AURORA
ENERGY RESEARCH

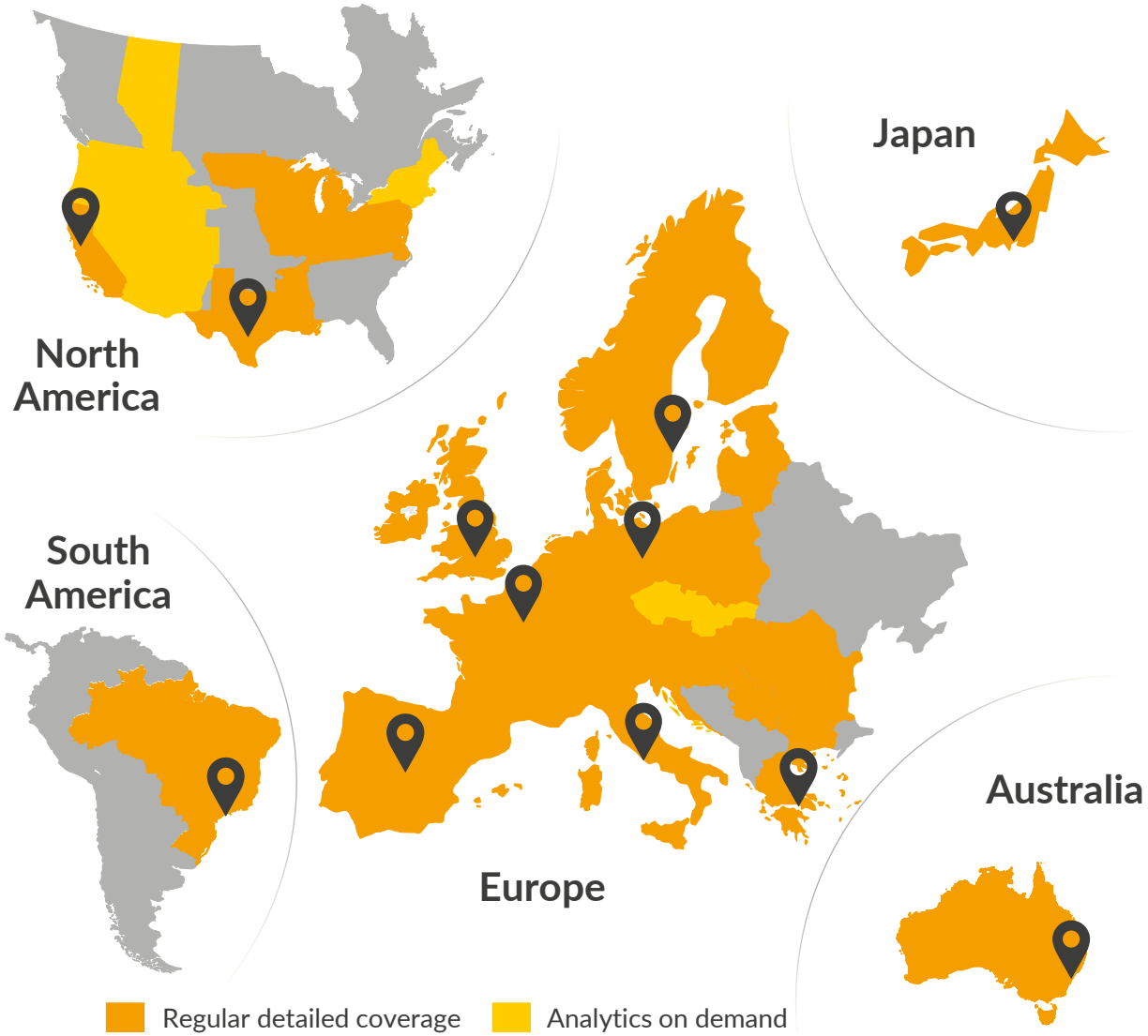
The Nuclear Option: Dutch Energy Security After the Russian Gas Crisis

Public Report

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

AURORA

- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



12 Offices

Oxford | Berlin | Madrid | Athens
Paris | Sydney | Austin | Oakland
Rome | Stockholm | Tokyo
São Paulo

430+

market experts

700+

subscribing companies

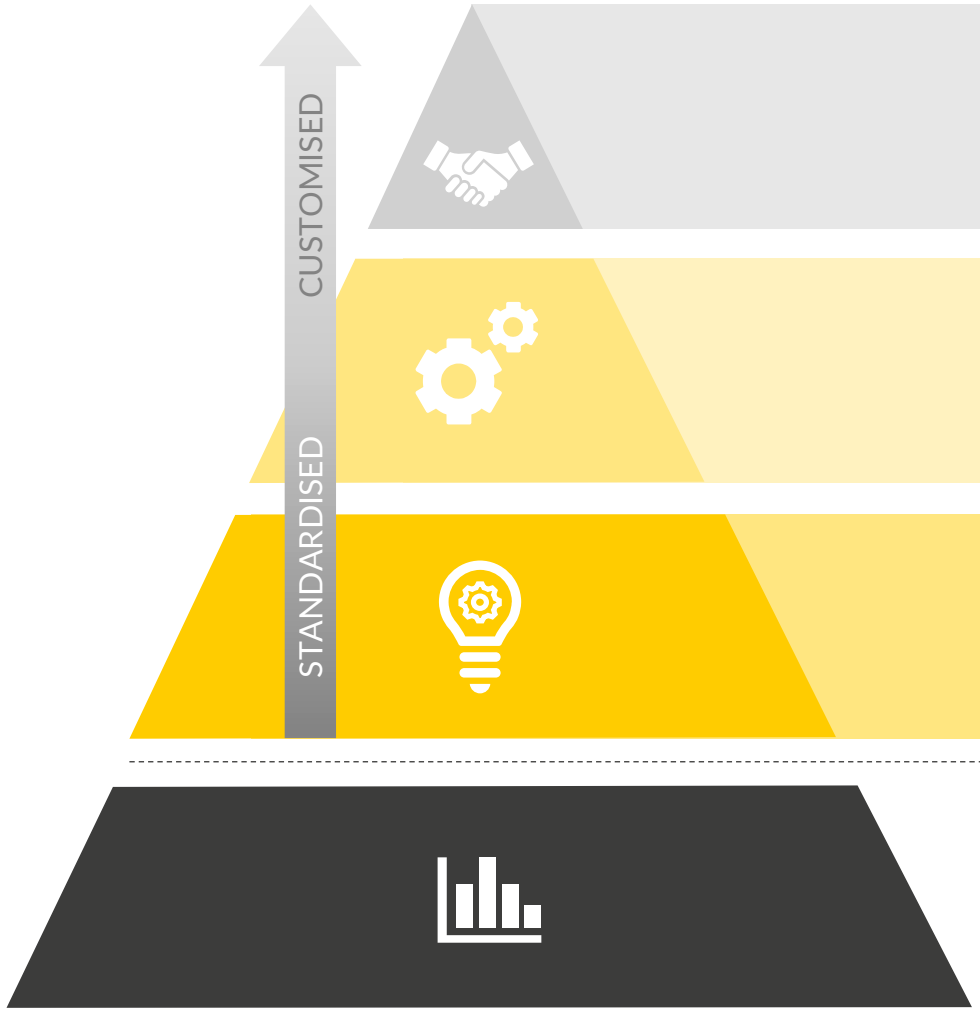
150+

transactions supported in 2022

Source: Aurora Energy Research

Our market leading models underpin a comprehensive range of seamlessly integrated services to best suit your needs

AURORA



Advisory

Access tailored expert advice and analytics for your crucial projects

Trusted advice and dedicated support for strategy, investments, transactions and policy engagement

1400+ projects globally

Software Solutions

Make standard analysis bespoke through direct access to our models

Unique SaaS subscriptions to create your own scenarios and asset-specific investment cases

100+ company licenses

Subscription Analytics

Receive regularly updated forecasts, sample investment cases and timely deep-dives

Industry-standard outlook reports, bankable price forecasts and strategic insights for power and commodities

600+ subscribing companies

Models & Data

Market-leading models for power, gas, hydrogen, carbon, oil & coal markets

Proprietary and continuously updated cutting-edge models populated with highest quality curated datasets

Developed over 10 years, 40+ dedicated modellers

Source: Aurora Energy Research

The approach has succeeded – we are working with the industry's biggest players

AURORA

> *"Aurora Energy Research is, I think, one of the smartest energy modelling companies around, and helped us on this Energy Outlook and continue to help us"*
>
> **Spencer Dale, Chief Economist, BP**

> *"Aurora's ability to forecast all the revenue streams relevant to UKPR's business model in a joined-up way sets them apart from their peers and has been very helpful to us in investment and business planning"*
>
> **Tim Emrich, CEO, UKPR**

Power & utilities

Energy consumers

Financial sector & investors

Oil & gas

Project developers

Policy & regulation

Source: Aurora Energy Research

Our researchers

Jesse Hettema

Market Lead – Netherlands & Belgium

Zeina Najjar

Senior Analyst – Netherlands & Belgium

Mael Denys

Senior Analyst – Netherlands & Belgium

Aurora's offerings

For more information on **the Dutch power market, future trends for energy prices, renewable build-out, the EU's proposed power market reforms and their impact in The Netherlands,** please contact **Alan Jabbour, Commercial Associate.**

✉ **alan.jabbour@auroraer.com**

To discuss speaking partnership opportunities with our team experts, please contact **Lucy Sovetova, Marketing Coordinator**

