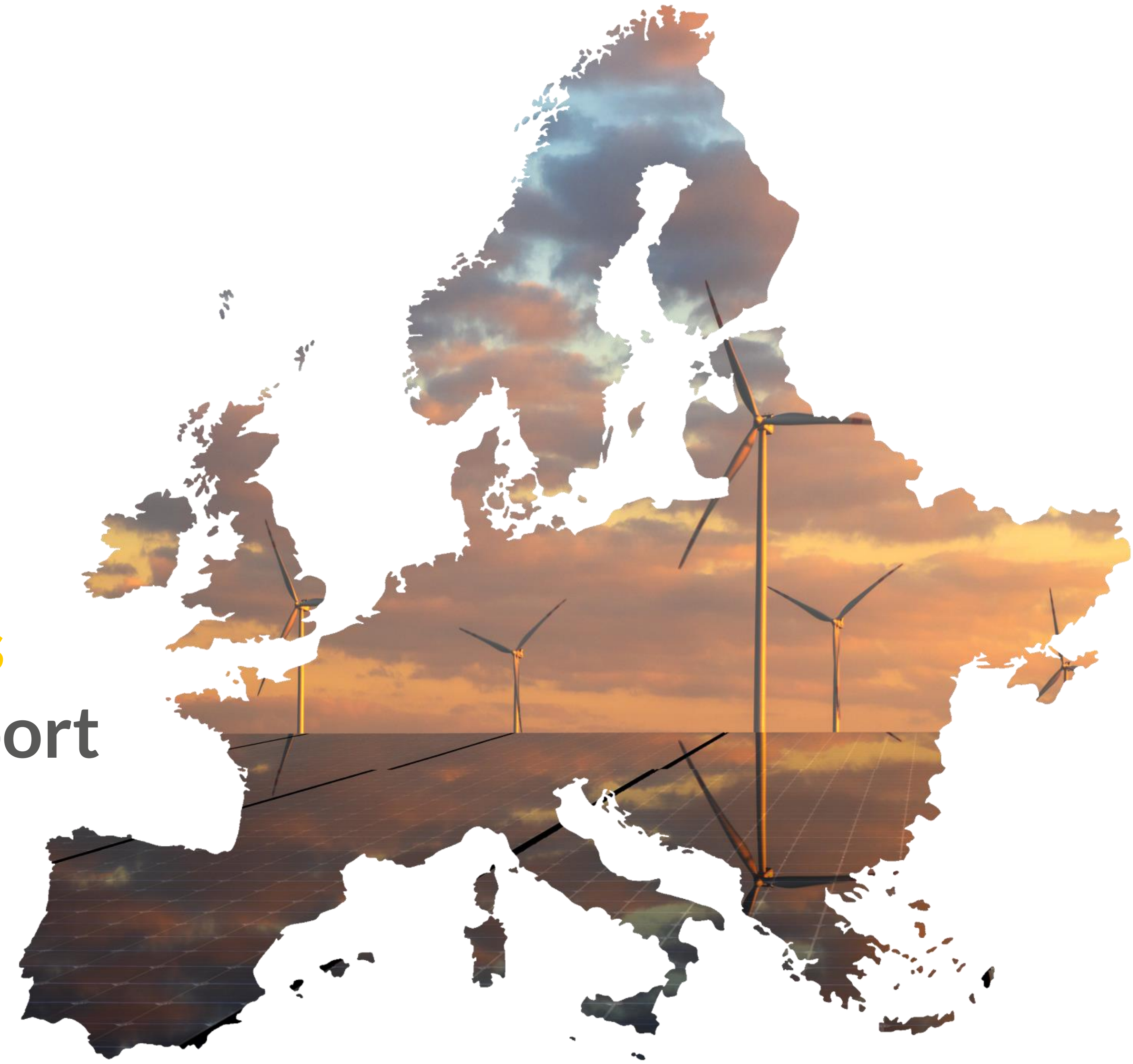
AURORA
ENERGY RESEARCH

REDACTED

European Renewables Market Overview Report



January 2025

Powered by AMUN

Powered by LUMUS

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

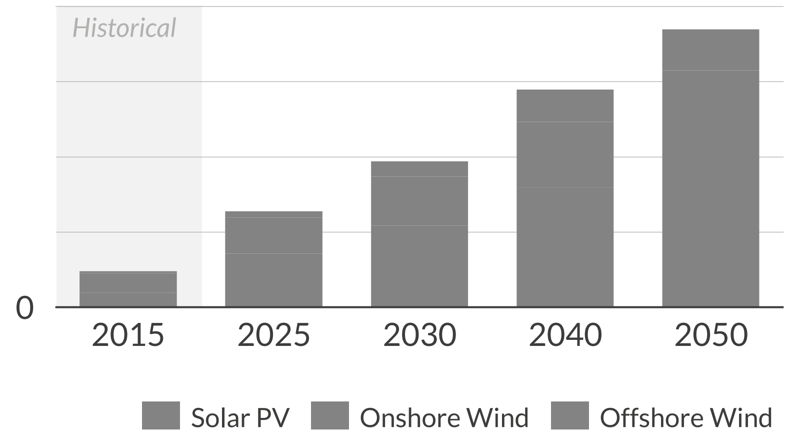
Executive Summary

1/2

**The information in this report draws on Aurora's October 2024 Flexible and Power & Renewables market subscriptions to provide you with an overview of European markets. For a deep dive into country specific markets, view our subscription services, or contact Bea Dunlop (bea.dunlop@auroraer.com) about finding a solution relevant to your needs.*

- **Growth in Renewables**: Europe's renewable energy capacity has grown to [redacted] over the last decade, driven by [redacted]
- **Investment Opportunities**: Substantial investment opportunities exist in new renewable energy capacity, with significant CAPEX required. Germany, Spain, and France are projected to invest heavily in onshore wind, with a potential cumulative investment requirement for solar PV and wind of over [redacted] billion in Europe by 2050. Yet, many markets fail to reach their national Net Zero targets in Aurora's Central scenario.

Installed variable renewable capacity in Europe[1]
GW



- **Policy Support and Targets:** Strong policy support across Europe is crucial for the deployment of renewable energy sources. [redacted]
- **Subsidy scheme design:** Most countries in Europe have adopted [redacted]
- **CAPEX reductions**: [redacted]
- **Routes to Market:** Currently, [redacted] are the primary routes to market for renewables in Europe, [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

AURORA

Executive Summary

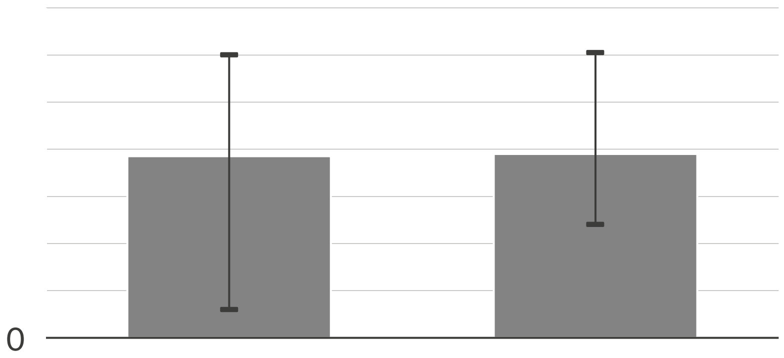
2/2

**The information in this report draws on Aurora's October 2024 Flexible and Power & Renewables market subscriptions to provide you with an overview of European markets. For a deep dive into country specific markets, view our <u>subscription services</u>, or contact Bea Dunlop (<u>bea.dunlop@auroraer.com</u>) about finding a solution relevant to your needs.*

- **Business Case Attractiveness**: Project economics for all markets were reviewed to assess business case feasibility[1]:
  - **Solar PV**: [redacted]
  - **Onshore wind**: [redacted]
  - **Offshore wind**: [redacted]

Average reference IRR for merchant projects
%, real, unlevered, pre-tax, COD 2028

Range



- **Risks to renewables**: The business case for intermittent RES can be affected by a series of risks across the continent:
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (<u>bea.dunlop@auroraer.com)</u>

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

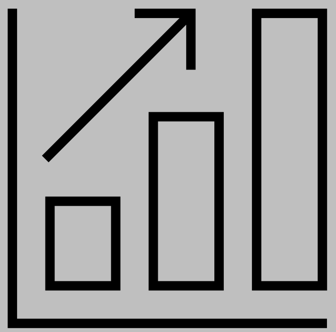
To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

AURORA

Executive Summary

Market size & composition



- Renewables capacity in Europe has had significant growth, [redacted]
- The decline in CAPEX costs for solar PV, onshore wind, and offshore wind has been substantial, making these technologies more economically viable. [redacted]
- The European PPA markets [redacted]
- Power demand in Europe is [redacted]
- Strong policy support across Europe [redacted]
- Europe's installed capacity of solar, onshore, and offshore wind is expected to reach [redacted]
- There are substantial investment opportunities in new renewable energy capacity, with significant CAPEX required. [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

AURORA

I. Executive summary

II. Market size & composition

1. Market developments
2. Long term outlook

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Decarbonisation efforts to date have driven strong growth in renewables capacity in Europe, [redacted]

