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European Renewable Key Drivers & Risks

November 2025

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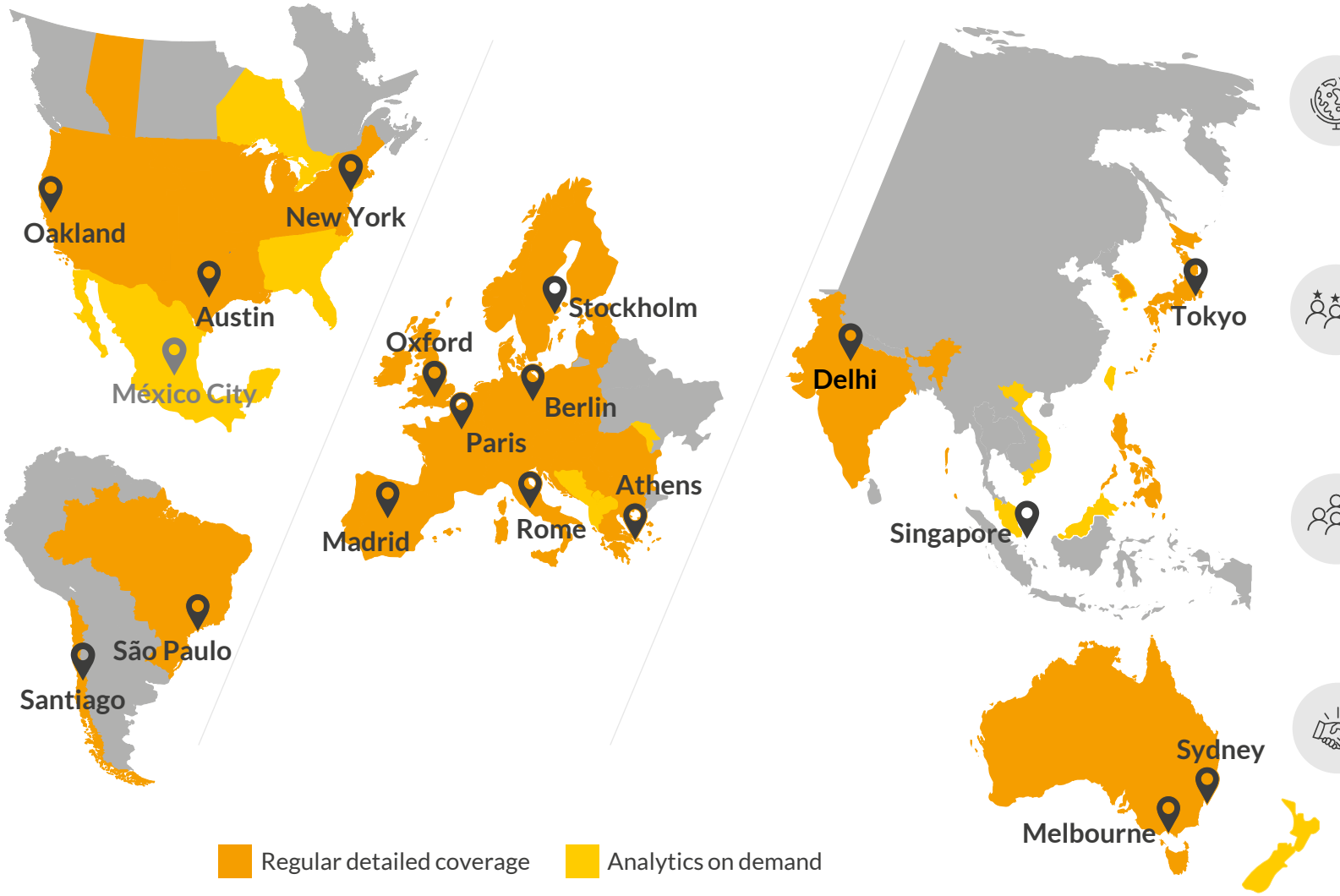

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Source: Aurora Energy Research

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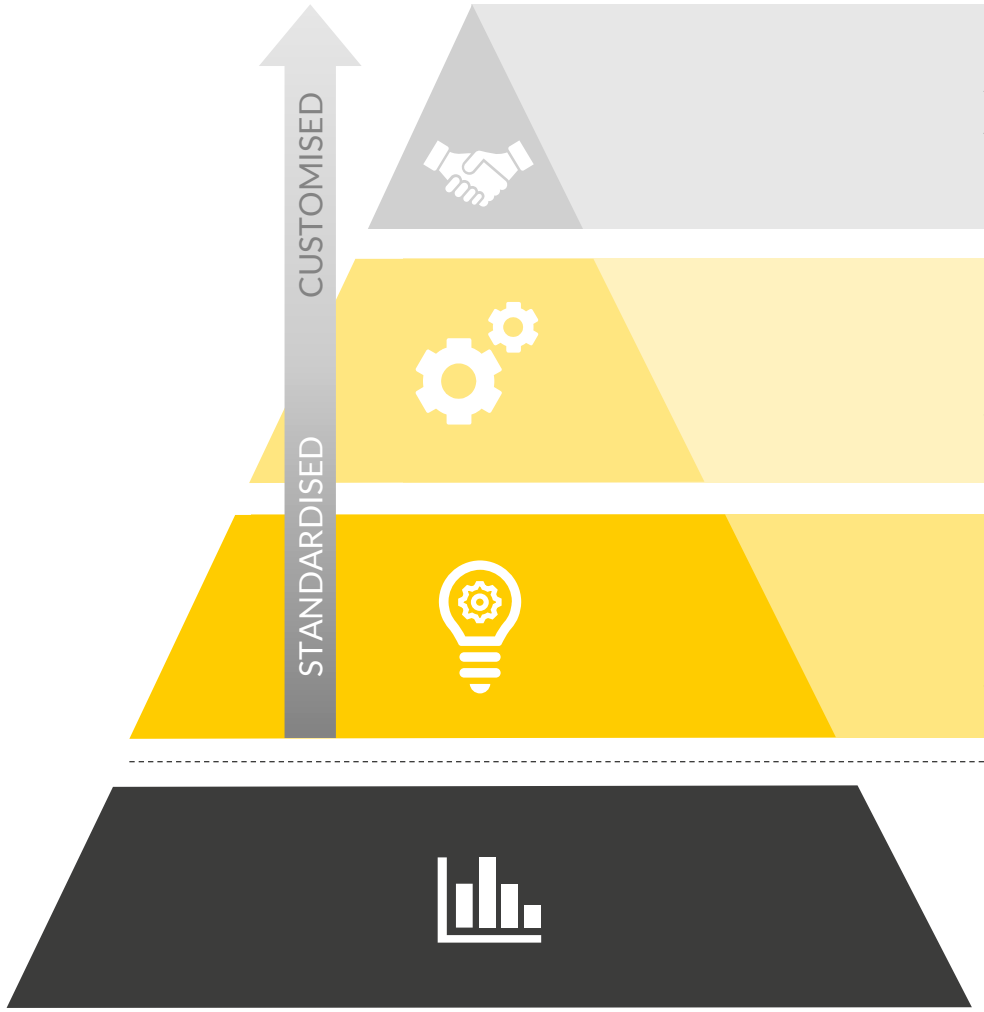

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Developed over 12 years, 90+ dedicated modellers

Source: Aurora Energy Research

Introduction

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Challenges & Risks

- How will emerging challenges, such as curtailment and negative prices, impact renewable projects?

