Unveiling Tomorrow: The Austrian Power Market until 2060

REDACTED VERSION

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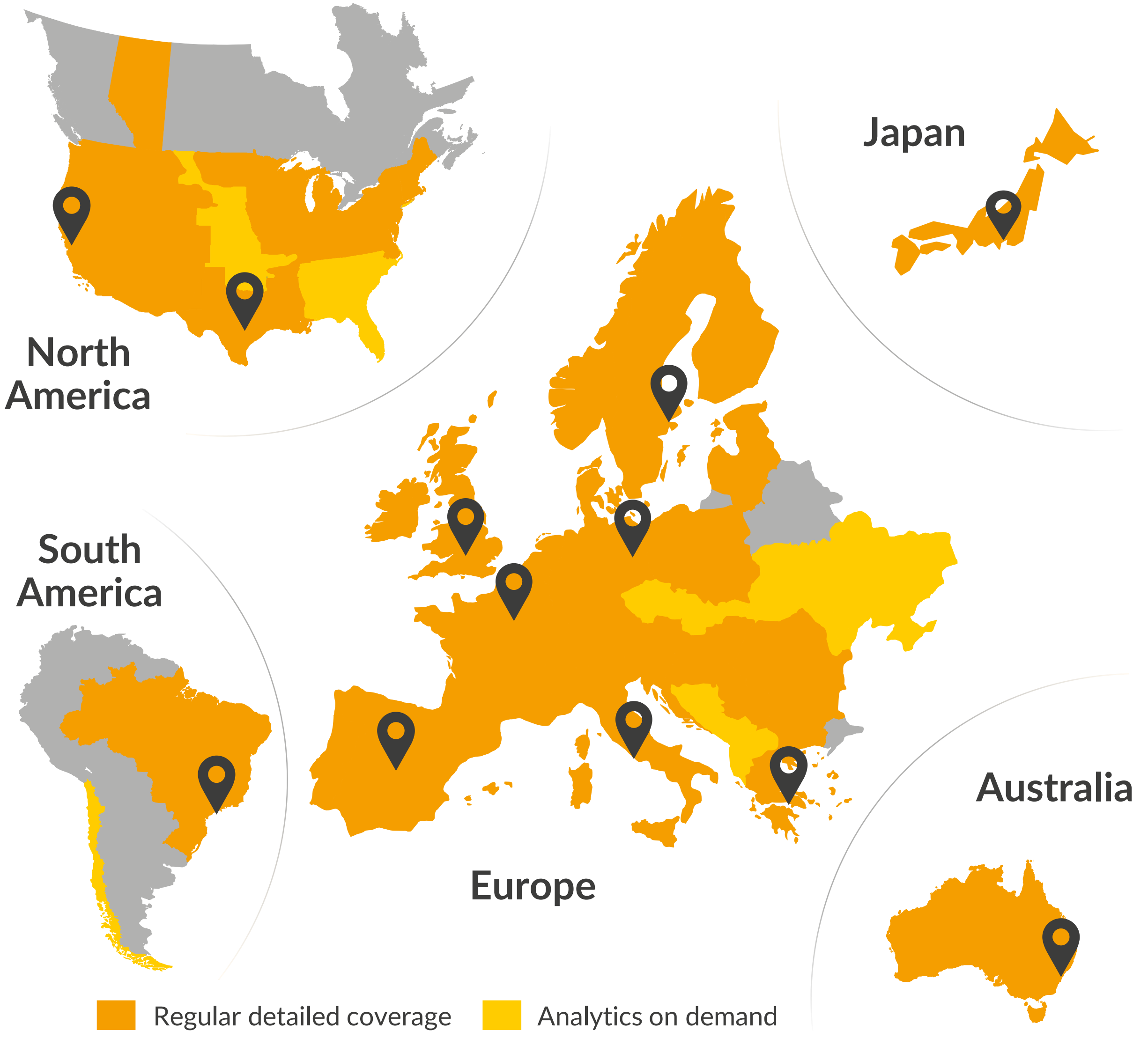

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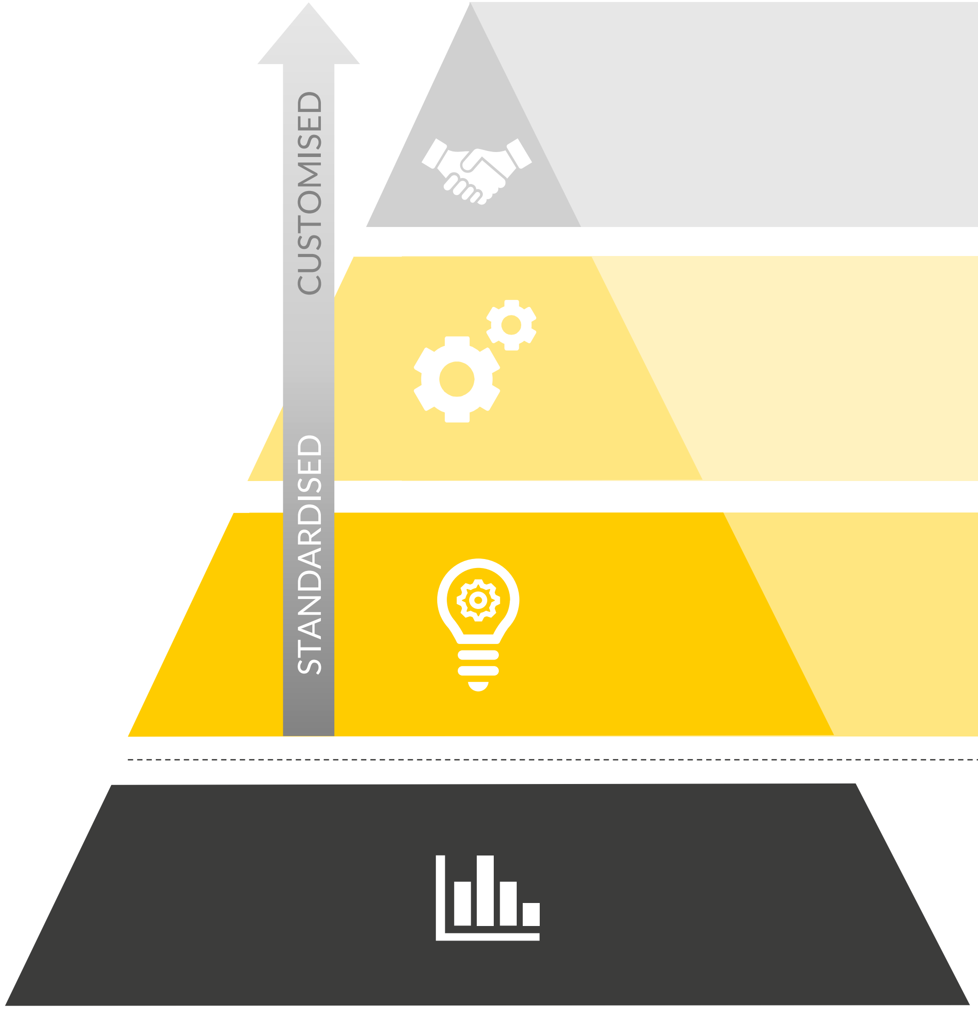

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"With its capabilities, intellect and with its credibility Aurora plays an essential role bringing the dialogue [in the global energy transition] to a different plane"

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"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."

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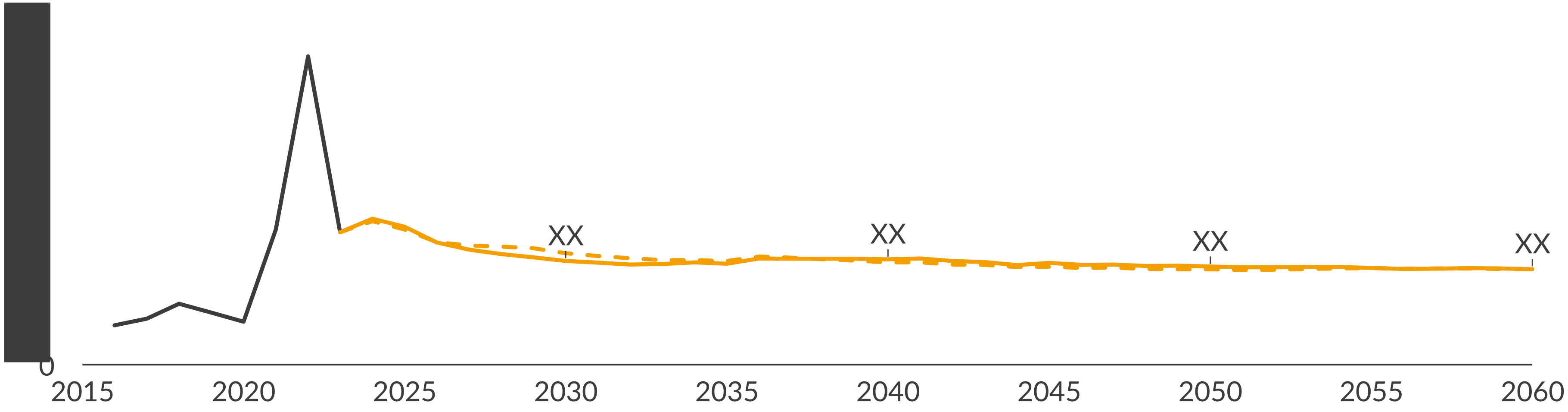
After a rapid decline post-2024, Austrian baseload prices continue to gradually decrease from [redacted] €/MWh in 2030 to [redacted] €/MWh in 2060

Baseload wholesale electricity price

€/MWh (real 2022)



Delta to previous forecast[1]

€/MWh (real 2022)

- After a price increase until 2027, driven by higher gas prices due to increased futures prices, baseload prices fall below our previous forecast until 2035, with the average delta of -[redacted] €/MWh ([redacted]%) reflecting lower gas prices between 2028 and 2035.
- Post-2035, power prices slightly rise above our previous forecast, with prices being [redacted] €/MWh ([redacted]%) higher on average. While lower power demand as well as higher merchant buildout and load factor assumptions for ground-mounted solar lead to slight downward price pressure, these effects are overcompensated by lower solar capacity in neighbouring countries (due to higher CAPEX costs) and lower availability of batteries in the Austrian wholesale market, driving up power prices.

