

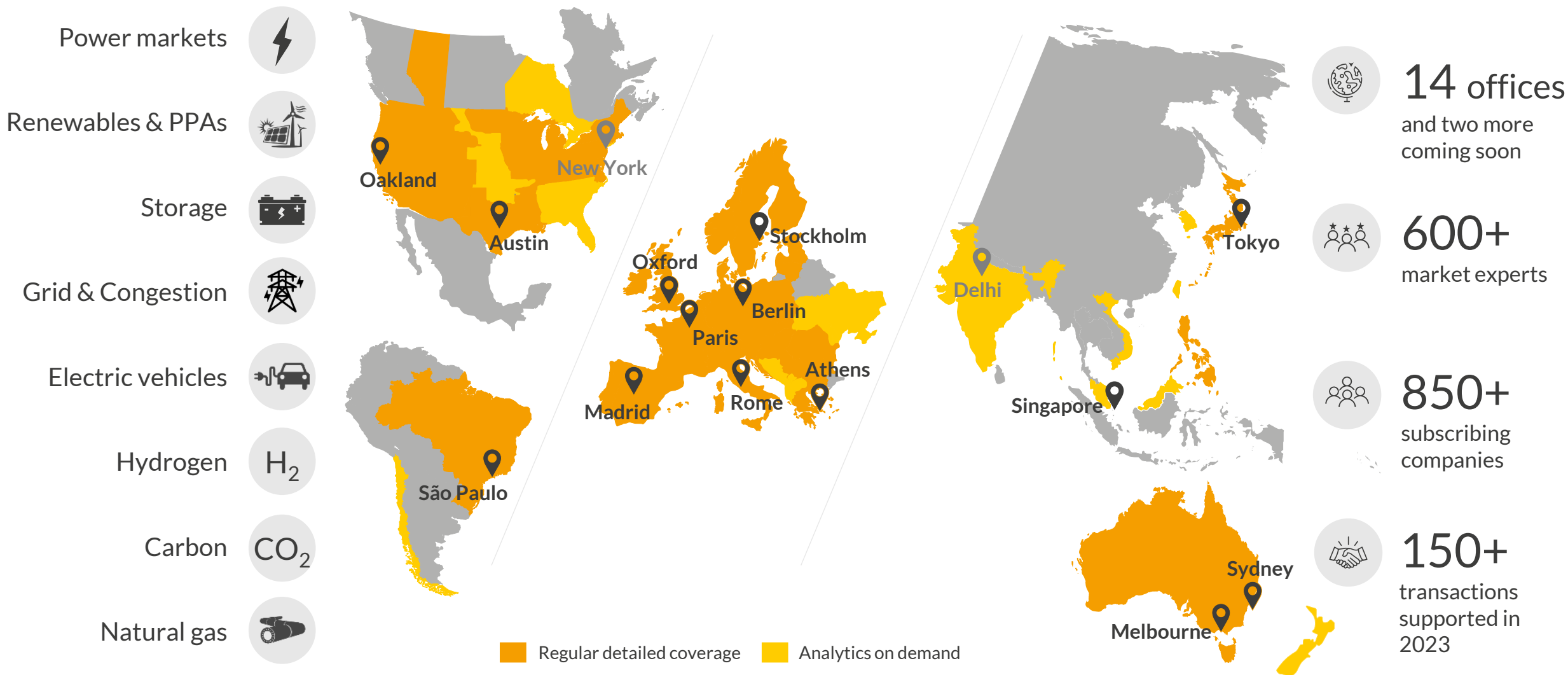
# The Slovak Power and Renewables Market: Long-Term Outlook

REDACTED VERSION

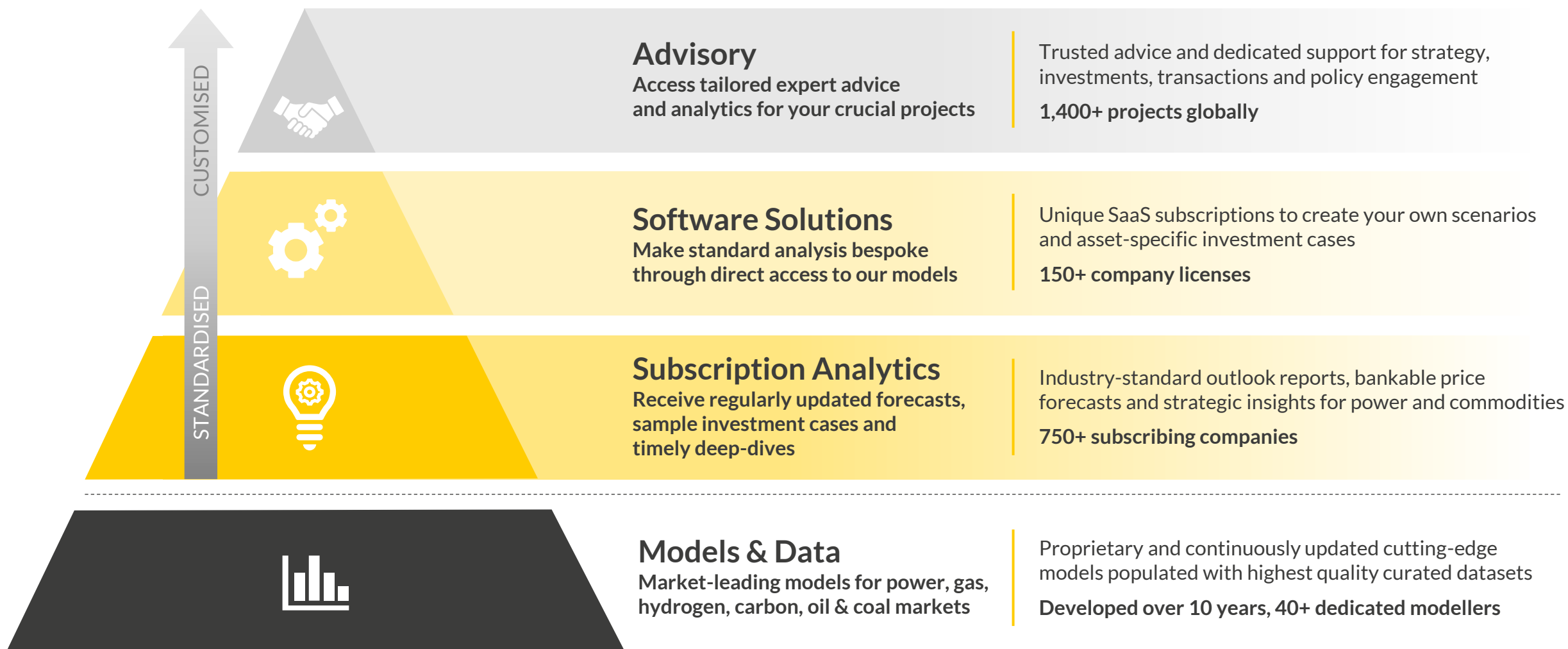


# Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

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Ben van Beurden, CEO, Shell



"Aurora analysis and the provision of reliance was crucial for our debt funding. Their ability to explain market logics and revenue streams was vital for this successful financing."

Jeremy Taylor, Director, Green Frog Power



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- I. Long-term outlook for the Slovak market
- II. Understanding price drivers
- III. Investing in solar
- IV. Key market uncertainties: Our High/Low Scenarios
- V. Key takeaways

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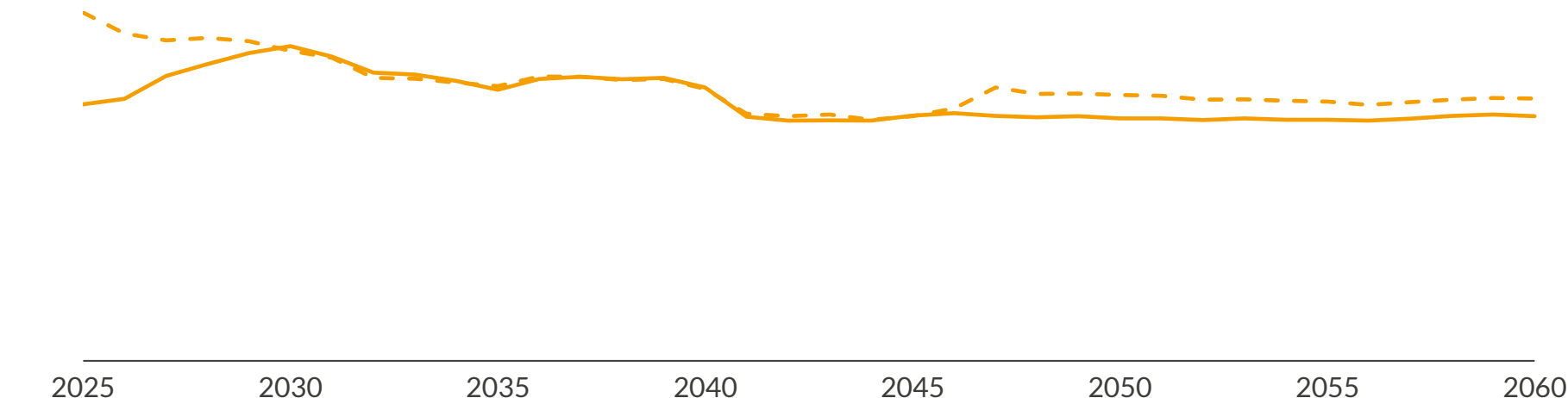
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# Our April 2024 forecast contains the following key updates and takeaways

Key assumption updates and takeaways		Description		
Assumption updates	Update of Slovak fuel and carbon price projections in the short term (deltas relative to February 2024 2 <sup>nd</sup> Mutli-Client Study Workshop)	Gas Price	Coal Price	Carbon Price
		- █ %	- █ %	- █ %
	Demand forecast revision	▪ We have accounted for the likely reopening of the Slovalco aluminium plant and the switch of U.S Steel Košice to electric arc-furnaces, leading to a steep demand rise by 2030. By 2060, base demand is down by █ TWh due to a lower assumed energy intensity, while demand from electrification in district heating rises by █ TWh.		
	Solar load factor revision	▪ We have developed specific load profiles for the Slovak market based on Solaris, Aurora’s tool for irradiation analysis. We assume a █ % load factor for bifacial utility-scale solar installations.		
Takeaways	Bohunice units lifetime extension	▪ Based on client feedback, we now assume that the existing units at Jaslovské Bohunice NPP will have their lifetime extended to 80 years, retiring beyond our forecast horizon in 2060.		
	Prices fall in the short term influenced by commodities	▪ A mild winter and slowdown in European industrial output have led to dramatic drops to gas and carbon prices. This results in baseload prices falling █ €/MWh on average between 2024 and 2029, with prices for 2024 down █ €/MWh.		
	Low long-term prices	▪ Slovak prices peak at █ €/MWh in 2030 and stabilise around █ €/MWh in the 2030s. Once additional nuclear is commissioned in 2041, baseload prices fall further, stabilising around █ €/MWh in the long-term, significantly below the level seen in neighbouring markets.		
	Switch to net exporter	▪ Slovakia has historically been a net importer, but the commissioning of new units at Mochovce means it becomes a net exporter already in 2024 and 2025. This trend is accelerated as Czech lignite is retired and Slovakia maintains an abundance of low marginal-cost generation from nuclear and hydro.		

