AURORA ENERGY RESEARCH

GOing granular?

The future of the European Guarantees of Origin market

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Introducing the Aurora speakers

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Source: Aurora Energy Research

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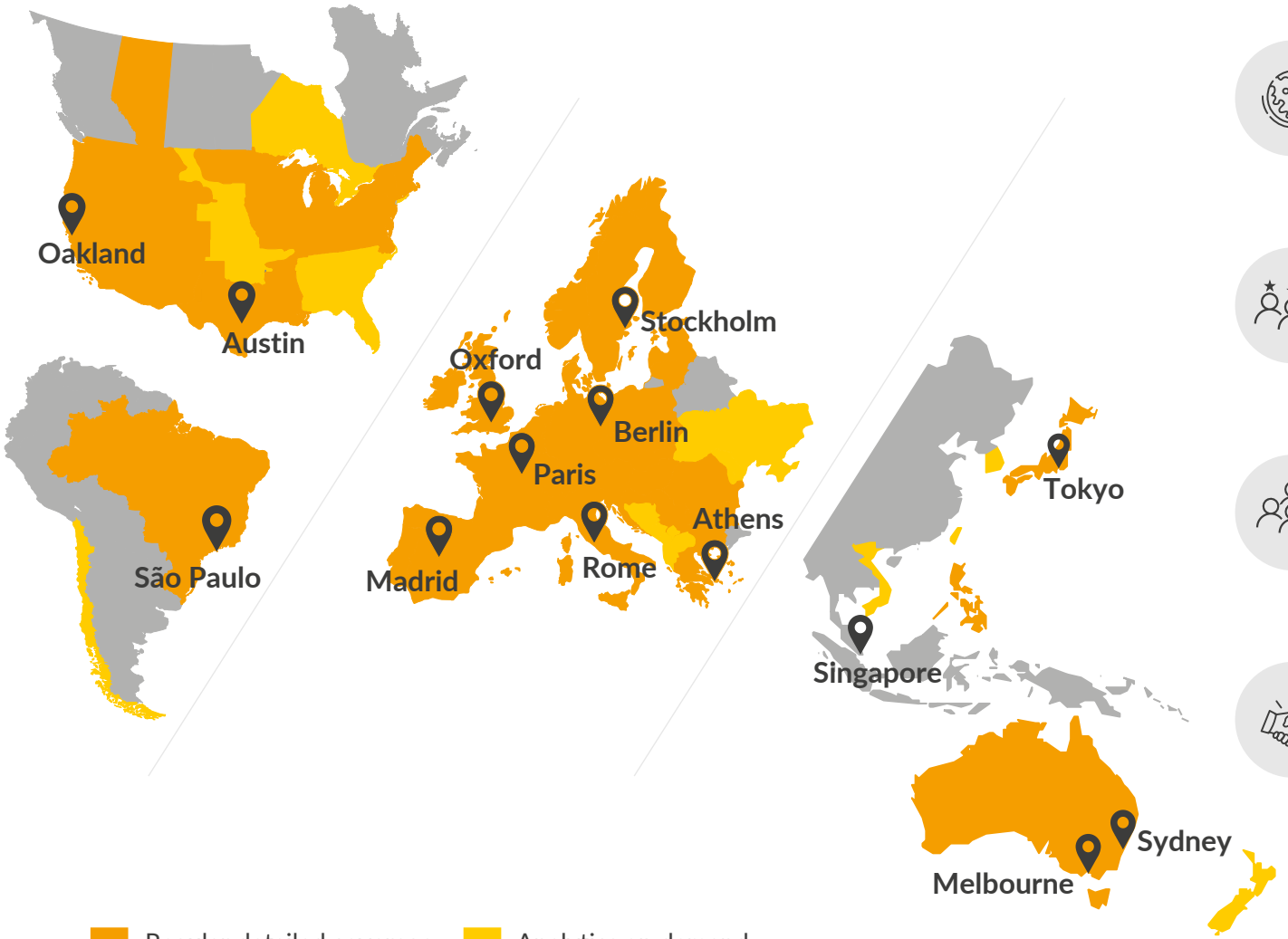

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Source: Aurora Energy Research

Agenda

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I. Market developments for European GOs

II. Implications of a granular GO system

Guarantees of Origin are the European Union's approach to Energy Attribution Certificates and have been in use for almost two decades

A Guarantee of Origin (GO) is an electronic certificate, issued by each Member States' respective regulatory body, proving the source of a discrete amount of energy. Each GO is defined by four key characteristics outlined below.

Volume of electricity
In the past, a GO typically referred to 1 MWh of electricity fed into the grid. However, as part of the RED III, European regulation will allow for the issuance of GOs of a size below 1 MWh.

Technology of the issuing asset
Each GO carries information on the producing asset's technology.

Geographical location
The location of the respective asset. While some member states provide information only on a country-basis, others provide more granular information (e.g. in Belgium)

Production period
Time period in which the corresponding electricity was fed to the grid. The granularity can vary; most instances now are either yearly or monthly.