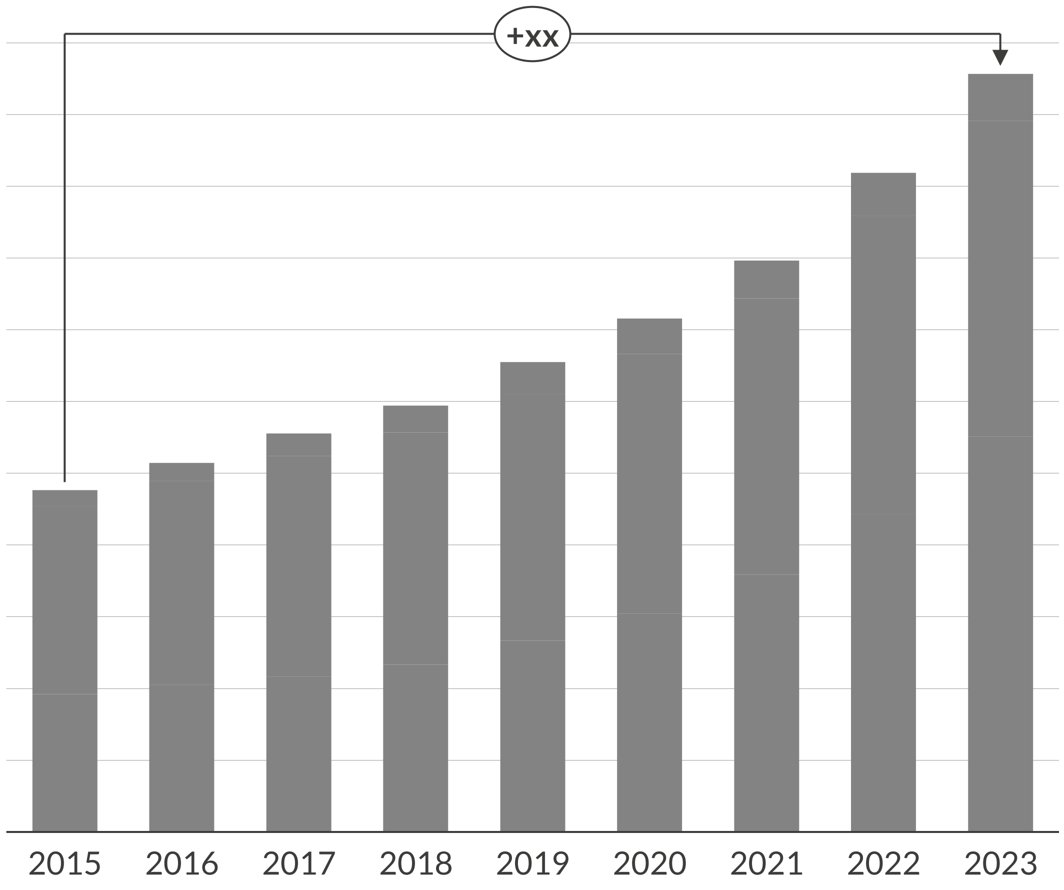
AURORA

Key drivers of past and future renewables deployment

Key Driver	Description
[redacted]	▪ [redacted]
[redacted]	▪ [redacted]
[redacted]	▪ [redacted]
[redacted]	▪ [redacted]
[redacted]	▪ [redacted]

Installed RES capacity in Europe[1]

GW



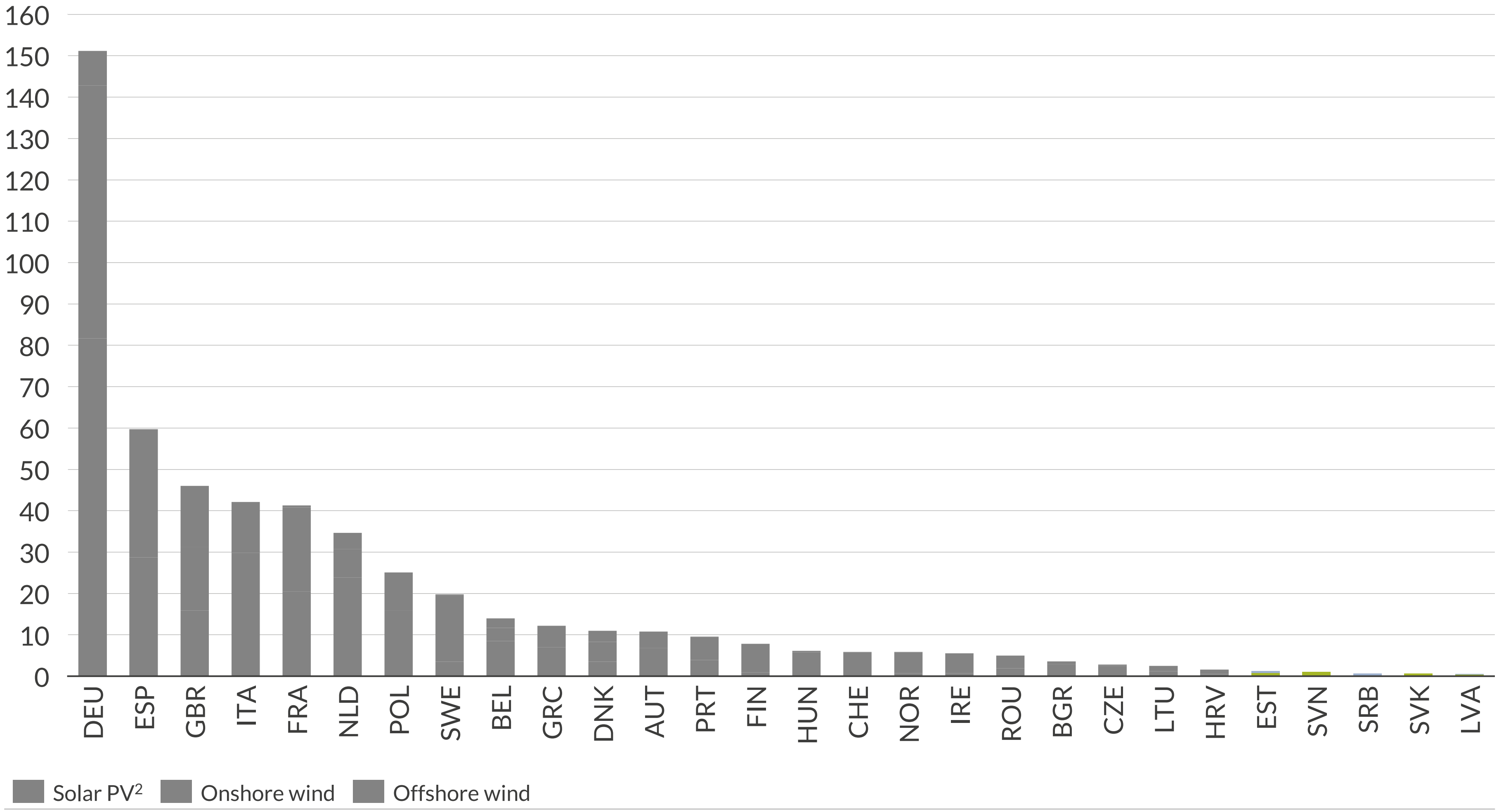
Solar PV[2] Onshore wind Offshore wind

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, IRENA

[redacted] and [redacted] lead the way in renewable energy deployment in Europe, with [redacted] GW and [redacted] GW operational to date, respectively

Operational renewables capacity in 2023[1]
GW



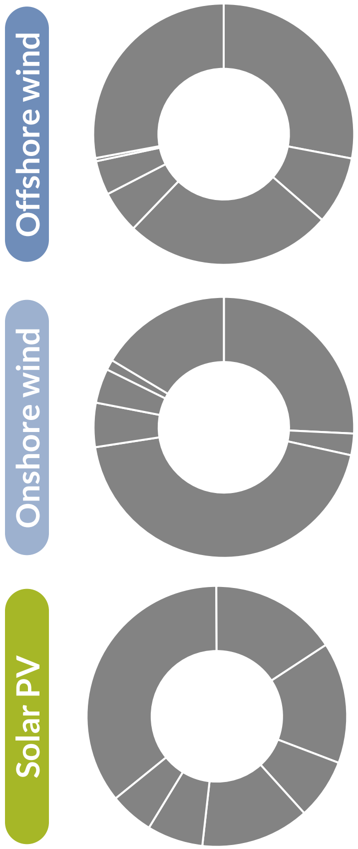
- [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

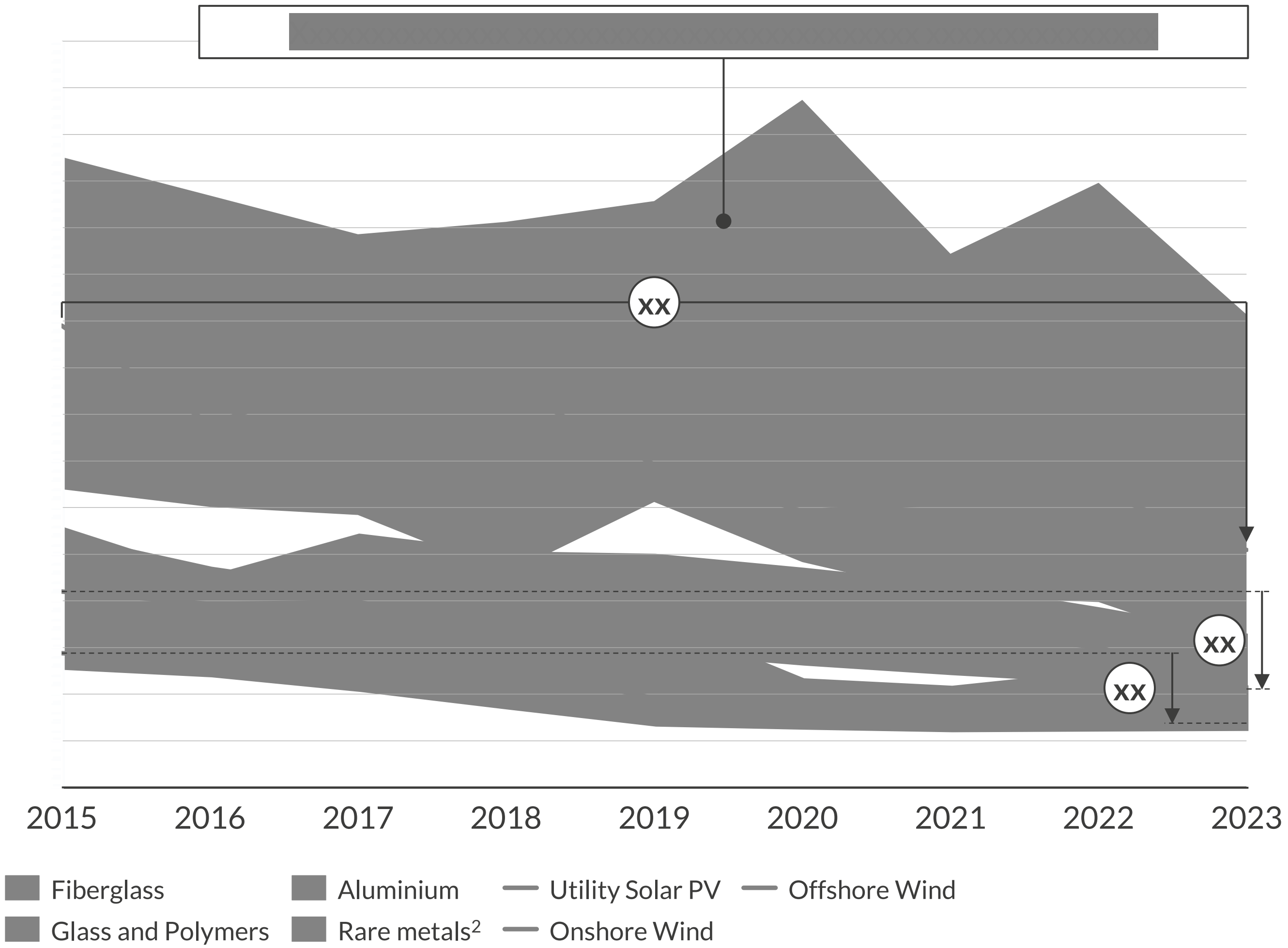
Source: Aurora Energy Research, IRENA

CAPEX costs have decreased significantly over the last decade due to economies of scale and technology-enabled efficiency improvements