# Baseload price peaks at █████ €/MWh in 2030, then gradually decreases, stabilising around █████ €/MWh between 2040 and 2060

Baseload wholesale electricity price  
€/MWh (real 2023)



Delta to previous forecast<sup>1</sup>  
€/MWh (real 2023)

- Compared to our previous forecast, the baseload price is █████ €/MWh lower on average from 2024–2030, mostly due to the short-term futures-driven decrease in commodity prices. Baseload prices then remain mostly aligned with our previous forecast until the late 2040s.
- We have revised the lifetime of the Bohunice nuclear unit, now assuming closure after 2060 rather than in 2047. This drives a relative decrease in baseload prices of, on average, █████ €/MWh compared with our previous forecast from 2047 to 2060.

— Historical baseload — Baseload - - Previous baseload — Delta

1) Refers to Aurora's preliminary market outlook for Slovakia presented during the 2nd workshop of the Czech and Slovak Multi-Client Study in Prague on 14 February 2024.

## Outlook for baseload prices

### 2024–2040

- Baseload price rises to a relative peak of █████ €/MWh in 2030, then rebalances around █████ €/MWh, as rising gas and carbon prices are combatted with RES buildout in Slovakia and its neighbours, Czechia and Hungary.
- Switching of gas-fired capacities to hydrogen in Germany causes a jump in baseload price in interconnected regions in 2035.

### 2041–2050

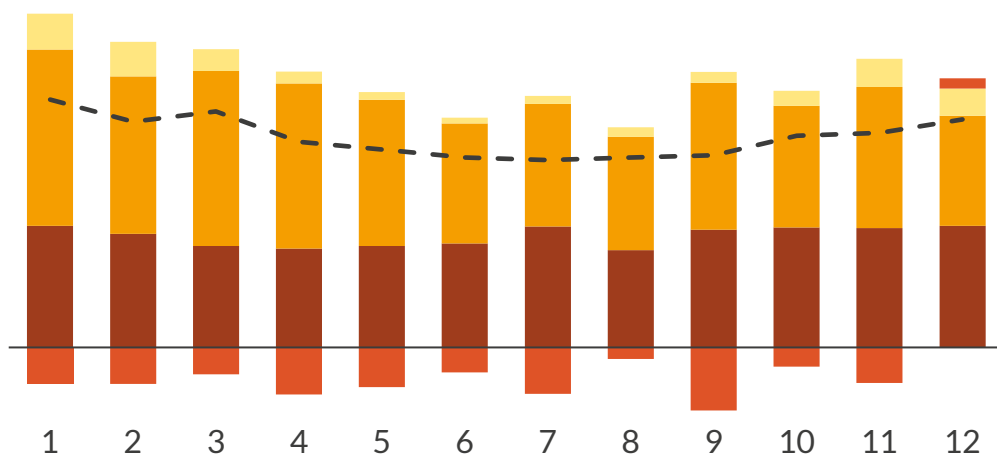
- Slovak prices fall by █████ €/MWh between 2040–2041 as the Bohunice nuclear reactor expansion is commissioned.

### 2051–2060

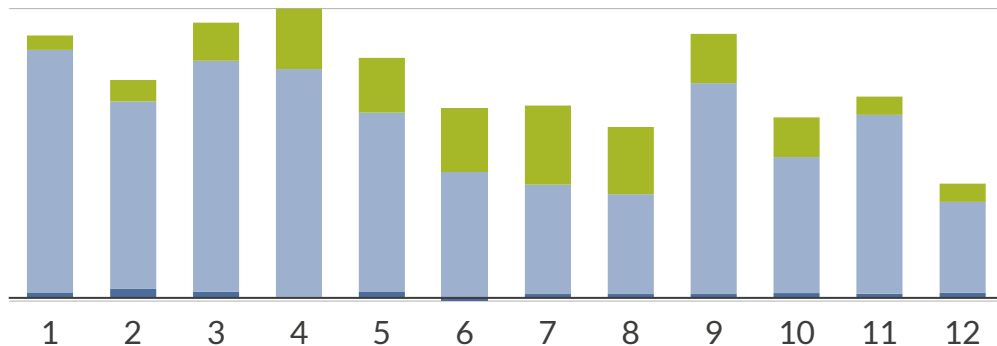
- Baseload price stabilises at an average of █████ €/MWh as RES and nuclear limit the role of dispatchable generation.

# Nuclear, high solar generation and lower seasonal demand drive an increasingly large discount between summer and winter prices

Monthly production 2040  
TWh



Variable renewable production delta 2025-2040  
TWh




- - Demand  
 ■ Inflexible generation<sup>1</sup>  
 ■ Nuclear  
 ■ Dispatchable generation<sup>2</sup>  
 ■ Net imports  
 ■ Onshore Wind  
 ■ Solar PV  
 ■ Hydro

1) Inflexible generation includes renewables and forced CHP generation. 2) Dispatchable generation includes generation from lignite, hard coal, gas CCGT, oil/gas peaker, hydrogen CCGT, hydrogen peaker, biomass, battery storage, DSR and pumped storage.

Sources: Aurora Energy Research

Monthly baseload price  
€/MWh (real 2022)

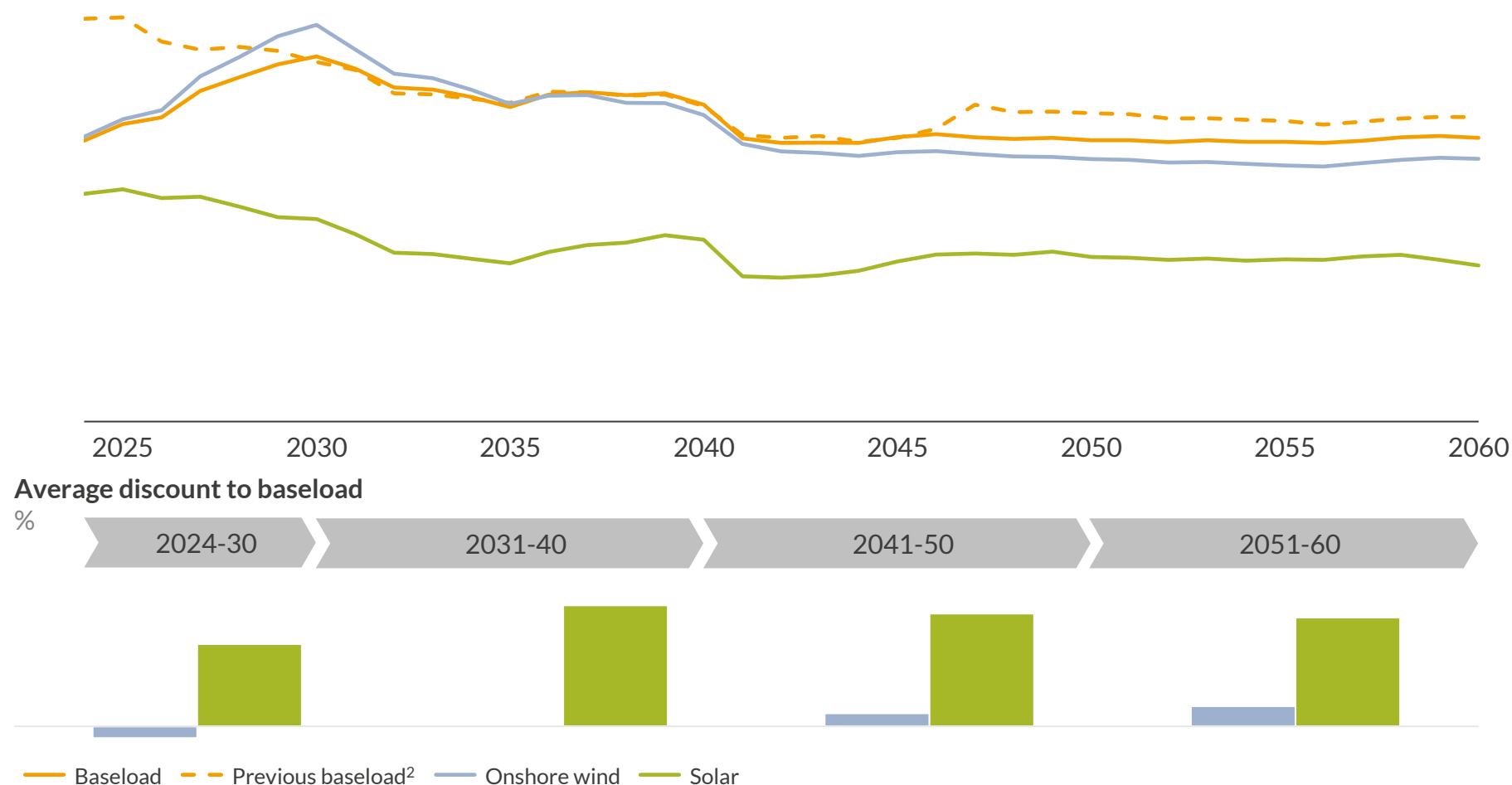


- Inflexible generation in Slovakia remains strong across the seasons, with renewable generation peaking in the summer months when solar PV potential is at a maximum, and forced CHP operation peaking in the winter months when heat demand is highest.
- Onshore wind offers an additional contribution to production in cooler months, but its weather-dependent nature means that dispatchable capacity is necessary to meet demand.
- Slovakia becomes a net importer in December 2040, allowing demand to be met when solar PV generation is minimal.
- Baseload prices in June 2040 are  % of the 2025 value, due to renewables and nuclear together exceeding the total demand in the summer months.



# Solar capture prices fall by €/MWh in the period to 2035, driven by subsidy, before stabilising as buildout stalls



Baseload and renewables capture prices<sup>1</sup>  
€/MWh (real 2023)




1) Uncurtailed generation-weighted capture prices. 2) Refers to Aurora's preliminary market outlook for Slovakia, presented during the 2nd workshop of the Czech and Slovak Multi-Client Study in Prague on 14 February 2024.

Sources: Aurora Energy Research

## Onshore Wind

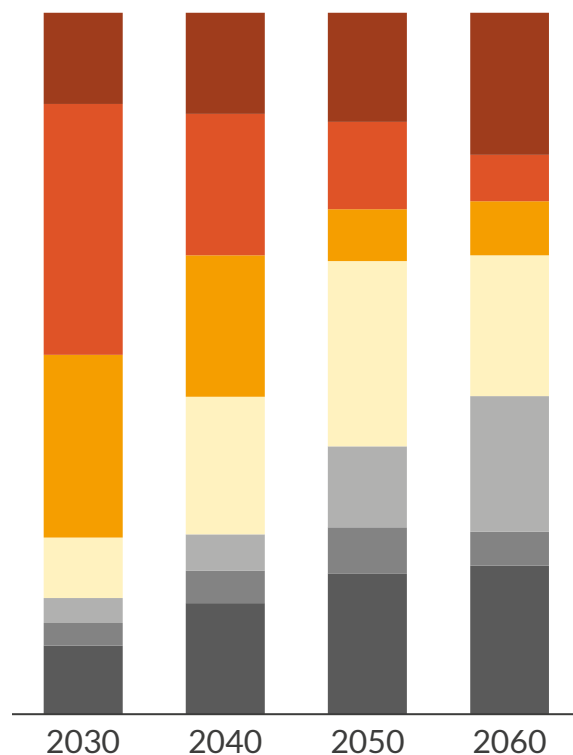
- Onshore wind capture prices rise in the short-term as permitting restrictions limit buildout, peaking at  €/MWh in 2030.
- Long-term buildout of onshore wind brings capture prices beneath baseload price, where they remain stable around  €/MWh after 2040.

## Solar

- Solar capture prices fall  €/MWh between 2024 and 2035, driven by subsidised solar buildout in Slovakia and neighbouring regions, before increasing in the period up to 2040 as subsidies are exhausted.
- In the long-term, solar capacity stabilises and capture prices follow baseload price behaviour, exposed to the impact of new nuclear capacity at Bohunice.