Historical baseload — Baseload — Previous baseload[1] — Delta

2023-30

- By 2030, power prices drop to [redacted] €/MWh. Falling gas prices reduce the cost of power production from domestic gas plants and lead to power imports becoming cheaper.

2031-45

- Baseload prices stabilise at an average price of [redacted] €/MWh, as upward pressure by increasing commodity prices, rising power demand, particularly from electrolysers and EVs, and the rise of H_2-fuelled CHP capacity is mitigated by strong renewables buildout.

2046-60

- Prices gradually decrease by [redacted] €/MWh ([redacted]%), as the increase in power demand starts to slow down and is overcompensated by the ongoing deployment of renewables in Austria.

1) Refers to Aurora's preliminary market outlook for Austria, presented during the 2nd workshop of the Austrian Multi-Client Study in Vienna on 12 September 2023.

Sources: Aurora Energy Research, ENTSO-E

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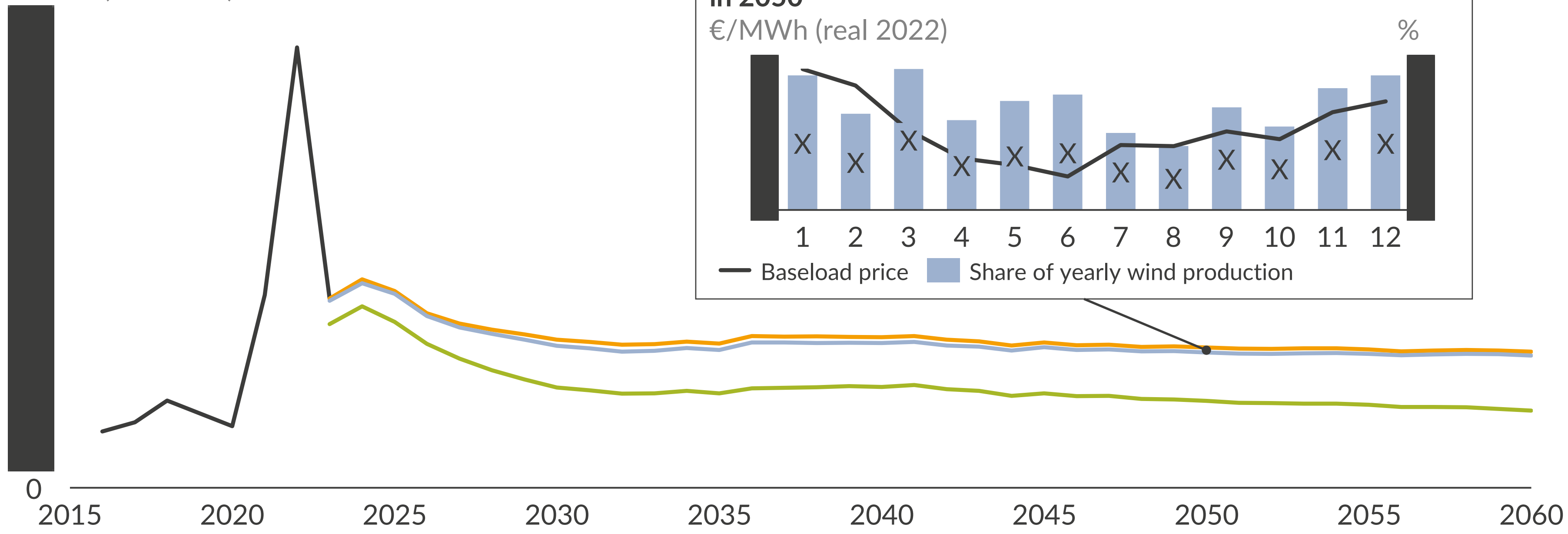
Solar capture prices are on average [redacted]% below baseload prices until 2030, with the discount increasing to [redacted]% post 2050

Baseload and renewables capture prices[1]
€/MWh (real 2022)



Monthly distribution of wind generation and baseload price in 2050
€/MWh (real 2022) %

Average discount to baseload

	2023–2030	2031–2040	2041–2050	2051–2060
Onshore wind	XX	XX	XX	XX
Solar	XX	XX	XX	XX

Historical baseload — Baseload — Onshore wind — Solar

1) Uncurtailed generation-weighted capture prices. 2) Considering a discount rate of [redacted]% (real, pre-tax) and [redacted]% load factor for ground-mounted assets. 3) [redacted]% (real, pre-tax). 4) Winter half-year lasting from 1 October to 31 March.
Sources: Aurora Energy Research, ENTSO-E

Outlook for renewables

Solar

- As we forecast significant solar buildout, capture prices decrease from [redacted] €/MWh in 2023 to [redacted] €/MWh in 2060, reflecting rising cannibalisation. Discounts to baseload prices increase continuously from [redacted] in 2023 to [redacted]% in 2060.
- While buildout will be mostly driven by subsidies, large-scale merchant buildout will commence in the 2040s[2]. A small capacity financed with a lower hurdle rate[3], driven by PPAs, is expected to come online already in the 2020s.

Onshore wind

- Benefitting from high power prices in winter[4], where [redacted]% of onshore wind generation occurs, capture prices are largely aligned with baseload prices.

Negative prices are caused by plants willing to accept negative output remuneration due to inflexibility and subsidies

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Reasons behind negative baseload power prices

- Due to inflexible conventional generation and the increasing share of generation from renewables, negative prices for electricity have been occurring at an increasing frequency.
- Negative power prices are the result of plants' willingness to accept negative output remuneration:
  - Many renewable assets (especially wind, solar and run-of-river hydro) do not have an incentive to curtail during negative price hours because of subsidies, direct marketer incentives[1] or lack of exposure to wholesale price signals.
  - High costs associated with shutting down and restarting (thermal) plants are an incentive to remain operational despite electricity prices below zero.

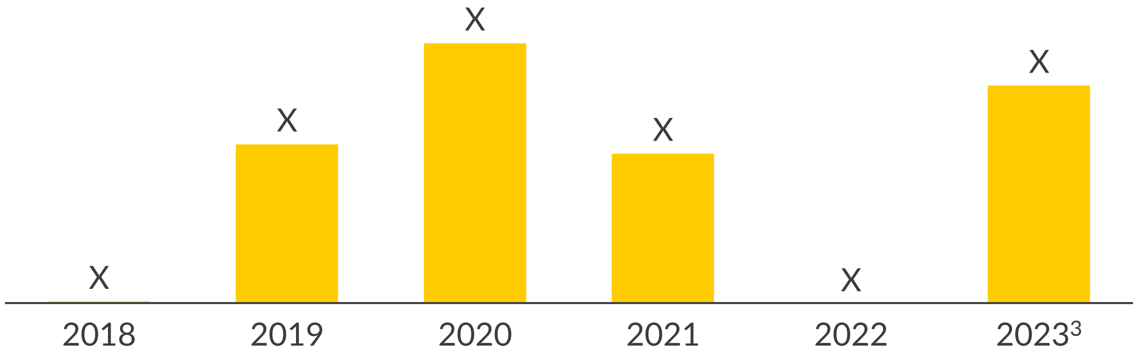
Factors affecting number of hours with negative prices in the future

- Technology advances and policy changes (affecting curtailment incentives) can affect the frequency of negative price periods in the future. Going forward, we expect two main drivers behind the frequency of negative power prices:

New flexible demand and storage options: New flexible demand and storage technologies like electrolysers or electric batteries, which can increase their power demand in times of low power prices, are expected to strongly increase in the future.

More renewable capacity: The Austrian government is expected to fund large volumes of new renewable capacity in this decade, which (depending on regulation, direct marketing agreement or tariff structure) do not have an incentive to curtail in times of negative prices. Similar trends are expected for neighbouring countries, particularly Germany.