Raw materials share by value[1], %



Global average renewables CAPEX utility scale (FID year), €/kW (real 2023)



- Renewables CAPEX costs for solar PV, onshore wind, and offshore wind have seen significant declines over the past decade.
- The decline in solar PV CAPEX has been driven by [redacted]
- [redacted]
- Renewable CAPEX also depends on [redacted]
- [redacted]

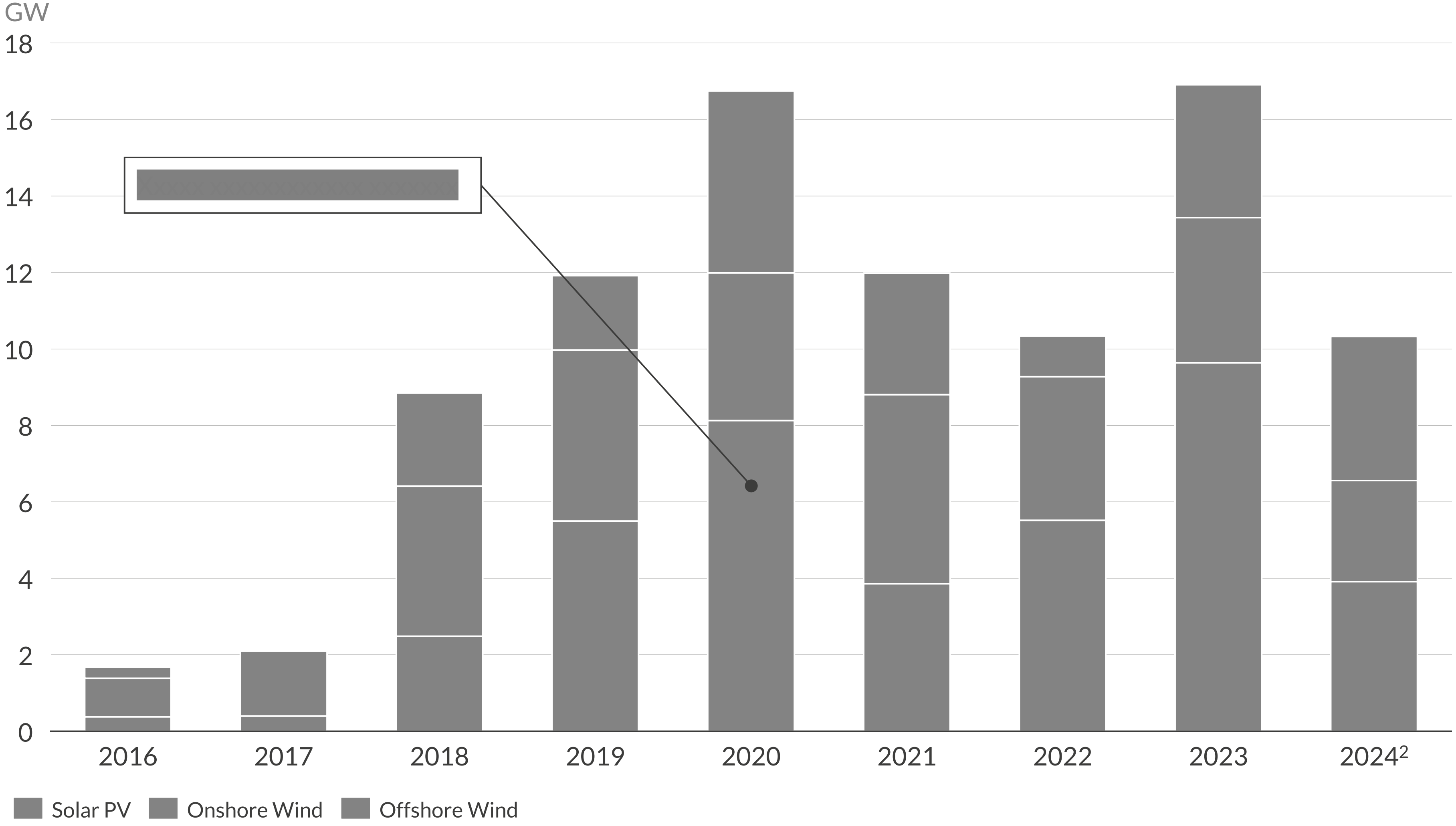
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, European Commission, IRENA

RES assets under PPAs account for [redacted] of the total intermittent RES capacity in Europe, with [redacted] the largest share

AURORA

Public PPA transaction volumes by announcement year in Europe[1]



- As a general trend, the European PPA market has been [redacted]
- [redacted]
- [redacted] is most the most dominant market for [redacted] PPAs deals, with almost [redacted] GW of deals signed to date.
- The most prominent markets for offshore wind PPAs are [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

AURORA

I. Executive summary

II. Market size & composition

1. Market developments
2. Long term outlook

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

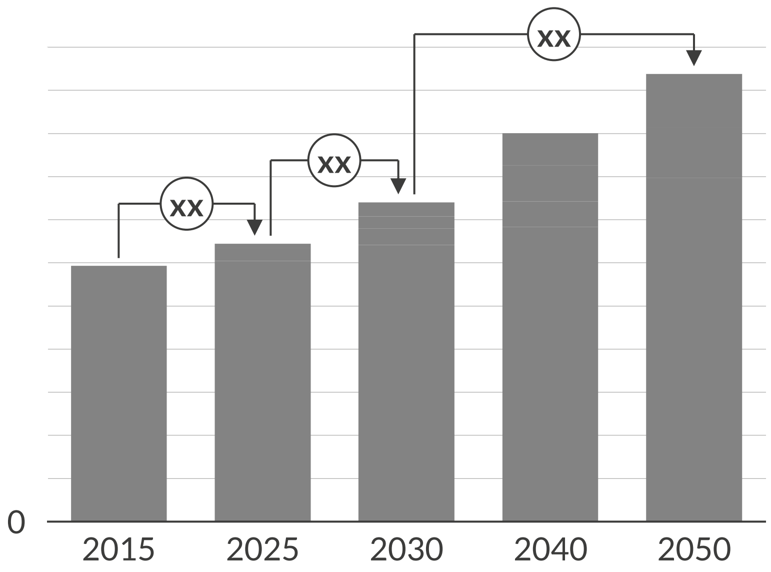
To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Power demand in Europe is expected to increase by [redacted] from 2025 to 2050, driven by [redacted]

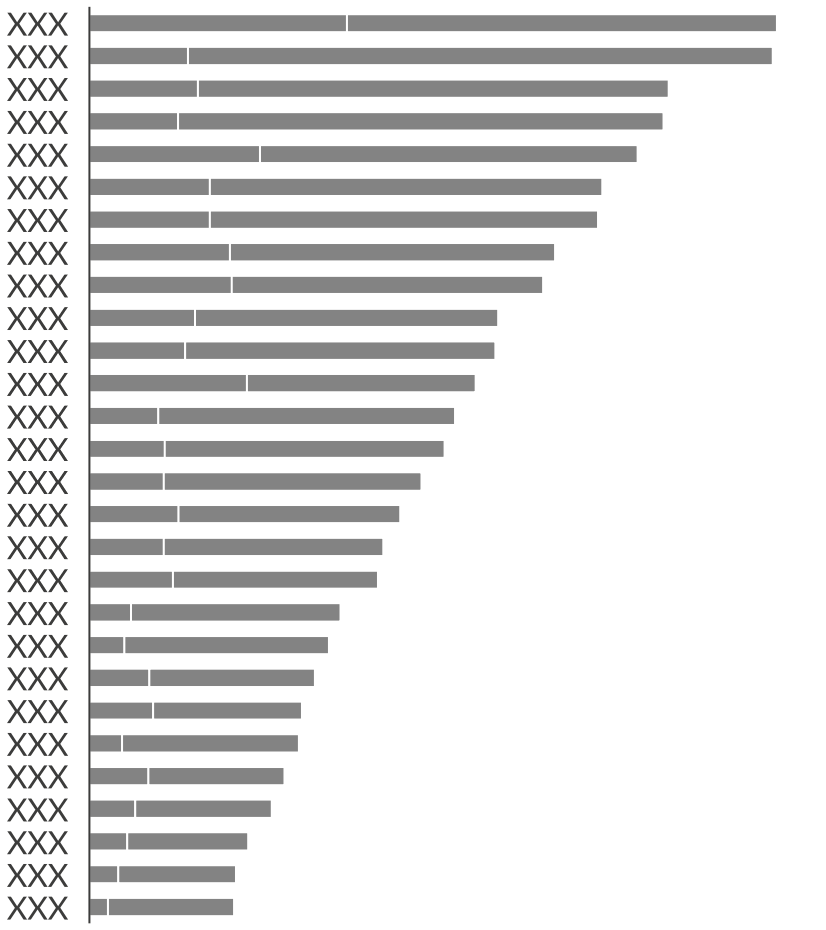
AURORA

Annual power demand in Europe[1, 2]
TWh



- In Aurora's Central outlook, European power demand [redacted]
- [redacted]

Percentage growth in demand by 2050 relative to 2025[1, 2]
%



- All regions observe higher percentage growth in demand [redacted]
- [redacted] sees the highest relative increase [redacted] in power demand by 2050 with total demand [redacted], driven by [redacted]
- [redacted] has the most significant relative demand growth between 2030 and 2050, due to [redacted]

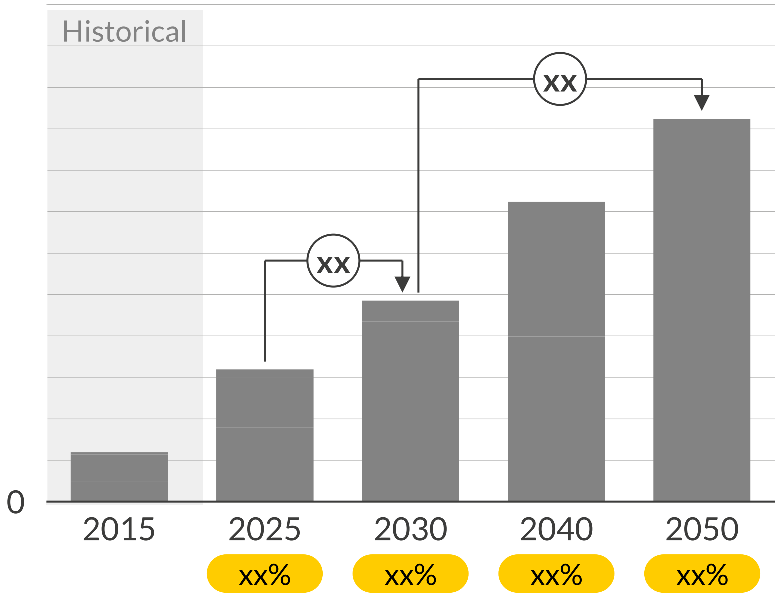
Hydrogen | Road transport | Heat | Base power demand | Historical | 2025-2030 | 2031-2050