Key Opportunities

- What are the available opportunities for renewables, and how can co-location with BESS de-risk projects?

Source: Aurora Energy Research

Renewable projects are exposed to a variety of market, development and policy risks

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X Deep-dives

Market

Negative prices

- Increased (subsidised) RES generation and times of low demand cause negative price hours.
- Most regions do not fully shield against these hours.

A

Market saturation

- Strong RES buildout over Europe leads to higher correlated generation volumes.
- This can lead to reduced capture rates and longer grid queues.

Sources: Aurora Energy Research

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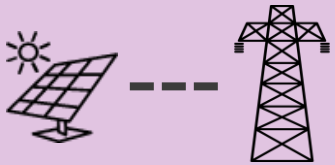
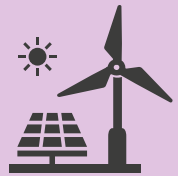
Development

Grid connections



- Long grid queues, sometimes spanning 10+ years, make it difficult to get connected to get projects online.

Supply chains



- Supply chain constraints can increase costs and cause delays in development.
- Permitting can take significantly longer than expected or be refused.

Sources: Aurora Energy Research

Renewable projects are exposed to a variety of market, development and policy risks

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X Deep-dives

Market

Negative prices (A)

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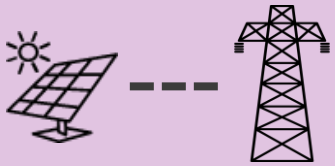

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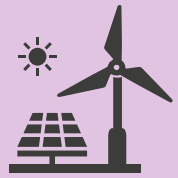
Supply chains



- Supply chain constraints can increase costs and cause delays in development.
- Permitting can take significantly longer than expected or be refused.

Policy

Grid congestion (B)

- The increasing renewables penetration raises curtailment risks.
- These can occur due to market prices or grid congestion.

Regulation

- Examples include:
  - Market access / reforms
  - Zonal markets
  - Regulatory technology requirements.

Sources: Aurora Energy Research

The magnitude and frequency of negative prices has been increasing across Europe, with highest frequency in central European regions

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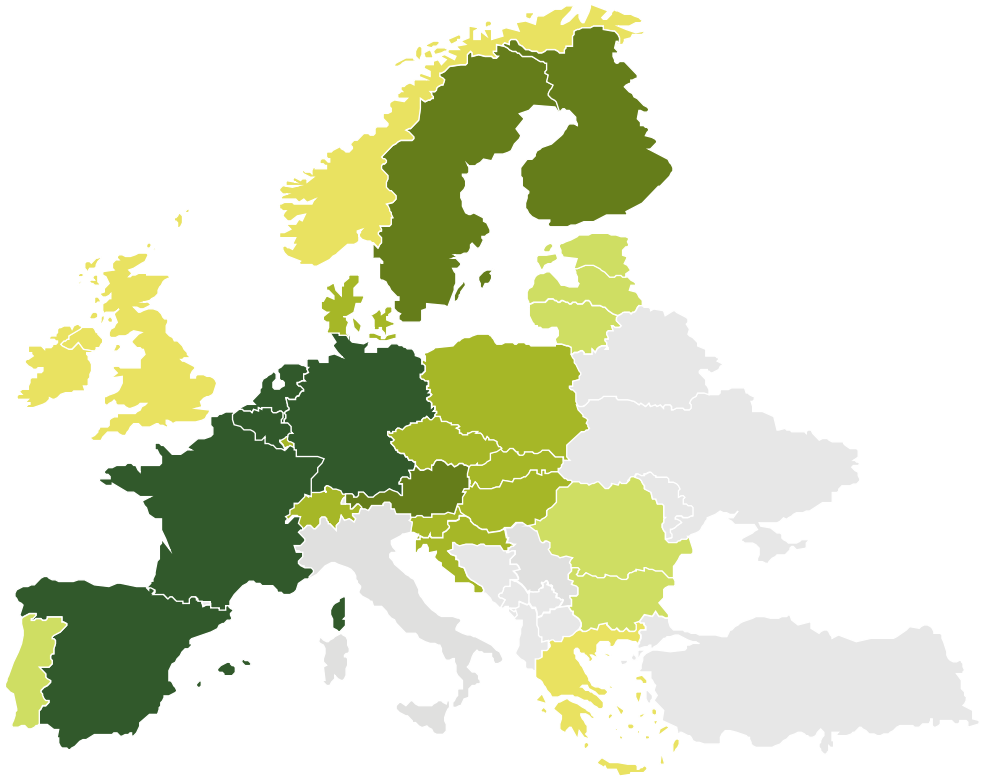
A Negative prices

Number of negative price hours on the Day Ahead market[1,2]