✉ **lucy.sovetova@auroraer.com**

Source: Aurora Energy Research

Agenda

AURORA

I. Introduction

II. Aurora's outlook on the Dutch power market

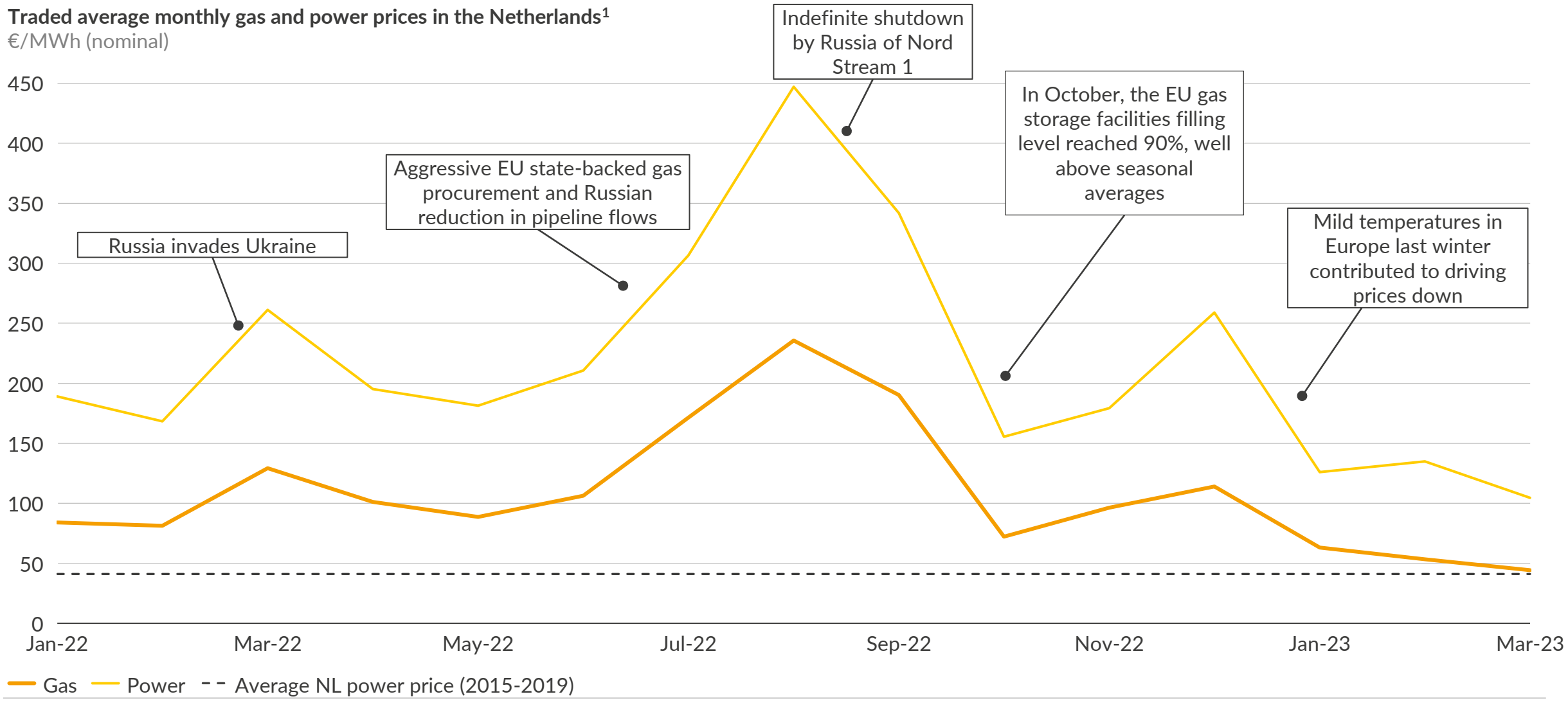
III. Potential impact of Dutch nuclear ambitions

IV. Policy outlook: EU market reform proposal

V. Key takeaways

Power prices in Europe have decreased significantly from their peak in 2022 and are currently below the level in Jan-22, prior to Russian invasion

Traded average monthly gas and power prices in the Netherlands[1]
€/MWh (nominal)



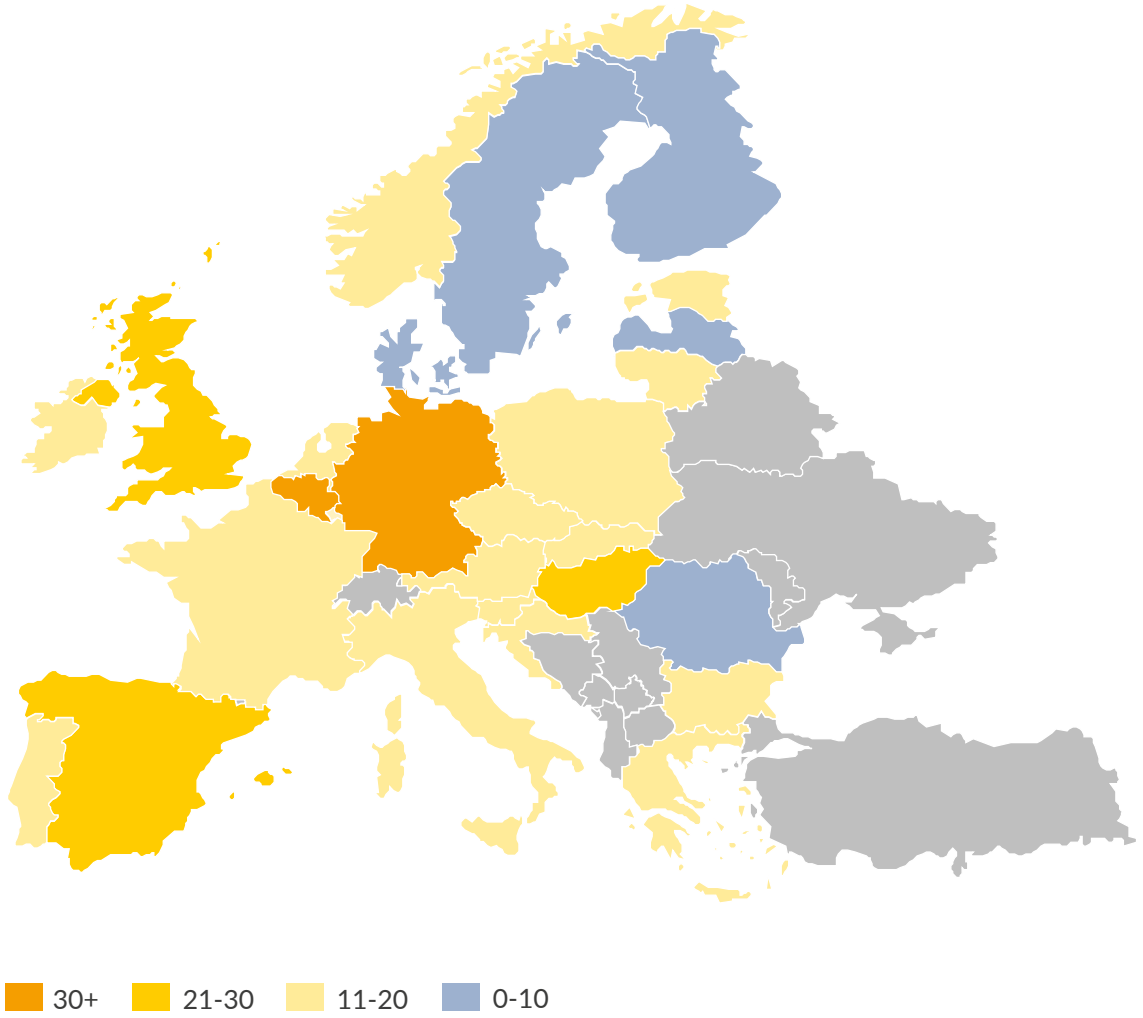
1) Monthly average of daily day-ahead prices as of 16 March 2023.

Sources: Aurora Energy Research, Refinitiv

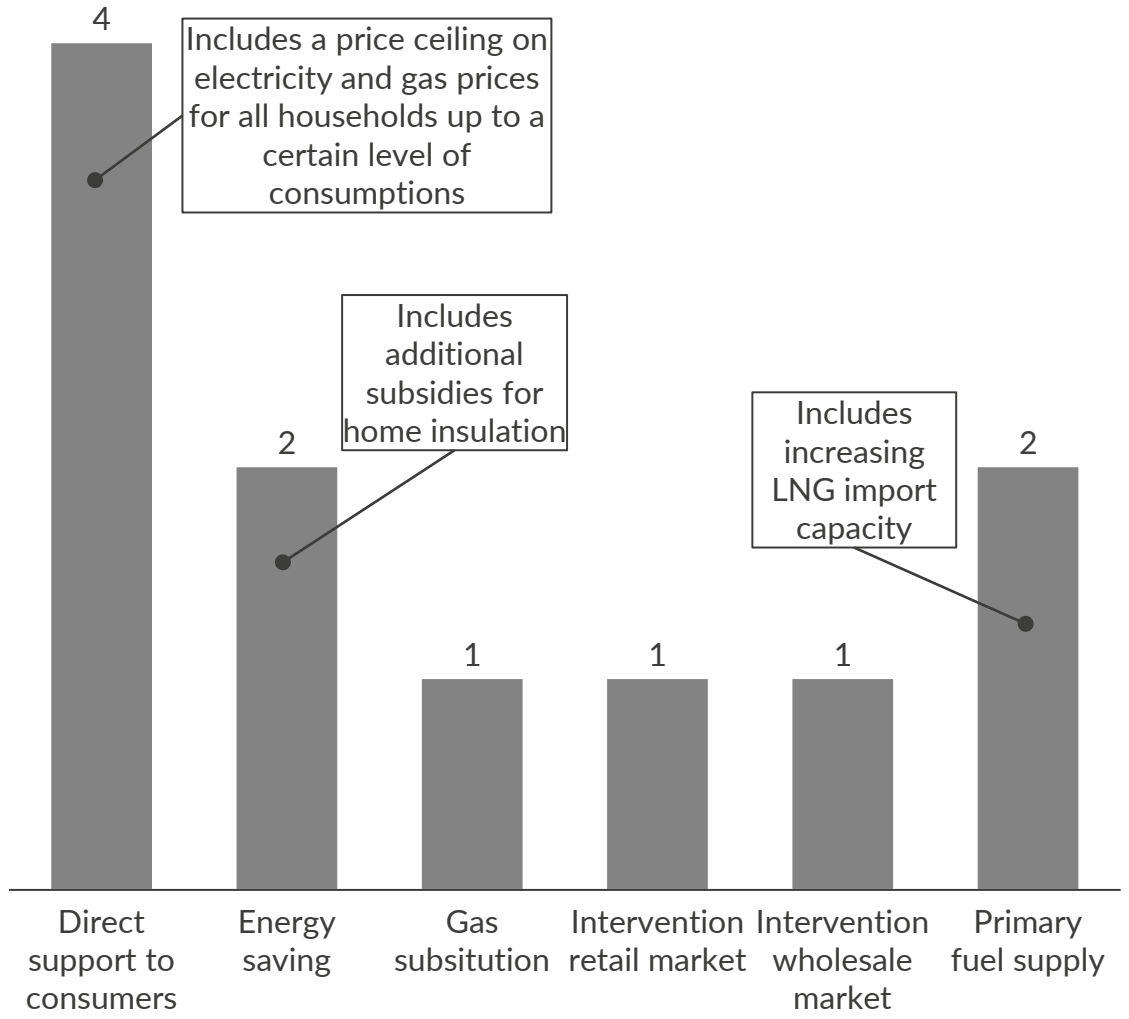
To alleviate the burden on consumers and enhance security of supply, the Dutch government took numerous measures in response to the crisis