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, Eurostat

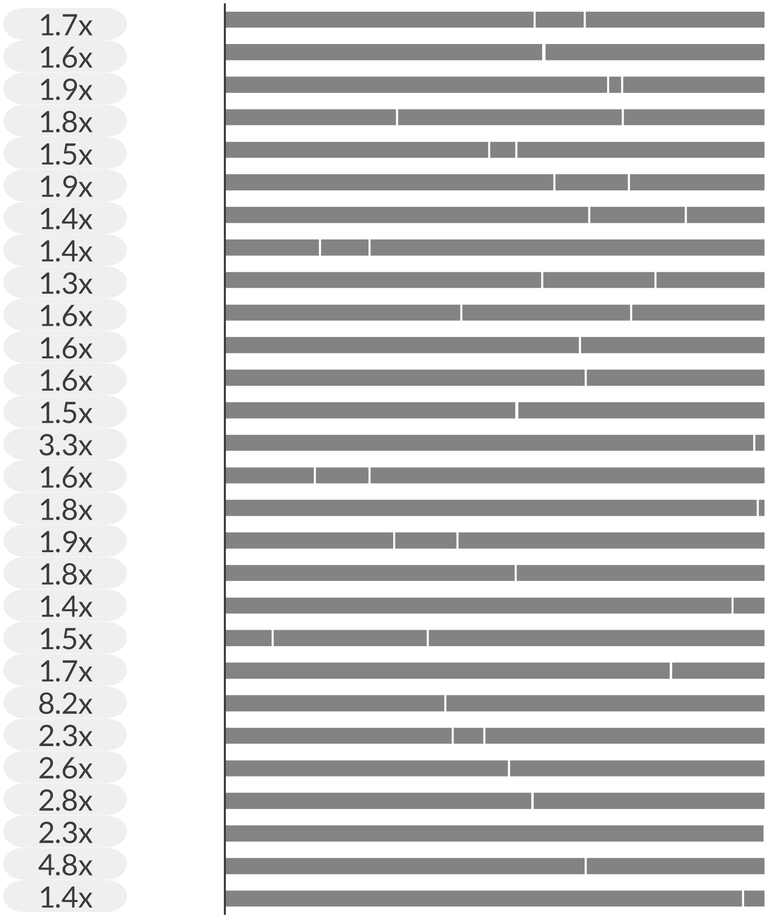
[redacted] of variable renewables deployment is expected by 2050, accounting for [redacted]% of total generation

Installed variable renewable capacity in Europe[1] (Aurora Central scenario), GW



- Europe's installed capacity of solar, onshore, and offshore wind is expected to [redacted]
- [redacted]

Installed variable renewable[2] capacity by 2030 (Aurora Central scenario), GW



Offshore Wind[4] | Onshore Wind | Solar PV[5] | xx 2030 capacity, relative to 2025 (GW) | xx% Variable RES share of generation[3]

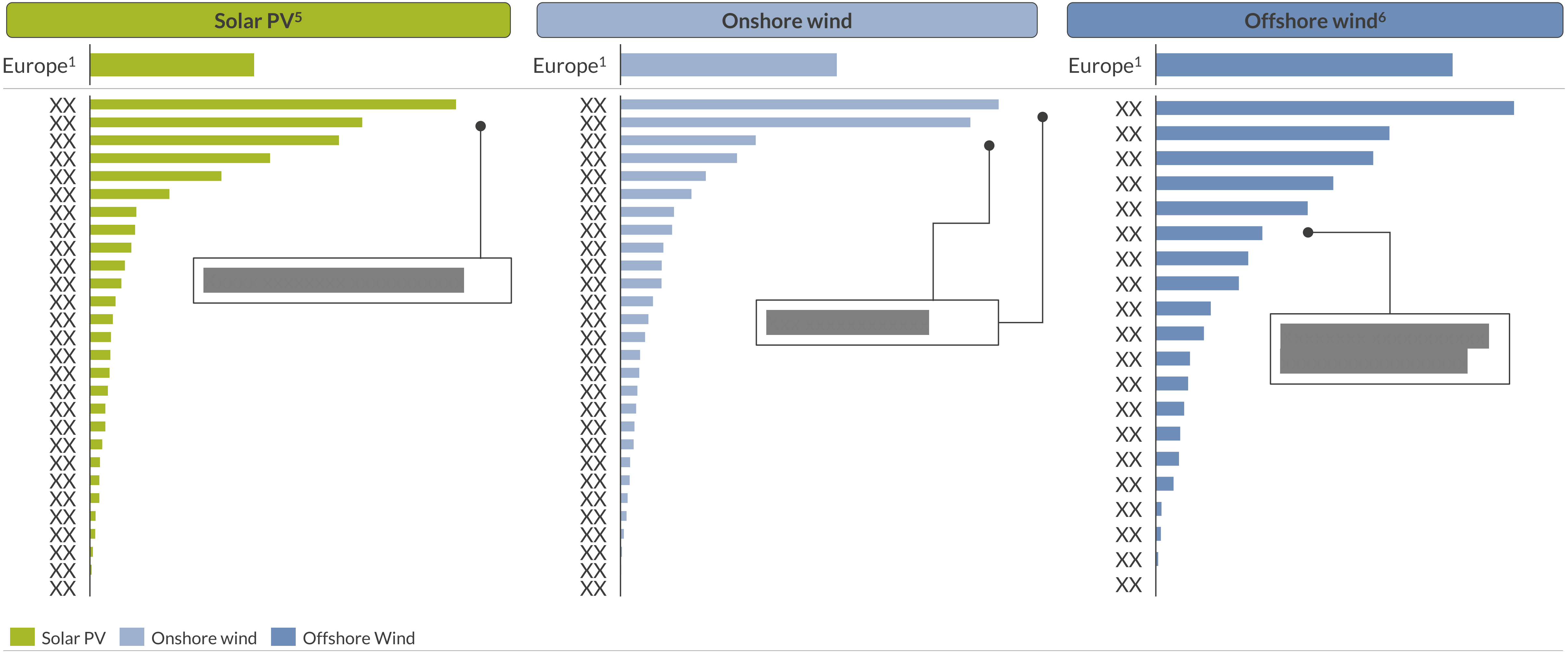
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

AURORA

- [redacted] have the greatest installed capacity of renewables by 2030, and together make up [redacted] of Europe's total, where solar is dominant among these countries, accounting for [redacted] of their 2030 installed capacities.
- [redacted] have the highest proportion of solar in their renewables mix , at over [redacted]
- [redacted] have the largest share of onshore wind out of their installed renewables at [redacted].
- [redacted]
- The EU is targeting 1,102GW of solar and wind by 2030 under its REPowerEU Plan.

New RES capacity additions represent a potential cumulative investment requirement in Europe of more than [redacted] €bn between 2025 and 2050

CAPEX investments[2,3,4]
€bn (real 2023)



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

By 2030, [redacted] has the highest share of solar PV generation at [redacted]%, with [redacted] taking the lead in 2050 with a share of [redacted]%

AURORA

Electricity demand[1] covered by domestic solar PV[2] generation in 2030
%, Aurora Central

Electricity demand[1] covered by domestic solar PV[2] generation in 2050
%, Aurora Central

- By 2030, [redacted]
- [redacted]

- [redacted] is projected to have the highest share of solar PV generation by 2050 [redacted]
- [redacted]

0-15% 16-30% 31-45% 46-60%

Source: Aurora Energy Research

[redacted] leads the share of generation from wind in 2030, while [redacted]

AURORA

Electricity demand[1] covered by domestic wind generation[2] in 2030
%, Aurora Central

Electricity demand[1] covered by domestic wind generation[2] in 2050
%, Aurora Central

- By 2030, [redacted] is projected to lead in the share of wind generation, accounting for [redacted] of its total energy demand, while [redacted] sits at the last place with less than [redacted]%.
- Regions with high shares of wind generation such as the [redacted]

- Regions that tend to lag behind in terms of wind generation share in 2050 such as [redacted]
- Landlocked countries such as [redacted] do not have access to coastal winds and offshore wind, in addition to [redacted]

0-20% 21-40% 41-60% 61-80% 81-100%

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

AURORA

Executive Summary

Policy & Regulation

- [redacted]
- [redacted]
- [redacted]
- Renewables in Europe are supported through various direct and indirect support schemes, with [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
- The European Commission acknowledges the importance of Power Purchase Agreements (PPAs) as a long-term market-based instrument to support renewables investment. [redacted]
- Policymakers have announced [redacted] of planned capacity procurement through auctions until 2030 across the continent, with [redacted] % for solar PV and the remaining [redacted] % split almost equally between onshore and offshore wind.

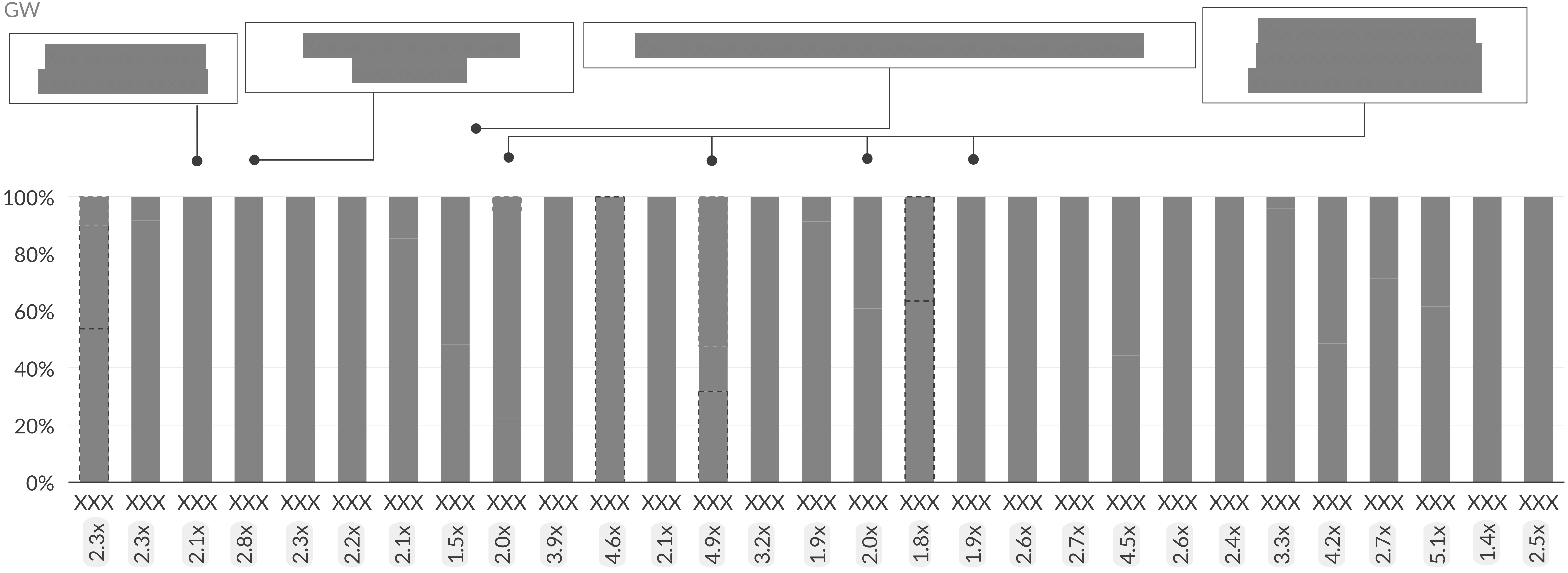
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Across Europe, several countries have set ambitious renewables targets, with the EU itself targeting [redacted] of solar and wind by 2030

