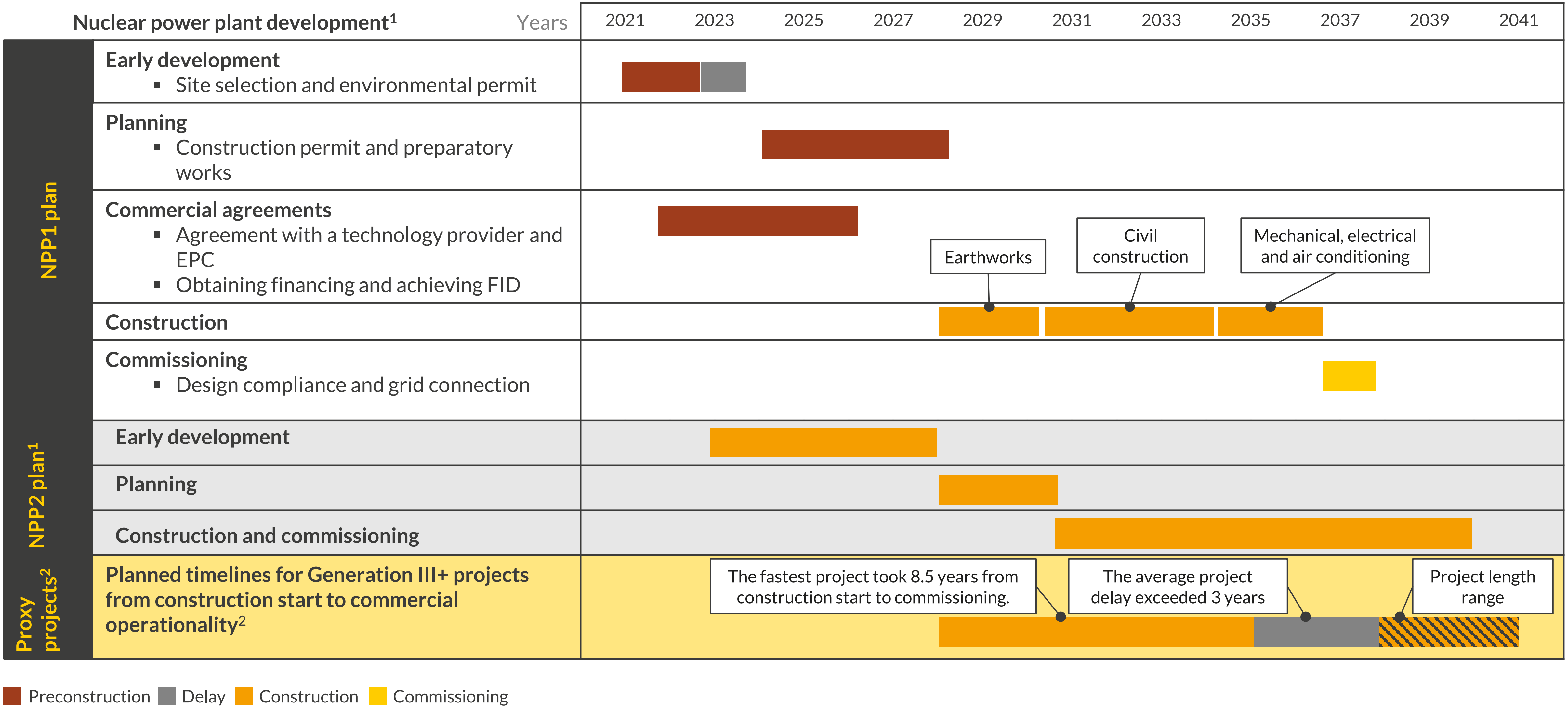
II. Power dependency in the tumultuous world

III. Poland’s Nuclear Objectives and Implications

1. Nuclear ambitions
2. Nuclear impact
3. Nuclear goals

IV. Key takeaways

The first polish nuclear reactor can begin commercial operations in 2038 at the earliest, given benchmarking



1) Compared to our previous Strategic Insight report from H2 2022, the timelines have shifted by 2 years. Please see Nuclear Dawn: impacts on Poland's power market for details. 2) Based on declared PPEJ targets. 3)Based on technology supplied by Westinghouse or KHNP, projects include Vogtle (USA), Hinkley Point C (UK), Barakah (UAE), Shin Hanul (South Korea), Haiyang (China).