# Abundant cheap generation and coupling with more expensive neighbouring markets drives high price volatility after 2030

Frequency distribution of the electricity price (real 2023)  
%

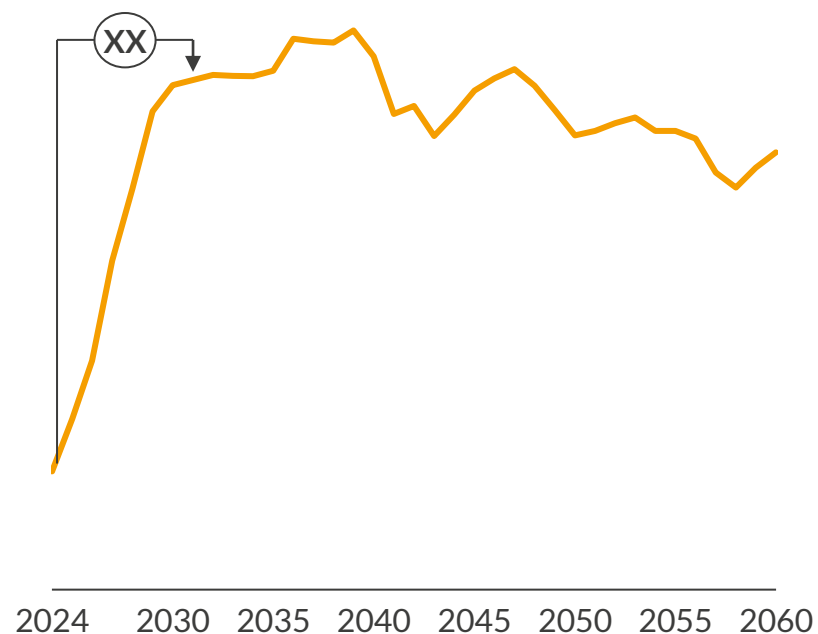


Standard Deviation €/MWh (real 2022)



<20 €
  20-40 €
  40-60 €
  60-80 €
  80-100 €
  100-120 €
  >120 €

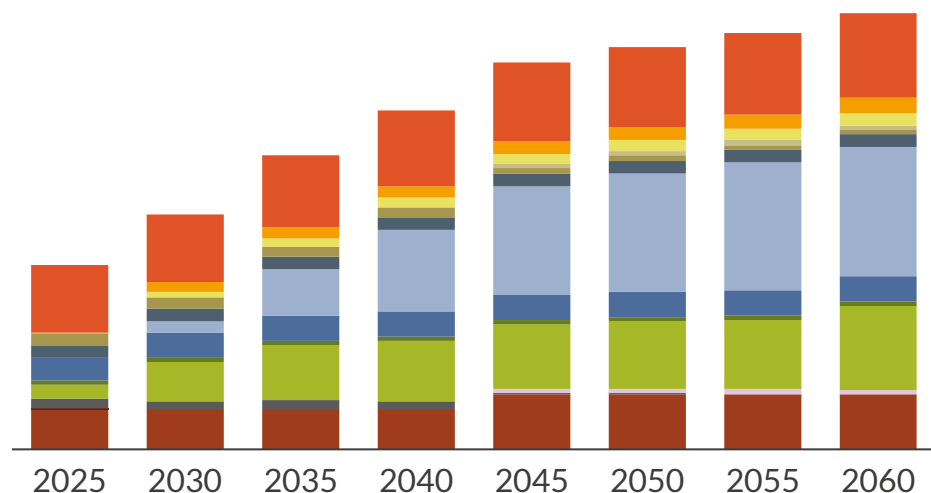
Average daily 1h spread in Day-Ahead market  
€/MWh (real 2023)



- The retirement of lignite capacities in Czechia and steep growth of Slovak demand results in capacity tightness by 2030. Alongside recovering commodity prices, this leads to increased occurrence of high price hours.
- Concurrently, the fast buildout of solar in Slovakia and neighbouring markets causes XX % of hours to be priced below XX €/MWh by 2040.
- Together, these factors lead to 1-hour spreads above XX €/MWh from 2027 onwards, creating an attractive case for battery investments.
- In the long term, the commissioning of an additional nuclear reactor increases the occurrence of low-price hours and reduces spreads slightly.

# The development of nuclear and renewables in Slovakia enables low carbon generation to exceed its demand and makes it a net exporter

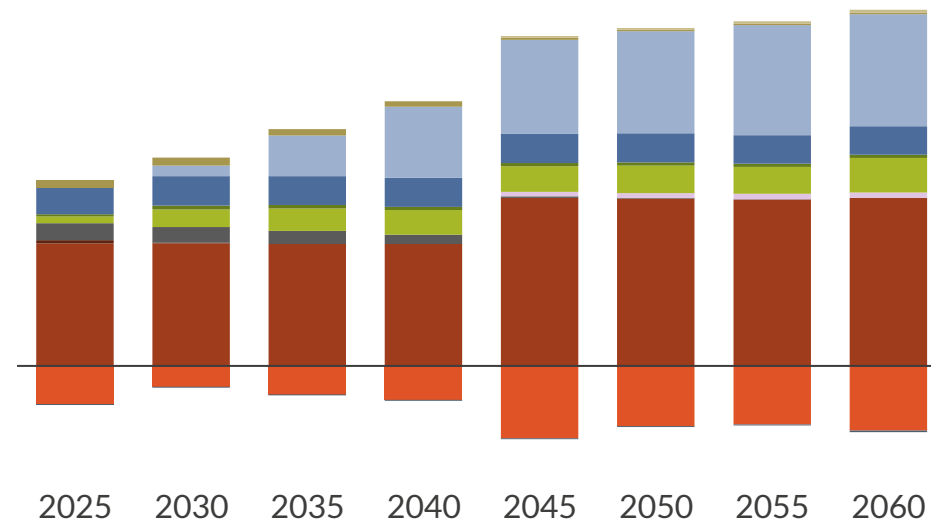
Installed capacity  
GW



- Installed capacity increases by **3.5** GW until 2060, mainly driven by renewables, whose total capacity reaches **3.5** GW. Fast short-term solar buildout is driven by available investment subsidies, and onshore wind builds later in the forecast where permitting restrictions provide less constraint.
- Dispatchable capacity remains stable, with gas CHPs being replaced by hydrogen in the 2040s. Additional capacity comes largely from BESS and DSR.
- Nuclear capacity rises to **1.5** GW with a replacement unit commissioned at Bohunice in 2041 and older units staying online across the forecast horizon.

■ Nuclear ■ Gas CCGT ■ Solar ■ Hydro ■ Pumped storage ■ Hydrogen peaker ■ DSR  
■ Lignite ■ Hydrogen CCGT ■ Other RES ■ Onshore wind ■ Gas / oil peaker ■ Battery storage ■ Interconnectors

Electricity production and net imports  
TWh



Low carbon share of net demand<sup>1, 2</sup> %



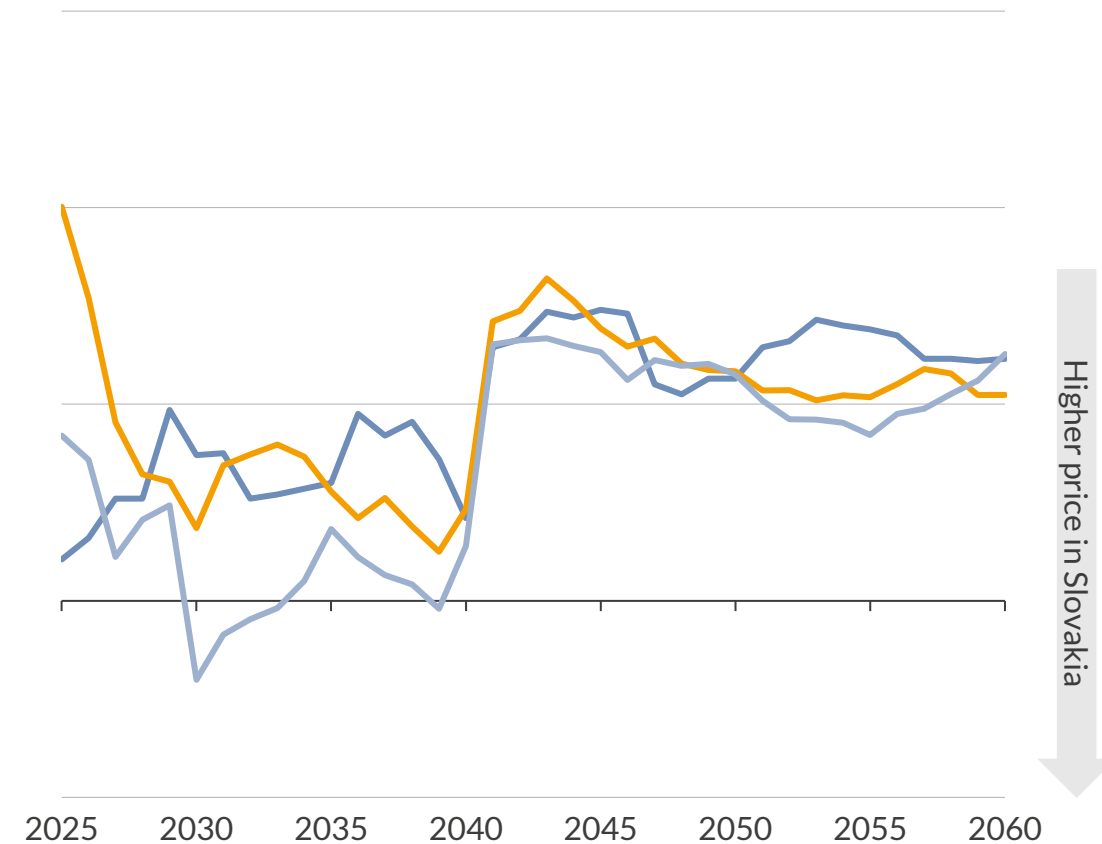
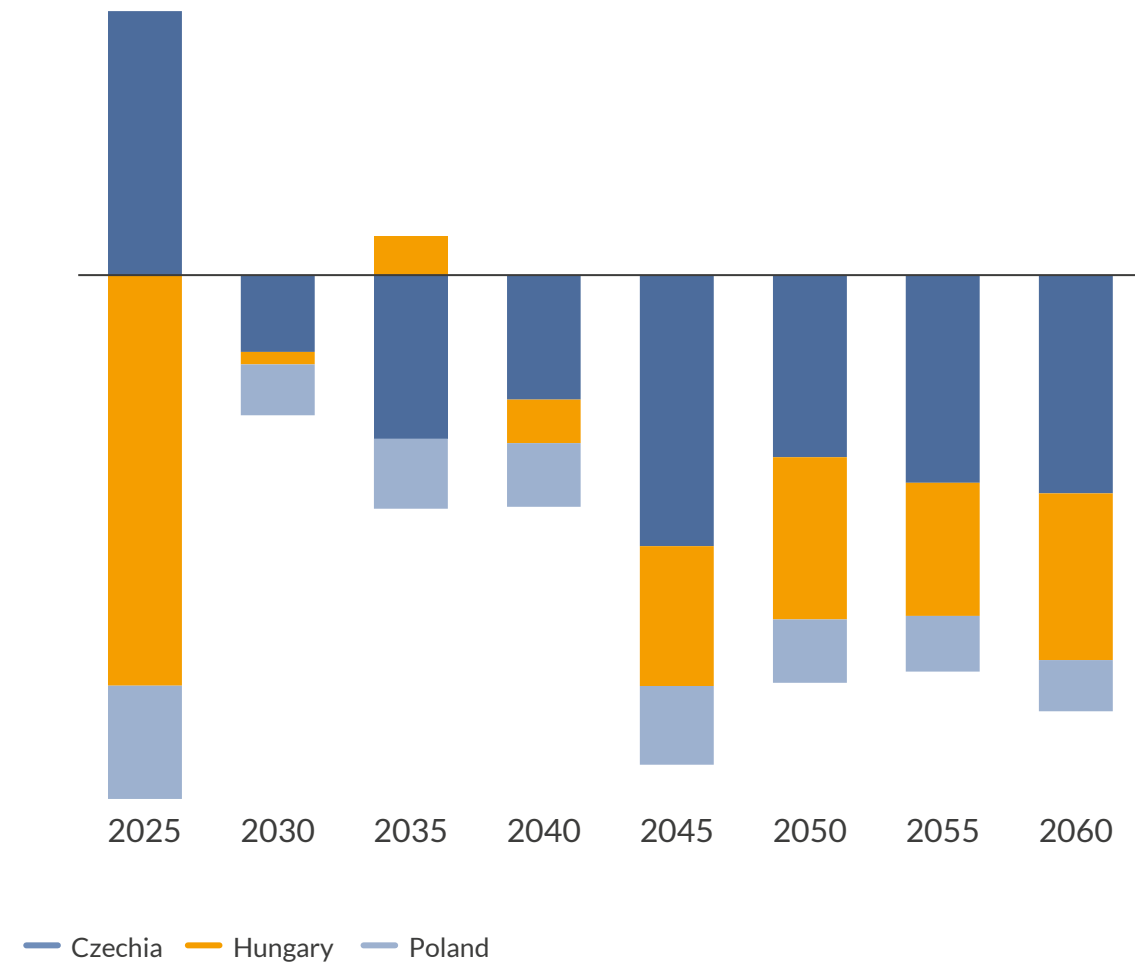
- Slovak power demand is expected to rise **10**% to **110** TWh in 2060.
- Renewable generation increases by **3.5** TWh in the period to 2060, rising from a **40**% share of power demand in 2024 to a **110**% share in 2060.
- Slovakia was a net importer of electricity until 2022 but solidifies its position as a net exporter from 2024 and across the entire forecast.