In March 2023, the EU increased renewable energy targets to [redacted]

Target RES installed capacity by 2030
GW



Solar PV | Onshore wind | Offshore wind | Other[5] | Estimated[6] | XX Targets relative to 2024 installed capacity (GW)

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Since its introduction in 2019, the European Green Deal has aimed to support the deployment of renewables across the continent

AURORA

Measures as part of the over-arching European Green Deal framework

	2019	2021	2022	2023
	[redacted]	[redacted]	[redacted]	[redacted]
Key objectives	[redacted]	[redacted]	[redacted]	[redacted]
Emissions reduction	[redacted]	[redacted]	[redacted]	[redacted]
Renewables deployment	[redacted]	[redacted]	[redacted]	[redacted]
Energy efficiency	[redacted]	[redacted]	[redacted]	[redacted]
Security of supply	[redacted]	[redacted]	[redacted]	[redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, European Commission

The Green Deal Industrial Plan is the EU's response to the Inflation Reduction Act and introduces legislation to achieve net zero and geo-strategic goals

AURORA

Net Zero Industry Act

Deep dive 1

- [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

Critical Raw material Act

- [redacted]

- [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]

Reform of the electricity market

- [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: European Commission

The Net Zero Industry Act is the latest initiative of the Green Deal Industrial Plan, aimed at scaling up manufacturing of clean technologies in the EU

Deep dive 1

Category	Description
Key content and goals	▪ [redacted] 1. [redacted] 2. [redacted] 3. [redacted] 4. [redacted] 5. [redacted]
Funding	The Commission intends to provide and unlock funds for clean-tech investments via multiple sources: 1 [redacted] 2 [redacted] 3 [redacted] 4 [redacted] [redacted]
Next steps	▪ [redacted] ▪ [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, Nexus , European Commission, Norton Rose Fulbright, US Congress, Financial Times

Renewables in Europe can be supported via direct and indirect support schemes; most countries have shifted to [redacted]

AURORA

Direct subsidies

Feed-in-tariff (FiT)

- [redacted]
- [redacted]

Contracts for Difference (CfDs)[1]

- [redacted]
- [redacted]

Fixed/sliding feed-in premium

- [redacted]
- [redacted]

Investment Subsidies

- [redacted]

Additional / indirect support

Green certificates

- [redacted]
- [redacted]

EU-Emission Trading Scheme (ETS)

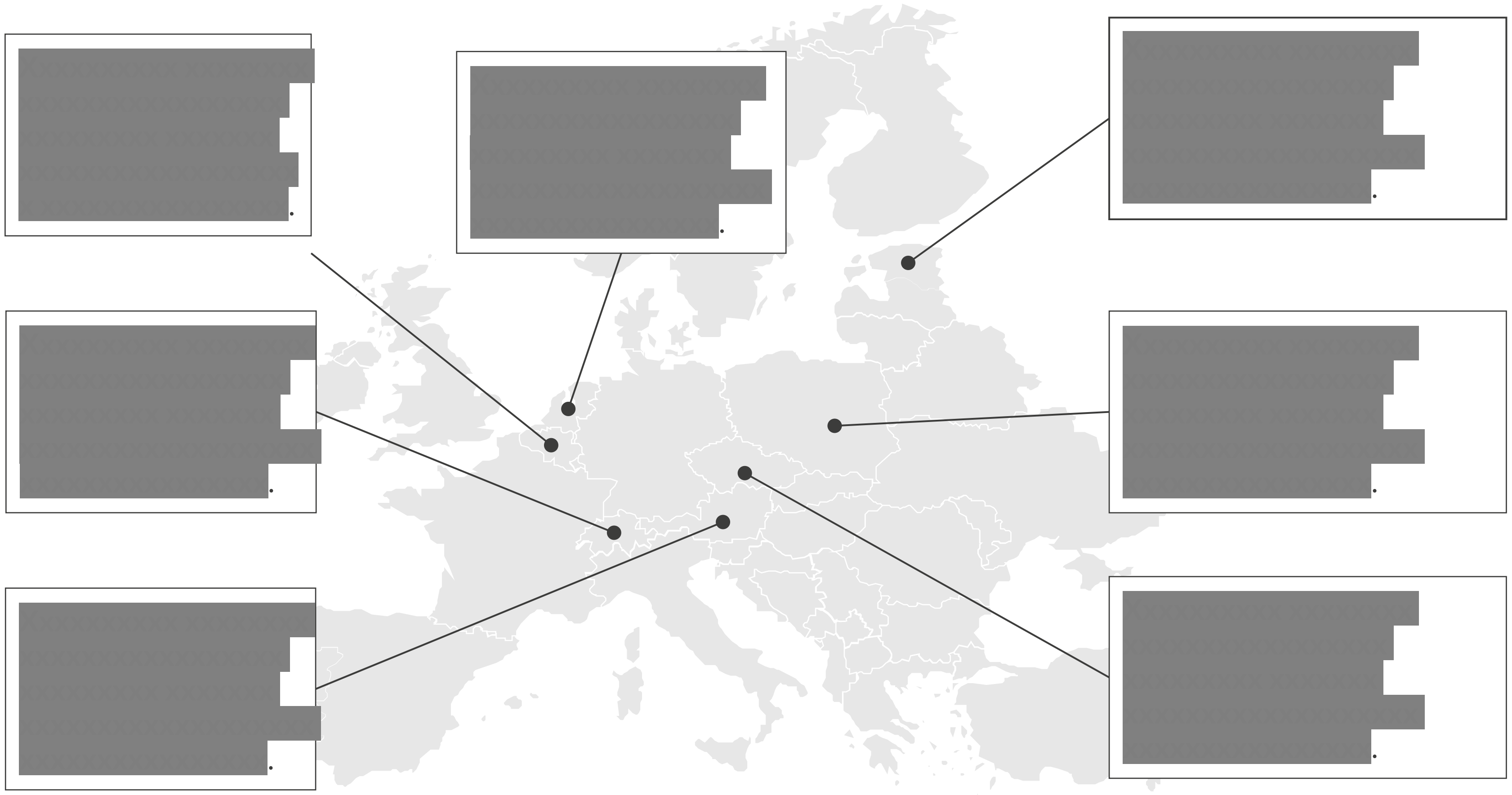
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

[redacted] are the most prominent government scheme driving solar PV and onshore wind buildout across Europe

Renewables support schemes available for both standalone utility-scale solar PV and onshore wind assets across Europe



Feed-in-premium | Two-sided CfD (implemented) | Green certificates[1] | Not covered
Two-sided CfD (planned) | No subsidies | Investment subsidy

- Out of the 28 countries covered in this report, [redacted]
- Subsidy support in the form of [redacted] are growing increasingly common, with [redacted] providing this support for one or both technologies.
- Countries with no subsidies for either solar PV or onshore wind are concentrated in [redacted]

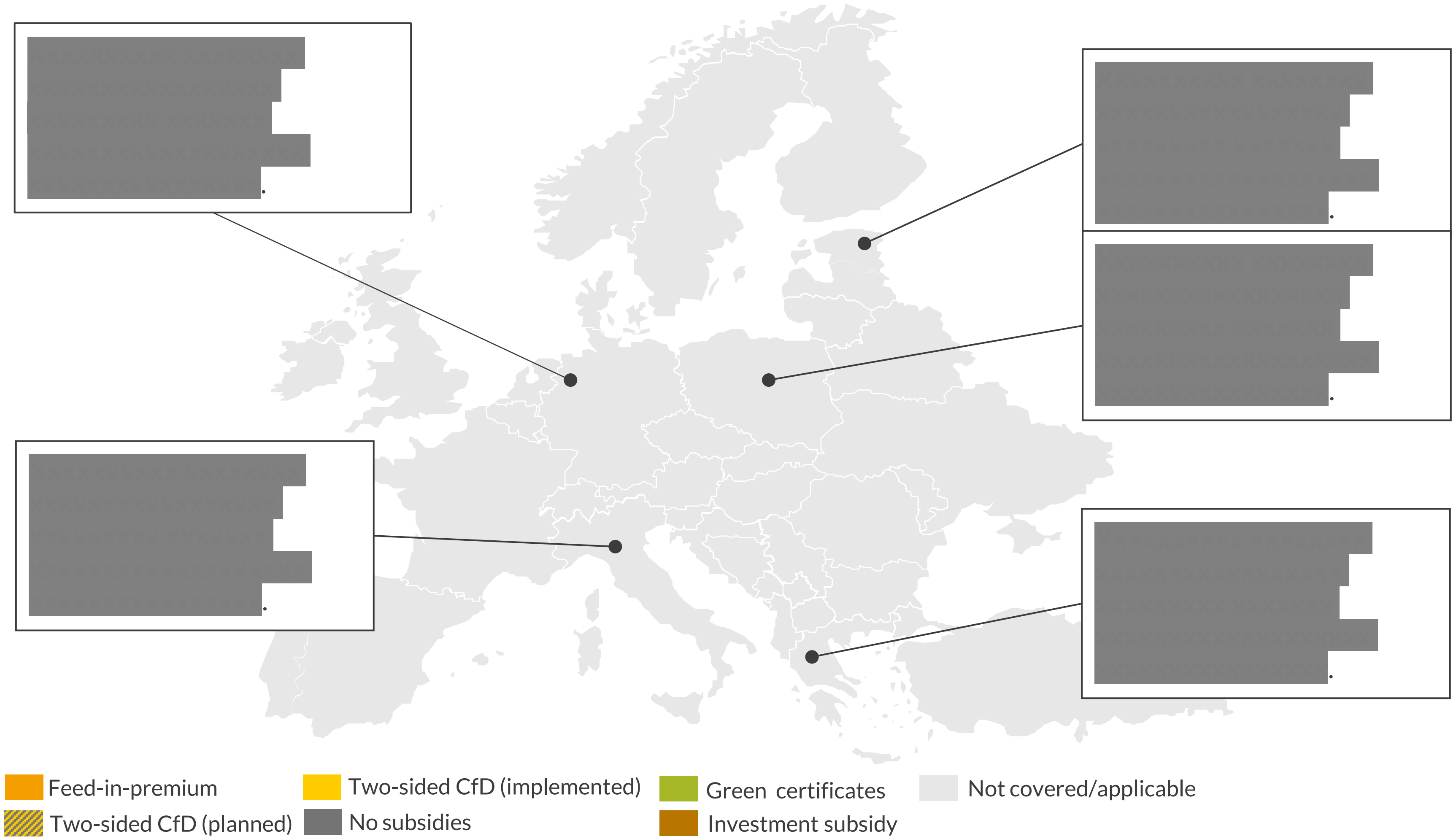
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