Number of negative price hours



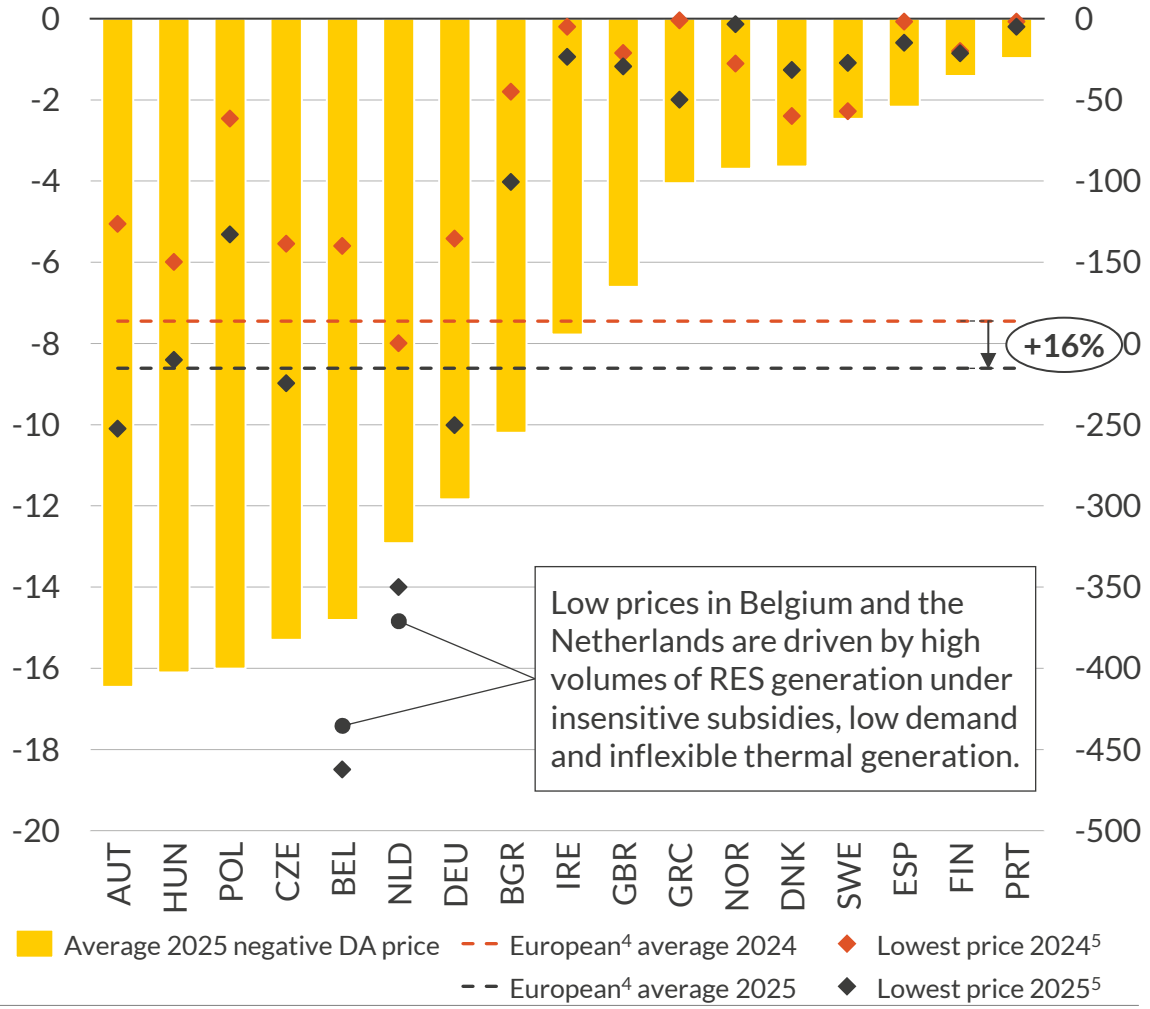
0-125 126-250 251-375 376-450 >450

Average DA[3] price during negative price hours[1,2]

€/MWh (nominal)

Lowest negative price[1,2]

€/MWh (nominal)



1) According to data extracted from ENTSO-E on the 01/10/2025; 2) Italy's current regulation prevents power prices from falling below zero; 3) Day Ahead market; 4) Regions include Hungary, Austria, Czechia, Belgium, Poland, Netherlands, Germany, Bulgaria, Greece, I-SEM, Great Britain, Norway, Denmark, Sweden, Spain, Finland and Portugal; 5) An average of lowest prices for each zones is used for countries with multiple price zones.

Source: Aurora Energy Research, ENTSO-E

In addition, the magnitude of negative prices has increased, with lowest prices seen in Belgium and Netherlands

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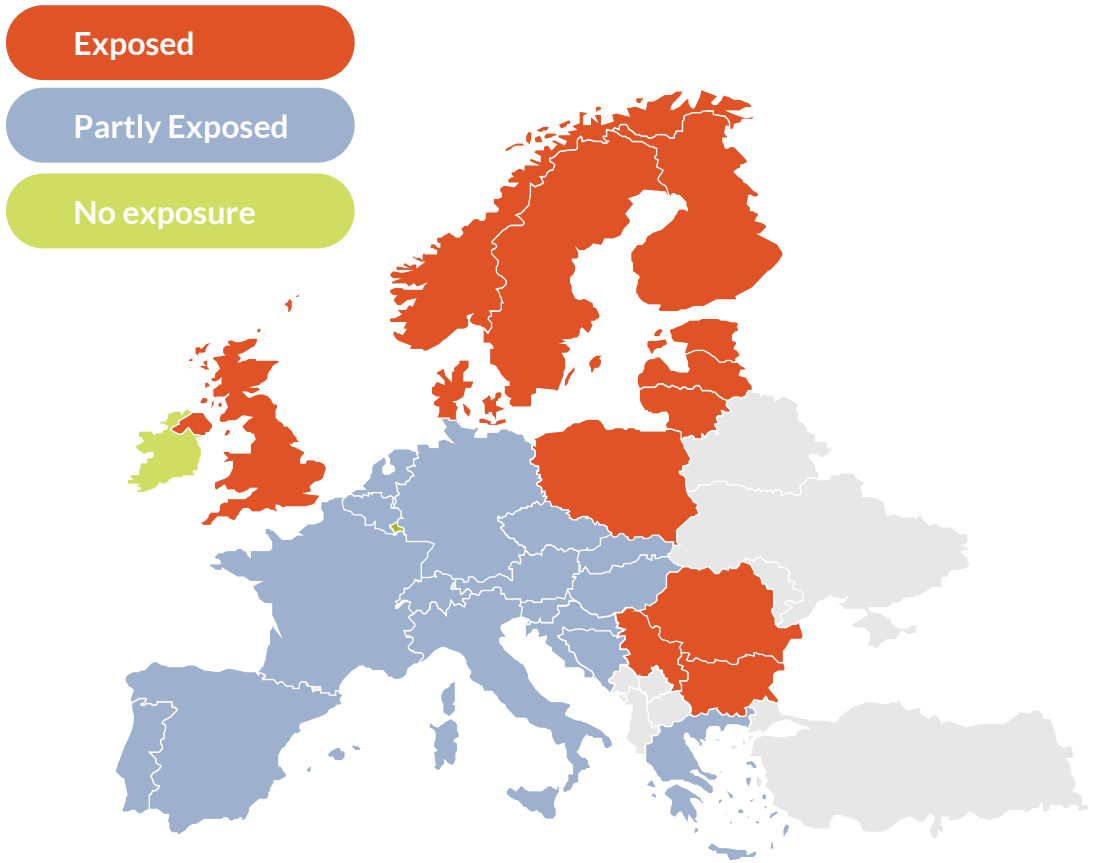
Number of negative price hours on the Day Ahead market[1,2]