Number of hours with negative day-ahead power prices after price zone split[2]



Negative prices and renewable renumeration

- To alleviate the downward price pressure caused by high renewable generation, renewables do not receive market premium payments in times when day-ahead prices are negative for a consecutive period.
- The length of this period was defined as 6h-rule in Austria[4] which was introduced by §15 EAG and applies to all plants receiving a market premium.
- The 6h-rule does not apply in case the uniform Austrian single intraday price coupling index is positive for those same six or more consecutive hours that had negative prices in the day-ahead market.

1) Direct marketers may bid negative prices due to risk aversion, contractual obligations or portfolio strategies. 2) The Germany-Luxembourg-Austria bidding zone was split on 30 September 2018. 3) Prices until 31 October 2023 included. 4) A tightening of this rule to a 1-hour rule is expected to conform with Art. 123 of the EU Guidelines on State Aid for Climate, Environmental Protection and Energy. Other countries such as Germany have already introduced a 1-hour rule starting in 2027.

Sources: Aurora Energy Research, ENTSO-E, European Commission

Negative price occurrences increase until 2030 before strongly declining towards 2060 as the power system becomes more flexible

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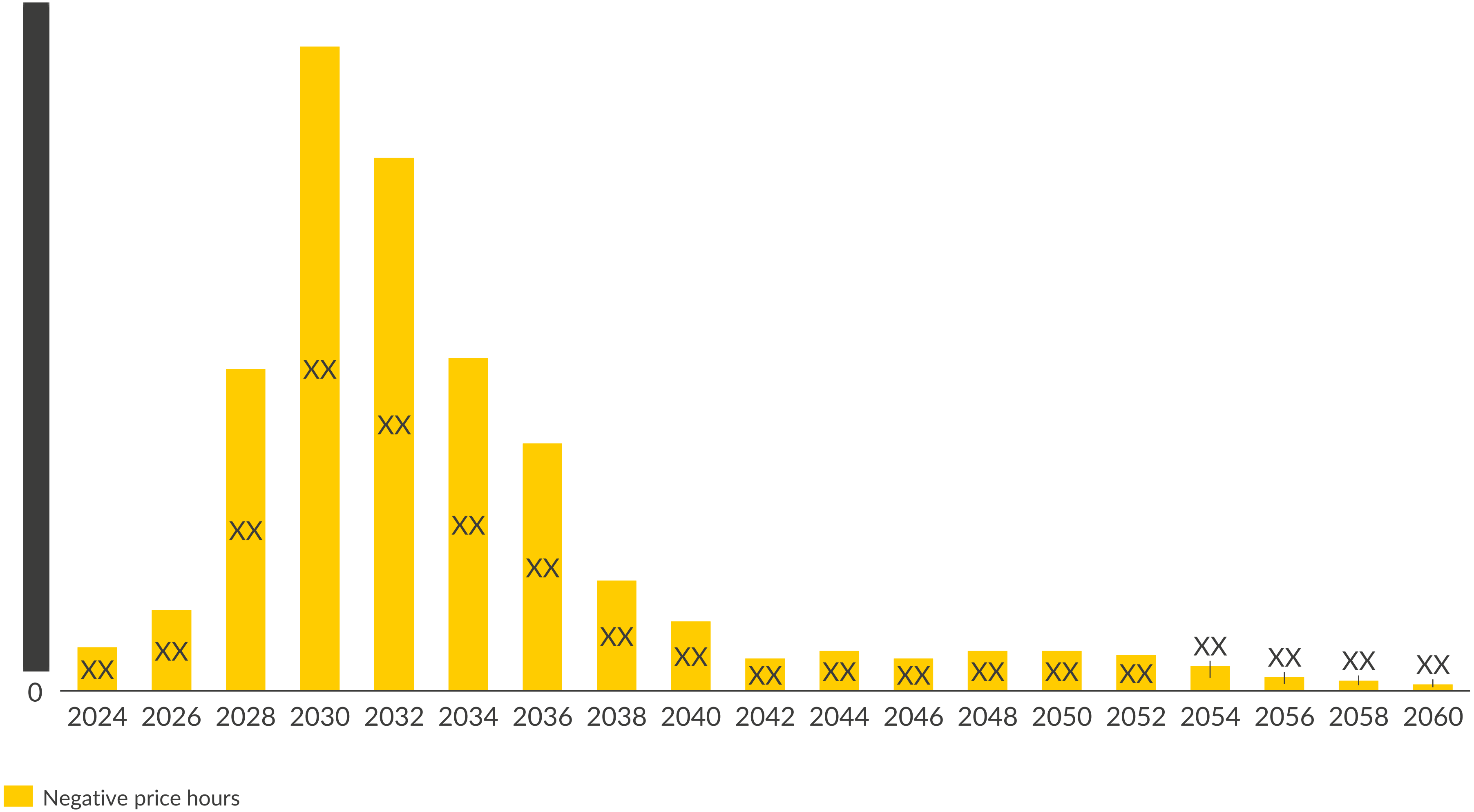
Total number of negative price hours
Hours p.a.



1) Renewable energy sources.

Source: Aurora Energy Research

Negative price trends

- The main driver of negative price periods by 2030 is the subsidised RES[1] buildout in Austria and neighbouring countries, as, depending on the assets' direct marketing agreements or feed-in tariff structure, RES are not incentivised to curtail with negative prices.
- Post-2030, the frequency of negative prices decreases as:
  - Growing flexible demand from technologies like EVs and electrolysers reduces the chance of negative prices, with demand being shifted to hours with high RES output.
  - RES fleet becomes more flexible as old inflexible assets leave the market and regulatory changes incentivise new-built assets to curtail (both in Austria and in neighbouring countries).

Agenda

I. Unveiling tomorrow: Aurora's outlook on Austrian power prices until 2060

II. Exploring Austrian power price drivers: A deep dive

   1. Commodity prices
   2. Power demand
   3. Capacity and technology assumptions

III. Navigating key market uncertainties: Aurora's Low/High scenarios

IV. Austrian Power & Renewables Forecasts

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European gas prices drop through 2027 before rising steadily with global demand, as competition for LNG increases

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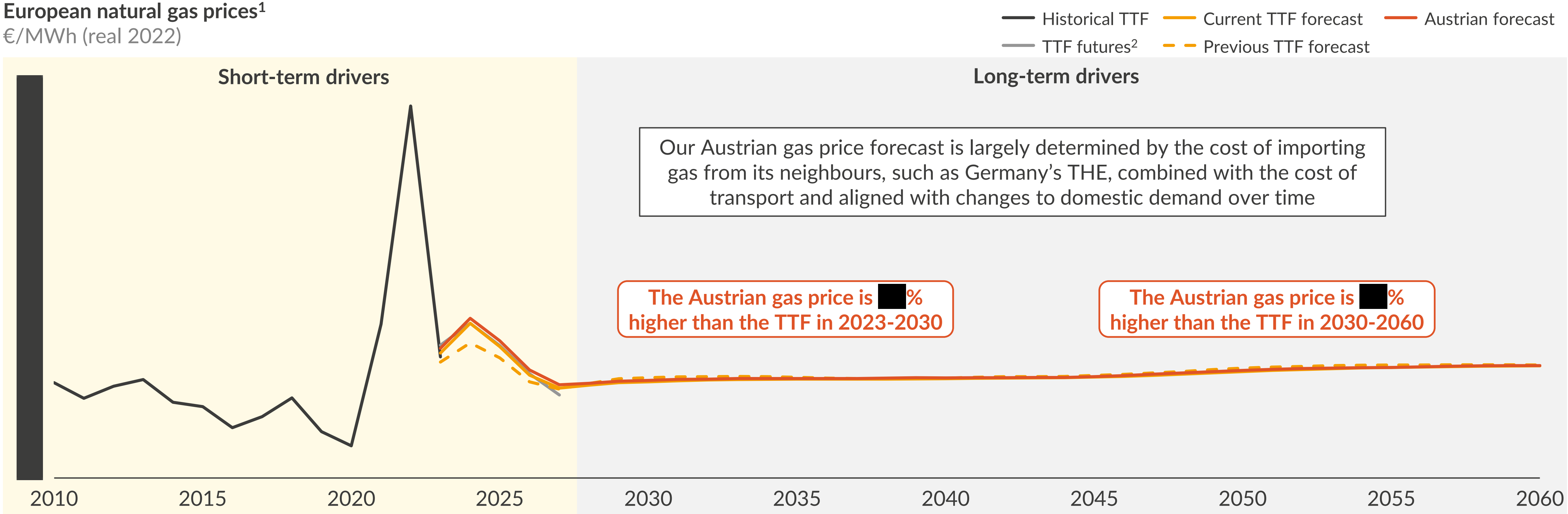
European natural gas prices[1]
€/MWh (real 2022)



Short-term drivers

1. The benchmark TTF gas price averages [redacted] €/MWh in 2023-2027, [redacted]% higher than the previous forecast.
2. By 2027, prices fall to [redacted] €/MWh as global liquefaction infrastructure expands. Competition from Asian importers supports global LNG prices, but the sharp rise in supply and decline in European demand keeps prices from climbing.