[redacted] are also a primary driver of offshore wind growth, with the scheme being introduced in multiple countries across Europe

AURORA

Renewables support schemes for utility-scale offshore wind assets across Europe



- [redacted] regions have introduced [redacted] making this the most prominent mechanism for offshore wind in Europe.
- [redacted] do not have equivalent support mechanisms for solar PV and onshore wind.
- [redacted] Member States have until 2027 to adapt their subsidy schemes to comply.
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Member States have three years to reform their subsidy mechanisms to comply with the two-sided support mechanism requirement

AURORA

Countries impacted by the mandatory CfD introduction

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Change to subsidy mechanism required

No change required

- The EU's electricity market reform, adopted in May 2024, aims to enhance the resilience of the energy market by implementing two-sided subsidy schemes to structure investment support.
- [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

The EU electricity market reform aims to further remove entry barriers to the PPA market, making them more accessible to offtakers

AURORA

In October 2023, the European Council set out its positions on the EU power market reform package and confirmed that one of the goals is to facilitate a dynamic PPA market across the EU, making green PPAs accessible to a broader range of corporate offtakers.

EU Target	EU Measures
Removing entry barriers to the PPA market	[redacted]
Incentivising faster renewables buildout across the EU	[redacted]
Creating a more dynamic EU PPA market through standardisation	[redacted]

Comments and selected implications

Removing entry barriers

[redacted]

More consistent regulation

[redacted]

Creating a more dynamic EU PPA market

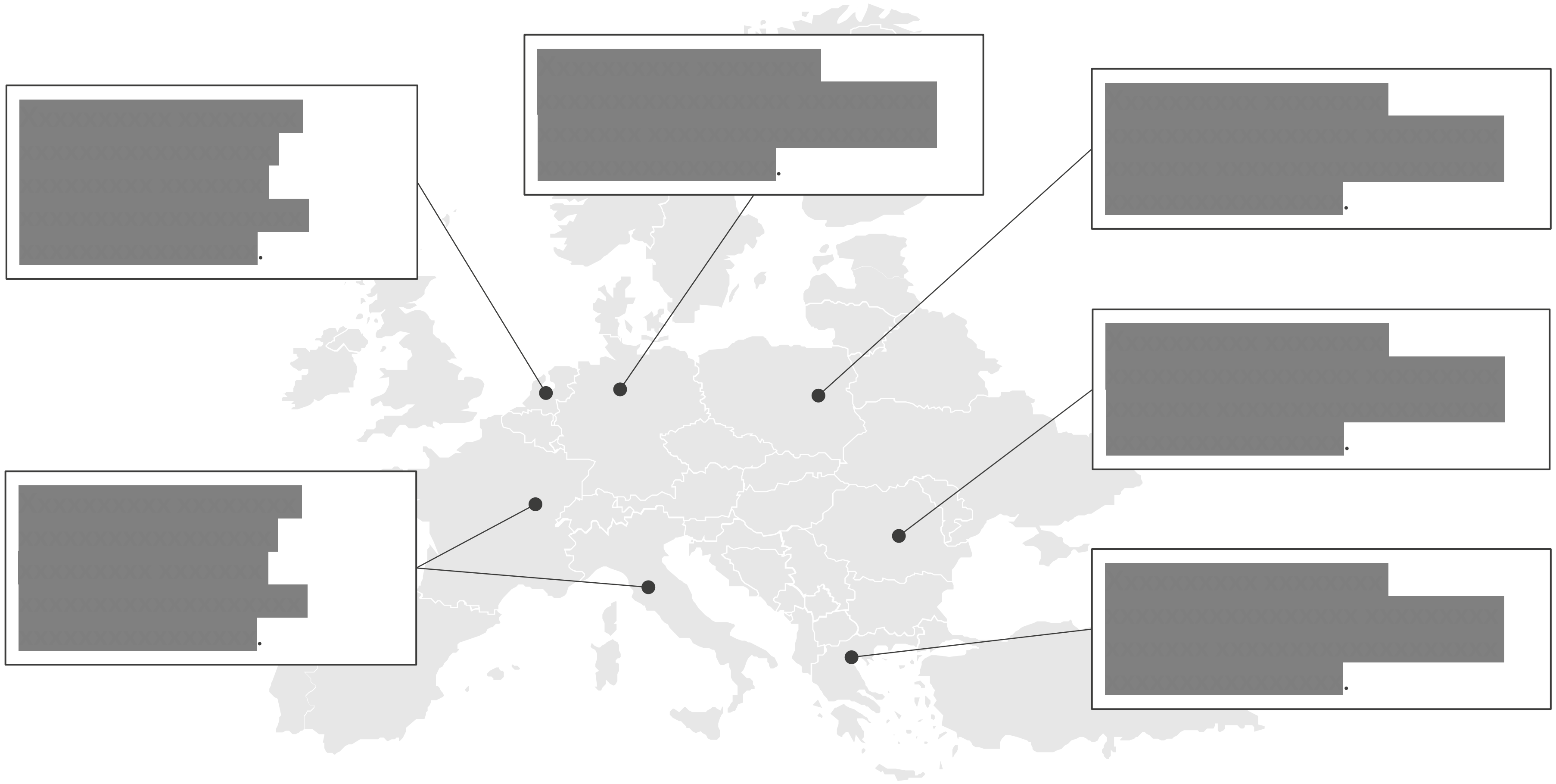
[redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, BPI France, EU Commission

[redacted] covered in this report have current or future subsidy schemes which allow for a flexible combination with PPAs

Combination of renewable subsidy schemes with PPAs



Subsidy scheme currently allows combination with PPAs
Future scheme to allow combination with PPAs

European Policy on PPAs

- The European Commission acknowledges the importance of PPAs as a long-term market-based instrument to support investment decisions for renewables. However, the Commission mainly relies on voluntary measures by Member States to encourage the use of PPAs, such as through:
  1. [redacted]
  2. [redacted]
  3. [redacted]
- [redacted]

Source: Aurora Energy Research

Despite the growth, obstacles in the way of further development of the PPA market remain; the European experience could be valuable

AURORA

Obstacle	European examples	Comments
[redacted]	France: [redacted] Norway: [redacted]	[redacted]
[redacted]	Spain: [redacted] Netherlands: [redacted]	[redacted]
[redacted]	Sweden, Finland: [redacted]	[redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

AURORA

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

AURORA

Executive Summary

Project economics

- [redacted] are the dominant routes to market for renewables in Europe. Fully merchant projects, which face higher risks, are currently only feasible in selected European markets such as [redacted]

CAPEX for renewables is expected [redacted]

Wind capture prices in 2030 range from [redacted]. Capture prices for solar PV in 2030 range from [redacted]

- LCOEs vary significantly across the continent based on load factors and local costs, [redacted]
- Aurora's reference project economics calculations, which analyse an average project in each market and should be considered a rough indication of the market situation, shows mixed findings depending on the technology:
  - **Solar PV:** [redacted]
  - **Onshore wind:** [redacted]
- **Offshore wind:** [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

1. Technology trends
2. Aurora outlook
3. Routes-to-Market

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Aurora's renewables business cases are underpinned by a series of sophisticated assumptions and results from our fundamental model

AURORA

Focus of this subsection

Aurora's in-house modelling assumptions

Capital Expenditures (CAPEX)
Upfront capital costs required, split across various cost components.

Operational Expenditures (OPEX)
Fixed and variable costs to operate the asset once constructed.

Load factor
Ratio of average power output to total potential power output.

Discount rate / Weighted Average Costs of Capital (WACC)
Represents a measure of risk and varies based on Route-to-Market.

Covered in the following subsection

Derived as part of Aurora's modelling

Capture prices
Realised revenues per MWh due to an asset's production profiles.

Economic curtailment
Reduced dispatched volumes due to low or negative market prices.

Imbalance costs
Price paid for incorrectly forecasted generation and fluctuations.

Guarantees of Origin (GOs)[1]
Revenues from certification scheme proving the source of electricity.

Power Purchase Agreement (PPA) prices
Fixed contracted offtake price per MWh for a set period of time.

Levelised Costs of Electricity (LCOE)
Levelised cost of energy is the ratio of the total discounted costs and discounted energy production over the project lifetime.

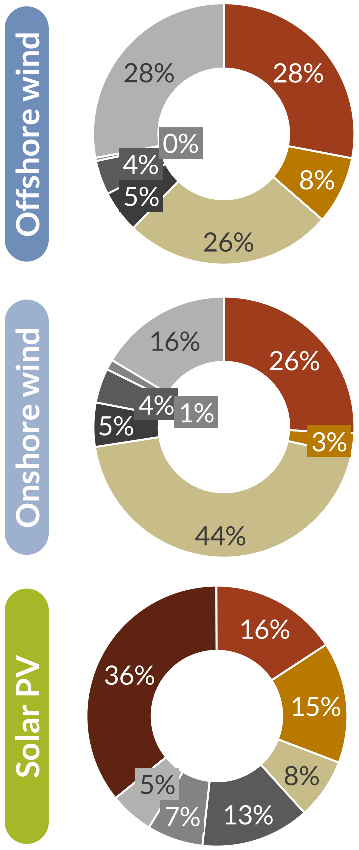
Internal rate of return (IRR)
The expected annual rate of growth for the respective project. At this discount rate, the project's NPV would be zero.