Number of negative price hours



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€/MWh (nominal)

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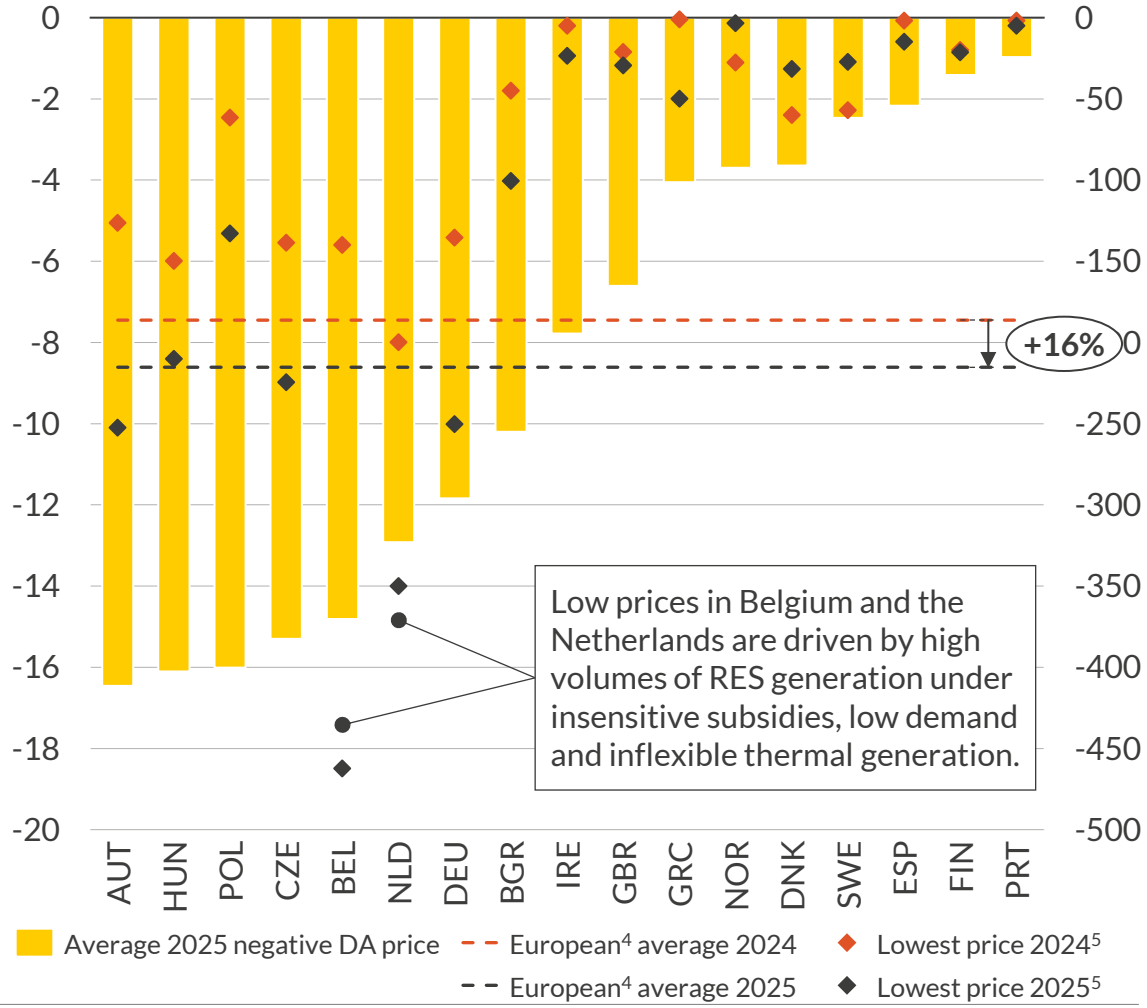

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Source: Aurora Energy Research, ENTSO-E

The increasing renewables penetration raises curtailment risks, which can occur due to market prices or grid congestion

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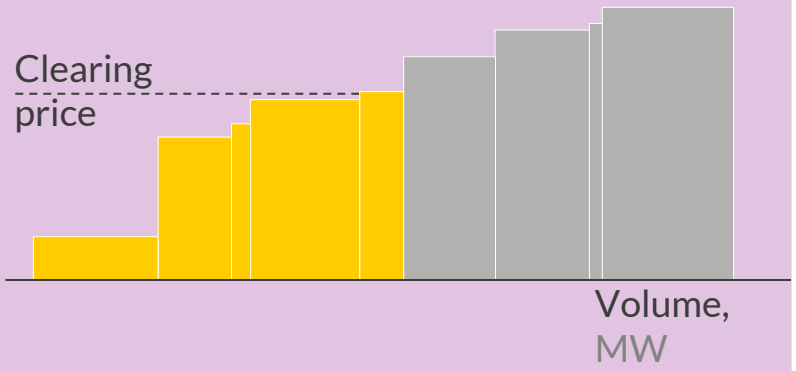
B Grid congestion

Economic

This occurs when the cost of generating electricity exceeds the market price.

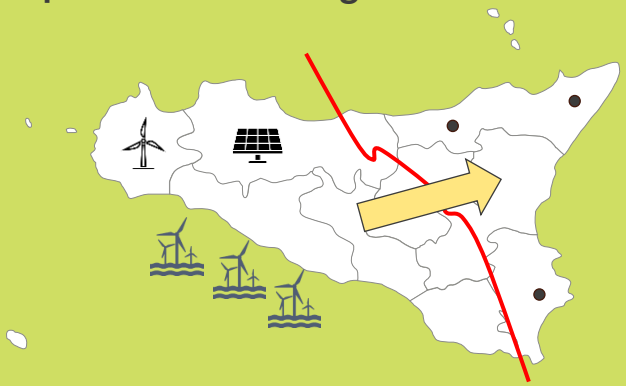
Bid price
€/MWh (illustrative)