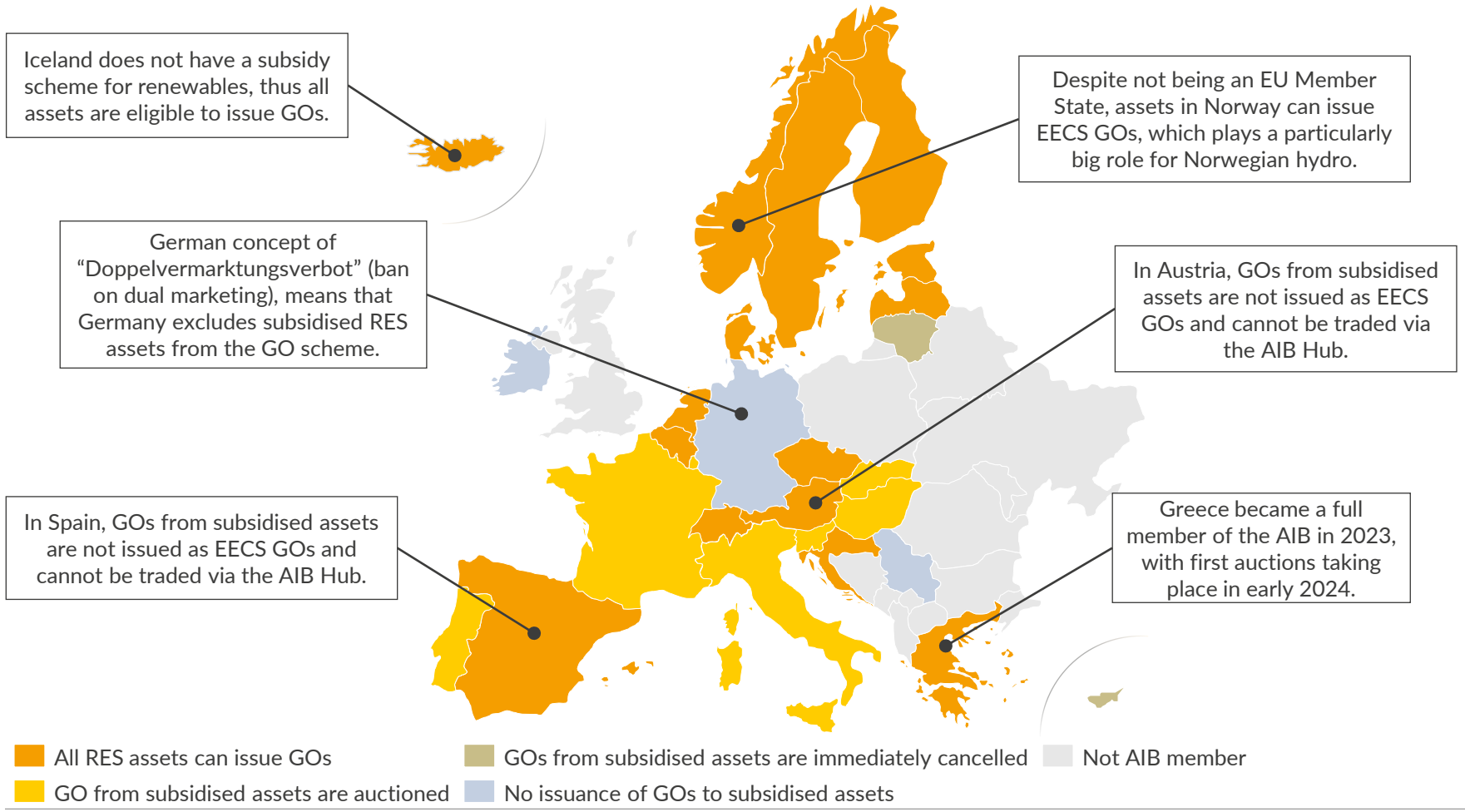
Possible additional characteristics of traded GOs

- In addition to the four key characteristics outlined, GOs can often provide further information on the generating asset and allow for the issuer to demand a price premium on the market. Example characteristics include:
  - Asset age: some consumers have preferences for new build assets
  - Certificate type: some environmental certificates are subject to additional criteria (such as EKOenergy, Green-e) which allow offtakers to showcase additional efforts made towards sustainability goals

Source: Aurora Energy Research

AIB Member States have varying national GO policies, in particular in relation to subsidised assets issuing GOs