AURORA

Number of emergency measures implemented by countries in 2022



Number of emergency measures taken by the Netherlands in 2022

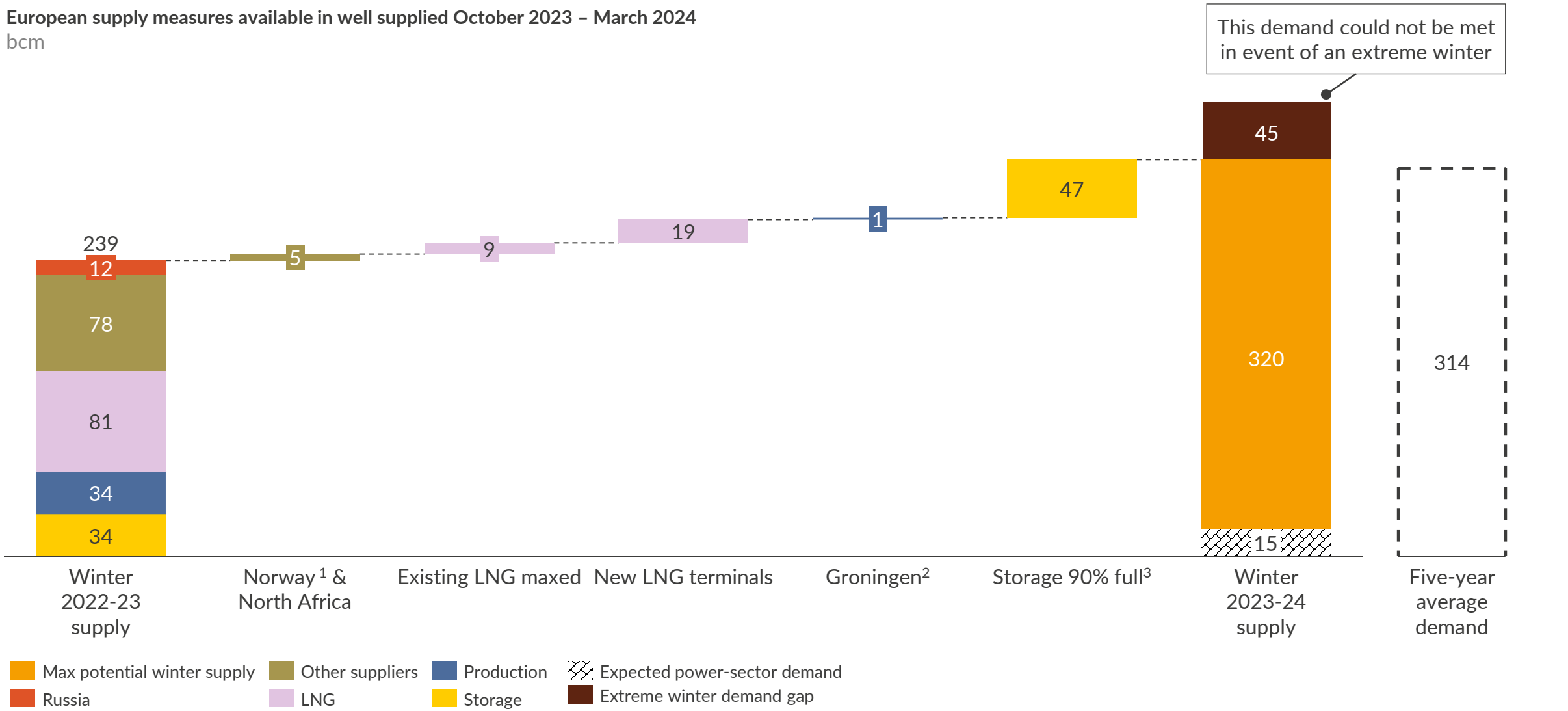


Sources: Aurora Energy Research, ACER

For additional information, please contact **Alan Jabbour, Commercial Associate**
✉ **alan.jabbour@auroraer.com**

Europe will likely have enough gas to cover average demand over the next year, but would struggle in an extremely cold winter

European supply measures available in well supplied October 2023 – March 2024
bcm



1) Planned maintenance is 0.4bcm lower in winter 2023-24, there was also about 1 bcm of unplanned maintenance last winter. 2) According to GTS' recommendations to keep Groningen online next winter. 3) Assumes storage is drawn down to 17.7% of capacity, matching the lowest in the last ten years.

Source: Aurora Energy Research, Entsog, Gassco, AGSI, European Commission, GTS

We present our Dutch power market outlook, reflect on the energy crisis' impact and assess the potential implications of Dutch and EU policy reform

AURORA

Aurora's outlook on the Dutch power market

- We present the forecasted development of power prices
- We dive further into the forecast of the main drivers of Dutch power prices towards 2030;
  - Commodity and CO_2 prices
  - Renewables build-out
  - Demand

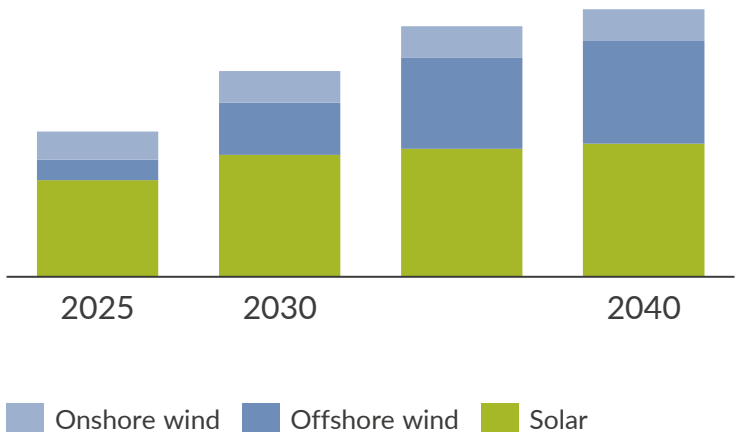
Potential impact of Dutch nuclear ambitions

- We examine the governments plan to build two new nuclear plants in the 2030s
- We analyse the potential effect of this nuclear build-out on the Dutch power system
- We discuss the financial viability of the nuclear plants

Policy outlook: EU market reform proposal

- We explain the recent European Commission's proposal for electricity market reform
- We analyse the potential effect of the main policies in the proposal on the Dutch power system;
  - Financing of renewables & boosting of PPAs
  - Flexibility support schemes & peak shaving

Renewable energy capacity



Potential sites for nuclear power plants

Main topics of market reform proposal

Promoting long-term markets

Promoting flexibility

Consumer protection

Agenda

AURORA

I. Introduction

II. Aurora's outlook on the Dutch power market

III. Potential impact of Dutch nuclear ambitions

IV. Policy outlook: EU market reform proposal

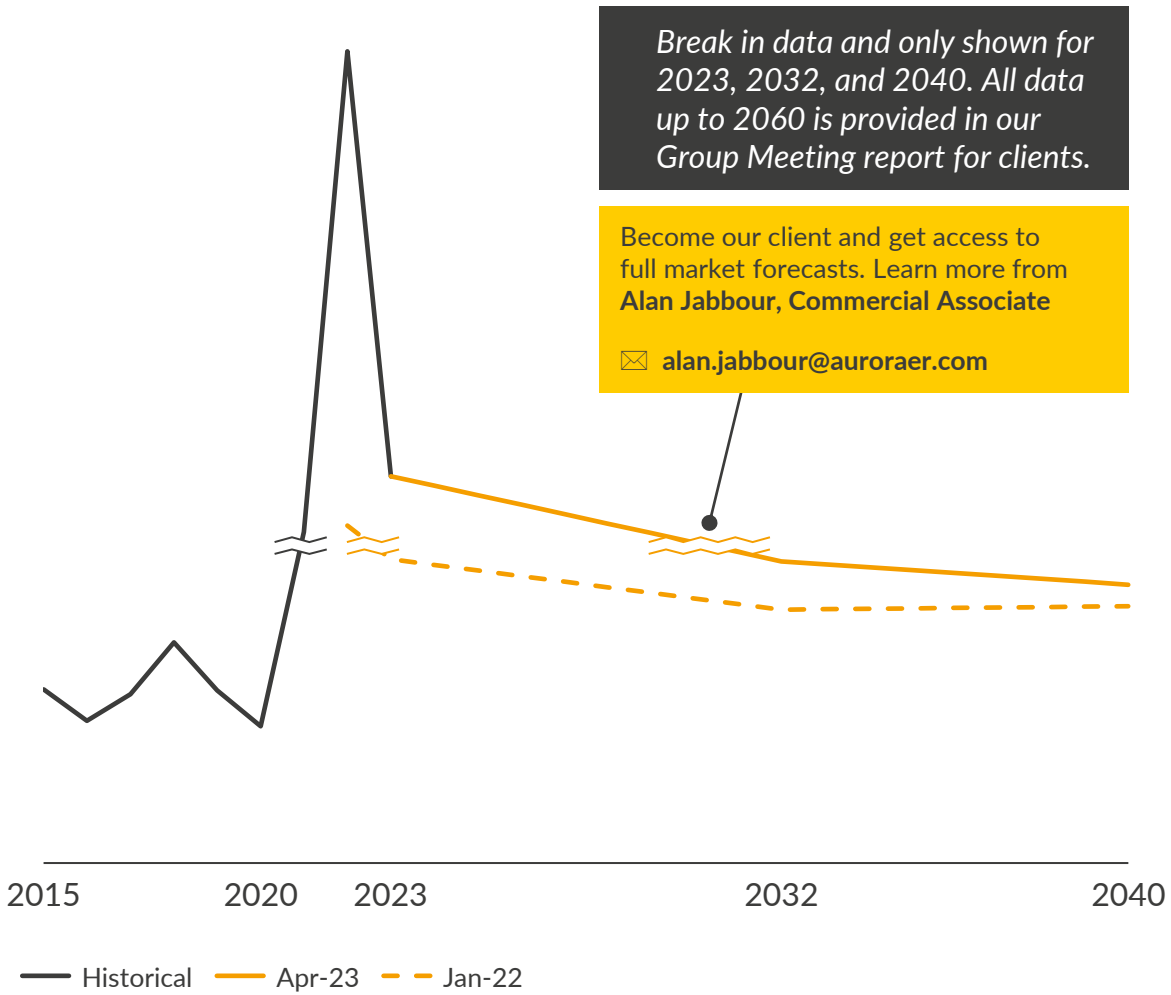
V. Key takeaways

Relative to our last pre-crisis forecast, baseload prices increased strongly in the 2020s; towards 2035 prices converge