1) Low carbon generation includes nuclear and renewables. 2) Net demand excludes exports, allowing low carbon share to be above 100%.

# Low marginal cost generation from nuclear and hydro and the retirement of Czech lignite turn Slovakia into a large net exporter

Net annual commercial export flows to CZE  
TWh

Average annual delta to SVK baseload electricity prices  
€/MWh (real 2023)



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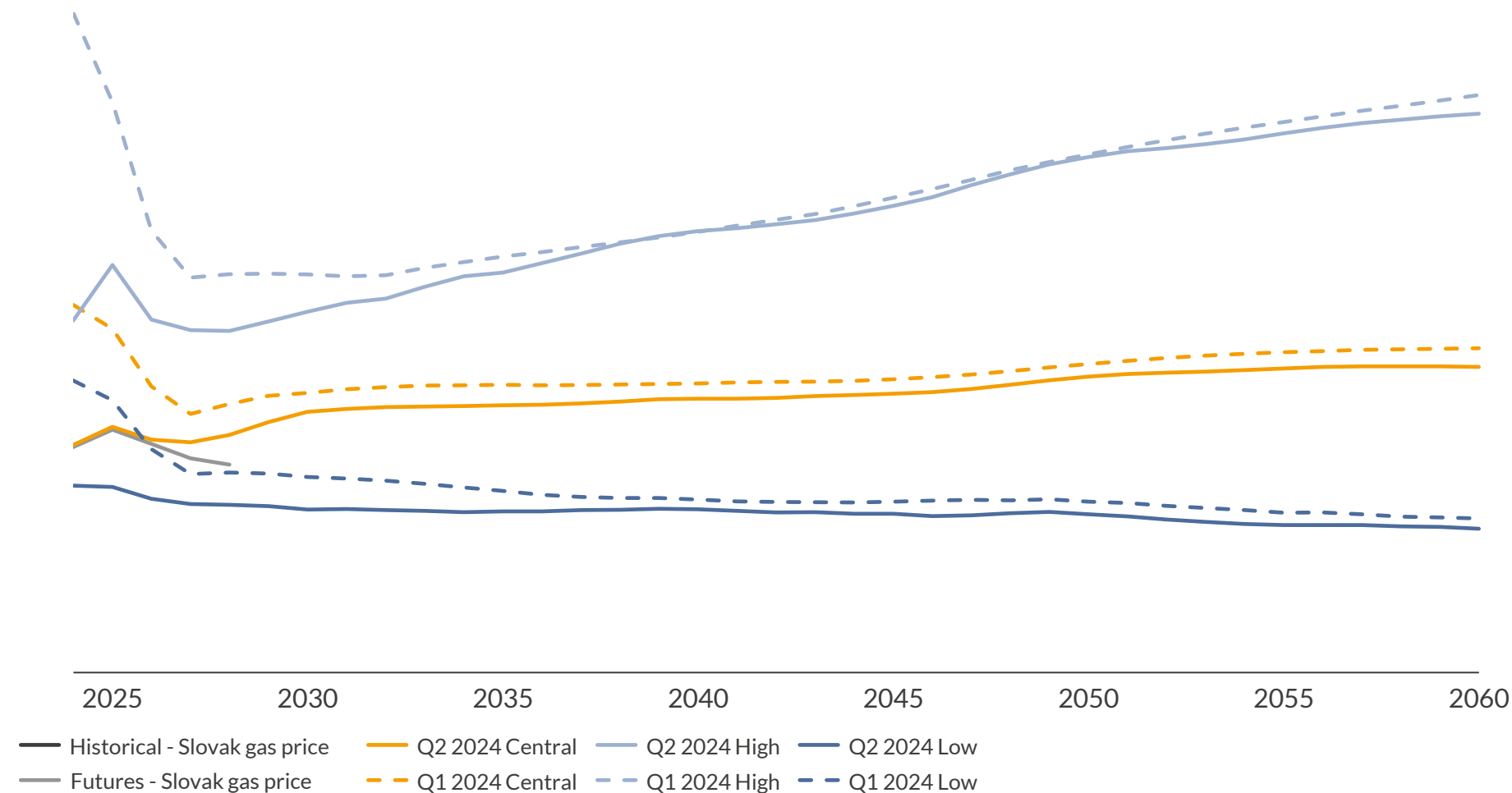
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# Gas prices in Europe stabilise by 2027, as more LNG is available in the global markets, then climb driven by ramping demand in Asia


Natural gas prices  
€/MWh (real 2023)<sup>1</sup>



1) CEGH VTP historical and futures gas prices are shown. For years 2024-2028, the prices shown take into account current futures prices for the years in question, with declining weights. In 2024, forecast prices include historical prices up to Feb-24. 2) Futures on trading days between 26/02/2024 and 08/03/2024.

Sources: Aurora Energy Research, EEX, CME

## 2024-2027

- The gas price averages €/MWh in 2024-2027,  % lower than the previous forecast due to mild weather, robust supply, and high stocks.
- After 2025, prices fall as additional LNG import capacity in Europe comes online and global export capacity expands.

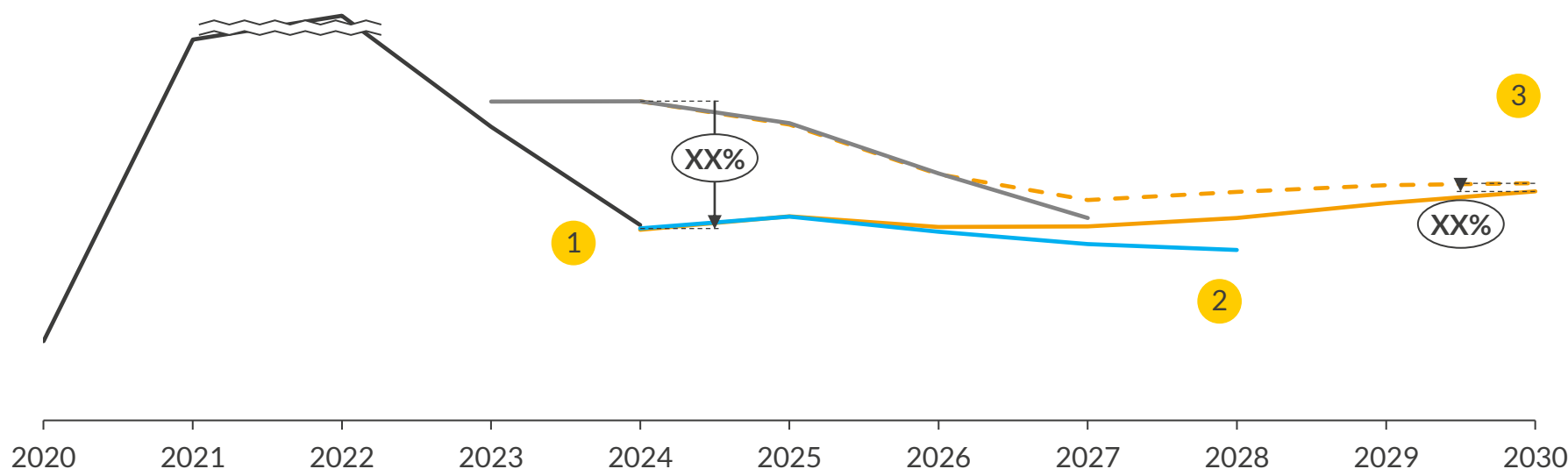
## 2028-2060

- The gas price averages €/MWh in 2028-2060,  % lower than the previous forecast, as Russian imports via Ukraine transit displace more expensive sources of supply.
- Prices rise by 2030 amid global demand growth, with limited new LNG capacity additions post-2027. After 2030, rising gas demand in Asia increases the cost of marginal supply, partially mitigated by renewables and electrification deployment in Europe.

# European gas futures for 2024 delivery fell XX% since our January report, however our expectation of 2030 delivery is down just XX%

## European (TTF) gas price<sup>1</sup>

€/MWh (real 2023)



## Why did 2024 futures drop by XX% since our January report?

### Q4 2023

Europe's industrial gas demand over winter was particularly low, resisting recovery from a year earlier.

Northeast Asian LNG imports remained unusually weak, freeing up supply and lower shipping costs.

### Q1 2024

Persistent mild weather limited residential gas demand and kept storage withdrawals low.

Underground gas inventories ended winter at high levels, cutting import demand and depressing prices.

— Historical — Apr 24 Central<sup>1</sup> - - Jan 24 Central<sup>1</sup> — Apr 24 Futures<sup>2</sup> — Jan 24 Futures<sup>3</sup>

1) For years 2024-2028, the prices shown take into account current futures prices for the years in question, with declining weights. 2) Futures on trading days between 26/02/2024 and 08/03/2024. 3) Futures on trading days between 17/11/2023 and 30/11/2023. 4) Futures on trading days between 21/08/2023 and 01/09/2023.