Long-term drivers

1. The gas price between 2028 and 2060 averages [redacted] €/MWh, [redacted]% lower than the previous forecast partly due to higher production than previously expected.
2. The global LNG market grows and becomes more spot-dominated as European production falls, increasing the continent's reliance on LNG.
3. Increasing Asian gas demand and appetite for LNG drive competition for cargoes with Europe.
4. Extraction costs rise as lowest-cost fields are depleted, supporting price growth.
5. Rapid renewables and electrification drive down European gas demand.

1) For years 2023-2028, the prices shown take into account current futures prices for the years in question, with declining weights. In 2023, forecast prices include historical prices up to Aug-23. 2) A rolling 14-day average as of 1 September 2023.

Sources: Aurora Energy Research, Refinitiv

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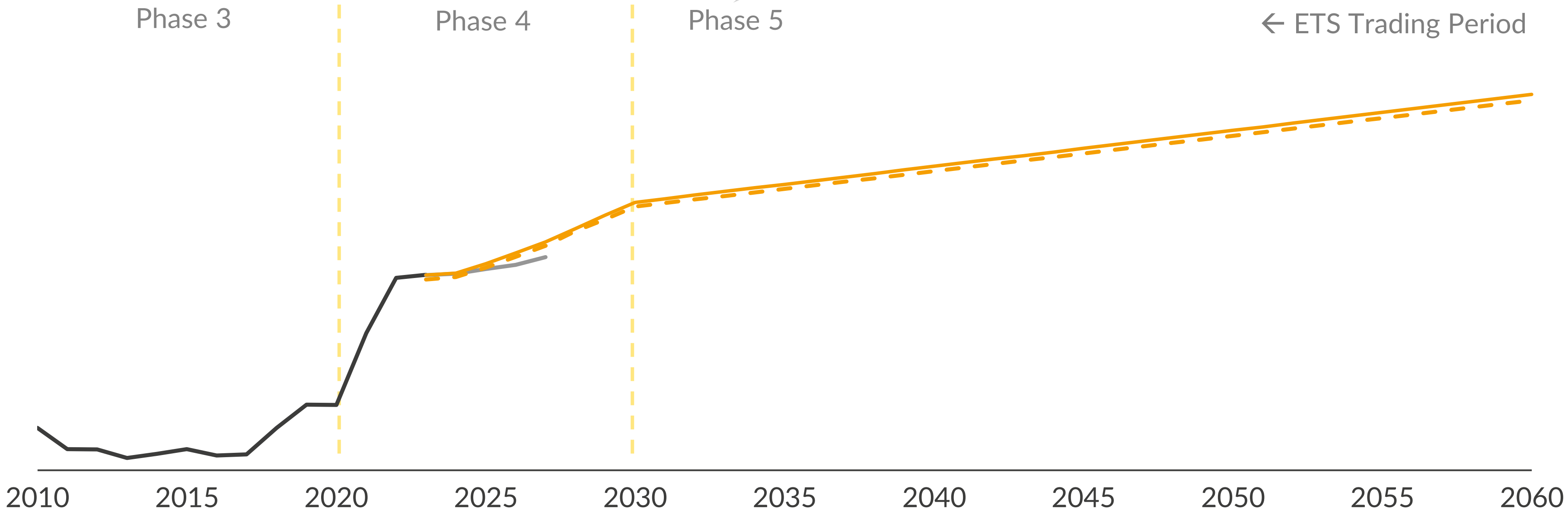
Relative to our previous forecast, we assume slightly higher carbon prices in the ETS, reflecting higher futures prices and hedging demand

Carbon prices under the EU Emission Trading Scheme (ETS)[1]
€/tCO_2 (real 2022)

As the details of Phase 5 have not yet been agreed upon, we assume net zero emissions are reached by 2060. More ambitious decarbonisation will significantly impact prices.



Delta to previous forecast[2]
€/tCO_2 (real 2022)

- Until 2030, we see an average increase in carbon prices of [redacted] €/tCO_2 ([redacted]%) compared with our previous forecast, driven by futures prices which have increased by [redacted] % compared to our previous forecast.
- In the longer term, post 2030, we expect the EU ETS carbon prices to be on average [redacted] €/tCO_2 ([redacted]%) above our previous forecast, driven by increased hedging demand in light of the planned introduction of the CBAM.

Historical Futures[2] Previous[3] Current

1) Until 2028, prices take into account current futures prices for the years in question, with declining weights. In 2023, forecast prices include historical prices up to Aug-23. 2) A rolling 14-day average as of 1 September 2023. 3) Refers to Aurora's preliminary outlook for Austria, presented during the 2nd workshop of the Austrian Multi-Client Study in Vienna on 12 September 2023.
Sources: Aurora Energy Research, EIKON

2023-2030

- The short-term price trajectory is mainly driven up by the post-COVID recovery, the 2030 reduction target of 62% compared to 2005 levels, and the phase-out of free allocation in some sectors accompanied by the introduction of the Carbon Border Adjustment Mechanism (CBAM).
- Additionally, the front-loading of certificates to finance REPowerEU eases prices for a brief period and increases prices in the late 2020s.

2031-2060

- The long-term price is driven by the decarbonisation trajectory of our forecast, expecting a net zero power and industry sector by 2060.
- The EU ETS price approaches the gas-to-hydrogen fuel switching price in 2060.

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Austrian power demand reaches [redacted] TWh in 2060, decreasing by [redacted] TWh compared to our previous forecast due to revised electrolyser assumptions

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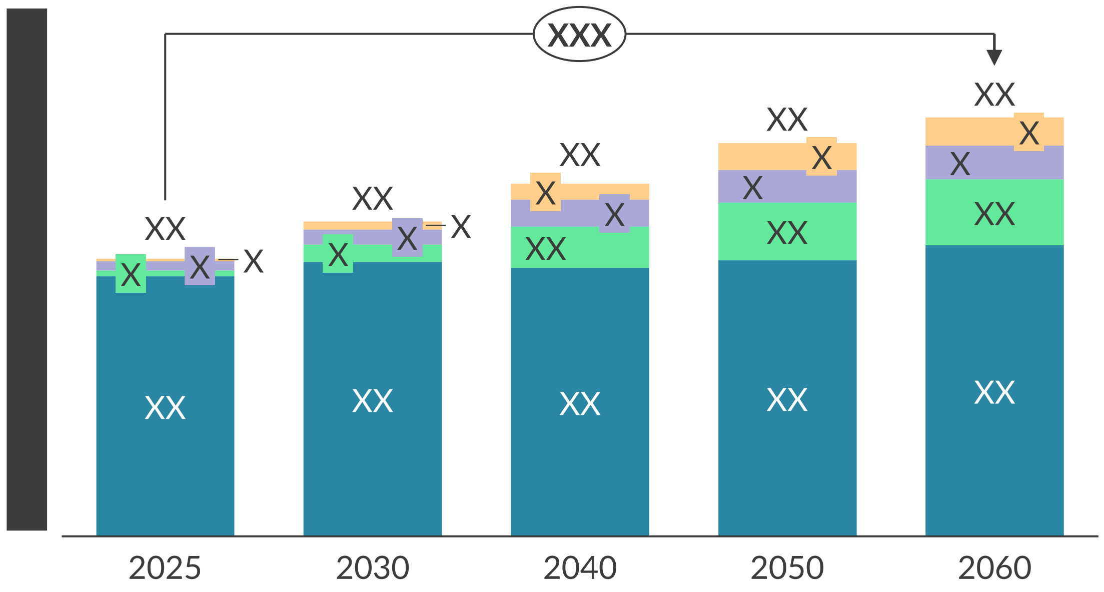
Net annual power demand by type[1]

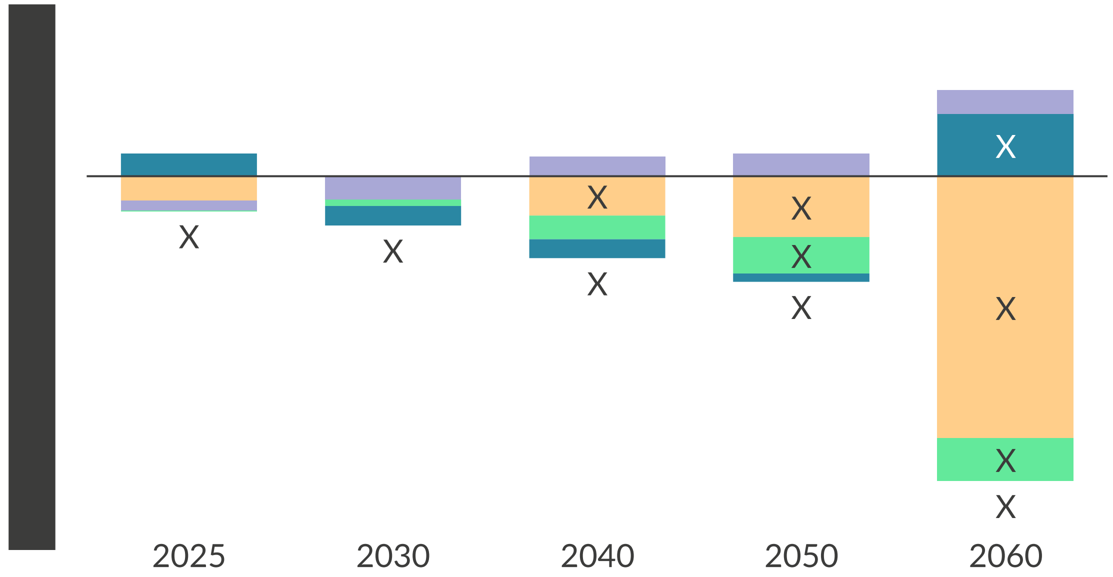
TWh



- We expect strong growth of power demand, increasing by [redacted] % by 2060 compared to 2025.
- EV and electrolyser uptake, incentivised by the Mobility Masterplan 2030 and Austria's Hydrogen Strategy, are the main drivers of increasing demand.
- Base demand sees a moderate [redacted] % increase by 2060, as economic growth and industry electrification are expected to be mostly counterbalanced by efficiency gains stimulated through the recently updated Energy Efficiency Act (EEffG).