Sources: Aurora Energy Research, EDF. Southern Company, PPEJ, Westinghouse, European Commission

Poland expects a much higher state involvement when compared to a peer project, to ensure maximum plant utilisation

	EC recent agreement	The Polish proposal
Basis	Approved state aid bill for Dukovany II	Polish proposal for state aid for Lubiatowo-Kopalino NPP
State aid mechanism	▪ Two-way CfD, strike price at 65-80EUR/MWh ▪ Strike price subject to inflation indexation	▪ Two-way CfD strike price at 470-550zł/MWh[1] (110-130 EUR) ▪ Strike price adjusted by inflation and cost overruns
Financing structure	▪ Preferential loan of 16-18bn EUR	▪ 30% Equity injection ▪ State guarantees up to 150bn zł (35bn EUR)
Market access	>70% sold on the SPOT and futures market <30% sold via competitive auctions	Primarily via long-term PPA, and futures, remainder on SPOT
Clawback mechanism	▪ Periodic IRR review every 5 yrs ▪ Lump-sum payback if returns exceed the threshold	▪ No formal clawback ▪ Excess returns flow into the consumer fund
Support length	40 years	60 years
Load factor	81-83%[2]	93%[3]
Capacity timeline	▪ Assumed total 3750 for NPP1 between 2039-2041 ▪ Further 4200[4] for NPP2 between 2040-2042	

Support scheme details | Modelling inputs

The EC has raised a number of concerns regarding the Polish formula

- **Limited market exposure** as price risk if fully hedged by the CfD for the 60 years of plant operations.
- **Risk of Overcompensation** as the proposal lacks profit sharing and clawback mechanism, as seen in the approved Dukovany II model.
- **Competitive imbalance** as the duration, size of equity injection and guarantee may be excessive, and other players would be unable to compete with this level of state aid to one player.
- **Lack of cost control and transparency,** as cost overruns would be covered by guarantees or a direct equity injection.

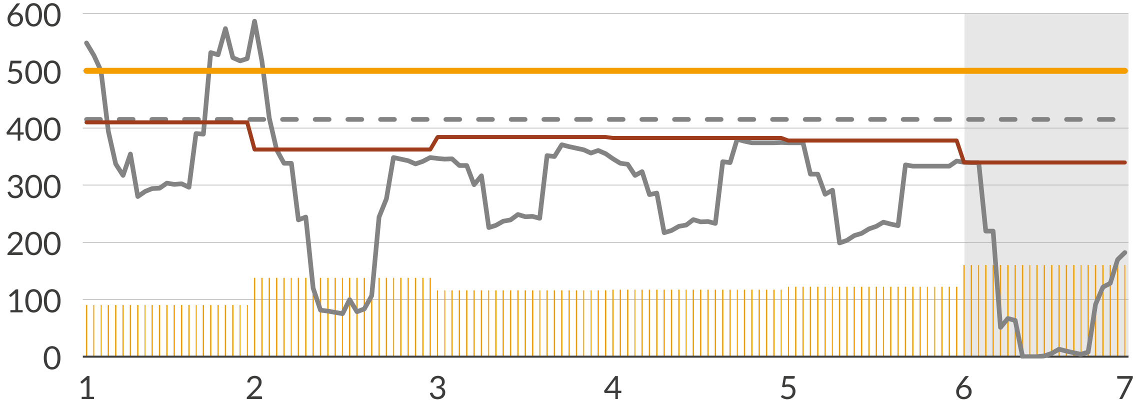
1) Initial strike price calculation in base scenario, subject to change. Strike prices in real terms. 2) Assumed in the financing model submitted to the European Commission. 3) Based on the optimal modelled plant dispatch. 4) Assumed KHNP APR1400 technology, as previously considered, the final technology provider is not yet known.

Sources: Aurora Energy Research, European Commission

The proposed CfD cushions the project against risks, while also blunting market signals

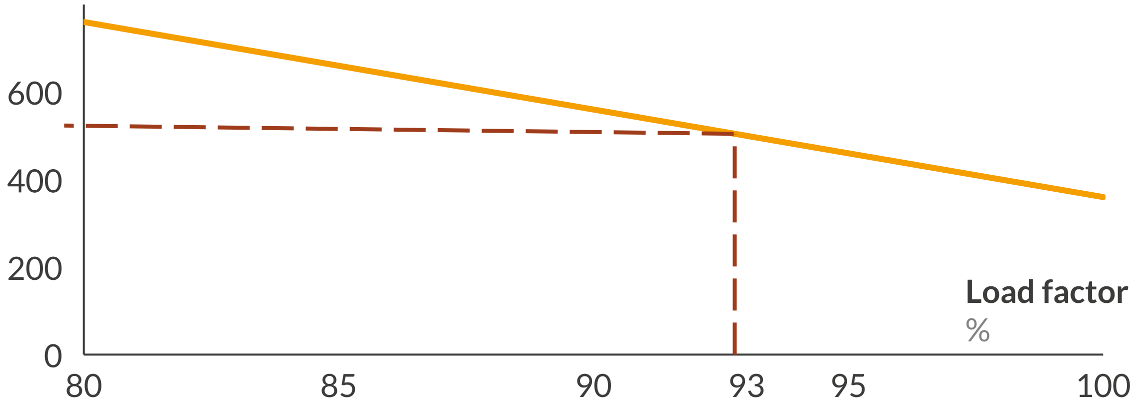
CfD compensation[1], 8-14 July 2045

zł/MWh



Load factor strike price (LFSP) adjustment mechanism

zł/MWh



The reference price is set daily based on a weighted sale route…

The proposed scenario is a **two-way CfD subsidy**, which insulates the plant from real-time market signals.