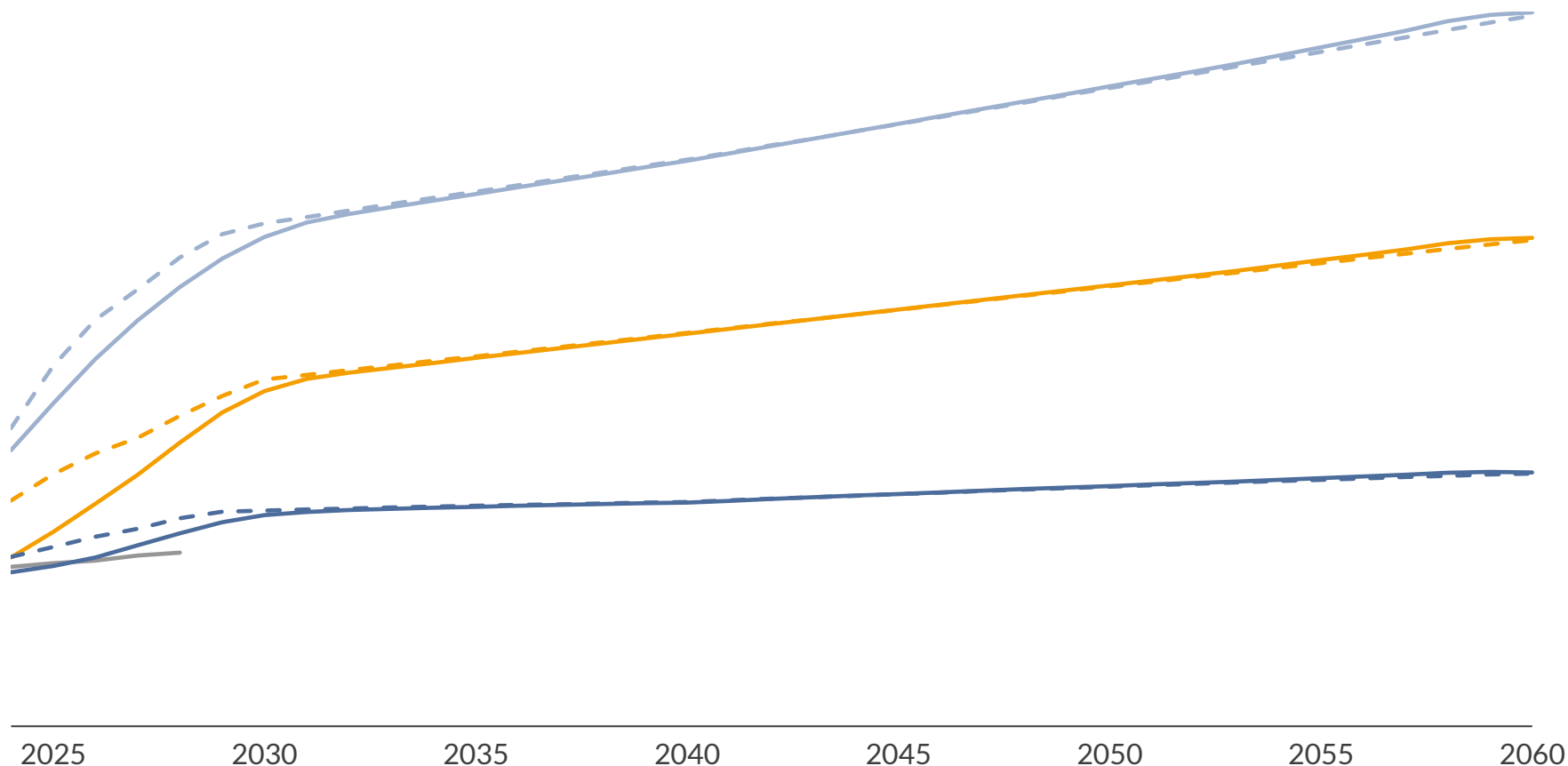
Sources: Aurora Energy Research, EEX, Carbon Pulse, Bloomberg, Petroleum Economist, Financial Times, Business Green, European Commission

- 1 **2024:** Driven by the drop in futures, we revised our 2024 gas price forecast XX% lower.
  - The drop in futures is driven by short-term factors, as well as lower European demand.
- 2 **Late 2020s:** In the late 2020s, we forecast prices to rise steadily in real terms, diverging from where futures were trading in early Mar-24.
- 3 **By 2030:** By 2030, our forecast is XX€/MWh, up from XX€/MWh in 2024.
  - This means our 2030 forecast is nearly unchanged from our Jan 2024 forecast.
  - The rise in gas prices in the 2020s and beyond is caused by bullish factors outside of Europe. Importers increasingly need to compete with growing appetite for LNG from other regions, particularly in Asia.

# 2030 EU carbon price declines by █% compared to our January forecast anticipating slower recovery of some industry sectors

## Carbon prices

€/tCO<sub>2</sub> (real 2023)<sup>1</sup>



— Historical — Q2 2024 Central — Q2 2024 High — Q2 2024 Low  
 — Futures<sup>2</sup> - - Q1 2024 Central - - Q1 2024 High - - Q1 2024 Low

1) For years 2024-2028, the prices shown take into account current futures prices for the years in question, with declining weights. In 2024, forecast prices include historical prices up to Feb-24. 2) Futures on trading days between 26/02/2024 and 08/03/2024.

Sources: Aurora Energy Research, EEX, CME

### 2024-2027

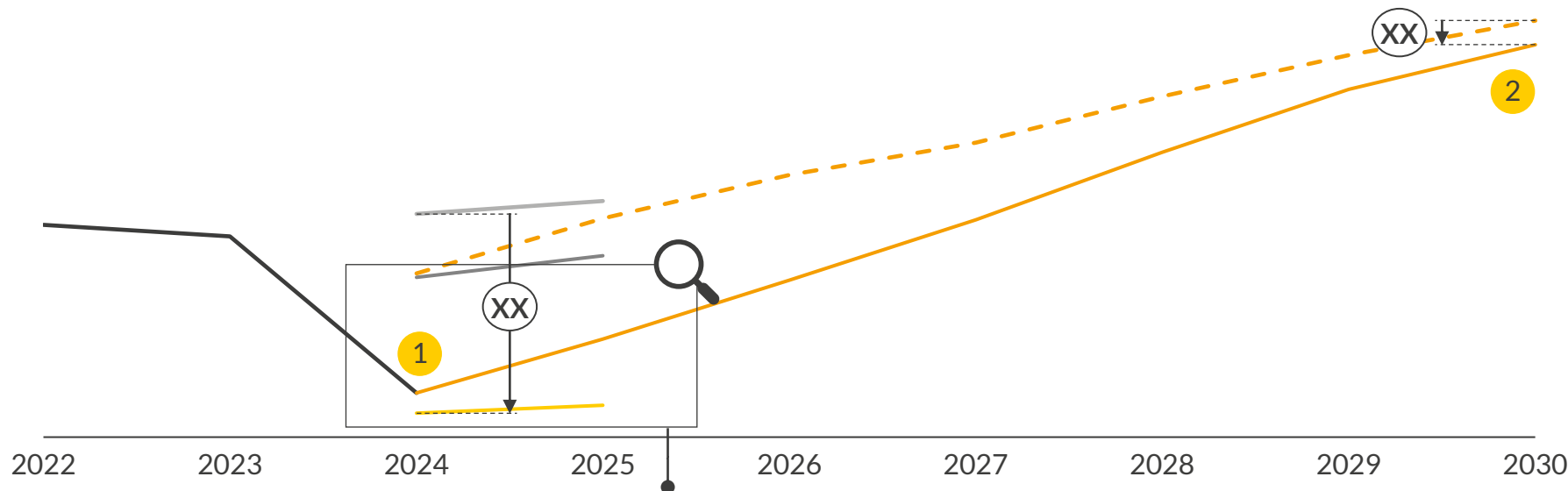
- Carbon prices average █ €/tCO<sub>2</sub>, █% down from our previous forecast, due to weaker economic activity from the EU's manufacturing sector.
- The drop in prices is driven by lower futures prices, higher cost of capital, and slower economic recovery for some sectors.

### 2028-2060

- Carbon prices average █ €/tCO<sub>2</sub>, unchanged from the previous forecast, and rise to █ €/tCO<sub>2</sub> by 2060.
- In the medium term (2028-2035), prices are driven by policy ambition and hedging demand which is balanced by a weakening economy.
- Our Central forecast assumes the carbon price approaches a subsidised fuel switch cost to green hydrogen for power production by 2060.

# Carbon futures dropped by █% for 2024 while we only expect █% lower prices by 2030 compared to our January forecast

Carbon price  
€/tCO<sub>2</sub> (real 2023)



## Why did futures drop by 37% since October?

Q2 2023	Q4 2023	Q4 2023	Q1 2024	Q1 2024
Announcement that frontloaded EUAs will be auctioned 2023-2025 to fund RePowerEU	German industrial output drops, particularly for high emitting sectors	ECB rates remain high at █% despite lower inflation expectations	Gas prices continue to drop, keeping emissions from the power sector low	Extension of compliance deadline eases short-term demand

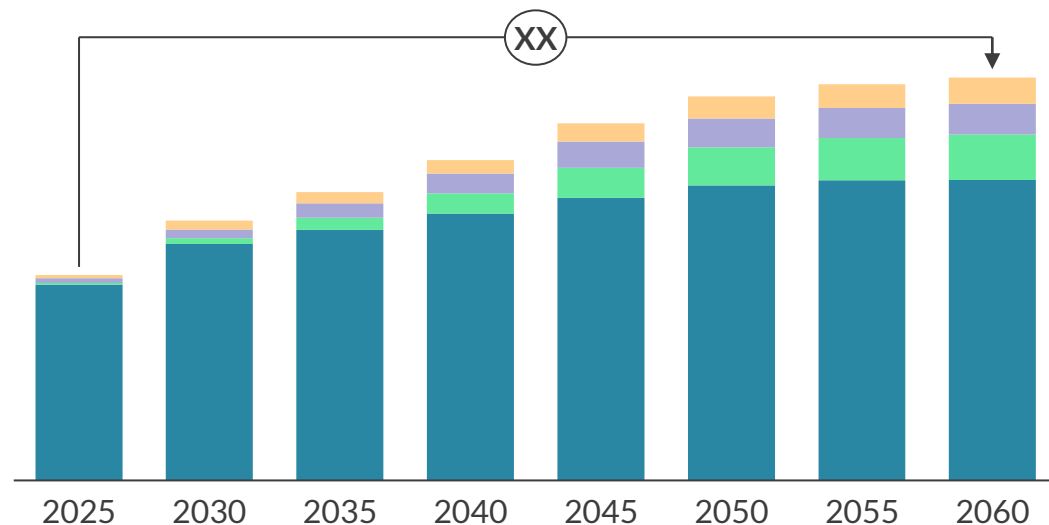
— Historical — Apr 24 Central — Jan 24 Central — Futures Mar 24 — Futures Dec 23 — Futures Oct 23

## Deep-dive on next slide

- 2024:** Driven by the drop in futures, we revised our short-term forecast of carbon prices downwards by █%
- Until 2030:** We expect prices to approach our January 2024 Central forecast by 2030
  - We continue to expect lower emissions from the power sector, but anticipate a recovery of industry demand and a steep decline in supply
  - The carbon price in 2030 is █% below our January forecast as we predict lower industrial output than previously anticipated in the long-term in the sectors glass, lime and paper

# Slovak annual power demand reaches █ TWh in 2060, almost doubling across the forecast

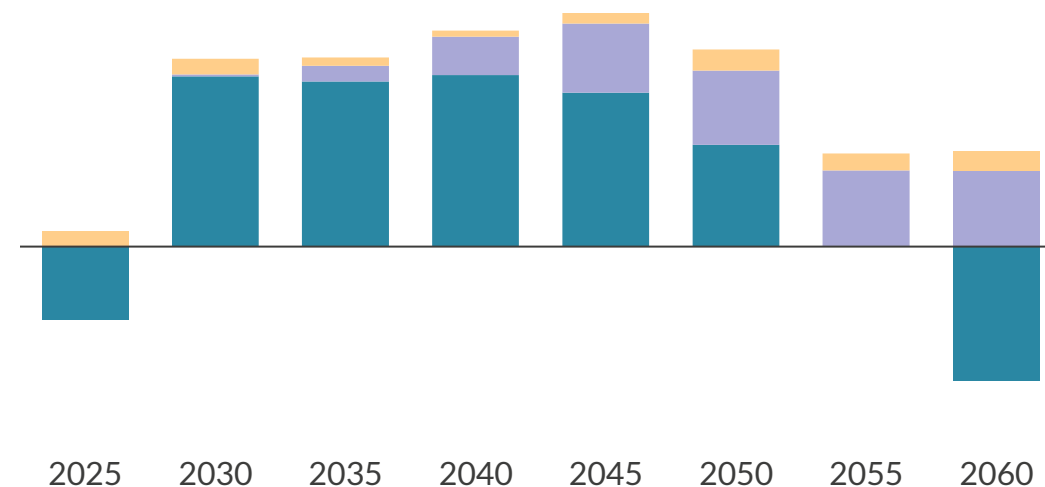
Net annual power demand by type<sup>1</sup>  
TWh



- Between 2025 and 2060, we expect total power demand in Slovakia to increase by █ TWh (█%).
- Industrial electrification is a key driver, with total base demand increasing by 14 TWh (█%) across the forecast – █ TWh of this growth occurring by 2030 – and █% of total demand in 2060 still comprised of base demand.
- Electrification of transport sees demand from electric vehicles reaching 6 TWh by 2060, making up █% of total demand, while demand from heat pumps reaches █ TWh by 2060.