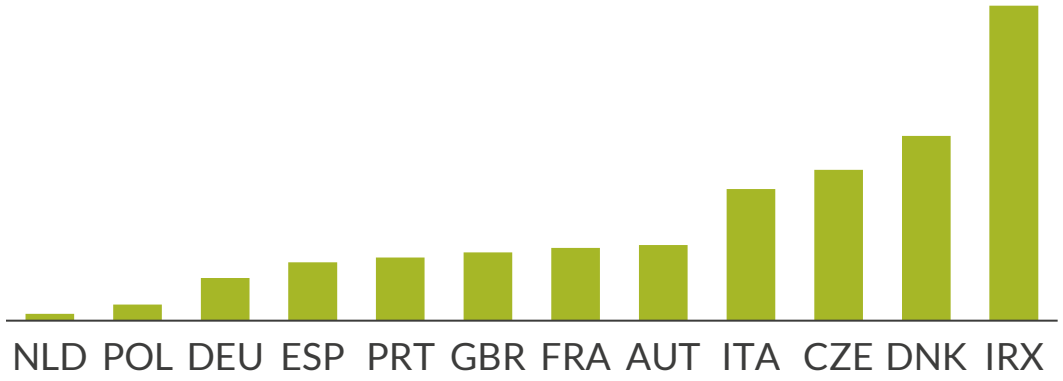
Technical

This occurs when network operators curtail RES to ensure the safe operation of the power system,

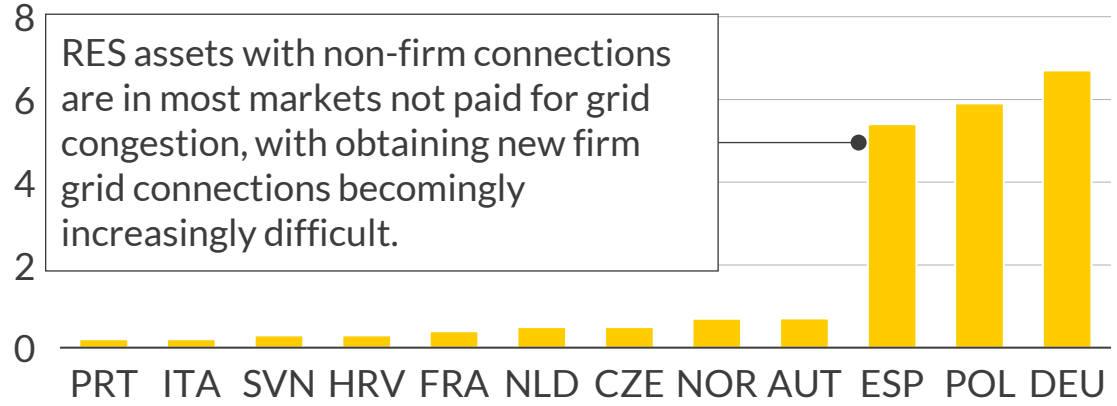
Illustrative limitations of electricity transported across the grid to demand



Solar PV economic curtailment[1] by region - 2030
%



Volume of remedial actions as a percentage of demand – 2023
%



1) Based on Aurora's Oct-24 Central scenarios in model curtailment.

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- How will emerging challenges, such as curtailment and negative prices, impact renewable projects?

Key Opportunities

- What are the available opportunities for renewables, and how can co-location with BESS de-risk projects?

Source: Aurora Energy Research

Co-location and siting decisions help manage the risks of uncompensated curtailment, but the key mitigations are grid expansion and market reforms

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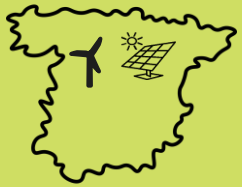
X Deep-dives

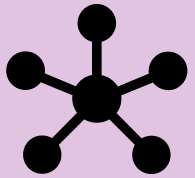
Portfolio diversification

A



- Adding assets with different generation profiles.
- Driven by assets' location, technological setup or combining different technologies.

Market Access



- Intermittent RES assets can access more markets than the Day Ahead and the Intraday market
- This offers the ability to diversify revenue streams.

Co-location

B

- Co-location enables renewables to shift their generation to less constrained times
- The battery may be able to participate in other ancillary markets

Exchange Hedging

- Using financial instruments, such as futures and options.
- This allows shielding against potential price volatility on electricity markets.

Sources: Aurora Energy Research

Diversification strategies via market revenues, route to market and technology can further support business cases

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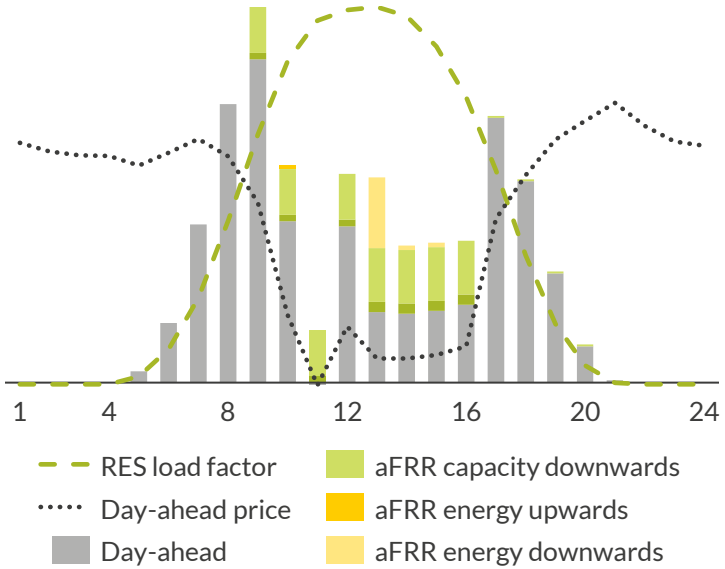
A Diversification

Balancing and ancillary markets

- Potential revenue upsides for solar PV and offshore wind from optimised participation across wholesale as well as balancing and ancillary markets.

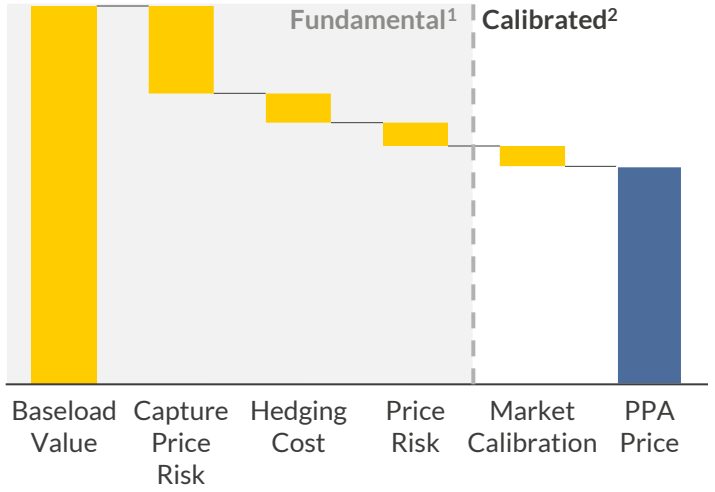
Illustrative hourly revenues – fixed solar PV



PPAs

- Some PPA contracts have specific clauses related to payment and delivery under negative prices, protecting them from negative price risk.