- The plant is remunerated based on the difference between the daily reference price and the strike price.
- The **reference price is a daily average blended price for each product sold**[2], weighted by the share of volume of electricity.
- The **plant is forbidden from selling energy below its SRMC**. If this or technical issues result in a lower generation, the strike price is increased to make up for the output reduction.

…while the strike price is adjusted anually and covers multiple risks

The strike price will be periodically adjusted by OPEX changes, inflation and the **load factor strike price adjustment mechanism**.

- The LFSP adjusts the strike price and cushions the impact of growing RES penetration. The retroactive settlement means that **the plant would receive a refund for the lower-than-expected generated volume**.
- The strike price is set at NPV=0, and **the initial level is expected at 470-550 zł/MWh**, but can differ significantly based on cost overruns and delays.

DAM price | PPA price | Reference price[3] | Strike price | Payment under CfD | Day with partial curtailment

1) Assumed 500zł/MWh strike price, a lower bound for the 500-580 zł/MWh range in a 1-year delay scenario as submitted to the EC. 2) Products here refer to spot, futures/forward contracts, PPAs. 3) Simplified example assumes 70% PPA and 30% via SPOT, as PPA is the primary sales route, forwards excluded for clarity purposes.

Sources: Aurora Energy Research, European Commission

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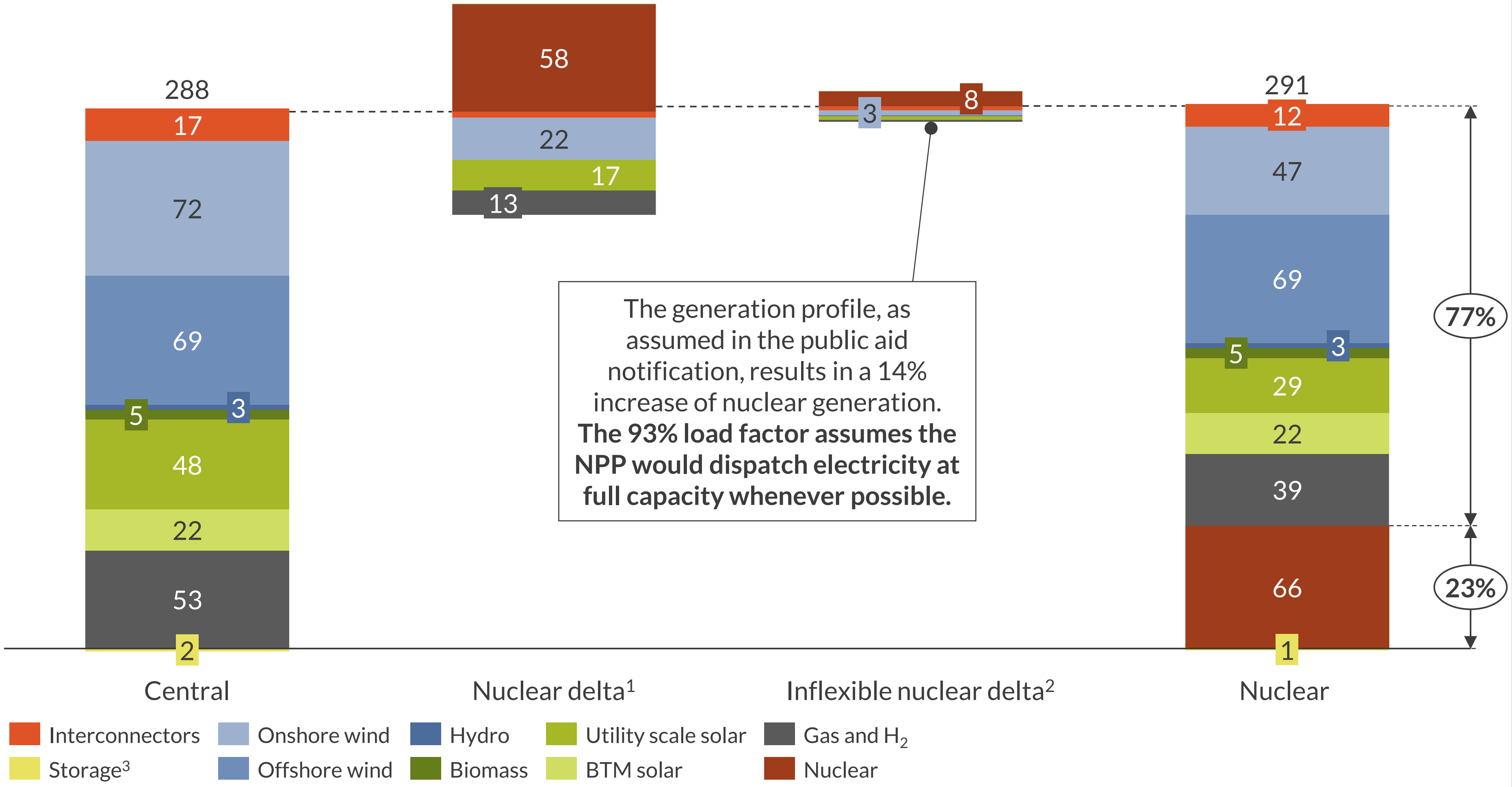
Despite a small capacity, nuclear may constitute up to 23% of total generation, with significant variation depending on support path