█ Base demand █ EV demand █ Electric heat demand █ Electrolyser demand

Delta in net annual power demand compared to previous forecast<sup>2</sup>  
TWh



- Changes in base demand relative to our previous forecast stem from revisions in our short-term demand assumptions, based on the recent closure of Slovalco aluminium plant, its assumed re-opening by 2026, and the pre-2030 electrification of U.S. Steel Košice via installation of two electric-arc furnaces.
- Revisions around the role of large-scale heat pumps in district heating, alongside a decrease in long-term energy intensity in the industrial, commercial and domestic sectors, causes further variation in our demand projection. Total demand in 2060 is █ TWh below our previous forecast.

1) Net power demand includes sectoral demand (i.e., industry, commerce, transport and households) as well as transmission losses. Power plant self-consumption and demand from efficiency losses of storage are excluded. 2) Refers to Aurora's preliminary market outlook for Slovakia, presented during the 2nd workshop of the Czech and Slovak Multi-Client Study in Prague on 14 February 2024.



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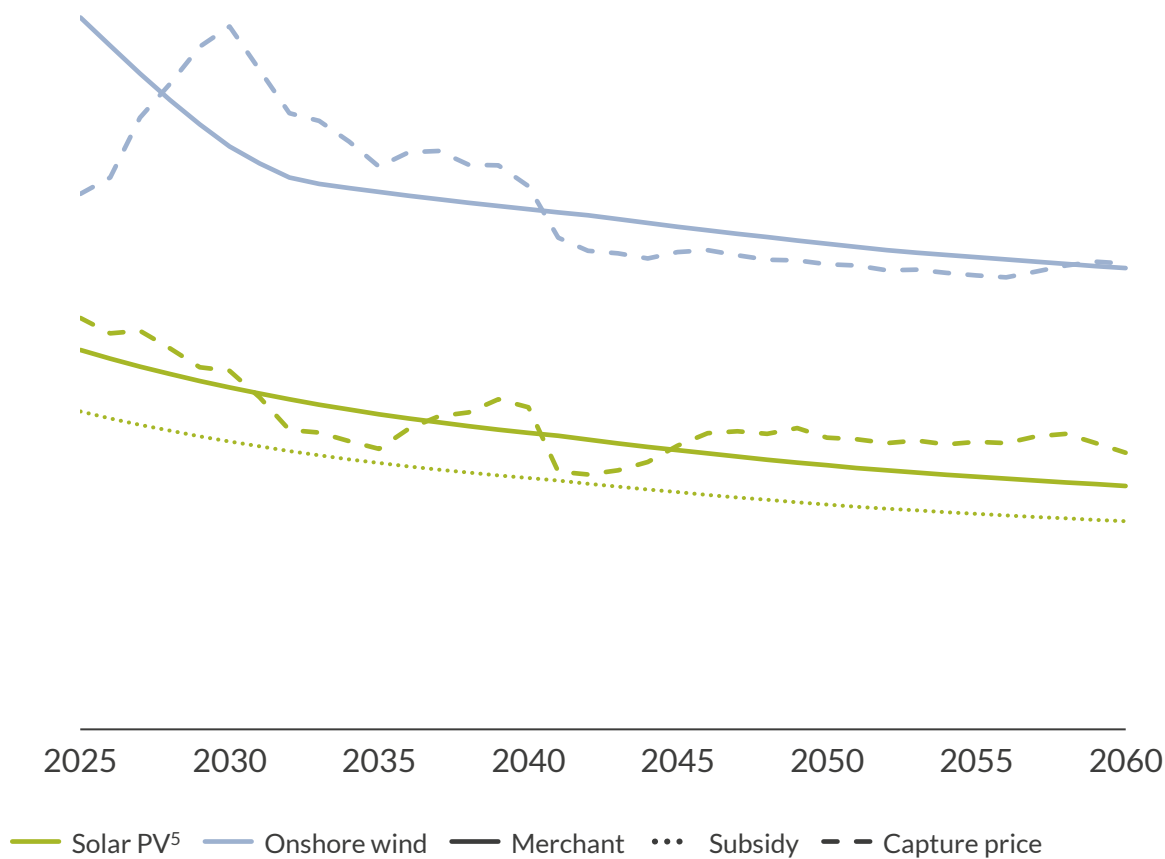
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# A subsidised solar PV asset entering the market in 2025 could achieve an LCOE of below █ €/MWh, amongst the lowest in Europe

The levelised cost of electricity (LCOE) shows the relative economic competitiveness of utility scale renewable technologies with different market entry years. As well as projected cost changes, the load factor and the cost of capital, based on the route to market type, strongly influence the forecasted LCOE curve.

Renewable LCOE trajectories<sup>1</sup>  
€/MWh (real 2023)

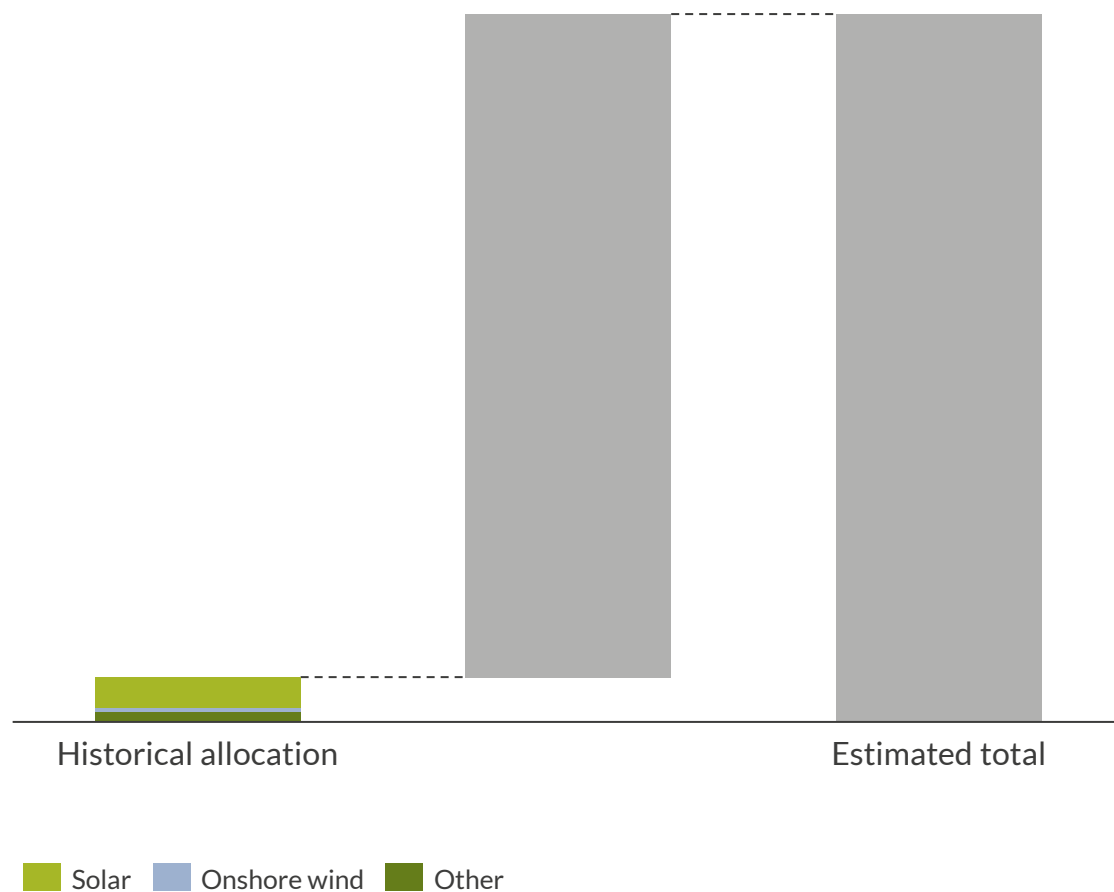


Technology	Parameter	Assumption
<div>Onshore wind</div> 	Size	100 MW utility scale
	Lifetime	27 years
	Load factor <sup>2</sup>	█%
	WACC (merchant) <sup>3</sup>	█%
<div>Solar PV</div> 	Size	50 MW utility scale
	Lifetime	30 years
	Load factor <sup>2</sup>	█%
	WACC (merchant) <sup>3</sup>	█%
	Assumed subsidy intensity <sup>4</sup>	█%