AURORA

Dutch baseload wholesale electricity price
€/MWh (real 2022)

Aurora Central scenario



Main drivers for Dutch power price development

	Driver	Impact of change on prices
1	Commodity prices	↓
2	CO_2 prices	↑
3	Renewables buildout	↓
4	Demand	↑

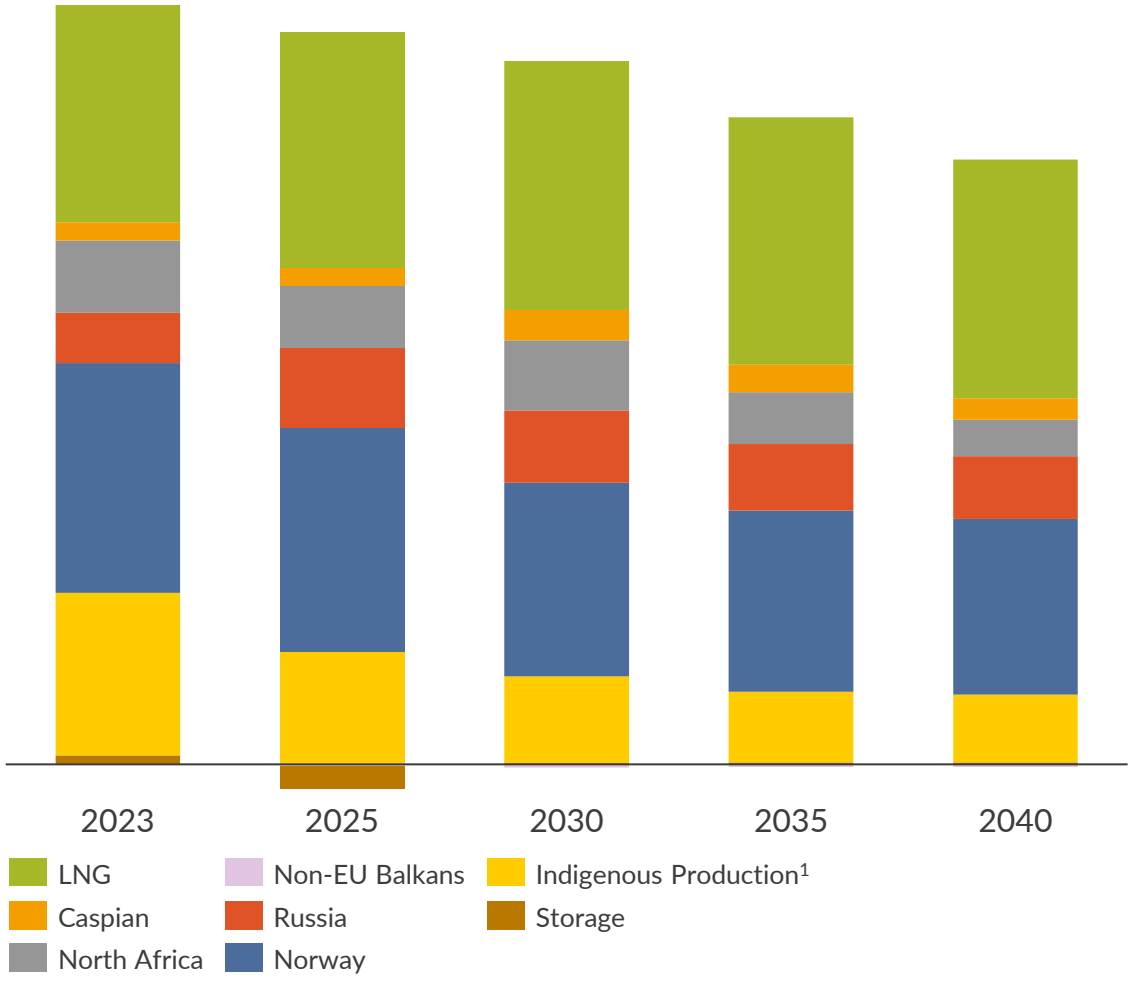
x Deep dive on next slides ↑ Positive impact ↓ Negative impact

Source: Aurora Energy Research

As liquefied natural gas supply expands and demand-side measures take effect, we expect gas prices to fall until 2027

AURORA

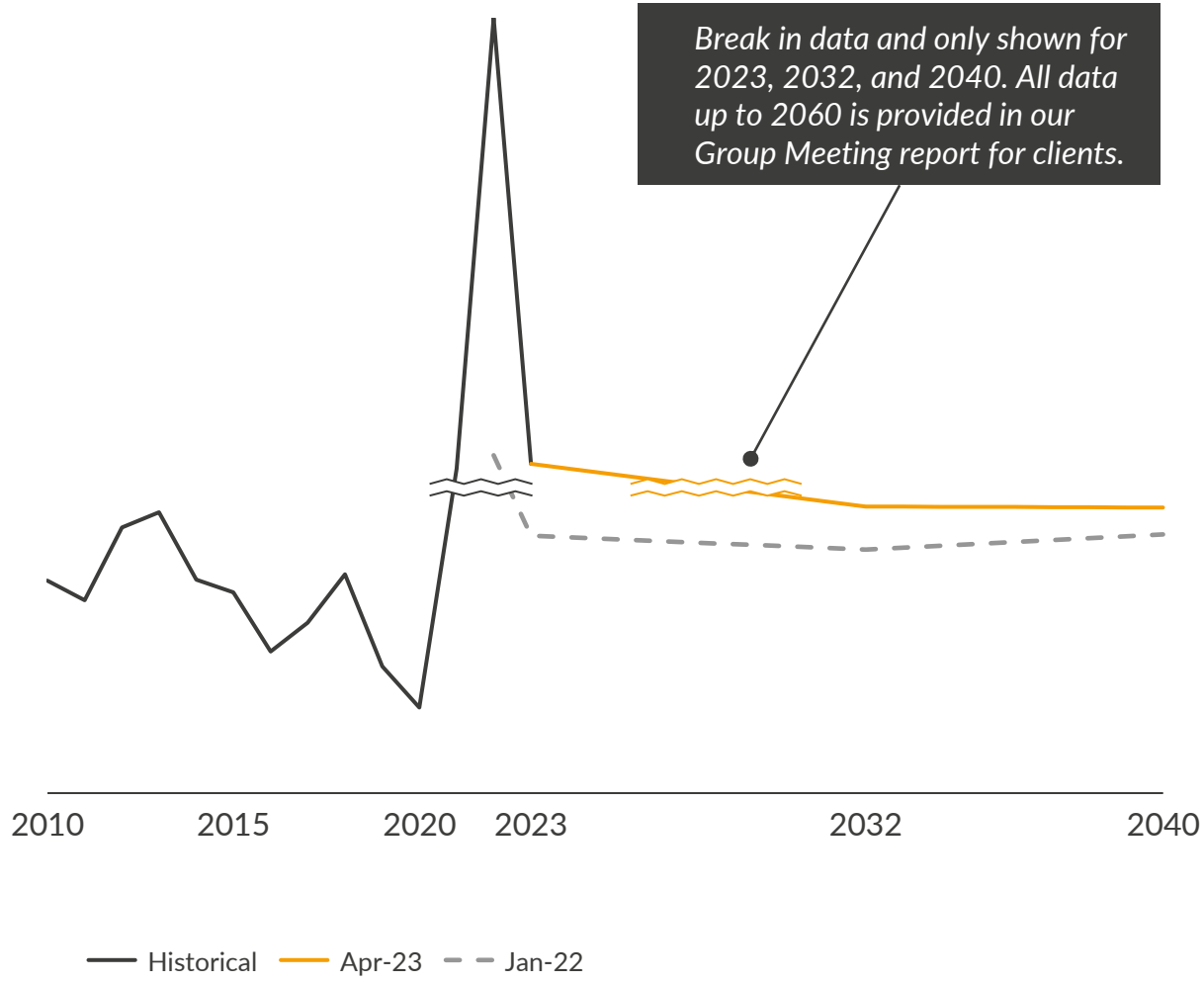
European gas supply
Bcm/year



European natural gas prices
€/MWh (real 2022)

Aurora Central scenario

Break in data and only shown for 2023, 2032, and 2040. All data up to 2060 is provided in our Group Meeting report for clients.



1) Indigenous production doesn't include Norway and includes natural gas and biomethane