Electricity production and net imports in 2045
TWh



1) Based on a flexible nuclear scenario as described on slide 17. 2) Additional delta assuming nuclear operating with a 92.7% load factor, based on submitted public aid notification. 3) Includes BESS and pumped storage.
Sources: Aurora Energy Research

- Given its high utilisation and baseload production profile, nuclear becomes a key part of Poland's generation mix.
- 8 GW of nuclear provides 58 TWh in 2045, or 20% of Poland's power demand. Assuming maximum potential load factor, in line with the Polish public aid notification, the nuclear share increases to 23%.
- By restricting the buildout of merchant renewables, nuclear replaces 54 TWh of generation from merchant onshore wind and solar.
- The baseload profile of nuclear production means a quarter of gas is displaced, as it is unable to compete with the new, heavily subsidised capacity.

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The investment opportunity in Polish renewables is cut by around 105 billion zł as nuclear limits the buildout of merchant assets

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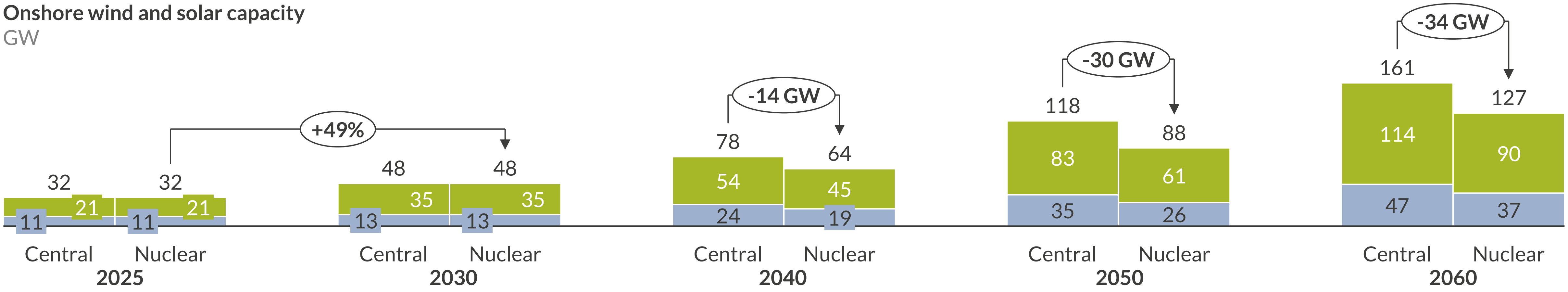
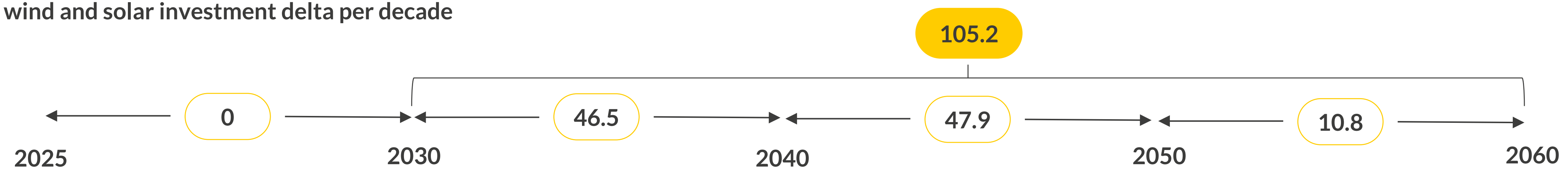
Renewables

Onshore wind and solar capacity
GW



Onshore wind and solar investment delta per decade
bln zł



1 Renewables investments grow by 49% driven by CfDs until 2030s…

- Renewable buildout is identical in both scenarios until the 2030s because most capacity is delivered under the CfD subsidy system and nuclear COD appears in late 2030s, keeping near-term merchant prospects relatively strong.

2 … but nuclear cuts the opportunity for merchant investments thereafter

- Post 2030s, renewable buildout is primarily governed by merchant dynamics, as most subsidy systems close to new entries.
- Nuclear entering the system from 2038 impacts these merchant dynamics as less renewable buildout is possible while still achieving required returns.