Illustrative representation of Aurora pricing model steps



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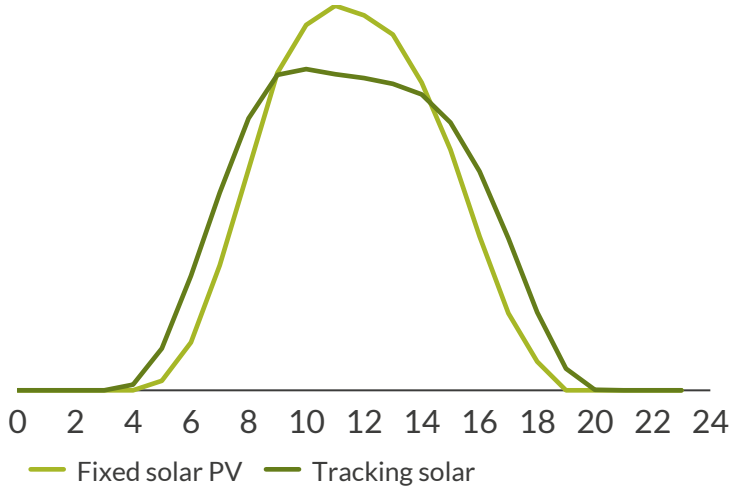
Innovative technologies

- Tracking solar assets generate more during the shoulder hours compared to fixed solar PV, reducing some of the exposure to the hours with the most negative prices.

Illustrative hourly generation profile



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1) Aurora's utility PPA valuation accounts for price risks and hedging costs, resulting in a fundamental PPA reference price; 2) Calibrated PPA prices incorporate a risk discount reflecting additional risk factors, calibrated with price quotes from the market.

Source: Aurora Energy Research

Co-location boosts IRRs through cost savings, avoidance of curtailment, and additional revenues from the battery asset

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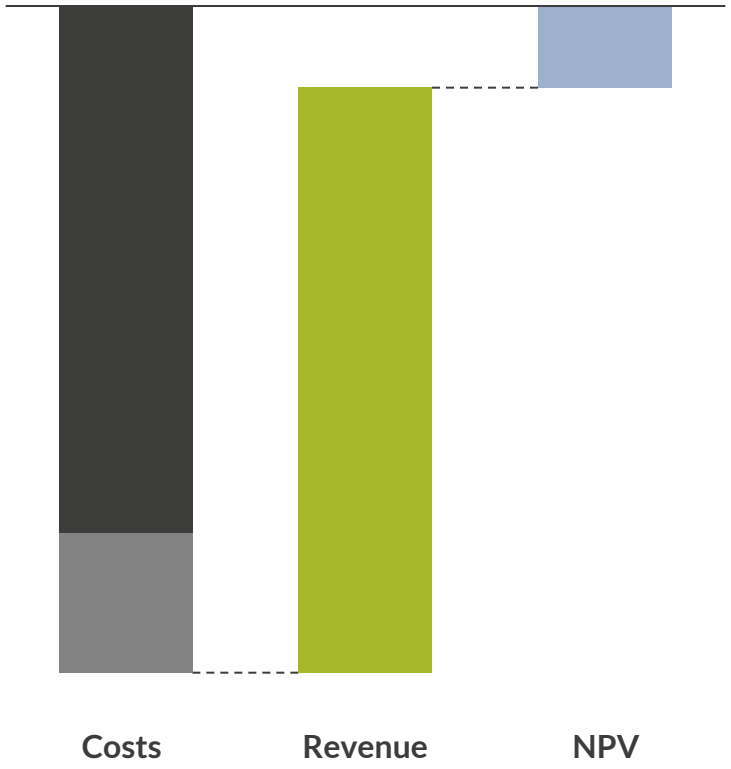
Firm connection	1.0	1.0

Standalone solar with firm connection NPV[1], 2025 entry
£/kW$_{grid}$



1) Discount rate of 11%

Sources: Aurora Energy Research

Co-location boosts IRRs through cost savings, avoidance of curtailment, and additional revenues from the battery asset

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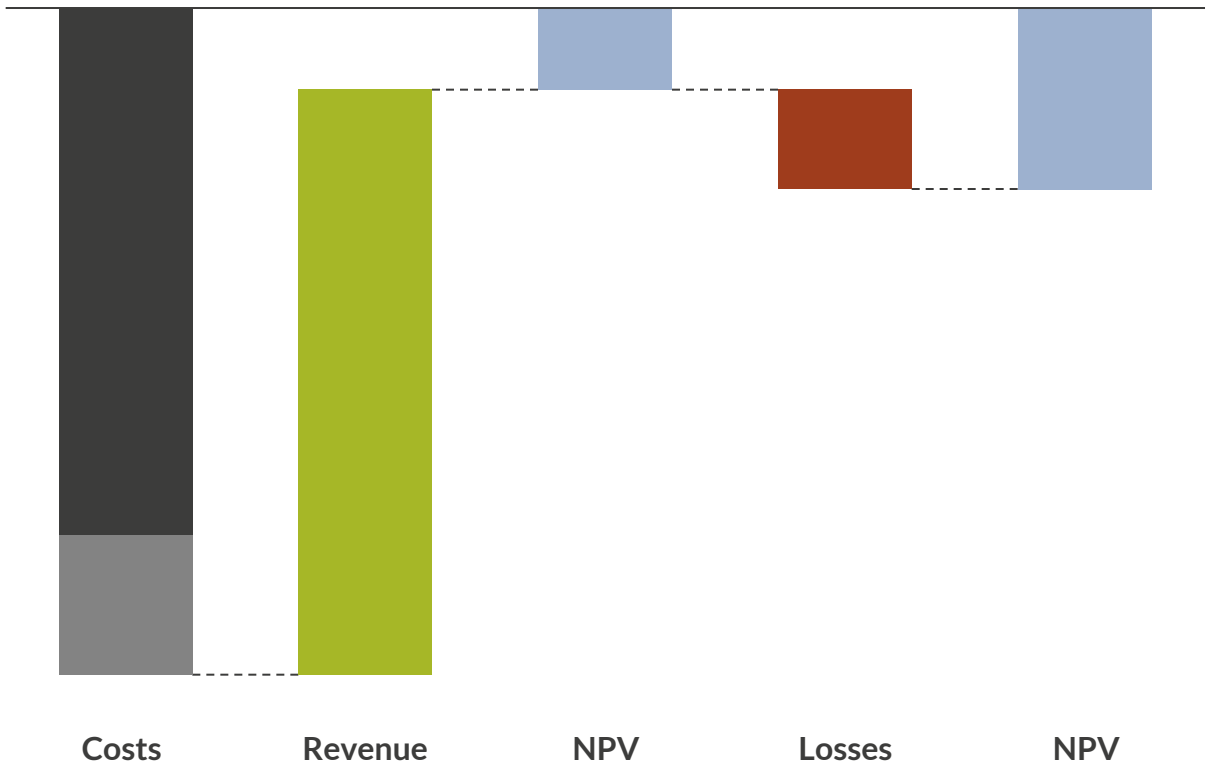
Non-firm connection	1.0	1.0