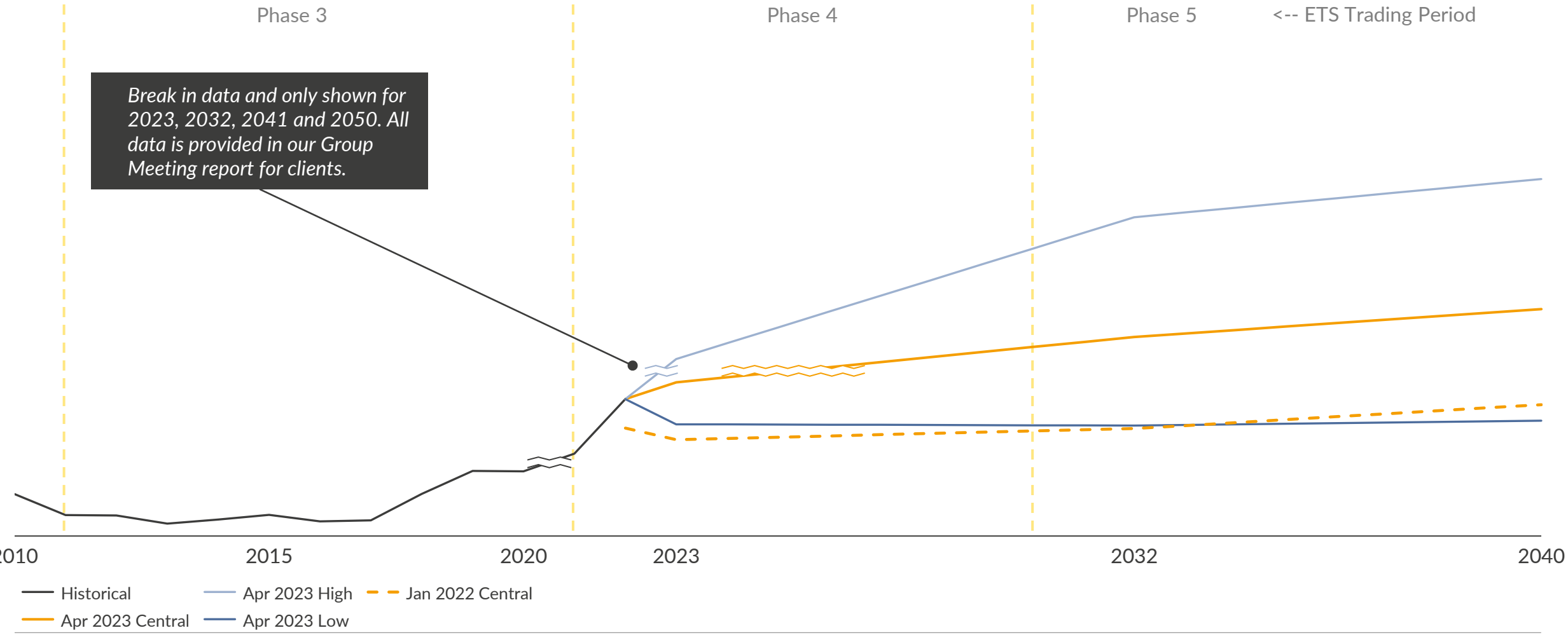
Source: Aurora Energy Research

Following the ETS agreement in December 22, we expect European carbon prices to continuously rise

AURORA

Carbon prices[1]
€/tCO$_2$ (real 2022)

Aurora Central scenario



1) 2023 price is a mix of historical price and forecast YTD as of February 2023. For years 2023-2027 the prices shown consider current future prices with declining weights.

Sources: Aurora Energy Research, EIKON

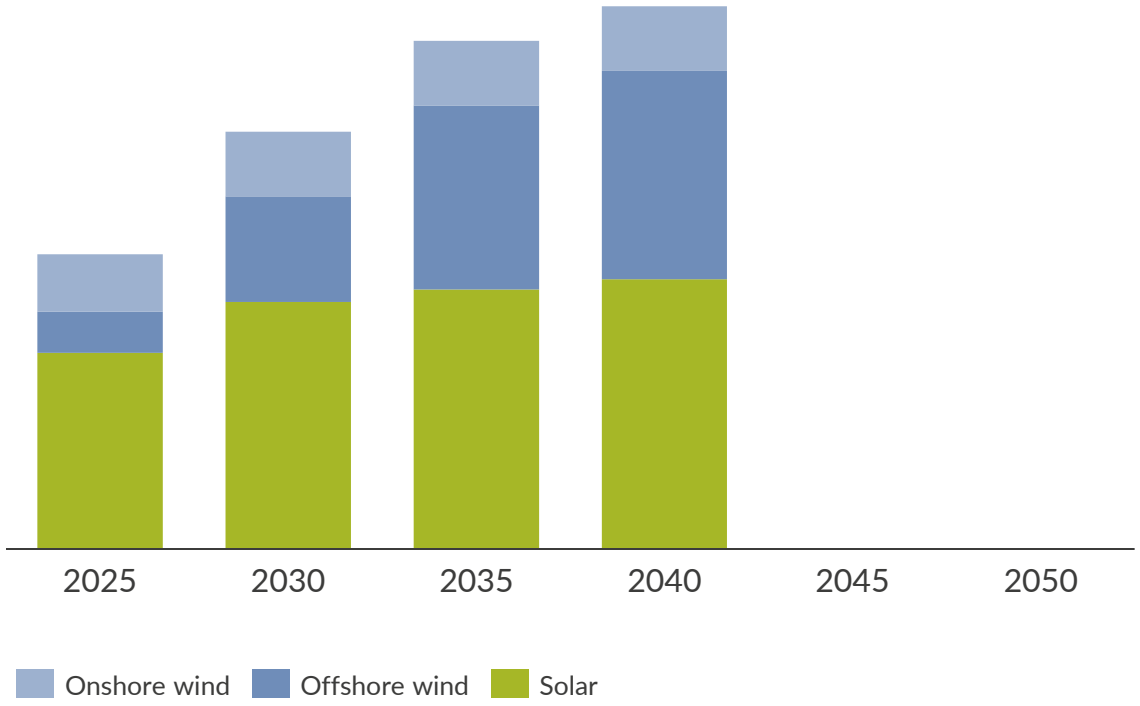
Buildout of renewable capacity over the last years has been strong, we expect further growth, but there are multiple limiting constraints

AURORA

Renewable capacity outlook – mid of year - NLD
GW

Aurora Central scenario

Data only shown up till 2040. All data is provided in our Group Meeting report for clients.



Potential constraints to growth

Economics

- SDE++ for large scale solar and onshore wind and net-metering phase out
- Solar is at risk after 2030 if there is insufficient subsidy support

Permits

- Long average permitting lead time for onshore wind in the Netherlands
- Dutch nitrogen crisis and the recent ruling against project Porthos by the Council of State

Grid congestion

- Heavily congested Dutch grid which affects new requests especially for solar fields
- Grid expansion and reinforcement takes time

Supply chain

- Supply chain disruptions during the pandemic and effects of its aftermath lead to rising polysilicon, steel and copper costs
- Price increases expected to clear by 2025, but further supply shortages cannot be ruled out

Source: Aurora Energy Research

We expect demand electrification to speed up, leading to higher power demand in 2030, which will also be more flexible

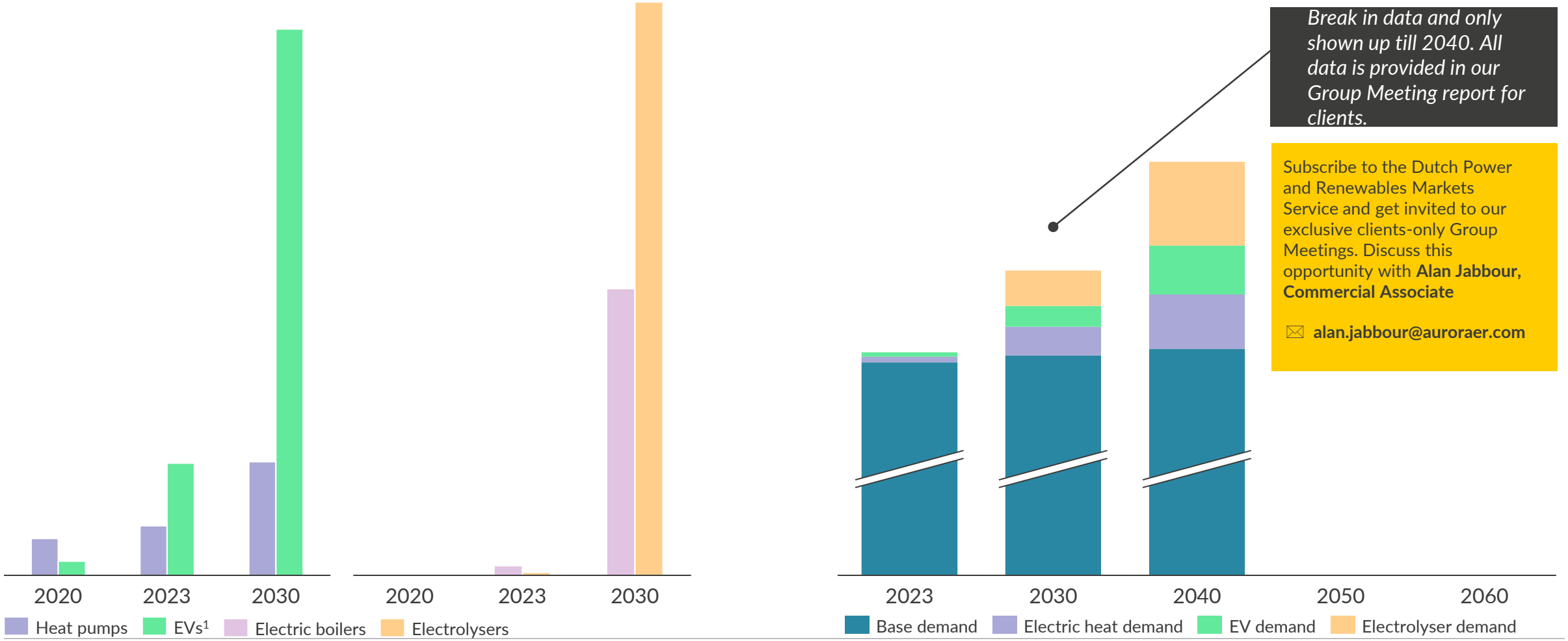
AURORA

Heat pumps & EVs
x1000

Yearly electrolyser & electric boiler capacity
MW_{output}

Net annual power demand by type
TWh

Aurora Central scenario



Break in data and only shown up till 2040. All data is provided in our Group Meeting report for clients.