Source: Aurora Energy Research

CAPEX continues to fall, due to [redacted]

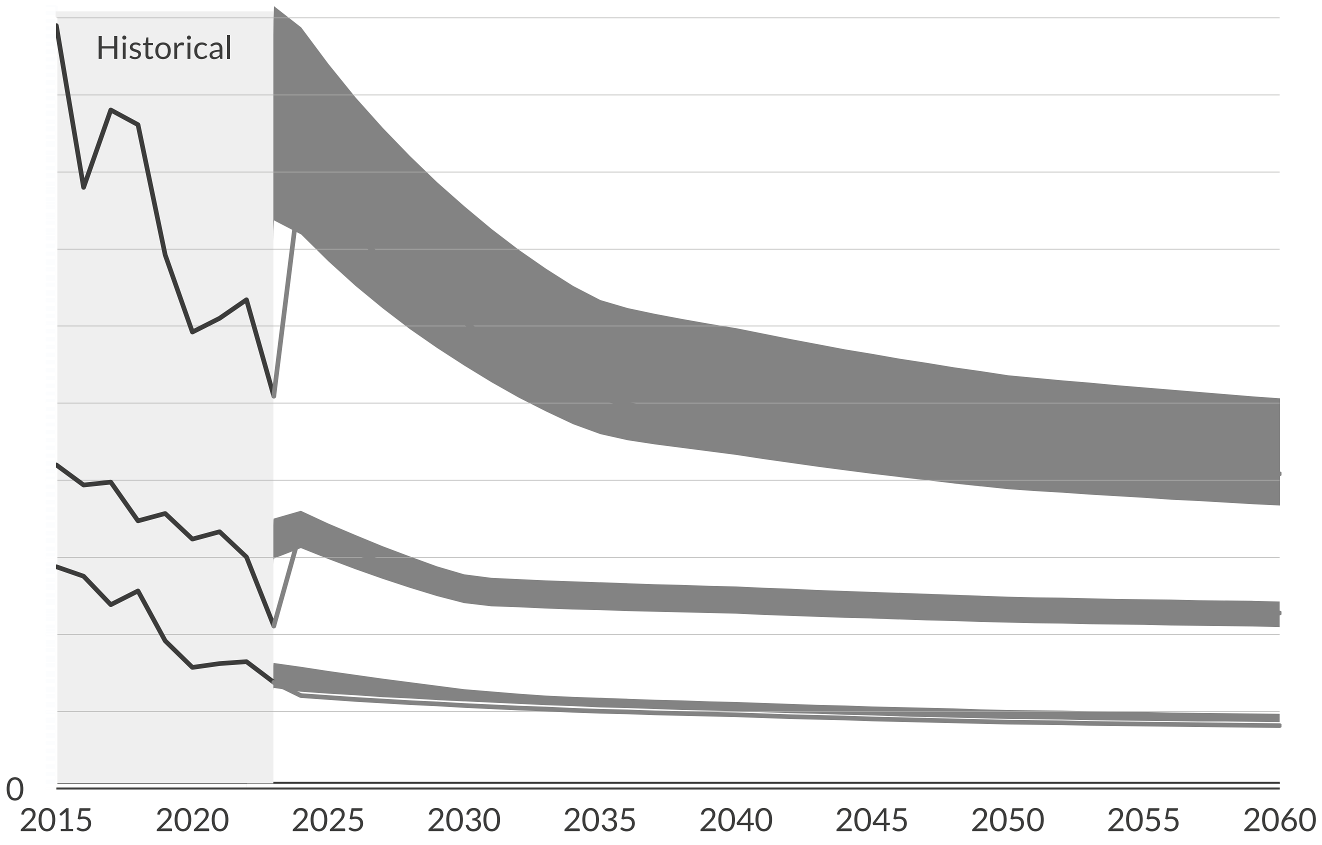
AURORA

Raw materials share by value[1], %



Renewables CAPEX utility scale (FID year) trajectories[3,4,]

€/kW (real 2023)



- [redacted]
- [redacted]
- [redacted]
- [redacted]

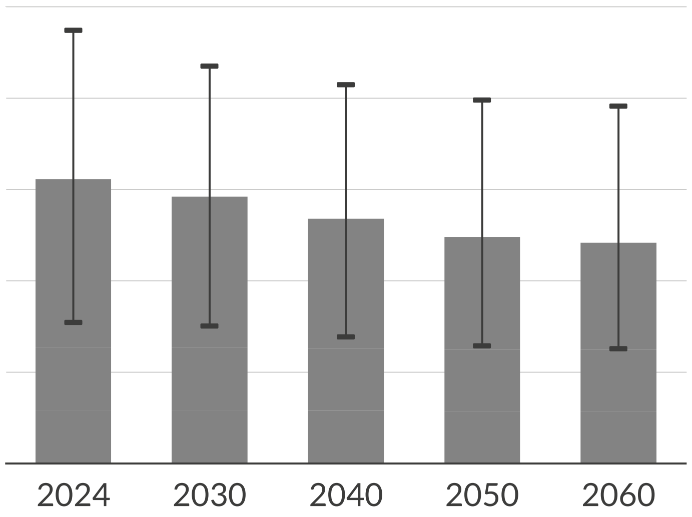
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, European Commission, IRENA

OPEX is expected to [redacted]

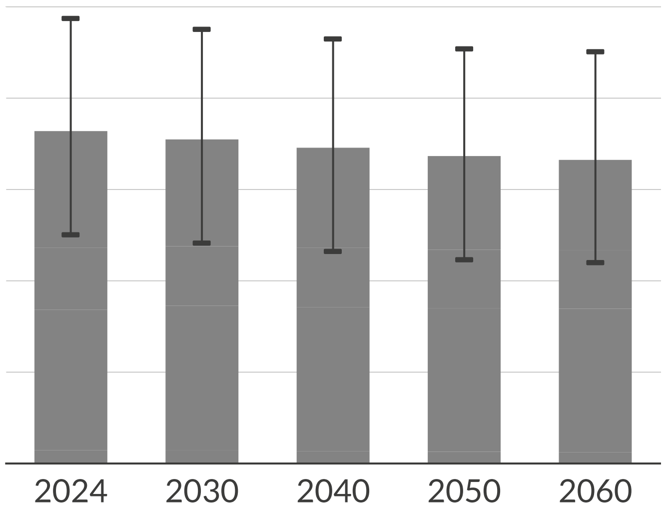
AURORA

Operational Expenditures[2] [redacted]
€/kW/year (real 2023)



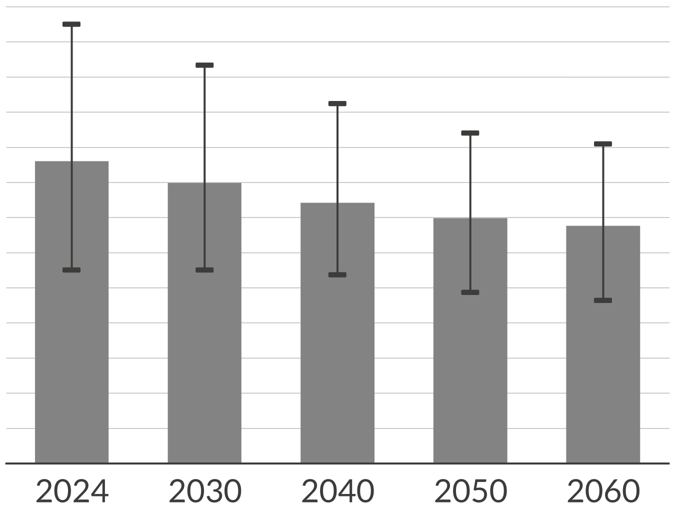
- [redacted]
- [redacted]

Operational Expenditures[2] [redacted]
€/kW/year (real 2023)



- [redacted]
- [redacted]

Operational Expenditures[2] – [redacted]
€/kW/year (real 2023)



- [redacted]
- [redacted]

Property Tax | Solar FOM | Other[4] | Land lease & Insurance | Onshore wind FOM | Offshore wind FOM | Range across countries

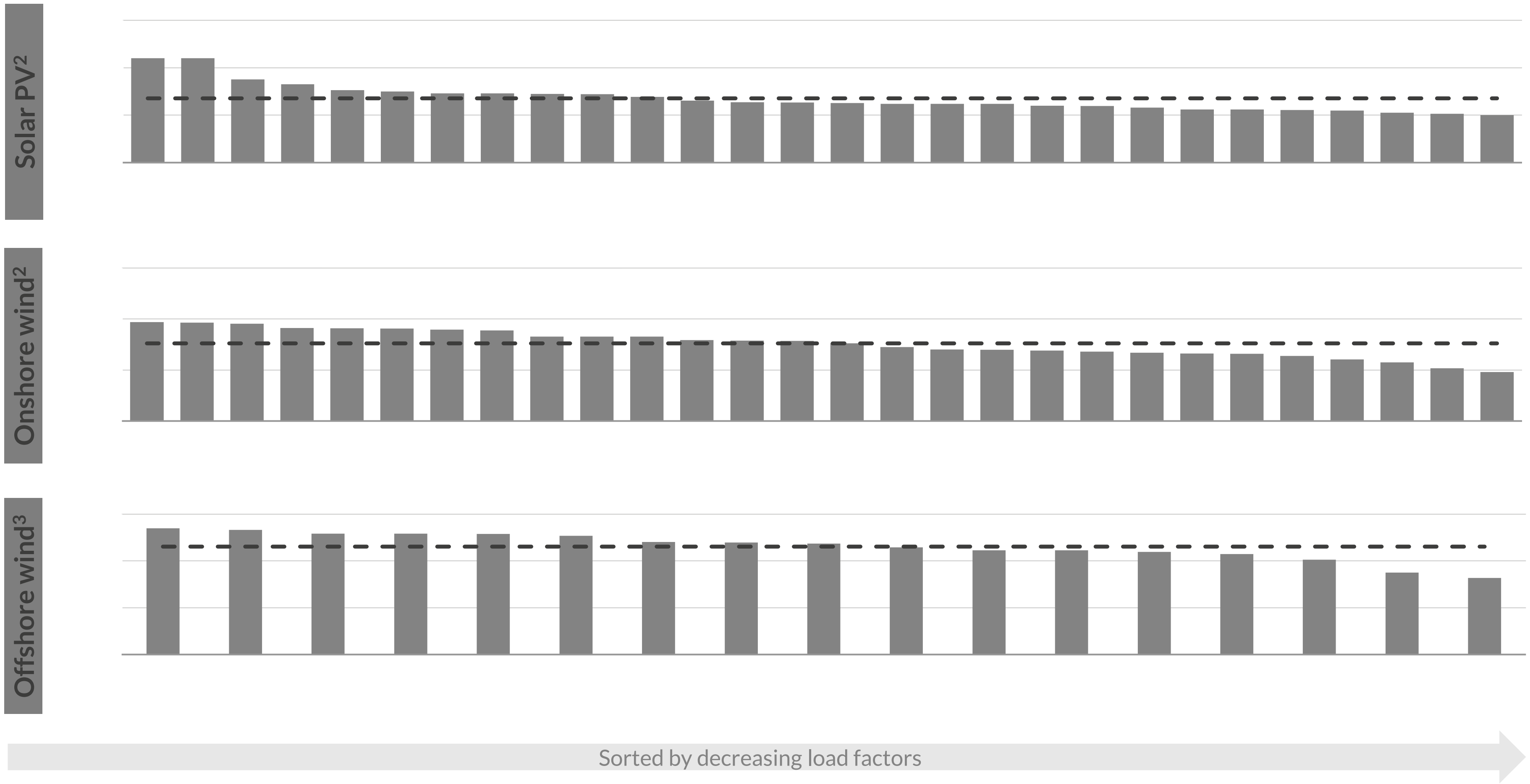
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Load factors can vary significantly within and across markets, depending on both technology and technological setup of the assets

AURORA

Renewables load factors for new build assets[1]
%



New-build average — European average

- Renewable load factors are strongly influenced by the prevailing weather conditions of a given region, and the fleet wide average load factor represents a range of different sites within a country.
- Sites with higher load factors will outperform the fleet average, however developers must weigh up other considerations e.g. grid connection point distances.
- Offshore wind load factors are consistently the highest in Europe, followed by onshore wind, while solar PV load factors are [redacted]
- Wind load factor spreads are derived from Amun, Aurora's proprietary wind valuation software, which is an advanced geospatial tool for site-specific price, revenue and economic curtailment forecasts.