AIB GO systems in place across member countries

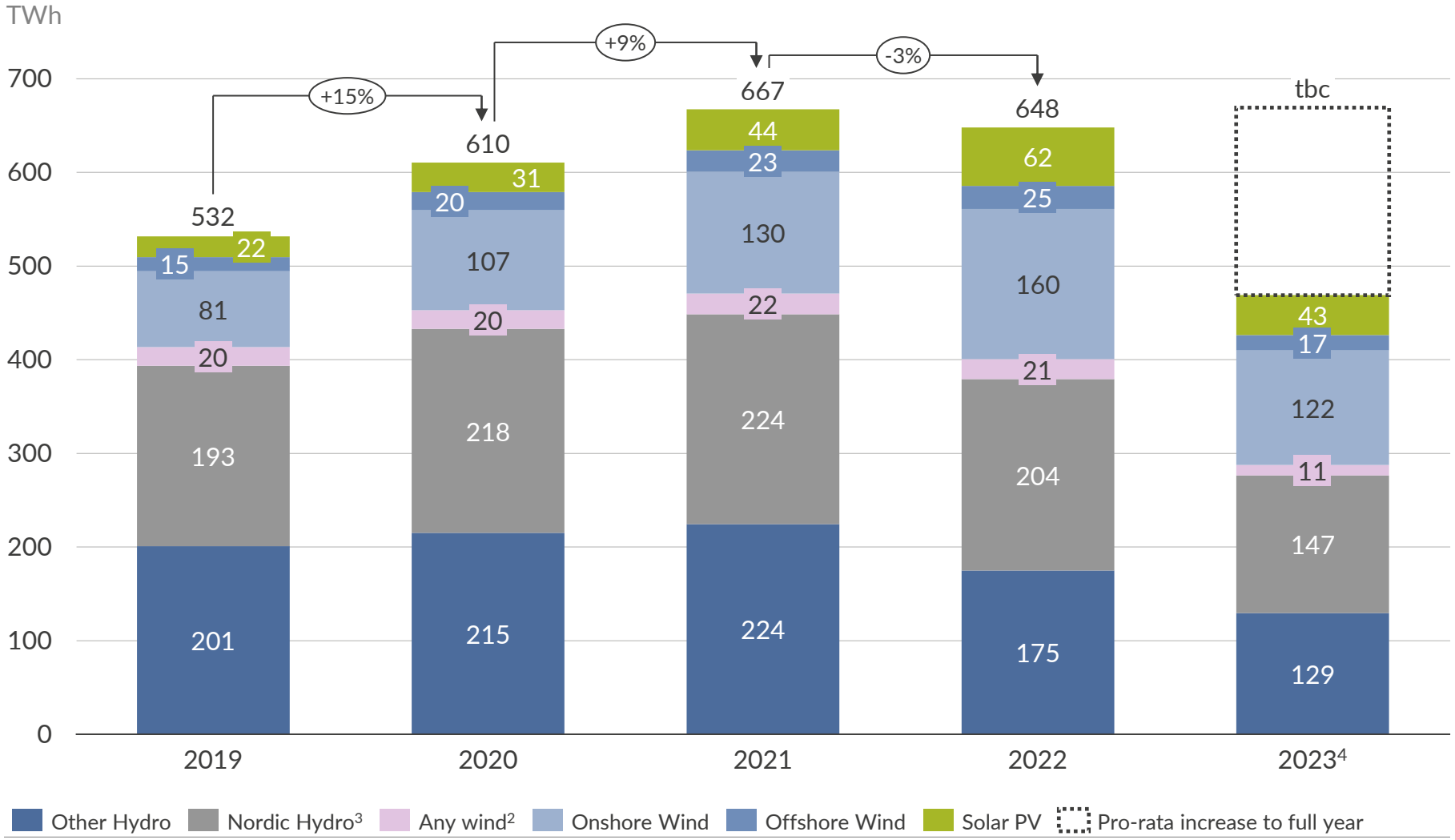


- Germany and Ireland stand out as two major European markets that prohibit subsidised renewables assets from issuing GOs
- In a first draft version, REDIII included a paragraph which would have required states to issue GOs for generation from all RES assets, including subsidised ones. This paragraph was removed as part of negotiations on EU level
- In countries such as France, revenues from auctions selling subsidised assets are kept by the state in order to further accelerate the national energy transition
- Some countries such as Spain prohibit the export of GOs from subsidised assets

Sources: Aurora Energy Research, AIB

Renewable GO issuance peaked at 667 TWh in 2021, with supply falling 3% y-o-y in 2022, due to a reduction in hydropower supply

Historical AIB renewable EECS GO supply[1]



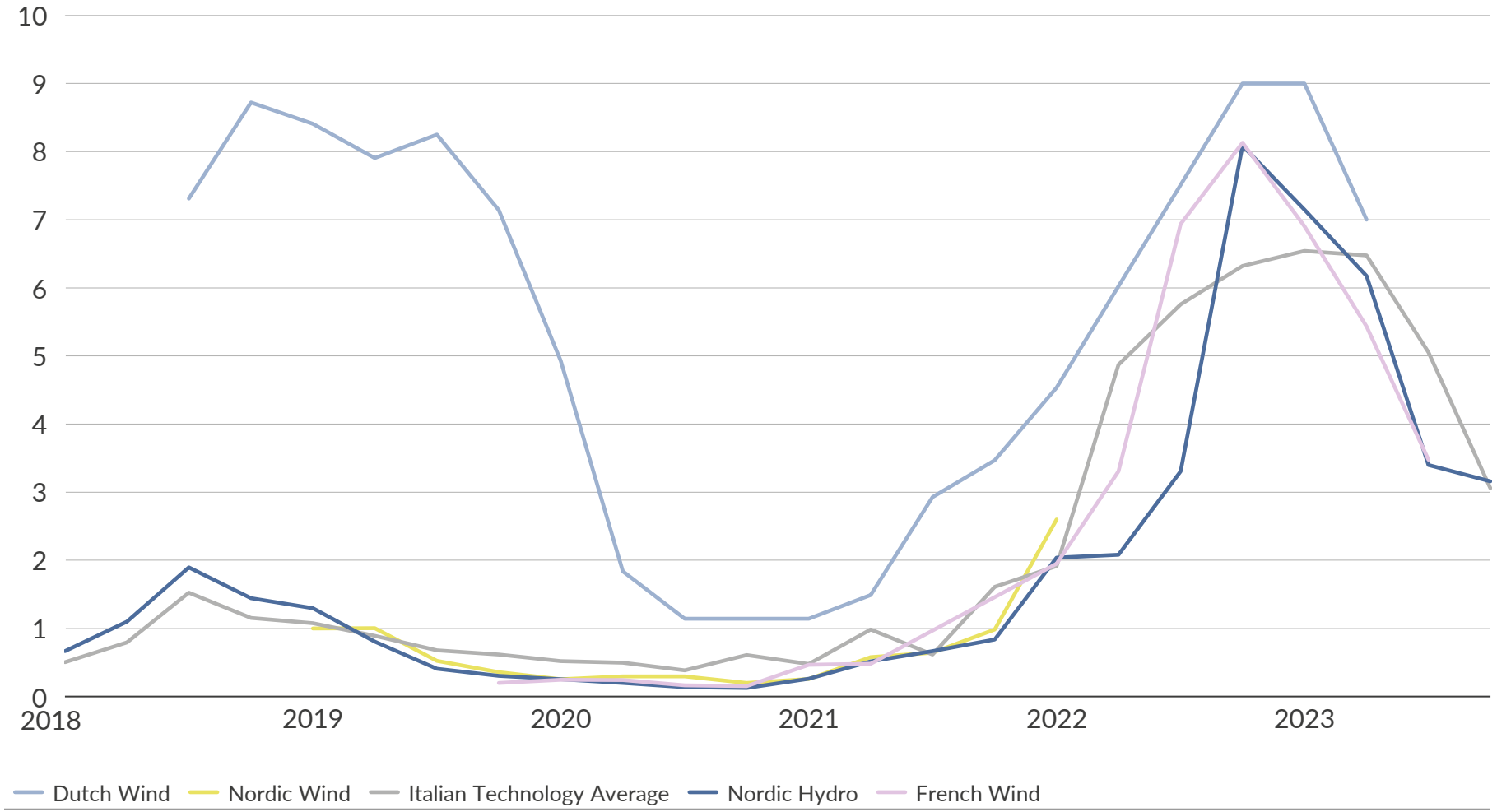
1) Based on AIB production data; 2) Uncategorised in the AIB's data set; 3) Nordic hydro includes Norway, Sweden, Denmark, Iceland and Finland; 4) 2023 data until September 2023.