Delta in net annual power demand compared to previous forecast[2]

TWh



- Total demand remains largely aligned with our previous forecast in the medium term, decreasing on average by [redacted] % until 2040, before the delta increases up to [redacted] % in 2060.
- Electrolyser demand decreases by [redacted] TWh in 2060 due to downward revised electrolyser capacity as well as higher baseload prices (i.e., [redacted] €/MWh delta on average to our previous forecast post-2040), making the domestic production of green hydrogen less profitable.
- Additionally, our updated view on long-term vehicle efficiency leads to a slight decline of power demand from EVs by [redacted] TWh in 2060.

Base demand | Electric vehicle (EV) demand | Electric heat demand | Electrolyser demand

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 Austria, presented during the 2nd workshop of the Austrian Multi-Client Study in Vienna on 12 September 2023.

Source: Aurora Energy Research

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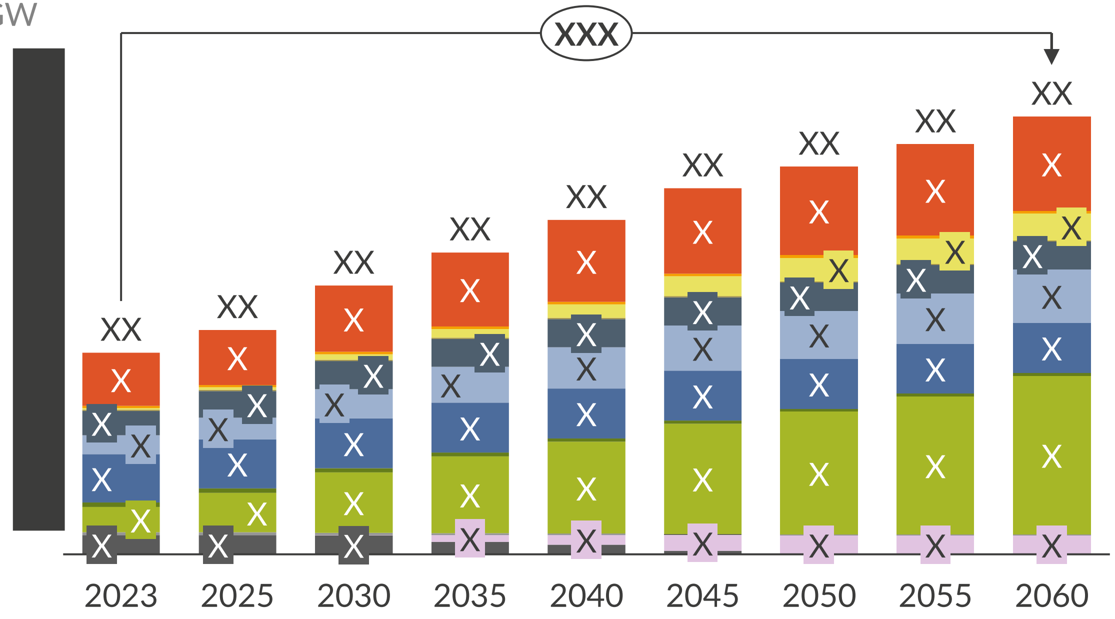
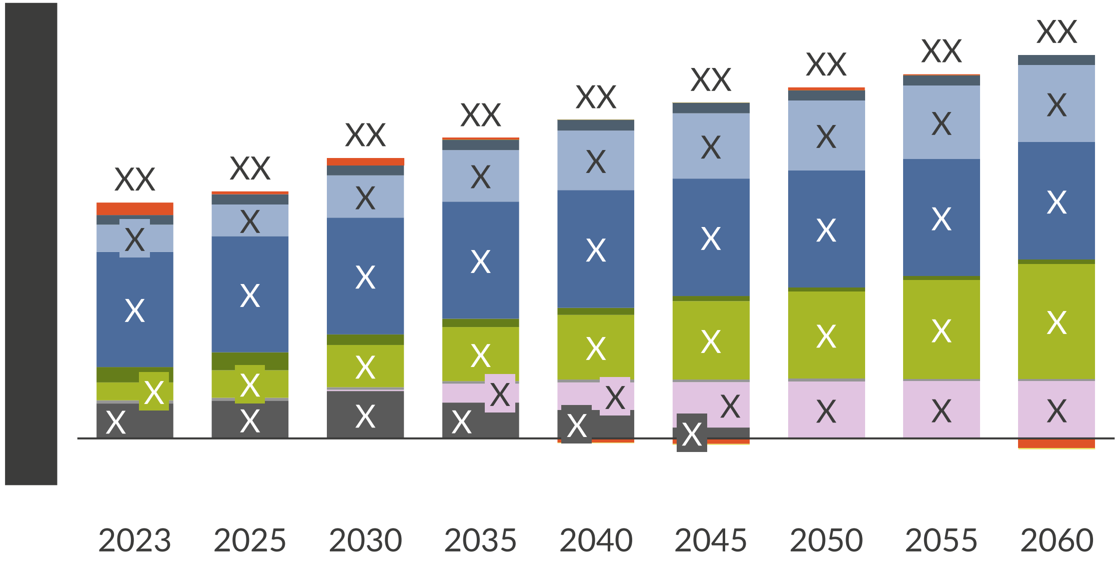
While we expect a strong buildout of renewables and gas to be replaced by hydrogen, hydropower remains a key pillar in the Austrian power mix

Installed capacity
GW



Electricity production and net imports
TWh



- Installed capacity increases by [redacted]GW ([redacted]%) across the forecast horizon, driven by the rapid growth of renewables and flexible capacities.
- Assuming a fuel switch from gas to hydrogen, we expect a full gas exit by 2048, with hydrogen-powered plants gradually replacing gas-powered CHP assets at the end of their lifetime, reaching a capacity of about [redacted]GW by 2060.
- Hydro capacity remains largely constant, as its potential is almost exhausted.

- Hydropower (incl. pumped storage) remains a key power source in the Austrian power system, supplying [redacted]% of total power generation in 2060.
- Due to strong buildout, wind and solar generation surpasses hydro generation (incl. pumped storage) in 2041, providing [redacted]% of generation in 2060.
- With continued RES deployment, Austria gradually reduces its import dependence, becoming a net exporter for the first time in 2036 with net imports averaging –[redacted]TWh between 2036 and 2060.

Gas CCGT | Other thermal[1] | Biomass / other RES[2] | Onshore wind | Gas / oil peaker | DSR
Hydrogen CCGT | Solar | Hydro | Pumped storage | Battery storage | Interconnectors

1) Includes waste plants and on-site industrial thermal power plants. 2) Includes other renewable gases.

Source: Aurora Energy Research

We expect solar PV capacity to more than double by 2030, driven mainly through subsidised rooftop solar

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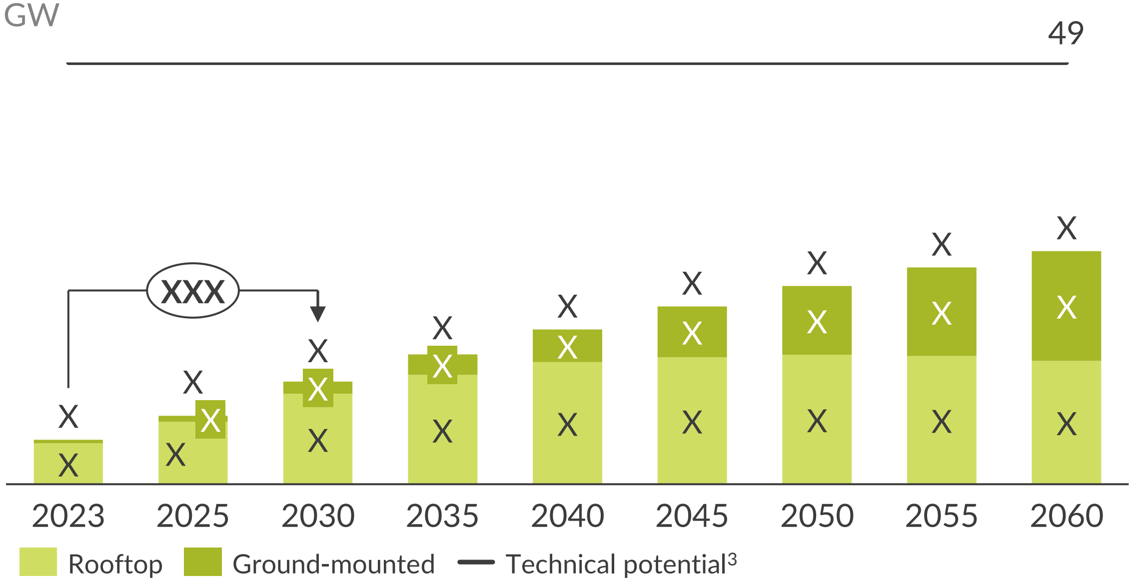
Overview

- While solar PV currently still plays a minor role in the Austrian power sector, it is experiencing a significant increase in capacity in recent years, with 2022 seeing a net buildout of over 1 GW for the first time.
- Buildout is expected to continue across the forecast horizon with the government providing support through investment grants and a market premium scheme to reach the EAG[1] solar generation target of an additional 11TWh by 2030 compared to 2020.