Subscribe to the Dutch Power and Renewables Markets Service and get invited to our exclusive clients-only Group Meetings. Discuss this opportunity with **Alan Jabbour, Commercial Associate**

✉ **alan.jabbour@auroraer.com**

1) Including heavy transport electric vehicles

Sources: Aurora Energy Research, EHPA, ACEA

Agenda

AURORA

I. Introduction

II. Aurora's outlook on the Dutch power market

III. Potential impact of Dutch nuclear ambitions

IV. Policy outlook: EU market reform proposal

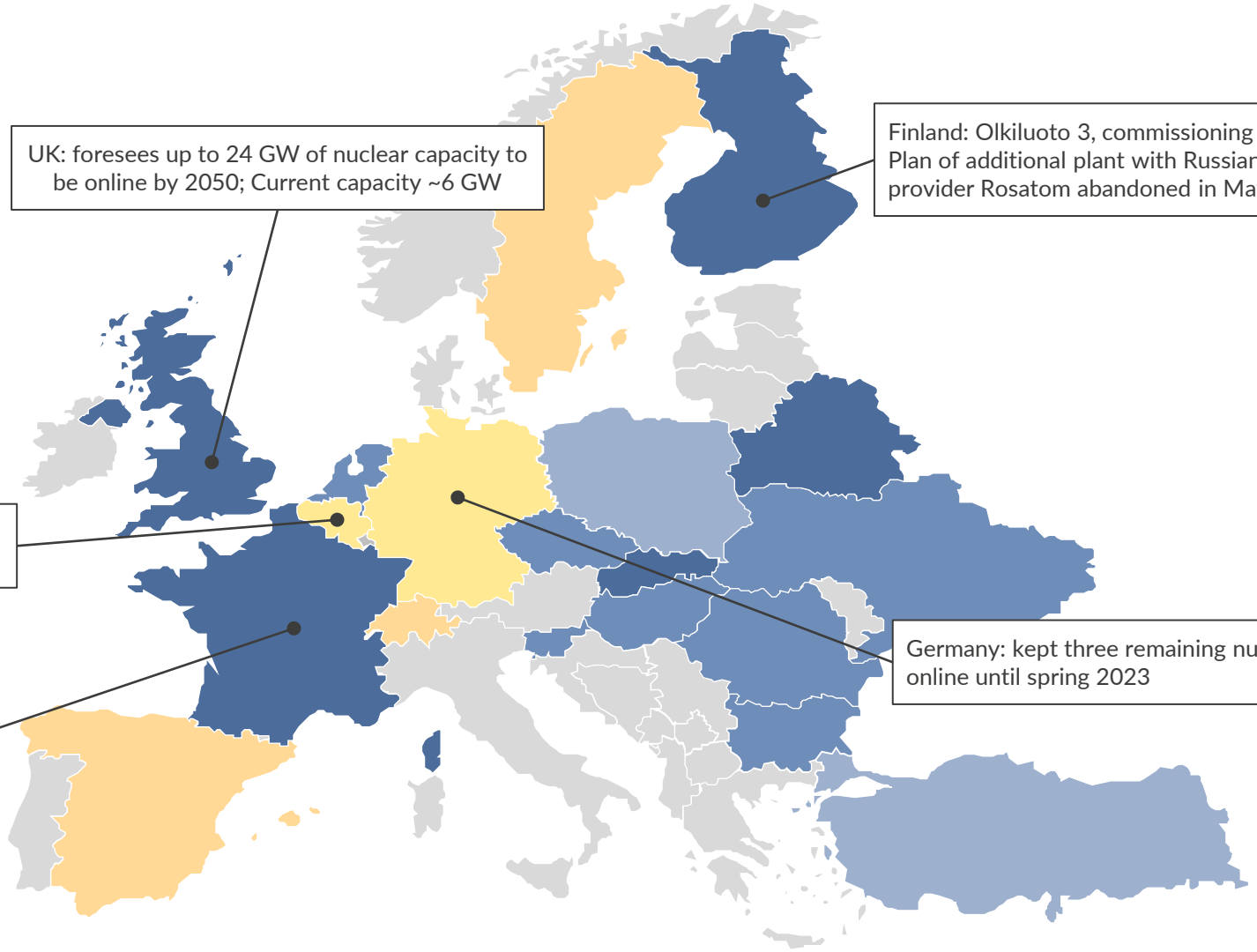
V. Key takeaways

A new focus on energy independence and the drive to decarbonise power systems is leading to a nuclear renaissance across Europe

AURORA

Nuclear energy policy and planning[1], 2022[2]

- Operating & building new nuclear power plants (NPPs)
- Operating & planning new NPPs
- Planning or constructing first NPPs
- Operating nuclear power plants with no plans for new ones
- Planning nuclear exit but currently undergoing policy change
- No NPPs and no plans to build them



1) Encompasses expressed interest in and sustained political discussion about building nuclear power plants, including small modular reactors, as well as announced plans to do so; 2) As of October 2022

Sources: Aurora Energy Research, International Atomic Energy Agency, Reuters, National Governments

The Dutch government's Coalition Agreement targets to build two new nuclear plants with a combined capacity of 3 GW in the 2030s

AURORA

Dutch Coalition Agreement

- **Total planned capacity**: 2.0 - 3.3 GW
- **Number of reactors**: 2
- **Number of sites**: 1
- **Potential technology providers**: France, USA, South Korea, Japan.
- **State involvement**: Several options:
    1. State-owned company to run the project
    2. Regulated asset base (RAB) model

Potential Nuclear Power Plant (NPP) sites

Existing NPP: Borssele

Sites up for selection for new NPPs:

- Borssele (pronounced preferred location)
- Maasvlakte Rotterdam

Government's planned milestones

2021	Coalition Agreement (first announcement)
2023	Start tender procedure
2024	▪ Final decisions regarding technology, location, financing and state involvement ▪ Final decision on construction
2025	▪ Signing contract with technology provider ▪ Permit-granting for construction
2028	Start (consecutive) construction of the new reactors
2033	Extension of lifetime existing reactor in Borssele
2035	Commissioning of the new reactors

Discover how our Dutch Power and Renewables Markets Service can help your business from **Alan Jabbour, Commercial Associate**

✉ alan.jabbour@auroraer.com

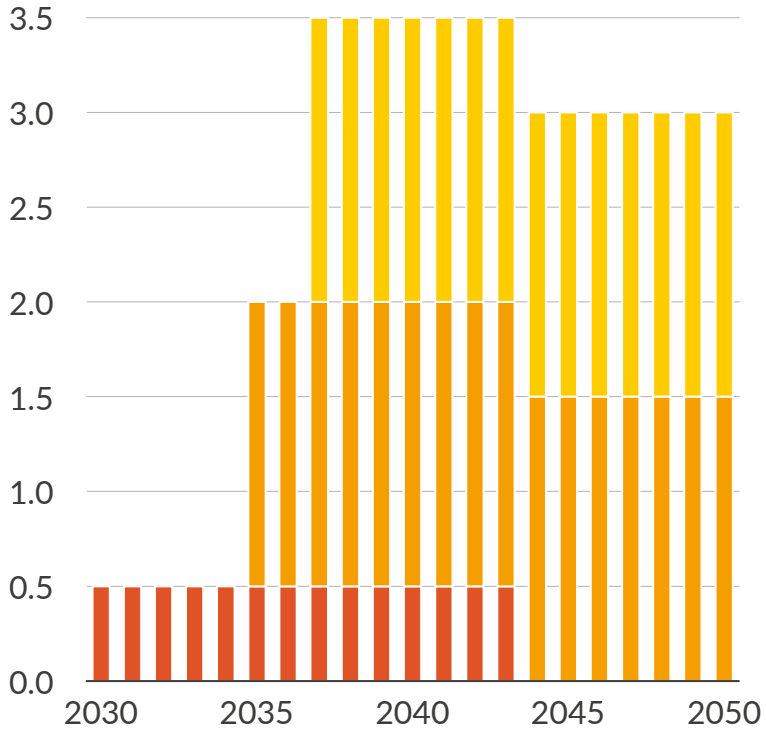
Sources: Aurora Energy Research, Government of the Netherlands, Energeia

If nuclear capacity is added from 2035 onwards, renewables build out less strongly and average prices are slightly lower

AURORA

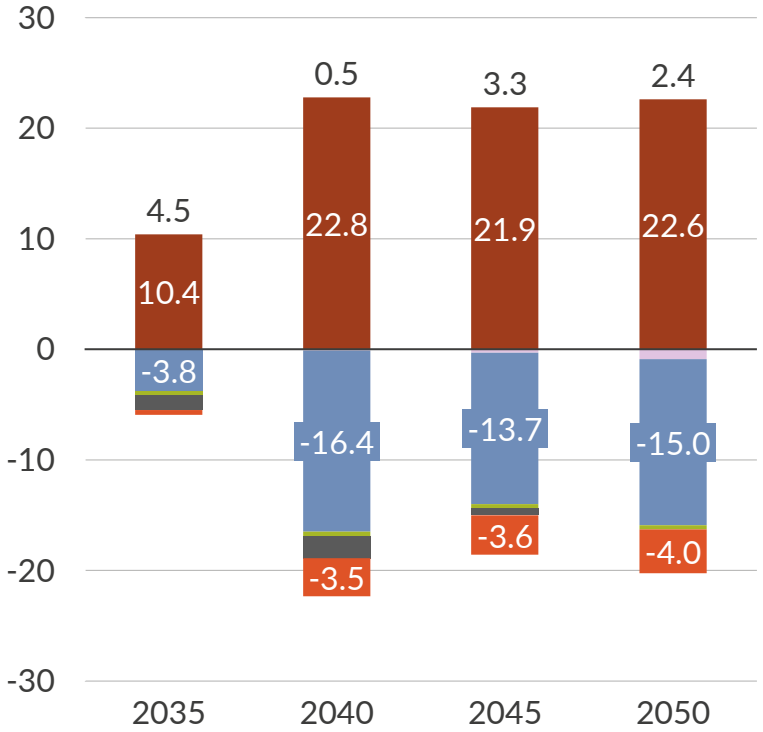
Installed nuclear capacity

GW



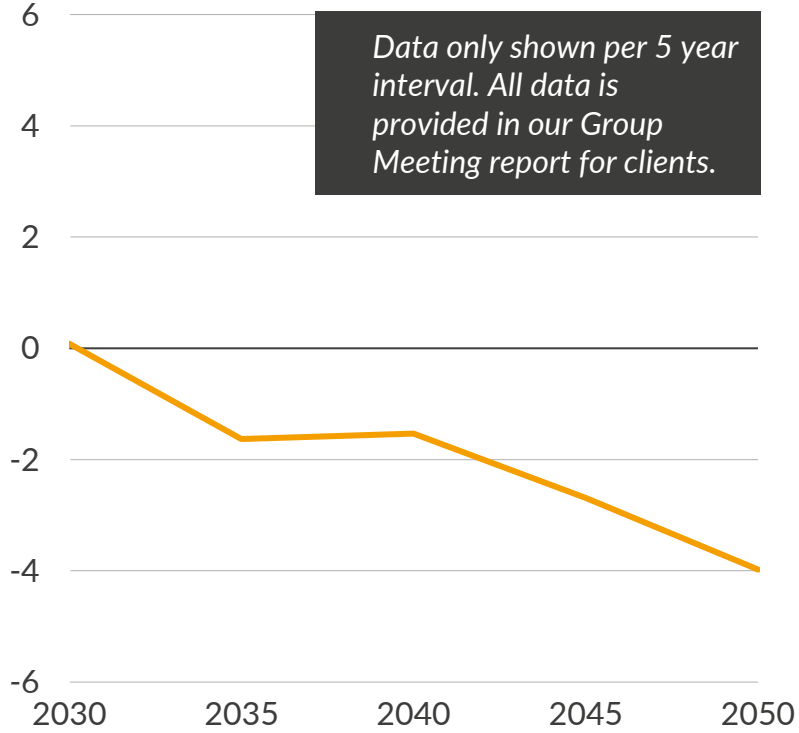
Generation delta vs. Central

TWh



Baseload price delta vs. Central

€/MWh (real 2022)



Data only shown per 5 year interval. All data is provided in our Group Meeting report for clients.