Sources: Aurora Energy Research, AIB

- Total GO issuance across the AIB decreased by 3% from 2021 to 2022, driven by lower hydro output across Europe due to a hot and dry summer which reduced reservoir levels
- Across the same timeframe issuance from solar PV and wind assets increased significantly
- Nordic hydro has a large market share, generating over 30% of total renewable GO supply in 2022

Historically GO prices in most countries have closely followed the Nordic hydro benchmark, except for the Netherlands

Historical GO prices
€/MWh (nominal)



- The Nordic hydro GO price is currently the benchmark across Europe, as it supplies the major share of cancelled volumes across the AIB
- Dutch GOs have historically had the highest prices due to a high pressure on consumers to demand local GOs
- Weather conditions play a key role in driving Nordic hydro prices. In 2022 prices rose dramatically as dry weather suppressed hydro output and the willingness-to-pay for GOs was significantly higher than initially anticipated
- GO prices have dropped from their 2022 peak, with 2024 Nordic hydro GO being traded at below 3 €/MWh

Sources: Aurora Energy Research, CE Delft, Gestore Mercati Energetici, Autoriteit Consument en Markt,

Structural policy and fundamental market changes are likely to have a large impact on future GO supply, demand and prices

Developments	Description	Probability
Increased European hydrogen production	▪ Under the RED II Delegated Act hydrogen will be classified as green if temporal, additionality and geographic criteria are met ▪ This calls for more granular certificates, to allow for monthly and hourly matching	
Uptake of PPAs	▪ PPAs are expected to become an ever more important tool for decarbonisation across Europe, which will affect both the supply and demand for GOs ▪ We assume for GOs as part of PPAs to be included in both supply and demand forecasts, hence no impact on prices	
Increasing decarbonization of electricity grids	▪ National demand for annual GOs will reduce once the grid almost fully decarbonised, as seen in countries like Norway, although full disclosure requirement in EU's Electricity Directive could counteract this	
Sub-annual GOs	▪ RED III announcements and an increasing pressure on energy consumers to certify their consumption on a more granular level will reduce demand for annual GOs and increase demand for more granular alternatives	
Ambitious reporting standards	▪ Increased ambition by buyers to purchase GOs from assets less than 15 years old (e.g. via recent RE100 guidance) could lead to a greater level of demand for green certificates from new renewables assets	
Increasing market transparency	▪ Various European energy exchanges have recently started to offer GO auctions, increasing market transparency, potentially lowering the barriers to entry for smaller players	
Increasing electricity demand	▪ Electricity demand is expected to increase significantly in Aurora's High scenario, which would drive up GO prices	
Increasing renewables	▪ Increasing renewables build out in Aurora's Low scenario would drive down GO prices	

Source: Aurora Energy Research

Aurora's GO model clears the market, considering trade constraints and national regulation on cross-border flows

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Inputs

- Total GO demand per region and type[1]
- GO supply per technology and region
- WTP[2] curves
- Trade constraints
- Country-specific regulation

GO model solve

Demand side

- Deriving subcategories of demand for specific GOs (young, local)
- Aggregation of individual consumer preferences to total market demand across the entire AIB

Solving as a mixed integer problem based on the WTP curves

Supply side

- Determining total supply available across markets, subject to trade constraints and national regulation