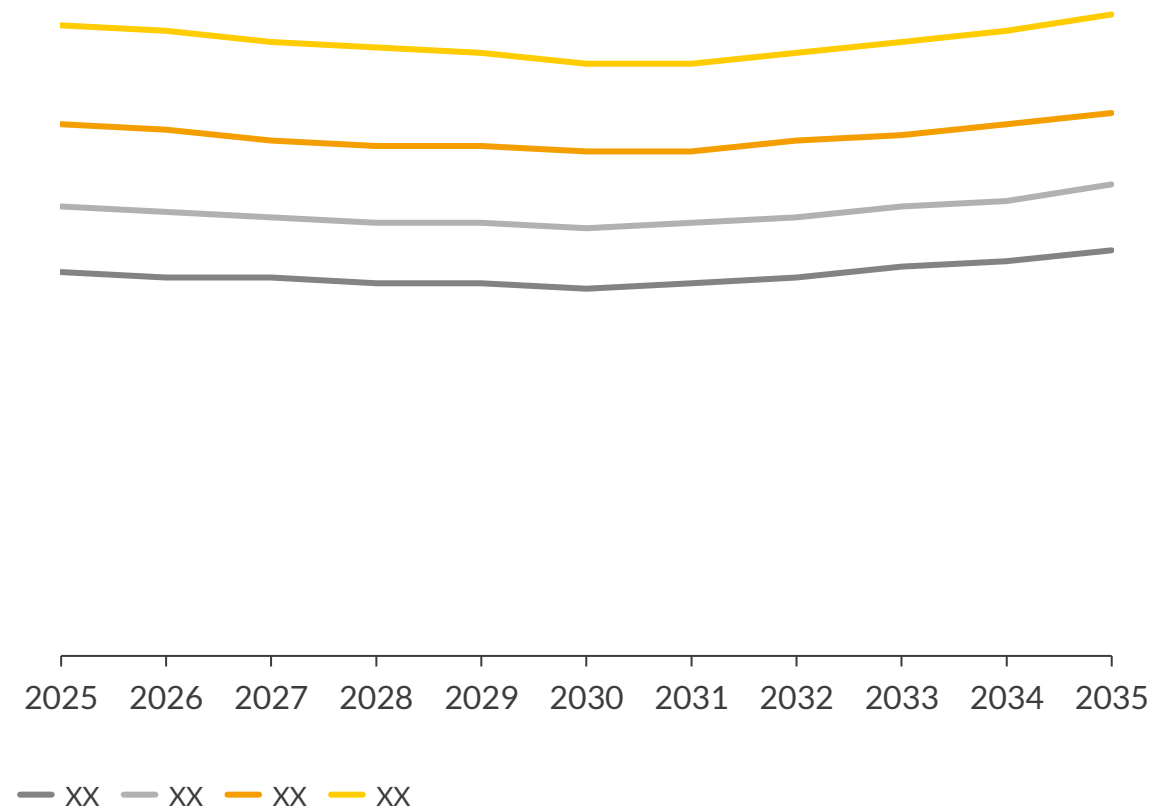
1) LCOEs for a representative newbuild asset pre-curtailment, for different commercial operation dates. Wind assets assume a 2-year construction period, and 1-year for solar assets. 2) Load factor increase assumed due to higher hub heights and larger rotor diameters for wind technologies, and greater penetration of bifacial solar cells for solar PV. 3) WACCs are in real terms and pre-tax. 4) Assumed proportion of CAPEX covered by investment subsidy. 5) Fixed bifacial solar PV>  
Sources: Aurora Energy Research

# 0.5 bn EUR of State Aid subsidy remains available; a [ ]% subsidy intensity enables IRRs between [ ]% and [ ]% depending on entry year

State Aid scheme budget allocation<sup>1,2</sup>  
mln EUR (real 2023)



Solar IRR by COD year<sup>3</sup>  
%



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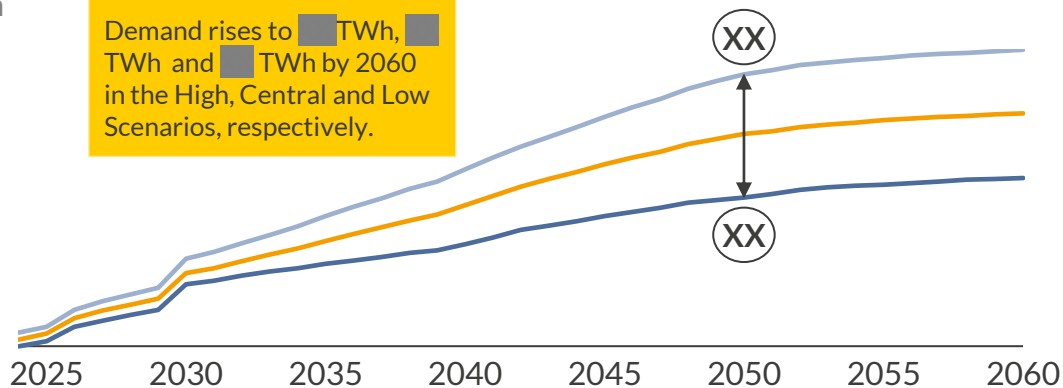
# Our High/Low Scenarios are constructed using plausible deviations in power demand, CAPEX and commodity prices

## A Power demand (base, transport, heat)

Annual power demand

TWh

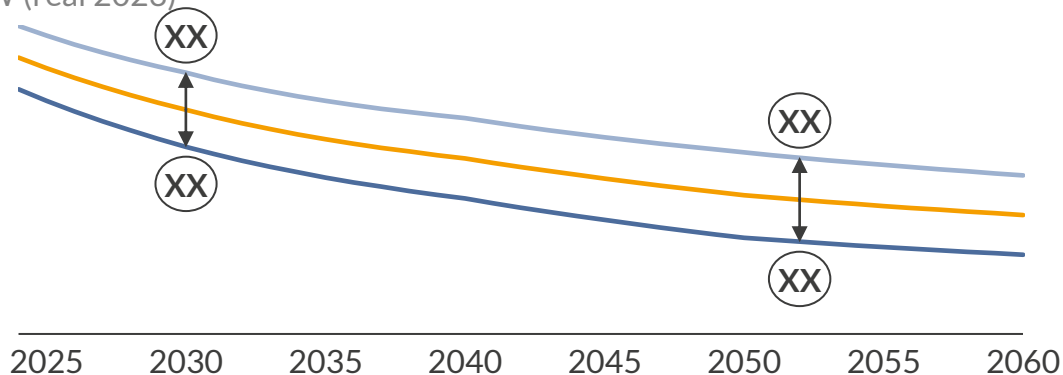
Demand rises to  TWh,  TWh and  TWh by 2060 in the High, Central and Low Scenarios, respectively.



## B CAPEX (solar, wind, battery)

Solar PV CAPEX<sup>1</sup>

€/kW (real 2023)



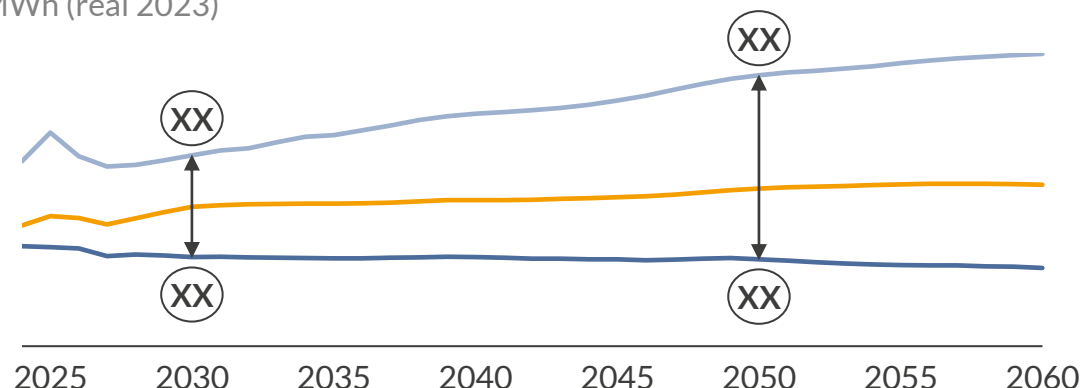
— Central — High — Low

1) Merchant bifacial solar PV CAPEX (unsubsidised) is shown,

## C Commodities prices (gas, carbon, hydrogen)

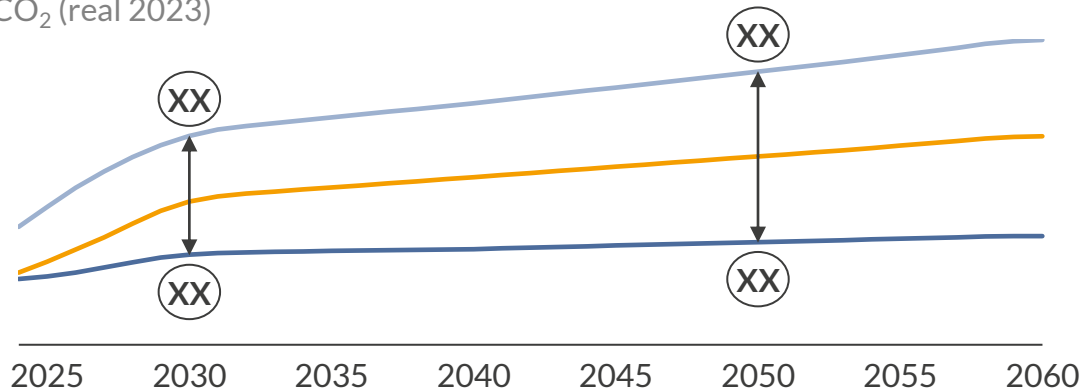
Gas prices

€/MWh (real 2023)



EU-ETS carbon prices

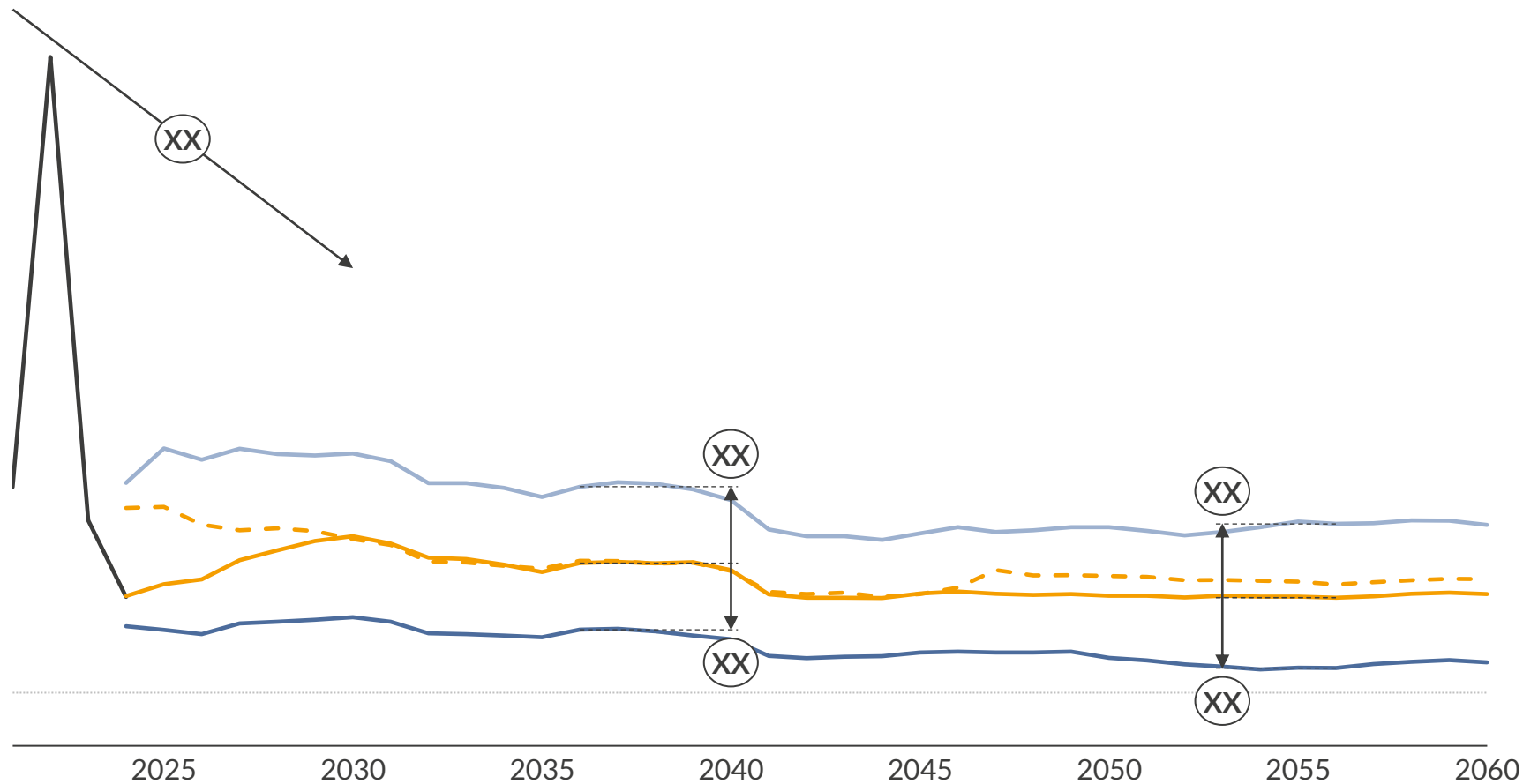
€/tCO<sub>2</sub> (real 2023)





Until 2060, power prices in the High case are █% higher on average relative to Central, and █% below Central in the Low case

**Baseload wholesale electricity price**  
€/MWh (real 2023)



— Historical baseload — Central — Low — High

1) Refers to Aurora's preliminary market outlook for Slovakia, presented during the 2nd workshop of the Czech and Slovak Multi-Client Study in Prague on 14 February 2024.