Standalone solar with non-firm connection NPV[1], 2025 entry
£/kW$_{grid}$



1) Discount rate of 11%

Sources: Aurora Energy Research

Co-location boosts IRRs through cost savings, avoidance of curtailment, and additional revenues from the battery asset

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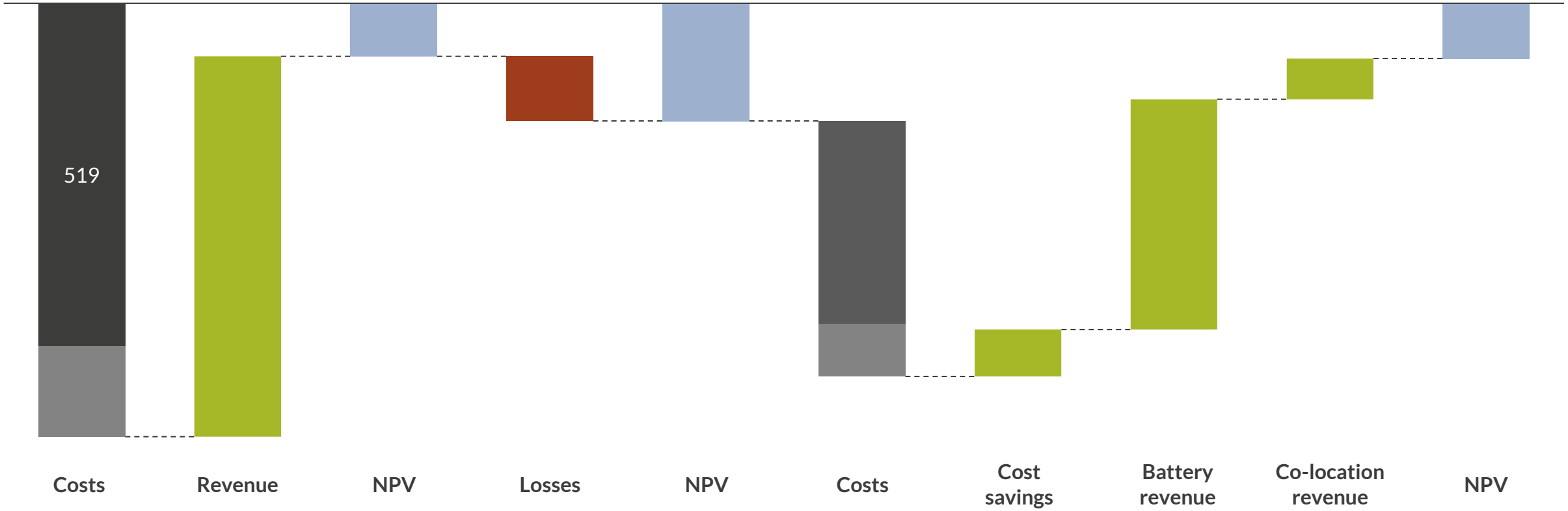
AC-co-located solar with non-firm connection NPV[1], 2025 entry

£/kW$_{grid}$

Co-located project 1.0 1.0 0.4



1) Discount rate of 11%

Sources: Aurora Energy Research

Returns can vary by the sizing of the co-located elements through cost savings and the ability to transfer energy from the renewable to the battery

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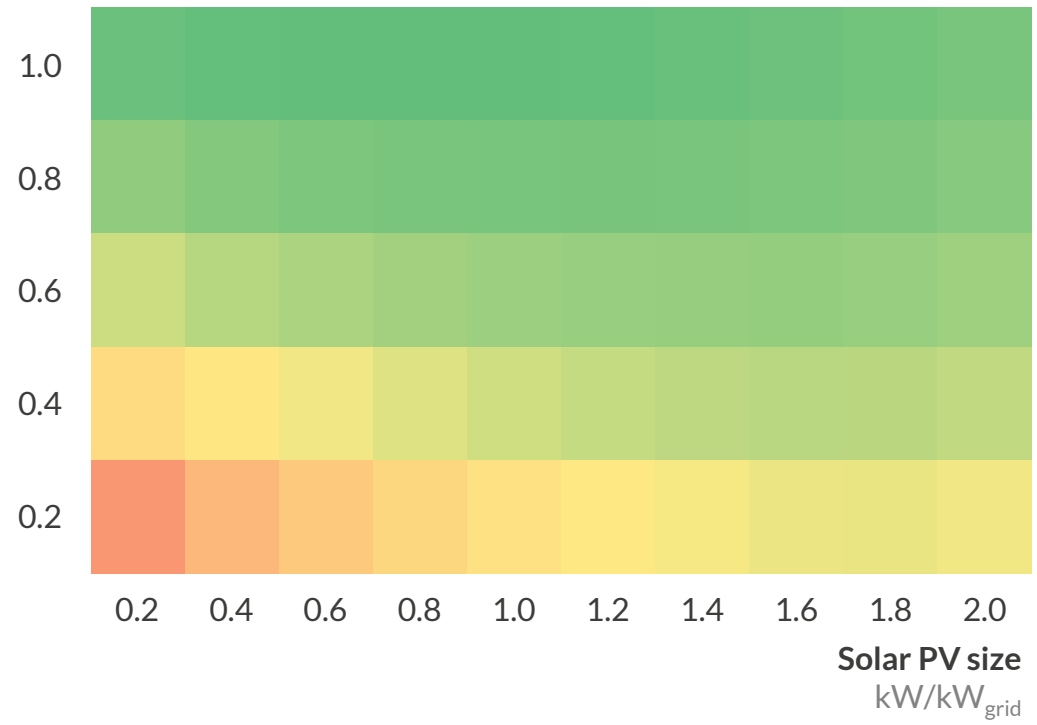
B Co-location

The optimal sizing ratio, to maximise IRR, favours a large battery and an undersizing of the solar asset

However, risk appetite will determine whether investors opt for a primarily battery storage driven business model

IRR comparison for variable co-location sizing
%, pre-tax (real 2023)