Outputs

- GO prices
- Cancelled Volumes
- Traded volumes
- Cashflows between regions

Comments

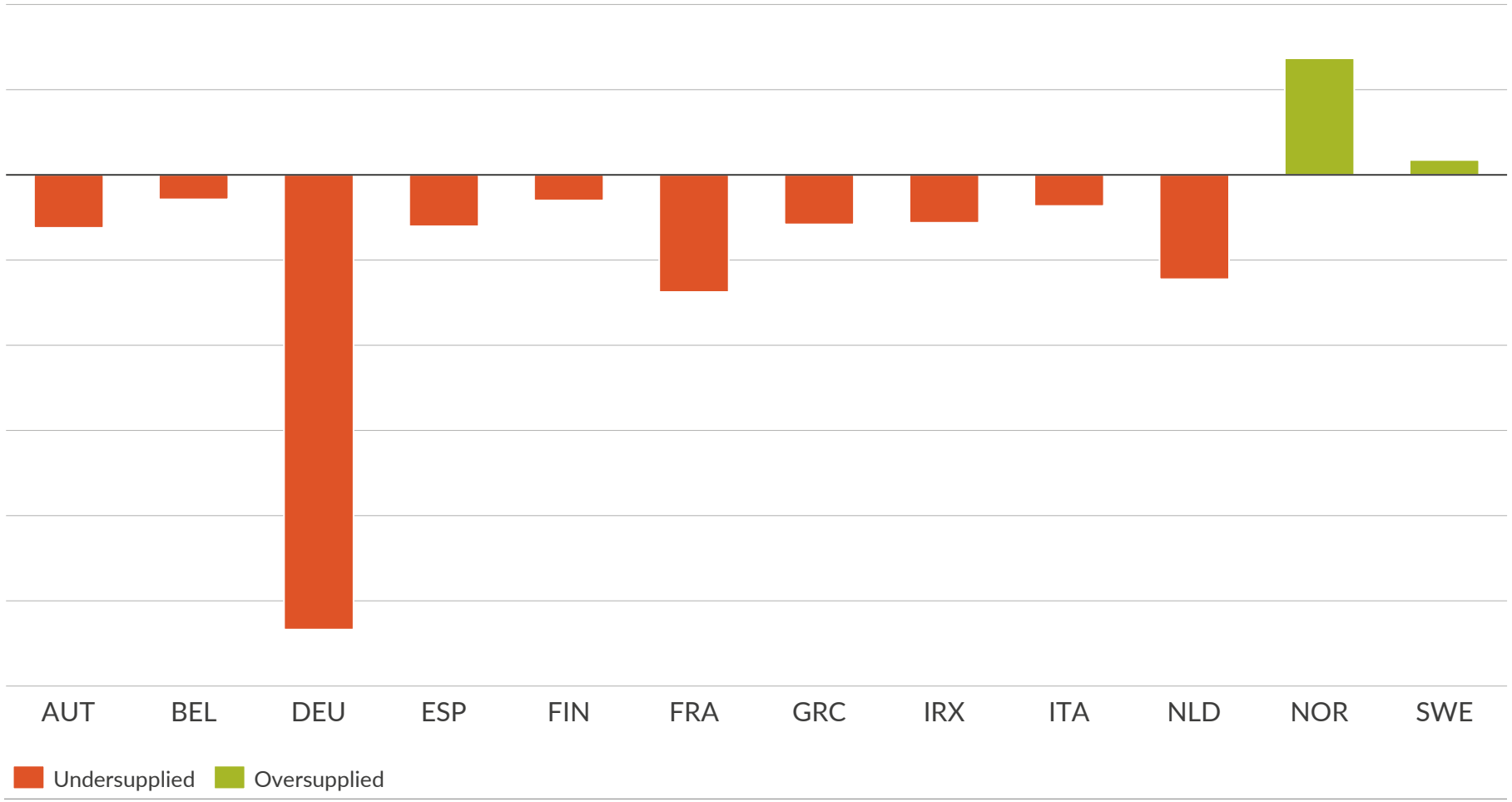
- All major AIB countries are modelled, with non-focus countries modelled as one larger aggregated region[3]
- Markets for which we do not publish price forecasts, but which are part of the AIB get treated as a single additional region to account for potential impacts of these on the supply and demand imbalance
- The model solves each year as a discrete interval, assuming certificates cannot be taken over between periods
- Trade constraints, such as issuance of non-EECS certificates which cannot be exported (e.g. in Spain), are accounted for

1) Referring to GOs from an asset of a specific age, technology or location; 2) Willingness-to-pay; 3) With the exception of Luxembourg, Slovakia, Iceland, Cyprus and Czech Republic. Cancellations from these regions make up less than 5% of total AIB GO demand.

Source: Aurora Energy Research

Germany faces the largest supply demand imbalance in 2030, whilst Norway continues to have excess supply

GO EECS supply demand imbalance in 2030
TWh, Aurora Central



- Germany has the largest GO supply/demand imbalance in 2030 as demand for GOs grows rapidly, whilst it is assumed that subsidised assets will not be allowed to issue GOs
- Ireland is expected to see an undersupply as subsidised assets are not allowed to receive GOs either
- In 2030, Norway will continue to run a GO surplus, with hydro issuances exceeding domestic demand
- The French system is shown as undersupplied as well, as we do not account for GOs from nuclear assets in our modelling

Source: Aurora Energy Research

Agenda

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I. Market developments for European GOs

II. Implications of a granular GO system

Granular GOs capture the temporal and spatial realities of electricity flows, allowing firms to make more credible green electricity claims

1 Granular GOs aim to improve the accuracy of carbon accounting schemes

Background

- The greenhouse gas (GHG) protocol defines the most widely used carbon accounting rules, including Scope 2 emissions which covers electricity procurement. These regulations are used by 90% of Fortune 500 companies to estimate carbon emissions.
- Under the current regulations, annual GOs are used to prove renewable electricity consumption allowing firms to make renewable electricity claims

Problem

- The current regulations fail to capture the temporal and locational nature of electricity as a commodity
- This means firms can use GOs to claim their consumption is renewable when:
  - Consumption is in winter, and electricity is generated in summer
  - Consumption is in Portugal, and electricity is generated in Norway

Solution

- Granular GOs better reflect the physical flows of electricity, such that:
  - Consumption must occur in the same period as generation (down to hourly or 15-minute granularity)
  - Consumption must occur in the same location as production, or power could have been transferred via an interconnector

2 Key arguments in favour of granular GOs

- ✓ Better reflection of physical power flows and therefore more robust renewable electricity claims and transparency
- ✓ Faster reduction in emissions and more rapid transition to Net Zero
- ✓ Greater incentives for storage and demand side flexibility
- ✓ Potential price hedging benefits for consumers

3 Key arguments against granular GOs

- ✗ Potentially greater costs if pursuing 100% hourly matched electricity
- ✗ Higher complexity and therefore greater barriers for firms to make green electricity claims
- ✗ More complex operational and accounting requirements

Source: Aurora Energy Research

Key design elements are still under discussion, with the exact implementation having a major impact on how the market will function