Onshore wind Solar

1) Calculation based on missed CAPEX and account for learning rates for both solar and wind technologies.

Sources: Aurora Energy Research

The 2038-2042 nuclear rollout threatens RES with increased curtailment; The size and length of negative prices depend on the selected nuclear path

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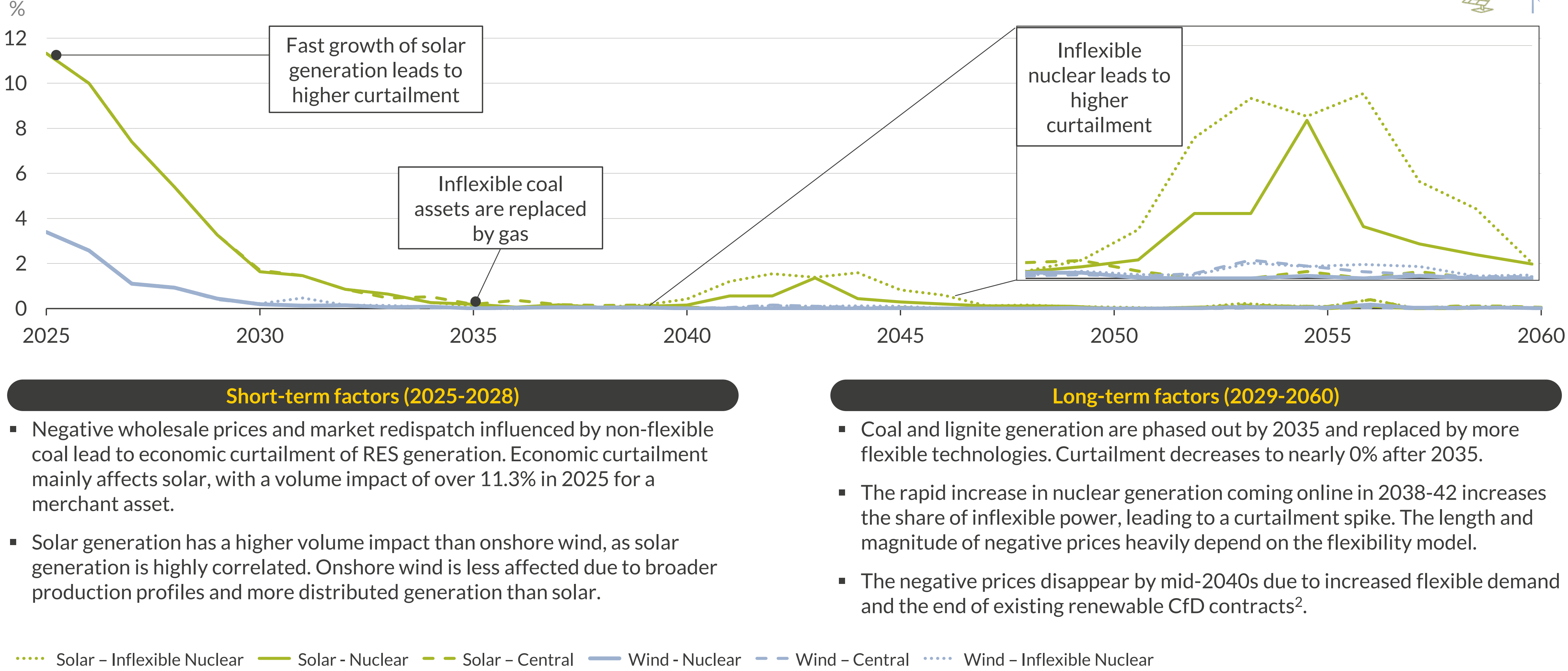
Renewables

Solar & wind curtailment[1]



Short-term factors (2025-2028)

- Negative wholesale prices and market redispatch influenced by non-flexible coal lead to economic curtailment of RES generation. Economic curtailment mainly affects solar, with a volume impact of over 11.3% in 2025 for a merchant asset.
- Solar generation has a higher volume impact than onshore wind, as solar generation is highly correlated. Onshore wind is less affected due to broader production profiles and more distributed generation than solar.

Long-term factors (2029-2060)

- Coal and lignite generation are phased out by 2035 and replaced by more flexible technologies. Curtailment decreases to nearly 0% after 2035.
- The rapid increase in nuclear generation coming online in 2038-42 increases the share of inflexible power, leading to a curtailment spike. The length and magnitude of negative prices heavily depend on the flexibility model.
- The negative prices disappear by mid-2040s due to increased flexible demand and the end of existing renewable CfD contracts[2].

1) Curtailment is in reference to curtailment in periods when prices are below zero. Curtailment below zero represents economic curtailment for a fully price-reactive asset, i.e. under a PPA with a negative price clause. 2) Renewable CfDs result in reduced incentives to adjust generation, as participants are partially protected against the impact of negative prices. Please see our September 2024 strategic report for more.