Exogenous capacity timeline[2]

GW



Assumptions

Capacity timeline

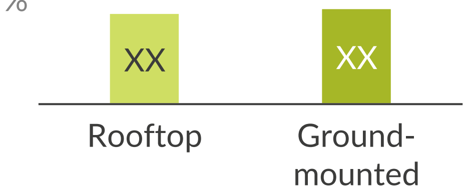
- While a capacity of 1.4GW has received investment grants in 2022, market premium auctions have been significantly undersubscribed by 80%[4] on average in 2023.
- While the new grid access guidelines from E-Control should increase transparency and lower bureaucratic complexity, grid access is expected to remain a major hurdle for PV expansion.
- Complicated bureaucracy, with different spatial planning, building and electricity acts in every federal state, and shortage of skilled workers are additional challenges while issues related to supply bottlenecks and funding are expected to ease until 2030.

Generation profile

- Our generation profile is derived from typical insolation patterns for Austria and benchmarked against historical output.

Load factor

%



Plant life

Years

Rooftop	Ground-mounted
XX	XX

1) Renewable Energy Expansion Act. 2) Assumed exogenous capacity timeline does not include merchant-risk buildout decisions of our model. 3) According to a 2020 study from Österreichs Energie, the technical solar potential lies at 49TWh, equal to 49GW of capacity assuming average load factors, with ground-mounted solar making up the largest share with 61% of total potential. 4) Including carried over capacity from previous auctions. Excluding this capacity, undersubscription was on average 69%.

Sources: Aurora Energy Research, BMK, Österreichs Energie

Battery capacity of [redacted] GW in 2060 is mainly driven by residential storage systems used for self-consumption optimisation

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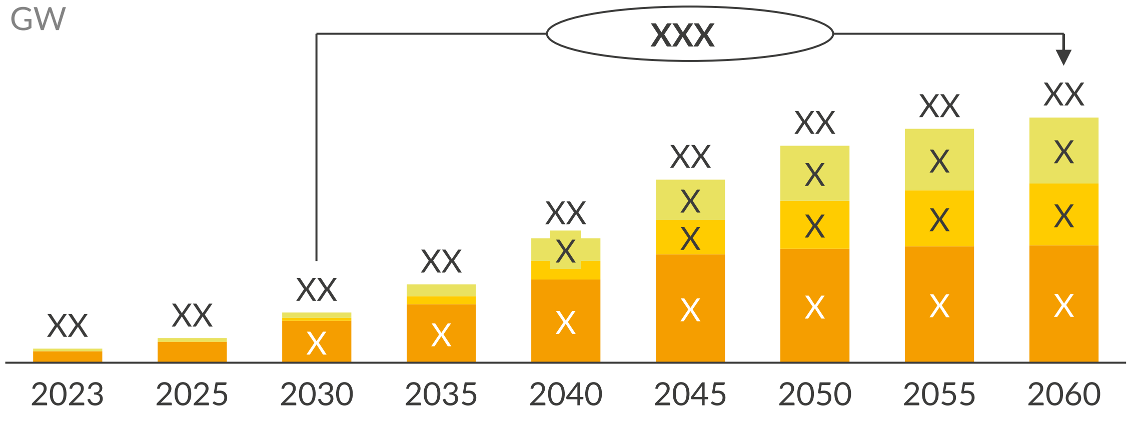
Overview

- Austria has one of the most developed residential storage system markets in Europe which is supported by national and provincial storage subsidies.
- We distinguish between three types of business models for batteries:
  - Residential behind-the-meter (BTM) batteries that allow for higher self-consumption of power generated by solar PV panels.
  - Pooling batteries, where decentralised storage systems are aggregated to form a virtual large-scale storage system which can be used by an aggregator to generate revenues on balancing markets.
  - Large-scale batteries participating in balancing markets, arbitrage and peak shaving. These can be stand-alone or in combination with renewable assets.

Exogenous capacity timeline
GW



Assumptions

Capacity timeline

- The expected decline of battery CAPEX costs post-2030 is the main driver behind battery buildout, which increases almost fivefold between 2030 and 2060.
- BTM buildout is additionally driven through continued deployment of rooftop solar, incentivising buildout already in the short term. BTM battery capacity increases to [redacted] GW in 2030 and accounts for [redacted] % of total installed capacity in the same year.

Generation profile

- Charging behaviour of self-consumption batteries is dependent on the generation profile of rooftop solar assets, with increased emphasis on self-consumption at home.
- Pooling assets have more freedom to optimise outside of rooftop solar production patterns and are able to provide system flexibility services just like industry and utility-scale batteries.

Lifetime[1]

Cycles

XXXX XXXX XXXX

... can have 15 years of lifetime.

Sources: Aurora Energy Research, SolarPower Europe

Austria's interconnector capacity is expected to grow by [redacted] GW by 2030 driven by projects with Germany and Italy

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Overview

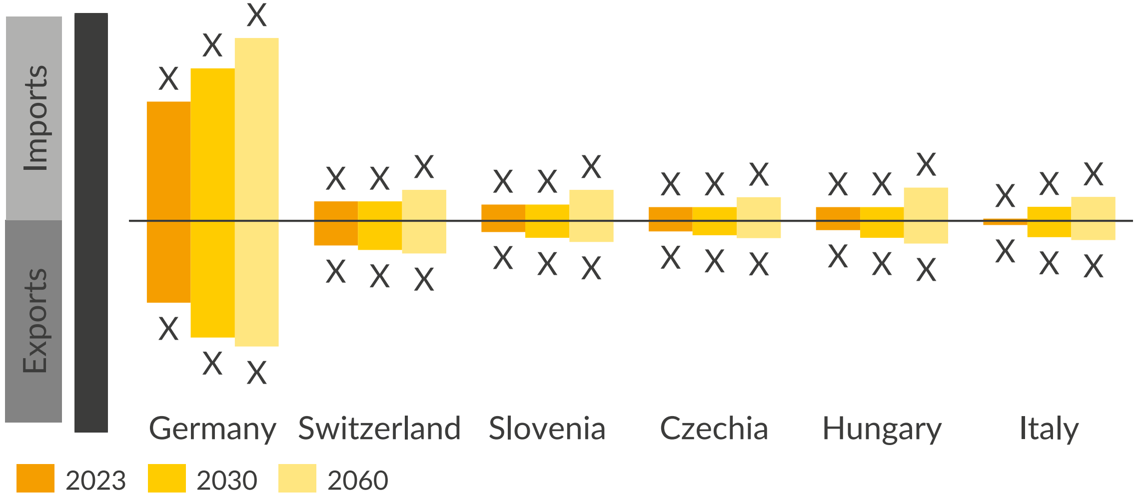
- Due to its location in Central Europe, Austria is highly interconnected with neighbouring countries, with the highest interconnection capacity existing between Austria and Germany.