Developments	Description
Carryover	▪ Carryover refers to the concept of transferring certificates from one period to another. ▪ If a carryover period of 1h were to be allowed, this would allow consumers to cancel a granular GO issued in the period from 1-2 pm of a specific day in the period from 2-3 pm of the same day.
Exclusivity	▪ How exclusive will GOs of specific granularities be? ▪ Would it, for example, be possible to use a GO which was timestamped at a particular hour of the year to cancel an annual obligation? ▪ An alternative would be to allow the conversion of i.e. an hourly to an annual GO.
Trading across schemes	▪ How would trading across regions work if markets were to implement GOs at different granularities? ▪ This could become an issue if some markets within the AIB move to hourly granularity earlier than others or if some countries were to choose to go even further and to implement GOs in i.e. 15 min granularity
Levels of granularity	▪ EU documents call for “ISP granularity”, but would a potential shift to monthly or daily GOs already satisfy a lot of the requirements voiced about granular GOs?
Storage	▪ While this would require a rather detailed tracking mechanism, allowing storage to transfer GOs could pose a significant contribution to enabling consumers to get closer to a 100% 24/7 green matching of their demand profile
Regulatory timeline	▪ Ongoing discussions focus mainly on potential market design elements and feasibility studies but without clear indication on by which point in time a functioning marketplace and regulation would be set up across the entire AIB ▪ Regulation for electrolysers calls for highly granular matching by 2030, which would require a functioning marketplace by this date

Source: Aurora Energy Research

Modelling granular GOs in Spain shows higher granular GO prices and a shift in captured GO prices

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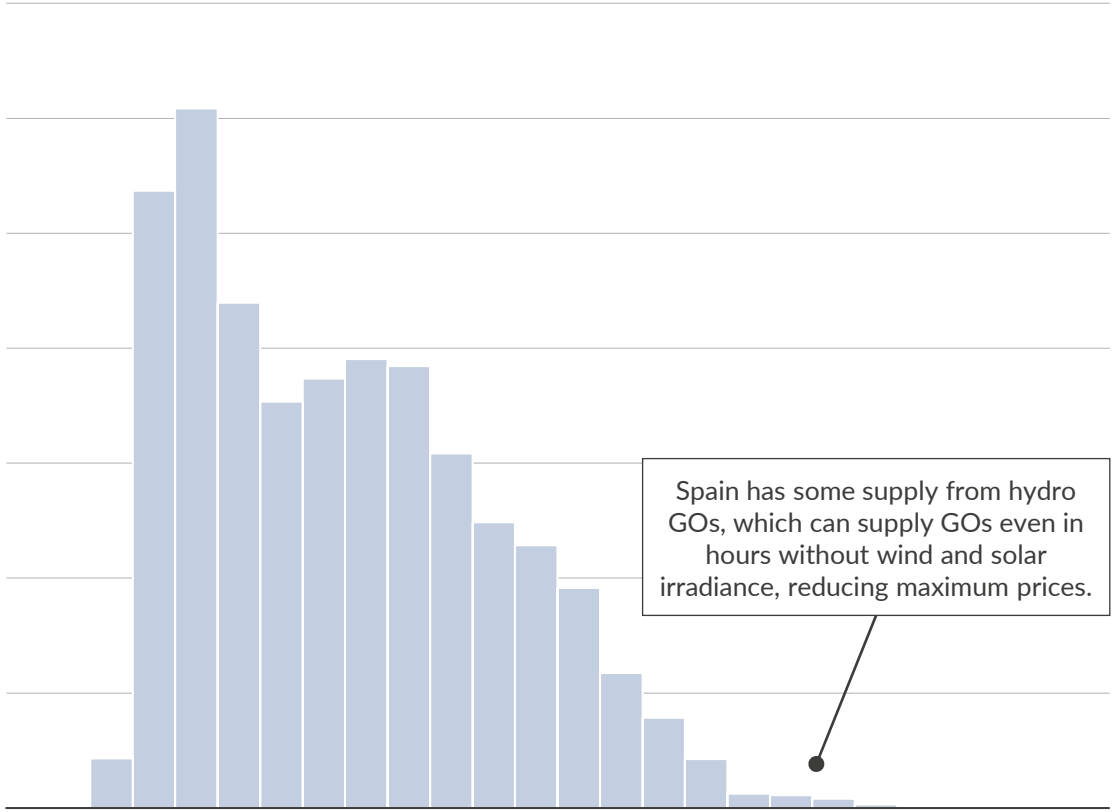
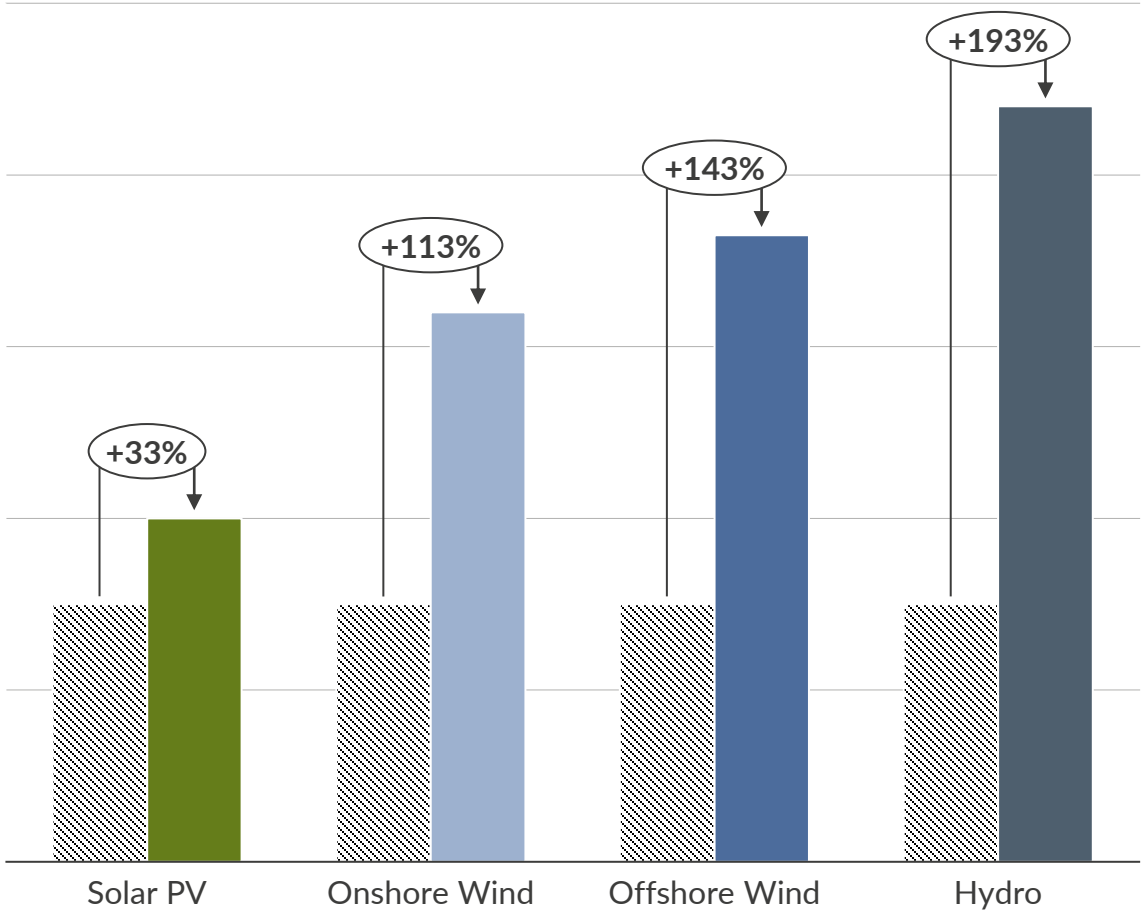
Hourly GO price distribution in Spain in 2030[1]
Count