Borselle 1 Borssele 2 Borssele 3 Nuclear Offshore wind Gas CCGT Hydrogen Solar Interconnectors[1] Baseload price delta

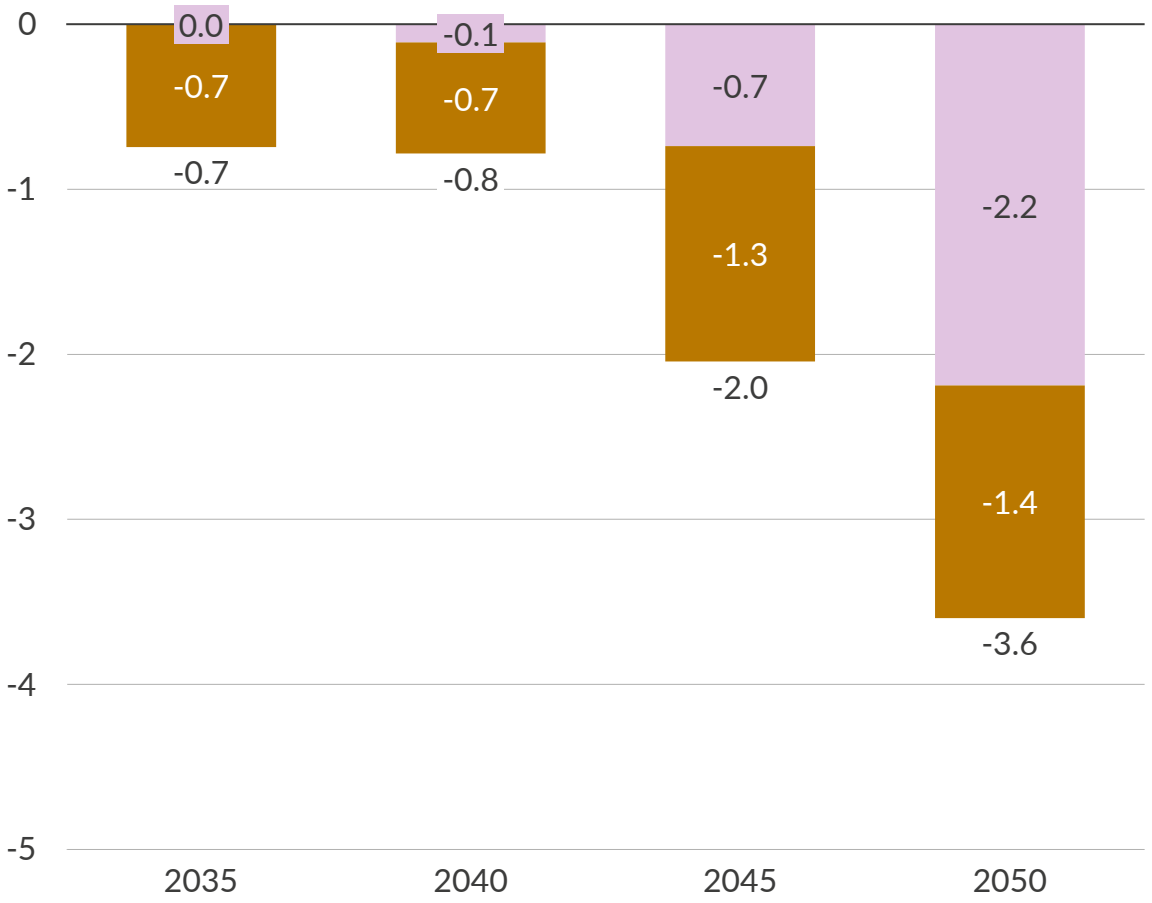
1) For generation, interconnectors represent the net imports or exports

Source: Aurora Energy Research

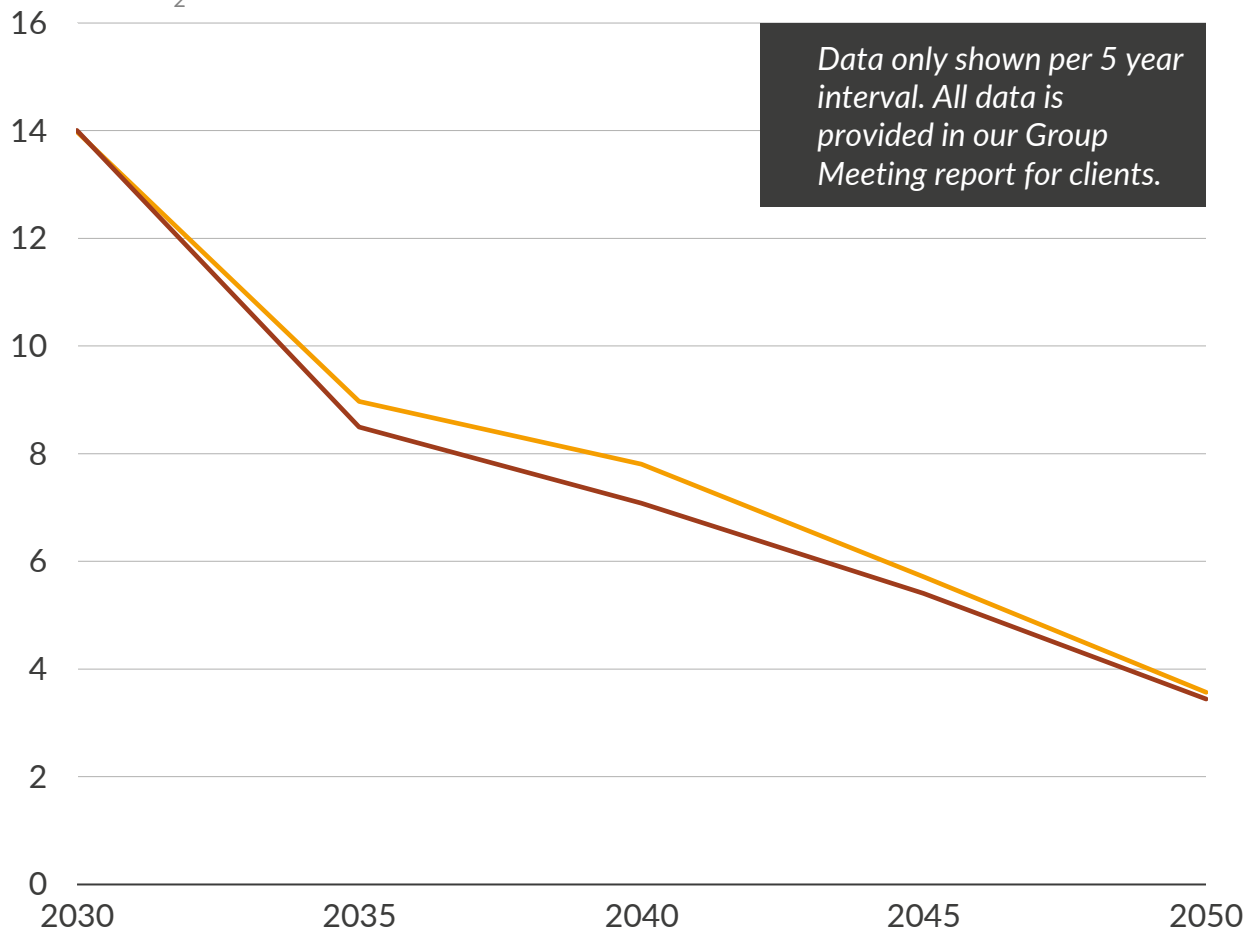
More nuclear leads to less gas and hydrogen power plants generation, and thereby reduces hydrogen import dependency and lowers emissions

AURORA

Delta of imported hydrogen
TWh



Power sector emissions
Mt CO_2



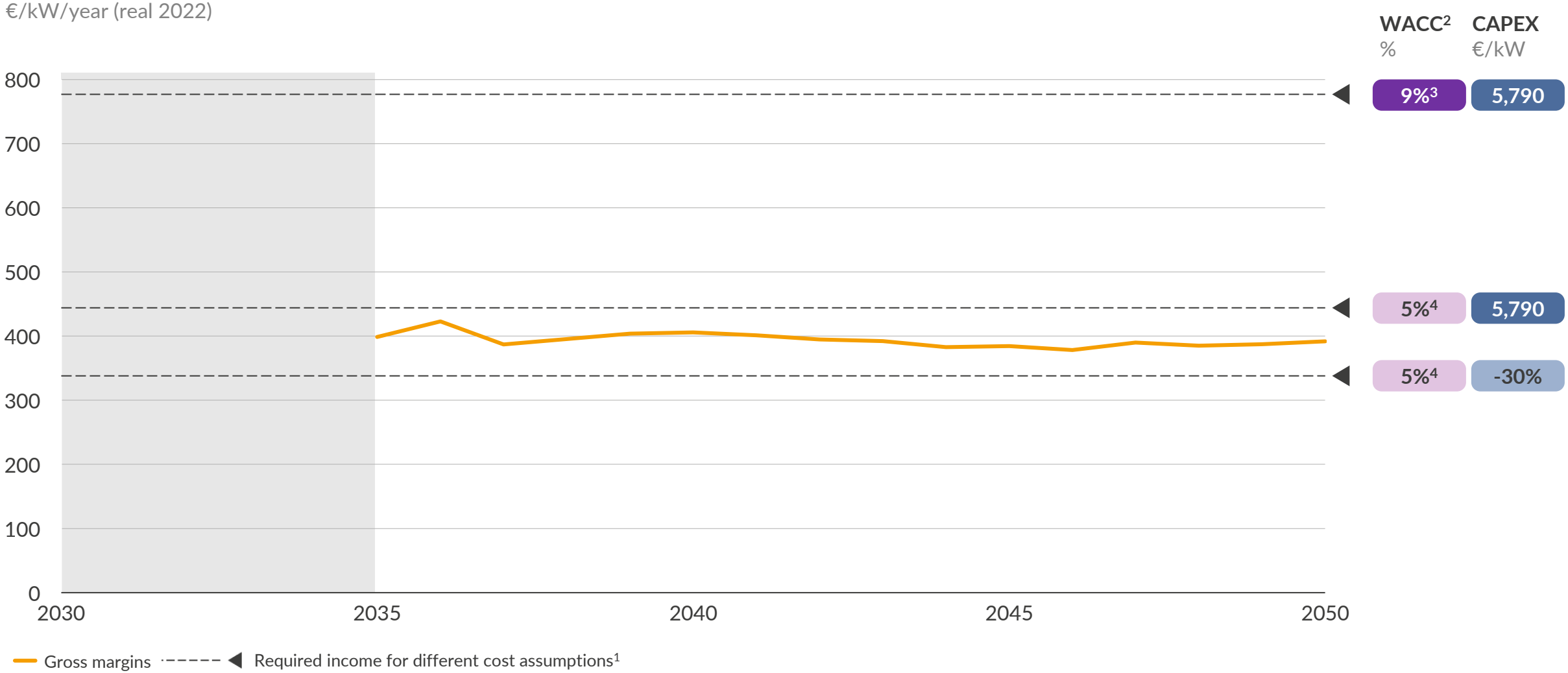
Data only shown per 5 year interval. All data is provided in our Group Meeting report for clients.