- High revenues can be gained by arbitraging with the day ahead, intraday, and balancing markets
- Additional revenue can be obtained by participating in ancillary services
- Battery storage merchant revenues are more uncertain given the risks of energy arbitrage
- The business model is more complex, requiring constant energy trading optimisation
- Battery storage dispatch is more optimal as solar generation does not utilise full grid connection capacity

Benefit of optimal sizing ratio | Drawback of optimal sizing ratio

1) 2025 entry solar asset assumed to have a 12.5% annual load factor co-located with a 2h 1.5 cycle battery

Sources: Aurora Energy Research

Increasingly favourable policy environments are enabling co-located projects across Europe

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B Co-location

Enabling environment for co-location (utility-scale solar with batteries)

Rating

- Moderately attractive co-location environment
- Currently attractive co-location environment

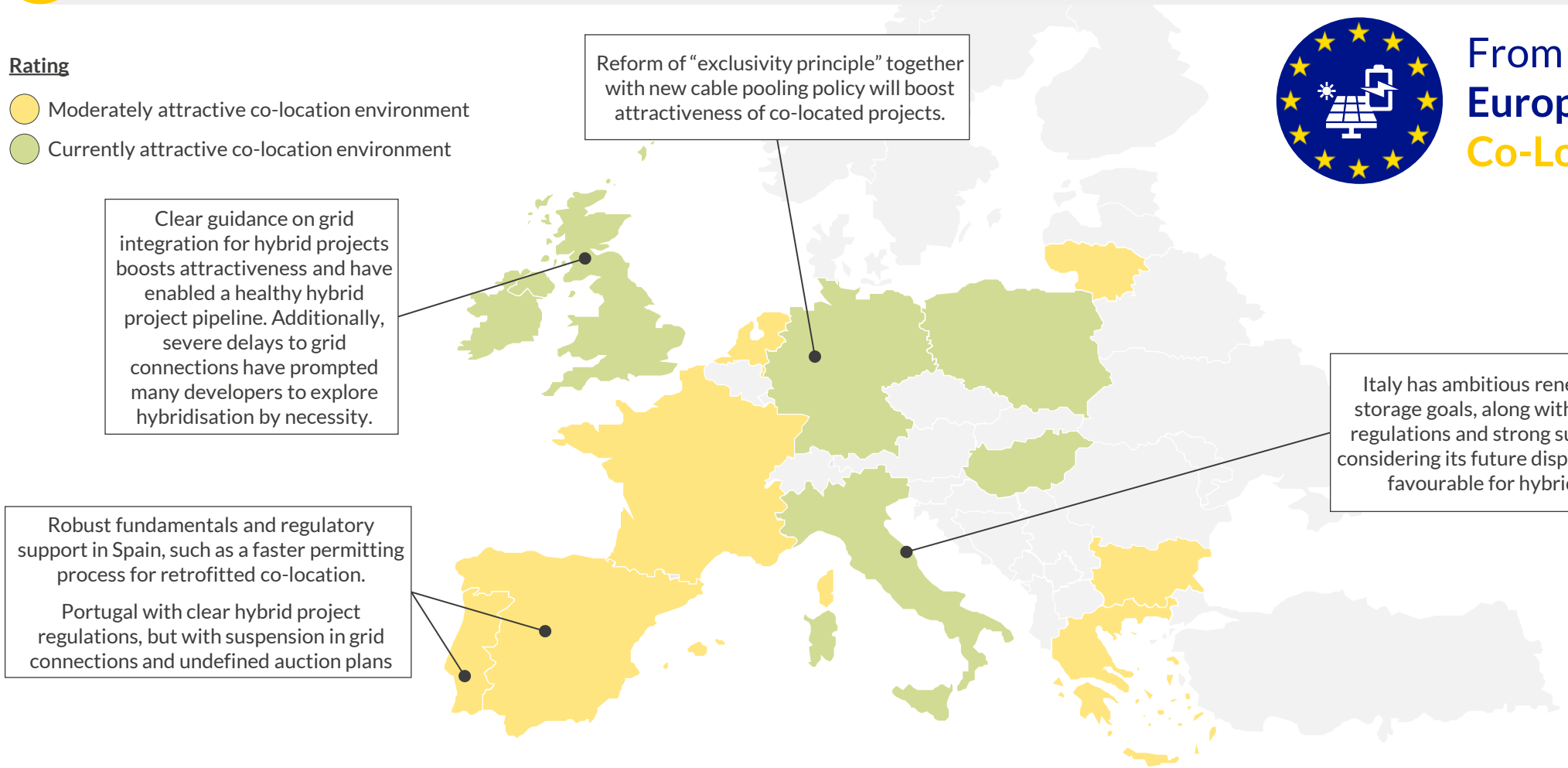
Reform of "exclusivity principle" together with new cable pooling policy will boost attractiveness of co-located projects.

Clear guidance on grid integration for hybrid projects boosts attractiveness and have enabled a healthy hybrid project pipeline. Additionally, severe delays to grid connections have prompted many developers to explore hybridisation by necessity.

Italy has ambitious renewable and storage goals, along with favourable regulations and strong subsidies, and considering its future dispatch reform is favourable for hybridisation.

Robust fundamentals and regulatory support in Spain, such as a faster permitting process for retrofitted co-location.

Portugal with clear hybrid project regulations, but with suspension in grid connections and undefined auction plans



From the Aurora **European Renewable Co-Location Report**

Source: Aurora Energy Research

Key takeaways

1. Co-locating renewables with battery storage can help mitigate the effects of curtailment, both price- and grid-driven, and save costs by sharing a grid connection

2. Within GB, co-locating with battery storage improves the IRR of a non-firm solar asset by 330 bps, exceeding the profitability of a firm standalone asset

3. Co-location deployment can be driven by poor standalone renewable economics, such as in Spain, or through policy intervention, such as in Germany, but its vital support measures are well designed to avoid unwanted side effects

Generate bespoke co-location investment cases using our leading battery analytics software, Chronos

CHRONOS

Now available in

Great Britain

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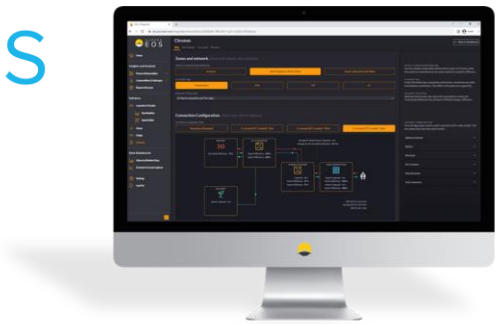
Italy



Compare market attractiveness across 12 European markets for co-location with our new report

European Renewable Co-Location Report

June 2024

Sources: Aurora Energy Research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