Hourly GO prices per technology in 2030
€/MWh (real 2022)



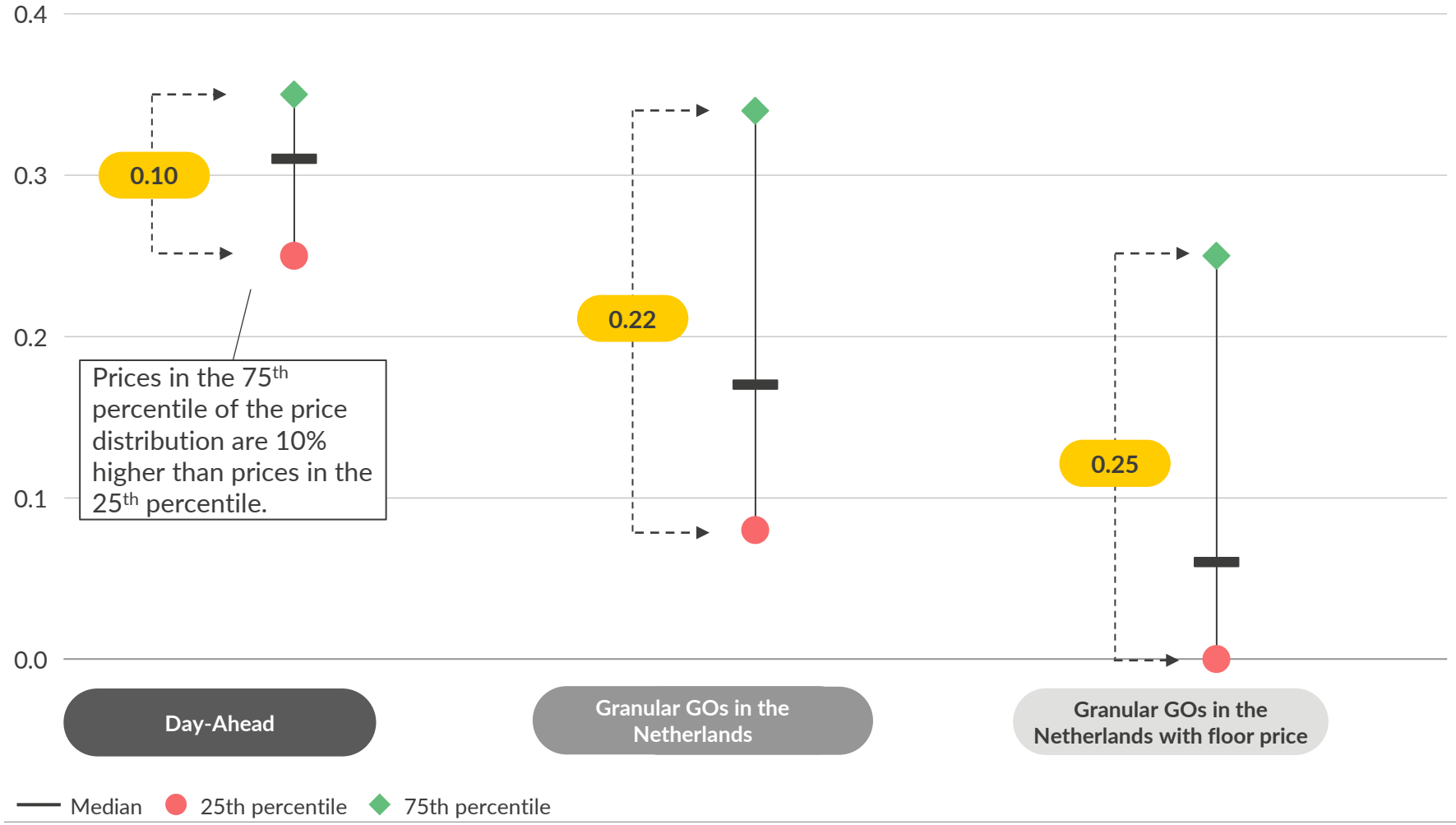
Spain

1) Assuming 100% of electricity demand would ask for GOs; 2) The respective price bucket includes all prices up to the number of the previous bucket (i.e. the price bucket for 2 would include all prices above 1 but below, and including, 2 €/MWh).