Sources: Aurora Energy Research

Battery investments are cut short due to reduced daily price volatility undermining arbitrage revenues

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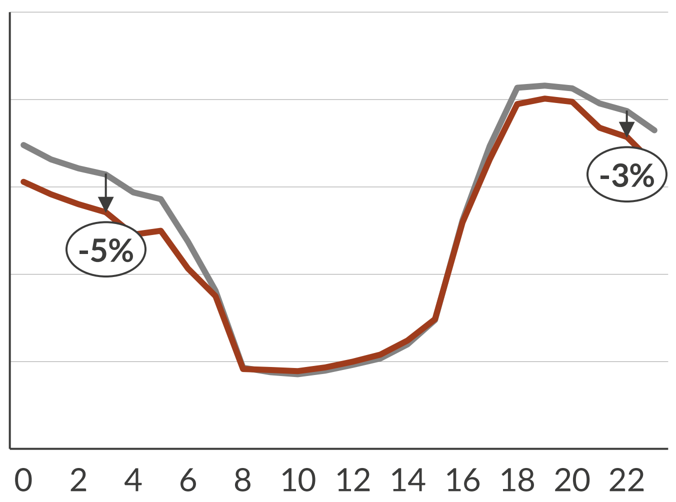
Disptachable

1 Flatter daily prices reshape battery dispatch

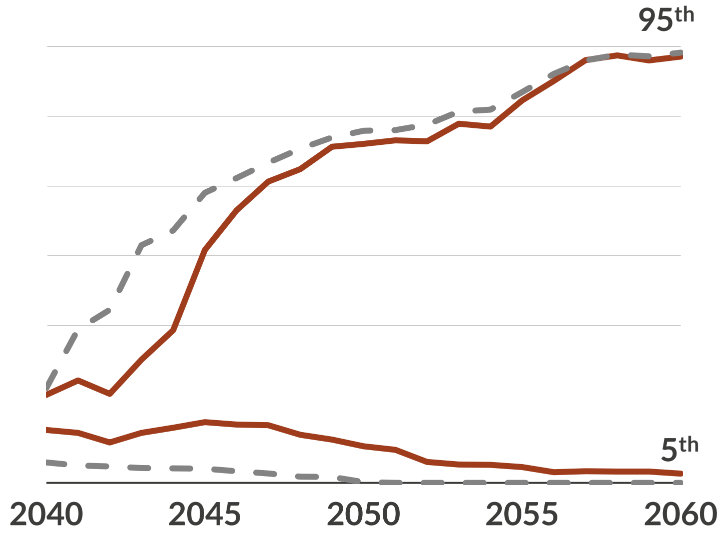
Average hourly price profile (2040-2060)
zł/MWh, real 2024



- With higher nuclear capacity, baseload generation increases, providing a steady electricity supply throughout the day.
- This consistent output suppresses price peaks, leading to a flatter hourly price curve.

2 Extreme events occur less often, meaning fewer high-profit arbitrage opportunities

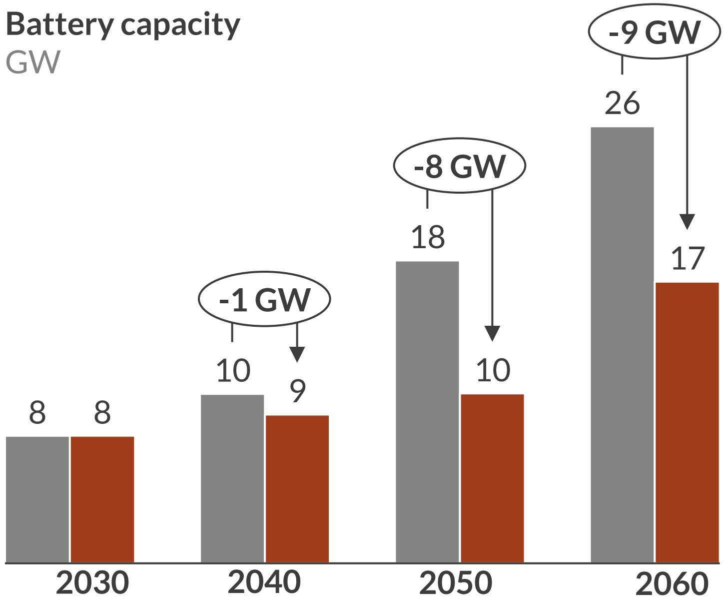
Price percentiles – 95th and 5th (2040-2060)
zł/MWh, real 2024



- The spread between the 95th and 5th percentiles tightens as nuclear displaces gas and RES.
- Price spikes are suppressed by reduced reliance on gas, while lower RES penetration leads to fewer overgeneration events, lifting the price floor.