Assumed capacity timeline

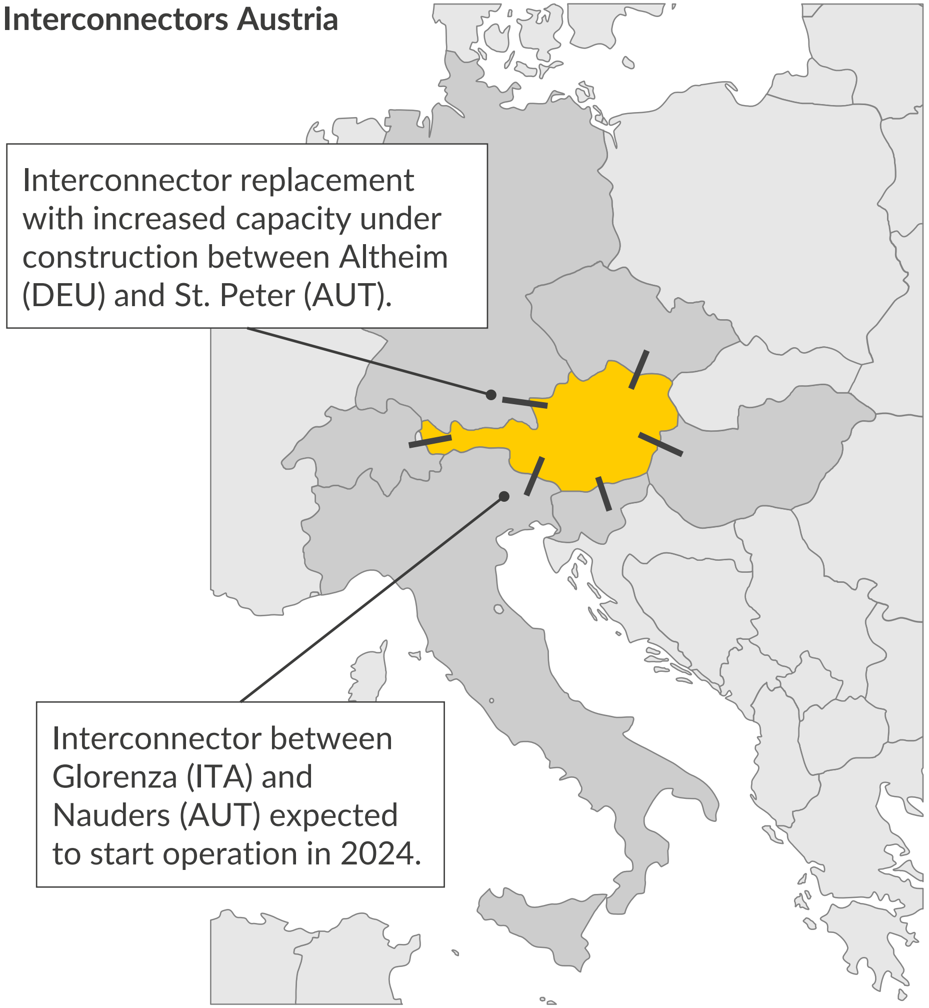
- Pre-2030 buildout timeline is based on announced projects whose capacity is weighted by the likelihood of realisation based on current project stage[1].
- Beyond 2030, projections are based on the System Needs analysis of the TYNDP[2], corrected for historical buildout rates, with interconnector capacities expected to increase by more than [redacted] GW by 2060[3] relative to 2023.

Austrian interconnector capacity

GW



Interconnectors Austria



1) Success rates correspond to the following project statuses: 'under construction' (100%), 'in permitting' (70%), 'in planning but not permitting' (60%), 'under consideration' (30%). 2) Ten Year Network Development Plan (TYNDP) published every two years by ENTSO-E. 3) Average of all interconnections, applicable to both imports and exports.

Sources: Aurora Energy Research, ENTSO-E

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Compared to Central, Low gas prices are [redacted]% lower in 2060, while power demand is [redacted]% lower in the same year reflecting weaker economic growth

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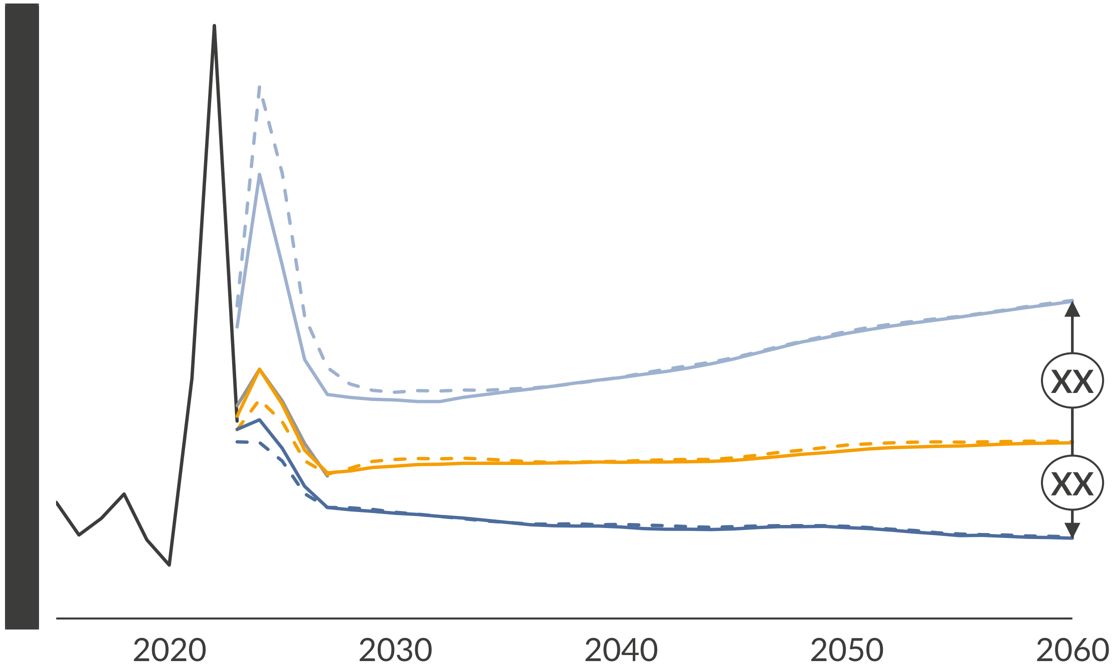
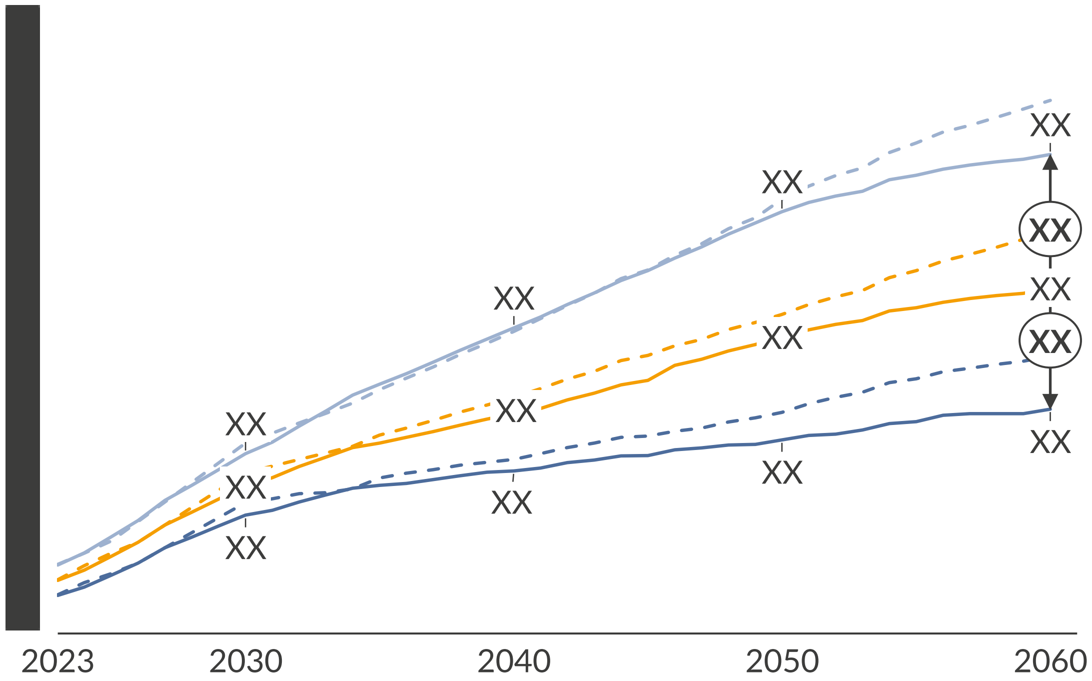
Natural gas price (CEGH VTP[1])
€/MWh (real 2022)[2]



- In 2028-2060, Low gas prices are [redacted] % lower on average compared to our Central scenario, driven by a slower increase in extraction costs on the supply side, as well as lower GDP growth resulting in lower gas demand.
- High gas prices are driven by the opposite price drivers and are [redacted]% higher on average than our Central scenario between 2028 and 2060.

Net annual power demand[3]
TWh



- Compared to our Central scenario, the Low case shows a reduction in net annual power demand of [redacted]% in 2060, at a level of [redacted]TWh. The key driver is weaker GDP growth compared to Central, which leads to lower economic output as well as slower electric vehicle and electric heating systems uptake.
- In our High case, demand grows more quickly and reaches [redacted] TWh in 2060, i.e., [redacted]% more than in Central.