Source: Aurora Energy Research

When comparing the GO price to the price on the Day Ahead market, we see a significantly higher volatility for hourly GOs

Normalised day ahead power and GO prices
Index 0-1



- Normalising both the Day-Ahead price as well as the granular GO price to the same scale reveals that the GO price is more volatile over the course of 2030
- In the current example of the Netherlands, the price of granular GOs is expected to be up to 2.5 times as volatile as the day-ahead price in 2030
- The increased volatility is to some degree driven by the fact that we assume that all GO demand must be met locally, which doesn't allow for neighbouring cross-border trades like on the Day-Ahead

Source: Aurora Energy Research

Aurora's new GO report includes country-specific GO prices in four scenarios, quantifying the range of uncertainty in this volatile market

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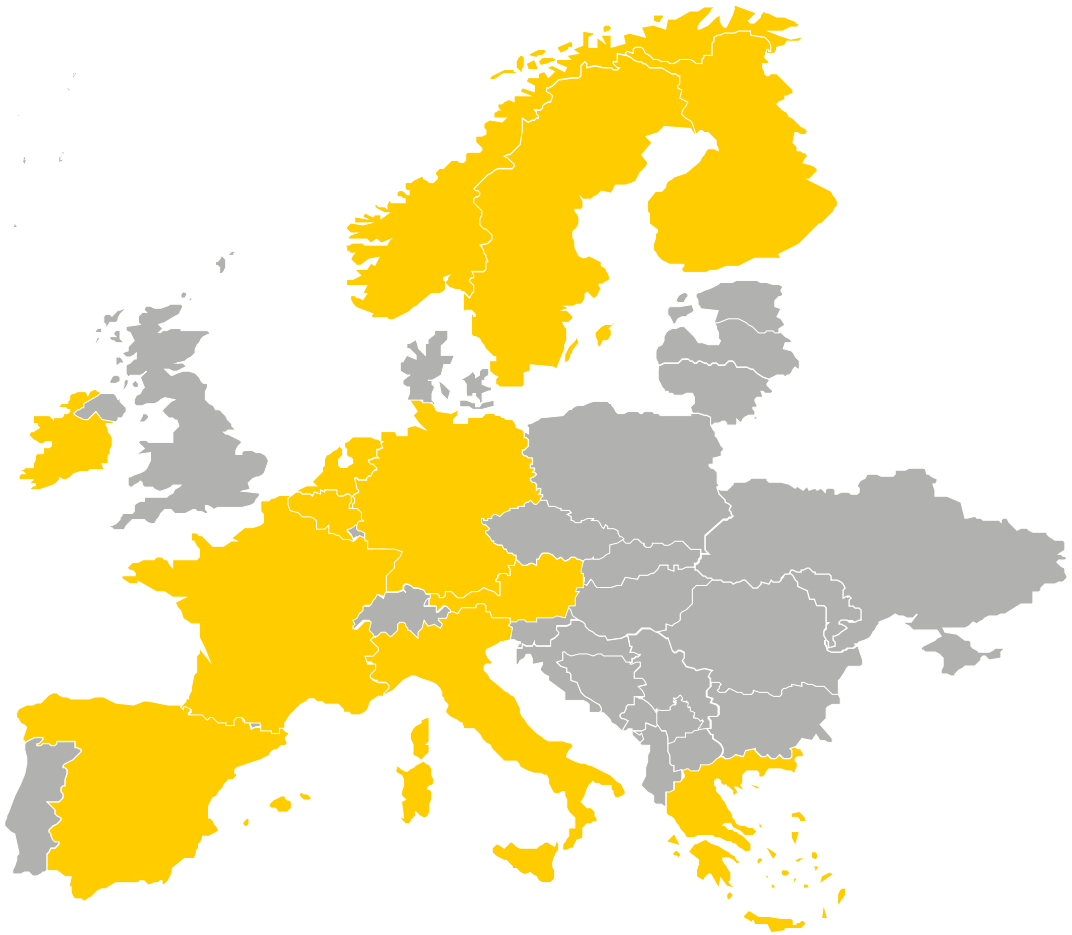
Markets with country-specific price forecasts in Aurora's GO report



Country-specific price forecasts in the report

Included in Aurora's new GO report

Your one-stop-shop to understanding the future of the GO market

- Overview of current regulatory landscape of GOs across Europe
- Details on Aurora's modelling approach
- Country-specific forecast of GO supply and demand for 12 markets[1,2] in four scenarios based on Aurora's in-house fundamental power market model
- Country-specific price forecast for annual GOs for 12 markets in 4 scenarios until 2060
- Outline of uncertainties affecting the GO market going forward
- Case study looking into the impacts of an hourly GO system and volatility in pricing

Accompanying data book

- Annual forecasts of GO demand and supply for each of the 12 markets in 4 scenarios
- Corresponding price developments per country and across the AIB

1) Markets included are Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands, Norway and Sweden; 2) AIB Member States not highlighted are considered in our modelling, but Aurora does not provide country-specific price forecasts.

Source: Aurora Energy Research

Q&A

- Please feel free to stay for a Q&A session
- Ask any questions you might have about the GO market or Aurora's analysis on the future of the market
- If you don't have time, or for any questions you might think of later, please contact Alex Hutcheson below

For more information

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Get a competitive edge on the GO market with our top-of-the-line analysis.

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