### High

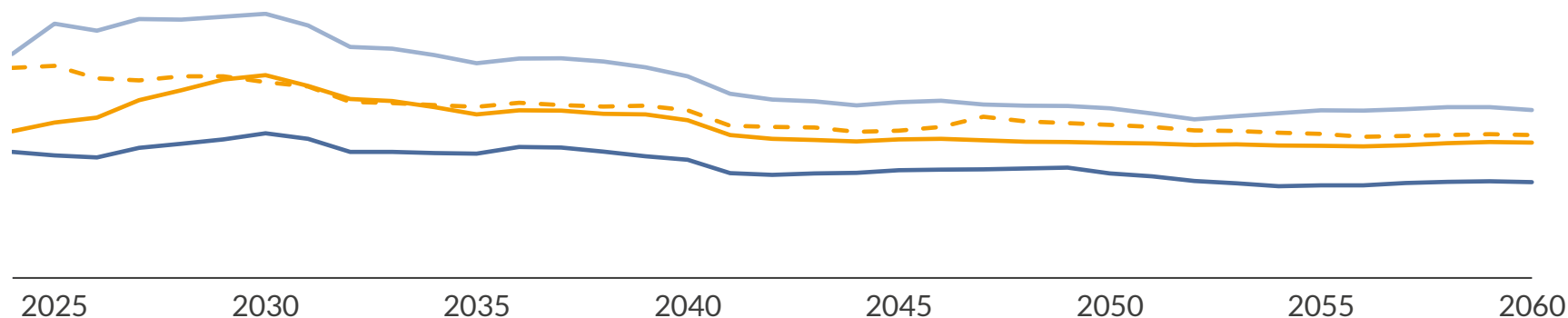
- The baseload price trajectory increases sharply between 2024 and 2025 and remains elevated at an average of █ €/MWh until 2031. Until 2060, the High baseload price averages at █% above the Central Scenario.
- Higher demand increases the tightness of the system, and elevated commodities prices further drive up baseload price in the High Scenario.

### Low

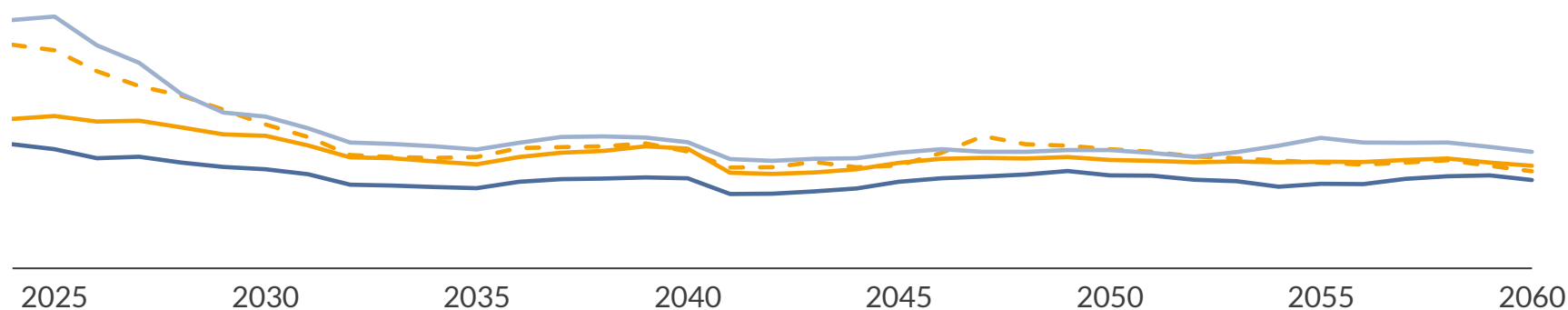
- The Low Scenario baseload price trajectory is depressed at an average of █ €/MWh: █% below the Central Scenario.
- The sustained low price-trajectory in this scenario is driven by low commodities prices, decreased renewables CAPEX and weak power demand.

# Capture prices in High fall in the long term due to higher RES buildout, whereas Low prices are more stable across the forecast

**Onshore Wind Capture Prices<sup>1</sup>**  
€/MWh (real 2023)



**Solar Capture Prices<sup>1</sup>**  
€/MWh (real 2023)





— Central — High — Low - - Previous forecast<sup>2</sup>

1) Fleet average, uncurtailed generation-weighted capture price across all regions. 2) Refers to Aurora's preliminary market outlook for Slovakia, presented during the 2nd workshop of the Czech and Slovak Multi-Client Study in Prague on 14 February 2024.

Sources: Aurora Energy Research

## Capture Price Outlook

### Onshore Wind

- Onshore wind sees limited cannibalisation and is strongly influenced by commodity and baseload price behaviour.
- The change in onshore wind capacity across scenarios drives the divergence of capture prices across the forecast, averaging +% in High and -% in Low compared with Central after 2030.

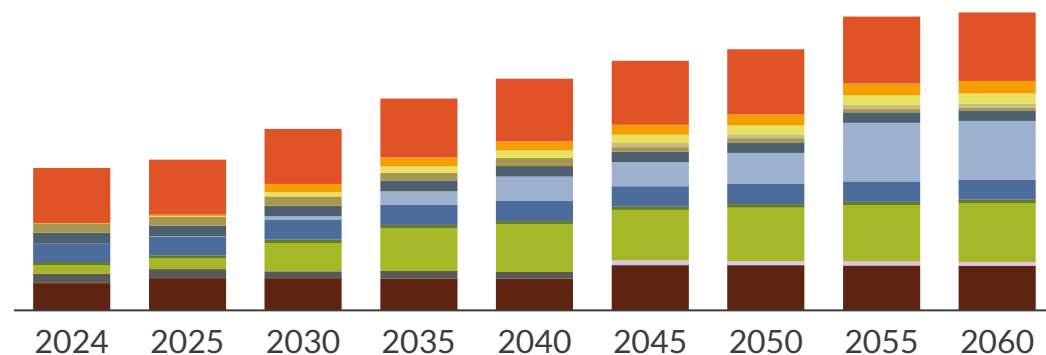
### Solar


- Baseload and commodity prices greatly influence solar PV capture prices in the short term, where cannibalisation is limited.
- High and Low solar capture prices converge with the Central Scenario in the mid-term, driven by buildout of subsidised capacity.
- After 2050, High capture prices converge with Central, as solar PV buildout continues.

# Total capacities increase to GW and GW by 2060 in the Low and High Scenarios, respectively

## 1 Low Scenario

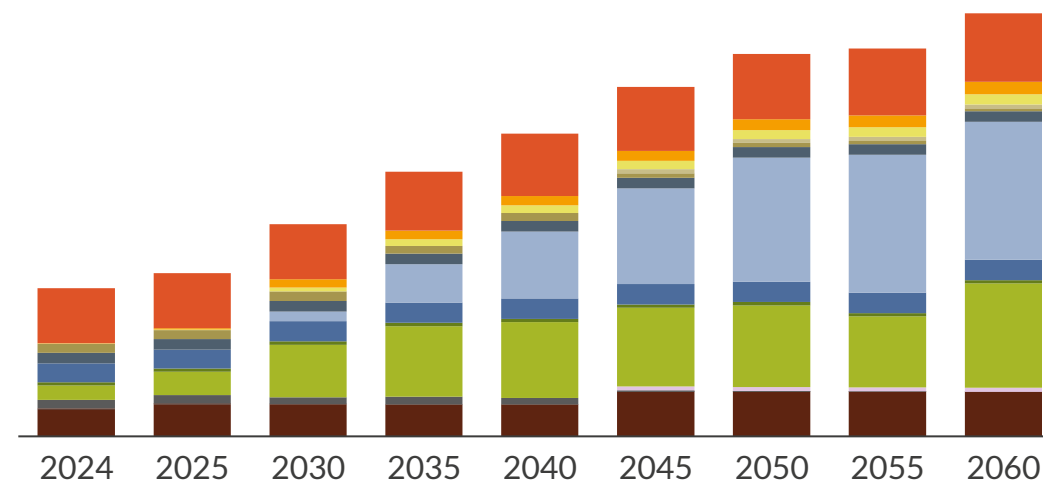
Installed capacity  
GW






- Solar PV buildout is mostly restricted to subsidised capacities benefitting from support from the Modernisation fund, and as retiring subsidised capacity is replaced at the end of the forecast, further solar buildout is limited.
- Onshore wind buildout occurs across the whole forecast, but the capacity in 2060 fails to utilise even % of the maximum geotechnical potential.

## 2 High Scenario

Installed capacity  
GW



- Renewable capacity increases by  GW, a % increase, between 2024 and 2060, with subsidised solar buildout in the first half of the forecast met with merchant solar and onshore wind buildout throughout.
- Fast demand growth and high capture prices drive onshore wind capacity to reach  GW of capacity, as we assume that regulatory adjustments allow permitting of additional capacity compared to Central.
- Merchant solar PV buildout replaces capacity retirements by 2060.



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- I. Long-term outlook for the Slovak market
- II. Understanding price drivers
- III. Investing in solar
- IV. Key market uncertainties: Our High/Low Scenarios
- V. Key takeaways

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[joanna.marszalkowska@auroraer.com](mailto:joanna.marszalkowska@auroraer.com)

- 1** Baseload prices have slumped with commodity markets, but will rise to a level of █ €/MWh by 2030. New capacities in Czechia stabilise prices around █ €/MWh in the 2030s, before they fall to a long-term level around █ €/MWh once new nuclear is commissioned in 2041.
- 2** Solar capacity reaches █ GW by 2035, before buildout slows as subsidies expire. Onshore wind is restricted by planning processes and reaches only █ GW by 2035, before capacity additions accelerate, leading installed capacity to reach █ GW by 2060.
- 3** An abundance of cheap nuclear and renewable generation make Slovakia a net exporter across the forecast horizon, reaching █ TWh in 2045. Prices are coupled to more expensive markets in many hours, driving **high spreads** and **strong seasonal variability**.
- 4** Fast buildout in neighbouring markets leads solar capture prices to fall to █ €/MWh in 2035, leaving projects reliant on Capex subsidies from the State Subsidy scheme. A 20% subsidy intensity can secure a █ % IRR for a project entering in 2028.
- 5** Baseload prices are around █ % lower under our Low Scenario, leading to solar capture prices fluctuating between █ and █ €/MWh after 2030 and onshore wind capture prices remaining between █ and █ €/MWh in the same period.



# Slovak Power & Renewables Forecasts:

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- Power price distributions
- **EU-ETS carbon price** forecasts
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### Strategic Insights



#### Analyst Support

- **Yearly workshop** to discuss specific issues on the Slovak market
- **Ongoing support** from our bank of analysts, including native speakers and on-the-ground experts

## Details and disclaimer

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### Publication

The Slovak Power and Renewables Market:  
Long-Term Outlook

### Date

16<sup>th</sup> April 2024

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