Source: Aurora Energy Research

Nuclear requires strong government support, but if properly derisked, it potentially only requires limited cash transfers

AURORA

Nuclear gross margins vs required income[1]
€/kW/year (real 2022)



1) Required income is the sum of fixed variable & maintenance costs and CAPEX annuity, including the effect of the construction period 2) real, pre-tax 3) A merchant case at 9% WACC reflecting the assumption of a market-driven buildout 4) A reduced risk with 5% WACC, considering a government support scheme to be in place to reduce the risk for asset development.

Source: Aurora Energy Research

Agenda

AURORA

I. Introduction

II. Aurora's outlook on the Dutch power market

III. Potential impact of Dutch nuclear ambitions

IV. Policy outlook: EU market reform proposal

V. Key takeaways

The EU market design reform process is now underway, but proposals became less ambitious as prices sank

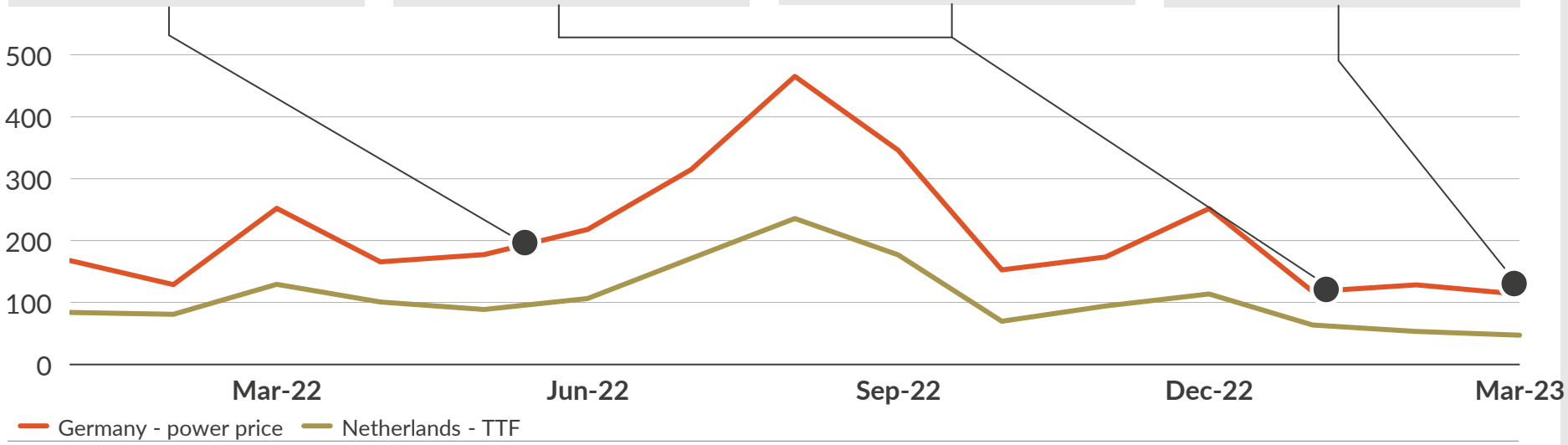
Monthly spot power and gas prices[1]
€/MWh (nominal)

Greece: CfDs & marginal prices
- Price cap for electricity market.
- Split wholesale market:
  - **Inflexible technologies:** compensation based on CfD
  - **Flexible technologies:** marginal pricing

Spain: CfDs & capacity markets
- Split per technology:
  - **Renewables:** voluntary CfDs for new and existing
  - **Nuclear & hydro:** forced CfDs
  - **Conventional:** capacity market

France: Post-market fund
- Maintain marginal pricing for all technologies.
- **Fund to redistribute revenues** above full costs from low carbon generation assets to consumers proportional to their consumption **post-market.**

EU: Supporting existing market
- Maintain marginal pricing for all technologies.
- No fundamental market design, but aim to:
  - strengthen **long-term markets**
  - strengthen **flexibility**
  - enhance **consumer protection.**



1) Monthly average of daily day-ahead prices.

Sources: Aurora Energy Research, European Commission

Timeline EU legislative process

- 23-Jan 2023: Consultation on EU electricity market design
- 14 March 2023: Official Commission proposal
- TBD (Q2 2023?): European Council and Parliament form their market reform positions
- TBD (aim Swedish Council presidency Q2 2023): EU Trilogue negotiations start.
- TBD (typically up to two years): Member States translate the new rules into national legislation.

Subscribe to our Dutch Power and Renewables Markets Service and keep up to date with all developments in the Dutch energy market. Contact **Alan Jabbour, Commercial Associate** to learn more.

✉ **alan.jabbour@auroraer.com**

The European Commission proposal focuses on three key areas, but remains unspecific on capacity adequacy and local price signals

AURORA

Topic	European Commission Proposal	How drastic is the change?
Promoting long-term markets	1 **For producers** ▪ Two-way CfDs encouraged 2 **For producers/consumers** ▪ Strengthening PPAs ▪ Strengthening long-term hedging	
Promoting flexibility	1 **Improve wholesale markets** ▪ Intraday gate closure time closer to delivery ▪ Lowering minimum bid size 2 **Flexibility support** ▪ Better incorporation of flexibility in capacity markets 3 **Peak shaving** ▪ New peak shaving product	
Consumer protection	1 **Peer-to-peer trading** ▪ Consumer right to share electricity 2 **Security of long-term supply** ▪ Consumer right for multiple tariffs ▪ Obligation of supplier of last resort	
Capacity adequacy	x **Capacity Markets - Not covered** ▪ **Why?** Ensure sufficient reliable capacity by providing payments to encourage investment ▪ No centralised approach regarding capacity market	
Local price signals	x **Locational pricing - Not covered** ▪ **Why?** Splitting market into zones incentivises more efficient location of storage and renewables ▪ No legislation on location pricing at present	

Current European level regulation European Commission proposal

Sources: Aurora Energy Research, European Commission

Agenda

AURORA

I. Introduction

II. Aurora's outlook on the Dutch power market

III. Potential impact of Dutch nuclear ambitions

IV. Policy outlook: EU market reform proposal

V. Key takeaways

Key takeaways

- Although gas and power prices have come down from their peak, the energy crisis of 2022 will have a continuing influence on the Dutch energy market
  - Short-term: emergency measures focusing on consumer alleviation and guaranteeing gas-supply for the coming winter
  - Long-term: national and European policies focusing on energy independence and decarbonisation

- In our Central scenario baseload prices are expected to decrease after 2023 driven by;
  - ⬇ A fall in gas prices, due to expanding liquefied natural gas supply and demand-side measures
  - ⬆ A continuous rise of carbon prices, following the latest EU ETS agreement
  - ⬇ A growth of renewable build-out towards 2030, which could be limited by several constraints on the longer term
  - ⬆ An increase of net power demand in 2030, due to sped-up demand electrification

- If realised, the government's plan to build two additional nuclear plants in 2035 will have an important effect on the future energy market
  - The additional nuclear capacity leads to less renewable build out, due to its downward pressure on power prices
  - Yearly average baseload prices could fall between 2035 and 2050, even when accounted for lower renewable build out
  - Strong government support is required for the plants to be profitable

- The EU proposal for electricity market reform focuses on promoting long-term markets, flexibility, and consumer protection
  - This could imply a change in the Dutch renewable support scheme and boost power purchase agreements
  - This could imply the roll-out of a peak shaving product and capacity-based support schemes for DSR and storage

Dutch Power and Renewables Markets Service:

Dive into key market analysis and forecasts for the Dutch power and renewables markets

AURORA

Full Power and Renewables
Subscription Analytics Service

Forecast Reports & Data

Bi-annual forecast reports with quarterly data updates

- **Policy outlook** detailing policy developments and their impacts
- Forecast of **wholesale prices** to 2050 in four scenarios: Central, High, Low, and Net Zero
- **Capture prices** of key technologies (onshore, offshore, solar) in four scenarios
- **Capacity development**, generation mix, capacity buildout, exports in four scenarios
- **Quarterly updates** to reflect near term commodity price changes
- **Imbalance costs** for wind and Solar
- **NL Guarantee of Origin forecast** for wind and solar
- **Utilisation rates** of key thermal technologies along different efficiencies
- **EU-ETS carbon price** forecasts
- All forecast data easily downloadable in Excel format and available as **interactive dashboards** on our EOS platform

Strategic Insights

3 Strategic Insight Reports

Three in-depth thematic reports on topical issues

Policy Updates

Timely research notes on recent changes to policy and regulation, demonstrating the impacts and opportunities for market participants

3 Group Meetings

Three Group Meeting roundtable events **in Amsterdam** with key market participants such as developers, investors, financiers, utilities, grid operators, government

Analyst Support

Bi-annual workshops and support from our bank of analysts, including native speakers and on-the-ground experts

Interested in our offering? Please contact **Alan Jabbour, Commercial Associate**
✉ **alan.jabbour@auroraer.com**


AURORA
ENERGY RESEARCH

Details and disclaimer

Publication
Dutch Power and Renewables Group Meeting

Date
9th May 2023

Prepared by
Mael Denys
(mael.denys@auroraer.com)
Zeina Najjar
(zeina.najjar@auroraer.com)
Jesse Hettema
(jesse.hettema@auroraer.com)

Approved by
Hanns Koenig
(hanns.koenig@auroraer.com)