Historical — Futures[4] — Central — High — Low — Previous forecast[5]

1) Central European Gas Hub Virtual Trading Point. 2) For years 2023-2027, the prices shown take into account current futures prices, with declining weights. In 2023, forecast prices include historical prices up to Aug-23. 3) Net power demand includes sectoral demand and transmission losses but excludes power plant self-consumption and efficiency losses of storage. 4) A rolling 14-day average as of 01/09/2023. 5) Refers to Aurora's preliminary market outlook for Austria presented on 12/09/2023.
Source: Aurora Energy Research

Post-2030, power prices in the Low case are [redacted] % lower on average relative to Aurora’s Central scenario and [redacted] % above in the High case

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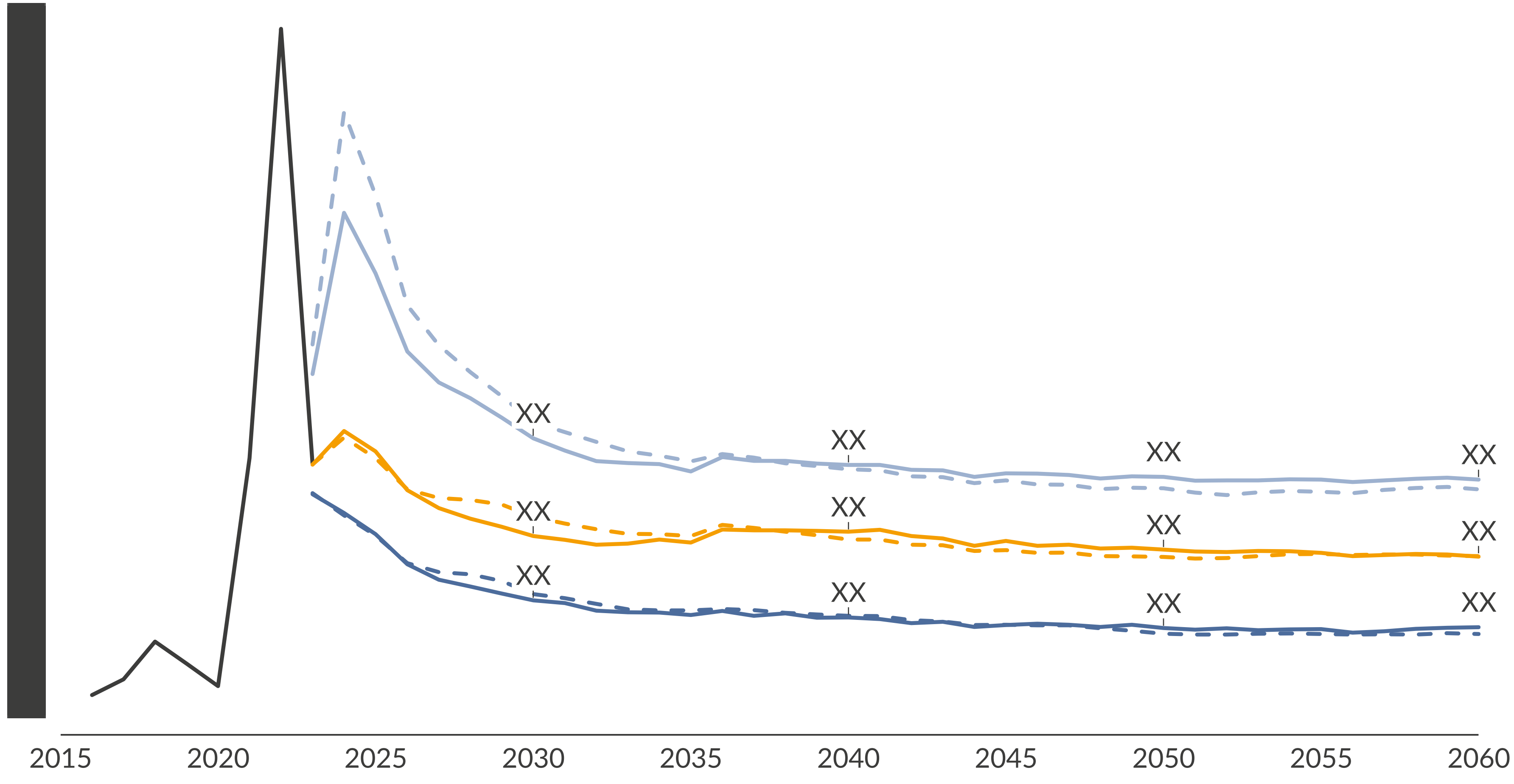
Baseload wholesale electricity price

€/MWh (real 2022)



1) Refers to Aurora’s preliminary market outlook for Austria, presented during the 2nd workshop of the Austrian Multi-Client Study in Vienna on 12 September 2023.

Sources: Aurora Energy Research, ENTSO-E

Low scenario

- Baseload prices in the Low scenario fall quickly from the current high of [redacted] €/MWh to [redacted] €/MWh in 2030.
- They remain depressed at an average of [redacted] €/MWh post-2030 with baseload prices being on average [redacted] % below our Central forecast.

High scenario

- After a rapid surge from 2023 due to a spike in gas prices throughout Europe, baseload prices decrease sharply in the short term and remain at an average of [redacted] €/MWh post-2030 until the end of the forecast horizon.
- In the same period, baseload prices are [redacted] % above our Central forecast on average.

Post-2030, solar capture prices are on average [redacted]% lower in the Low scenario and [redacted]% higher in the High scenario than in Central

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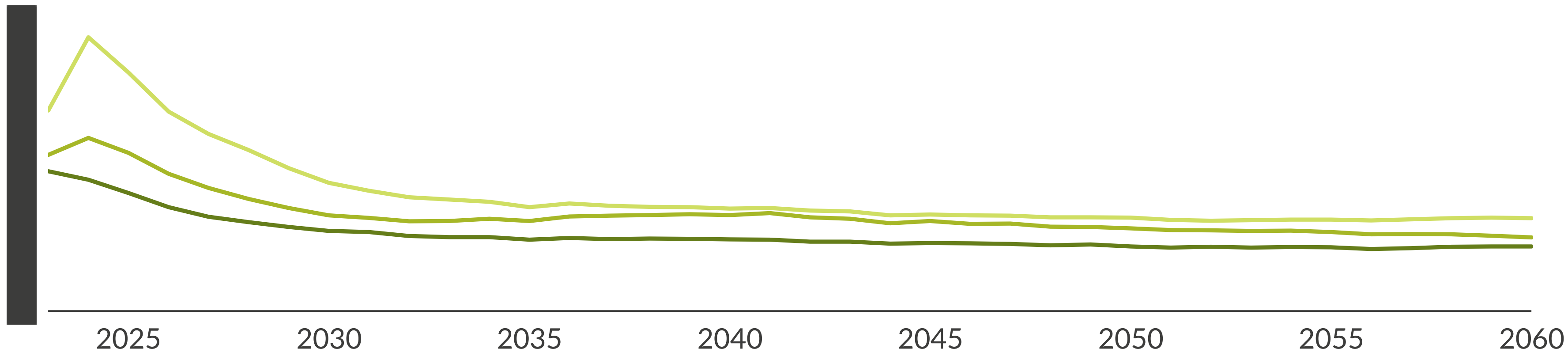
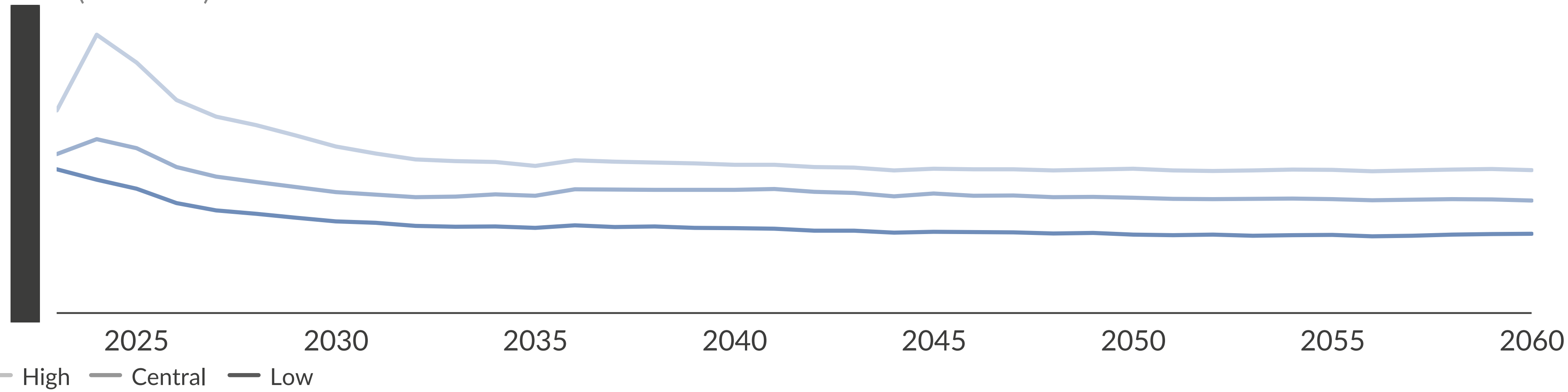
Solar capture prices[1]
€/MWh (real 2022)



Onshore wind capture prices[1]
€/MWh (real 2022)



1) Uncurtailed generation-weighted capture prices.

Source: Aurora Energy Research

Solar

- In Low, capture prices fall from [redacted] €/MWh in 2023 to [redacted] €/MWh in 2030. Post-2030, they remain relatively stable, averaging at [redacted] €/MWh, i.e., [redacted]% below Central.
- In High, capture prices fall gradually from [redacted] €/MWh in 2030 to [redacted] €/MWh in 2060, as increasing merchant solar buildout leads to downward price pressure, with deltas to Central averaging [redacted] % post-2030.

Onshore wind

- In Low, capture prices are on average [redacted]% below Central after 2030, stabilising at an average price of [redacted] €/MWh.
- After a gas price-induced spike in 2024, High capture prices decline with rising merchant buildout to an average of [redacted] €/MWh post-2030.

Agenda

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