3 Battery investments drop

Battery capacity
GW



BESS investment delta[1]
bln zł

29.3

- Battery investments decline as a flatter daily price shape and narrower price percentile spreads reduce arbitrage opportunities and overall revenue potential.

Central Nuclear

1) Calculation based on missed CAPEX based on Aurora Central view of BESS CAPEX development.

Sources: Aurora Energy Research

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Large scale nuclear primarily replaces independent generation with reliance on nuclear fuel imports

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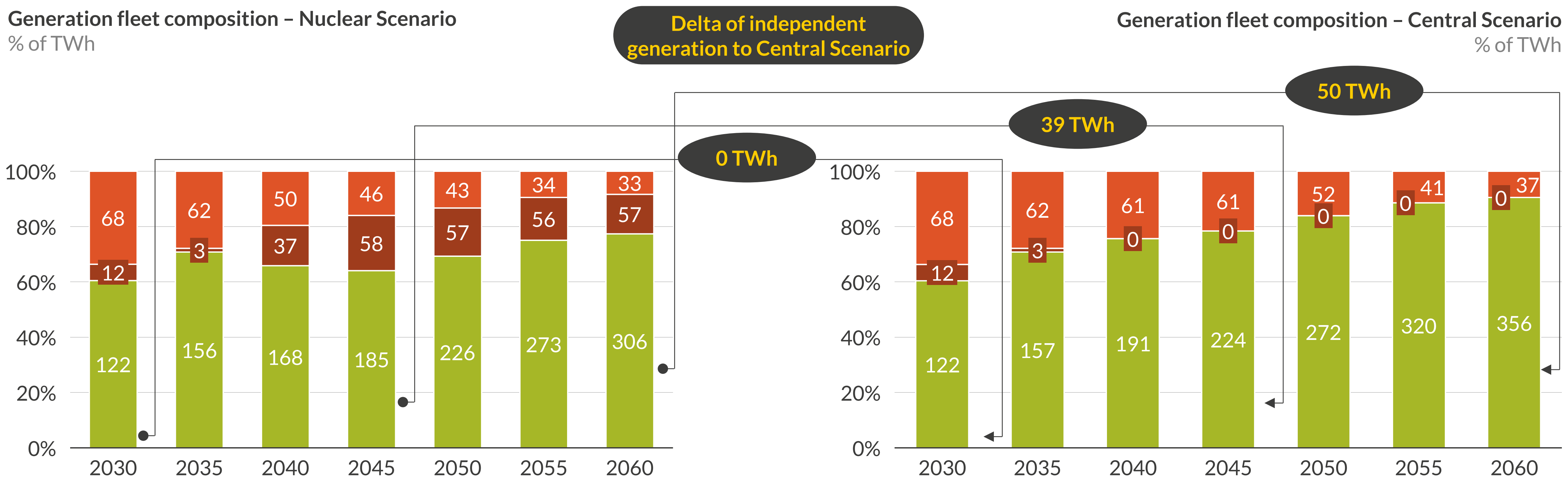


Nuclear effect on independent generation:

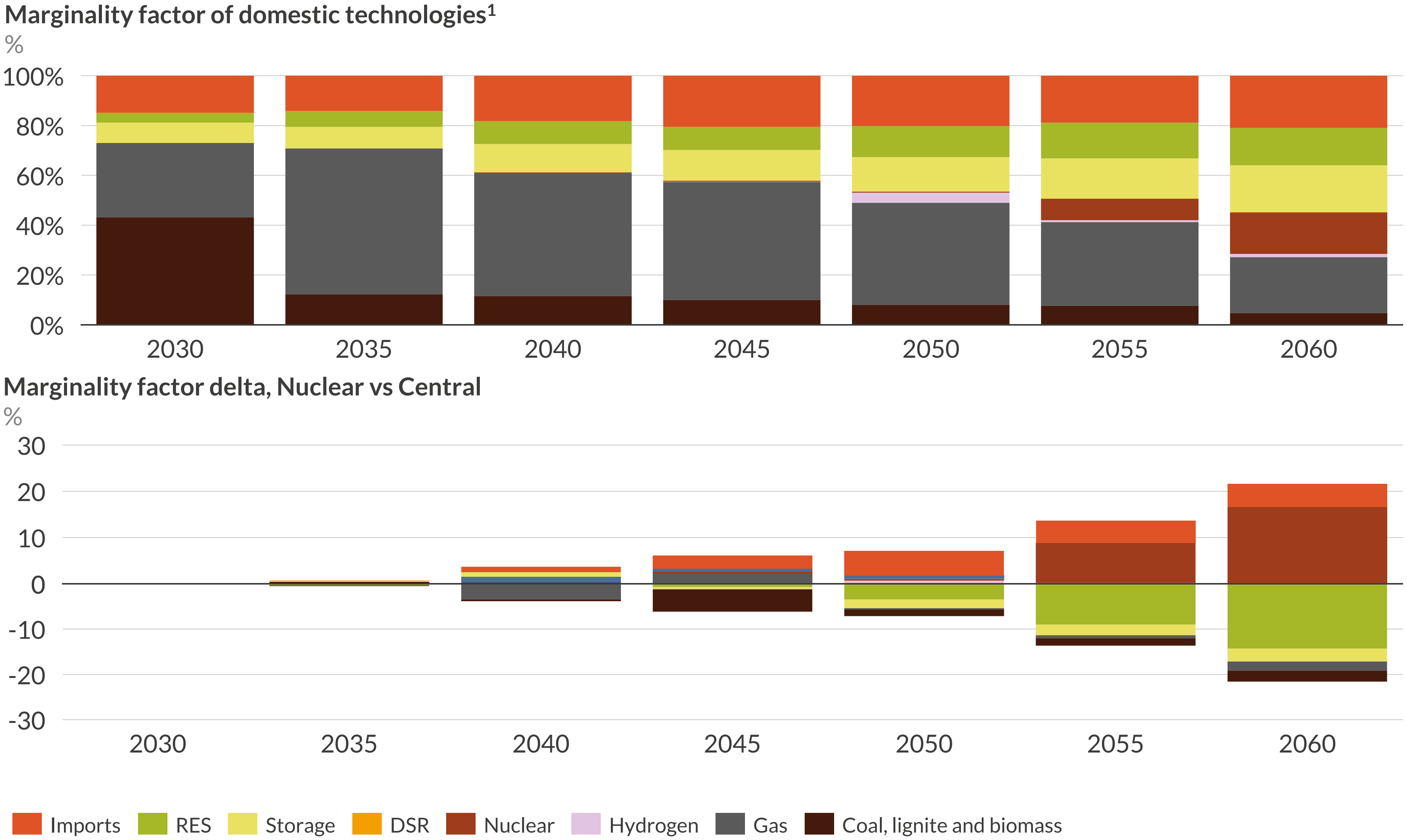
- Poland's exposure to external risks peaks in the 2030s, with up to 40% of power dependent on foreign suppliers. Nuclear power enters too late to protect the Polish system in this period.
- Domestic capacities are the most affected by the rollout of large nuclear plants, as renewables are displaced, and BESS does not materialise.
- Gas capacities and imports persist in the nuclear scenario. Gas production, while lower, plays a role throughout the modelled period.

Independent[1] Dependent[2] Volatile Dependency[3]

1) Independent includes renewables, BESS and country-sourced share of fuels. 2) Dependent is composed of nuclear and imported coal. 3) Volatile dependency portrays net electricity imports, coal, gas and H_2 imports.

Sources: Aurora Energy Research

In the long-term a mix of imports, gas and nuclear sets the price, marking higher external price exposure



1) Renewables include onshore and offshore wind, solar PV and hydro power. Storage includes BESS and pumped storage.

Sources Aurora Energy Research

- The technology **marginality measures how often a given type of technology sets the electricity prices** by being the last one in the merit order.
- **In the 2040s, prices are set by gas.** The impact of nuclear is minor, as nuclear remains low in the merit order.
- **Exposure to gas price volatility remains almost unchanged** throughout the forecast. The role of gas as a marginal technology continues, despite decreased capacity.
- Where the prices were previously set by a mix of renewables and storage technologies, nuclear and imports increasingly set the price.

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Key takeaways

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1. The Polish energy reliance on external fuel and power suppliers was relatively modest in 2024 but is expected to increase. **The level of foreign reliance peaks in the 2030s** amidst higher gas utilisation.

2. The first large-scale nuclear reactor in Poland is **unlikely to be operational before 2038,** given the current project state and benchmarking**.** Delays in construction, securing the financing structure or political priorities may further delay the project.

3. In our assumed scenario, nuclear **reduces RES investments by 105bn zł (25bn EUR) between** 2030 and 2060, resulting in **24GW less solar and 10GW less onshore wind capacity**. Further **29bn PLN (7bn EUR) of battery investments do not materialise**.

4. **Nuclear reduces independent power generation by 50 TWh by 2060**, compared to just 4 TWh of energy based on imports. The delayed nuclear rollout results in additional capacities entering too late to mitigate the peak exposure period.

Sources: Aurora Energy Research

Aurora's suite of software products for the Polish market

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ORIGIN
for markets

Our **market-level model** enables you to create your own market scenarios within hours and quantify market risks and upsides from policy, commodity, demand and supply changes.

AMUN
for wind

Our **software tool for asset-specific modelling of a wind farm's** financial performance that delivers bankable asset-specific revenue forecasts for wind assets within minutes.

LUMUS
for PPAs

Our **contracts valuation engine** lets you price and analyse Power Purchase Agreements, fully consistent with Aurora's view of the market.

Details and disclaimer

Publication
Glowing Prospects? The Future of Polish Nuclear Power
Date
13th May 2025

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