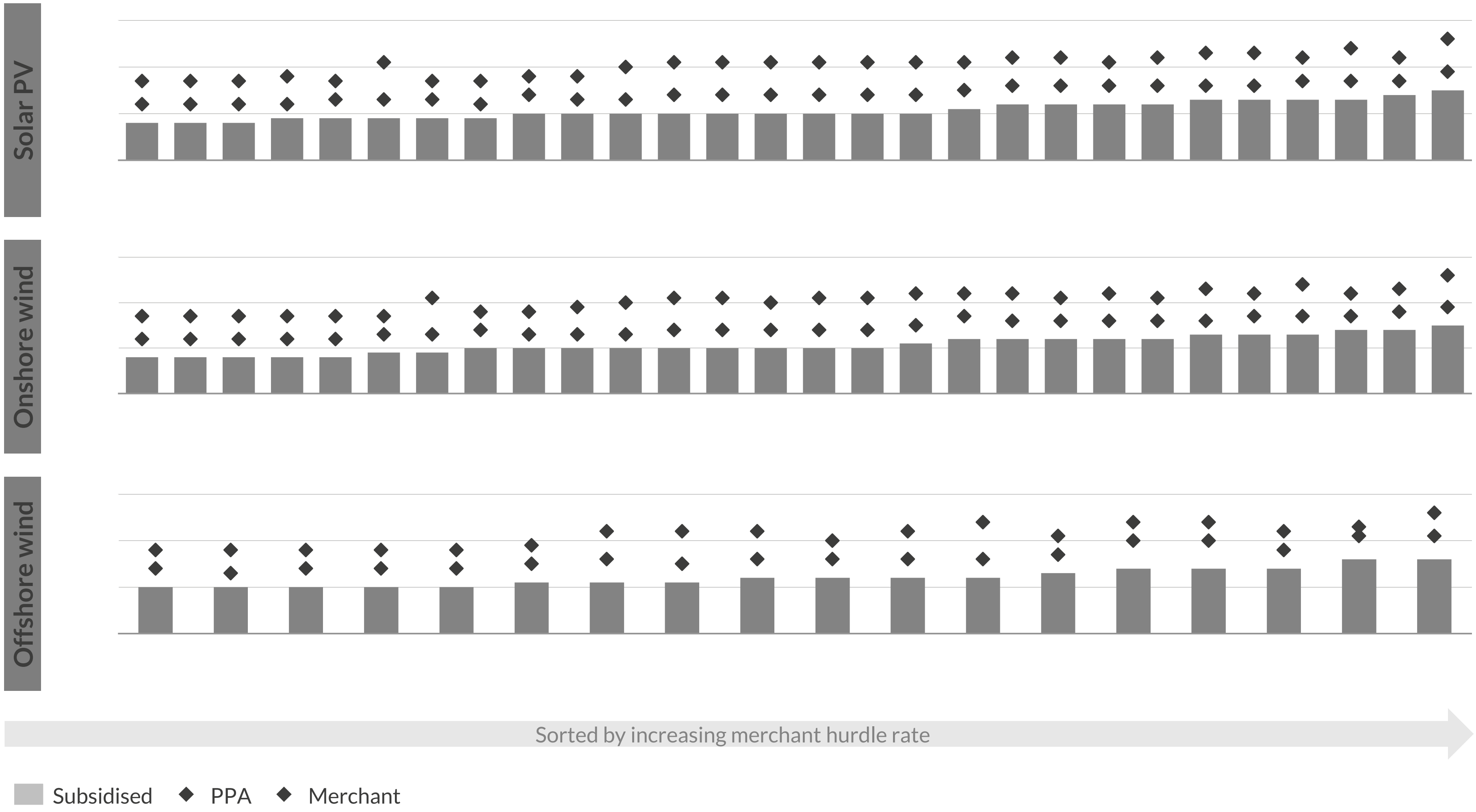
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Aurora's assumptions on costs of capital account for diverse impacts such as technology maturity and countries' financial situation

Renewables cost of capital benchmarking assumptions

%, real, unlevered, pre-tax



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

- The weighted average cost of capital (WACC) reflects the cost of financing operations reflecting the rate of return a company must achieve to satisfy both debt and equity investors.
- Aurora's in-house approach determines project WACCs on a country-average based on high-level economic drivers and financial market indicators[1], as well as technology maturity within the market, considering project buildout to date.
- The values shown on this slide should be thought of as the average benchmarking values for a full pipeline of projects. Cost of capital for particular projects varies significantly based on a variety of factors, with most competitive projects able to be financed at lower WACCs.

Agenda

AURORA

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

1. Technology trends
2. **Aurora outlook**
3. Routes-to-Market

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Aurora's renewables business cases are underpinned by a series of sophisticated assumptions and results from our fundamental model

AURORA

Covered in the previous subsection

Aurora's in-house modelling assumptions

Capital Expenditures (CAPEX)
Upfront capital costs required, split across various cost components.

Operational Expenditures (OPEX)
Fixed and variable costs to operate the asset once constructed.

Load factor
Ratio of average power output to total potential power output.

Discount rate / Weighted Average Costs of Capital (WACC)
Represents a measure of risk and varies based on Route-to-Market.

Focus of this subsection

Derived as part of Aurora's modelling

Capture prices
Realised revenues per MWh due to an asset's production profiles.

Economic curtailment
Reduced dispatched volumes due to low or negative market prices.

Imbalance costs
Price paid for incorrectly forecasted generation and fluctuations.

Guarantees of Origin (GOs)[1]
Revenues from certification scheme proving the source of electricity.

Power Purchase Agreement (PPA) prices
Fixed contracted offtake price per MWh for a set period of time.

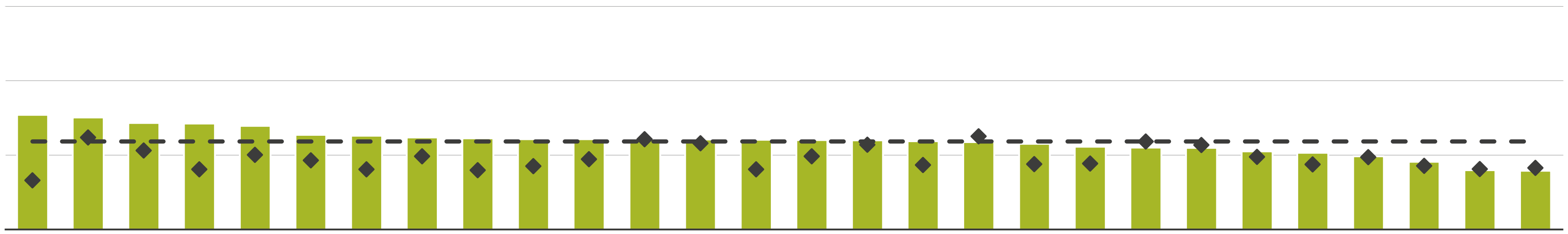
Levelised Costs of Electricity (LCOE)
Levelised cost of energy is the ratio of the total discounted costs and discounted energy production over the project lifetime.

Internal rate of return (IRR)
The expected annual rate of growth for the respective project. At this discount rate, the project's NPV would be zero.

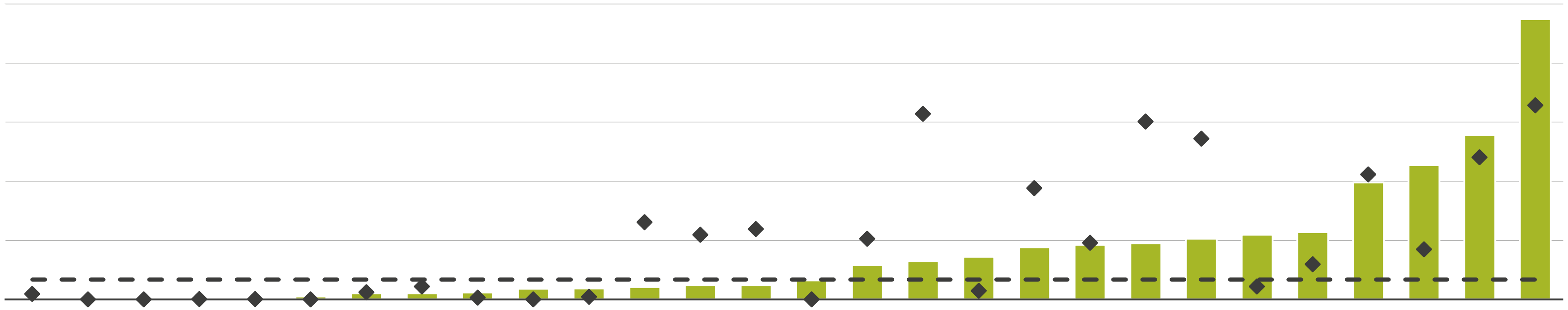
AURORA

Solar PV capture prices across Europe are expected to [redacted]

Solar capture prices[1,2] in 2030 vs 2050
€/MWh (real 2023)



Solar PV economic curtailment[2] over generation by region (2030 vs 2050)[2]
%



Sorted by decreasing capture prices and increasing economic curtailment in 2030

2030 ◆ 2050 – – European average of displayed regions (2030)

- Solar load factors are more correlated compared to wind, generally leading to lower capture prices. [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Tracking solar PV faces a [redacted]

AURORA

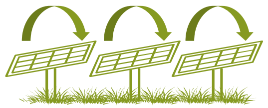
Example from [redacted]

Technology overview

Fixed solar PV

- Fixed tilt, south-facing, mono-facial solar PV modules.
- Standard south-facing assets typically have their highest energy yield around noon and have been the most commonly used modules in the past decade.

Tracking solar PV



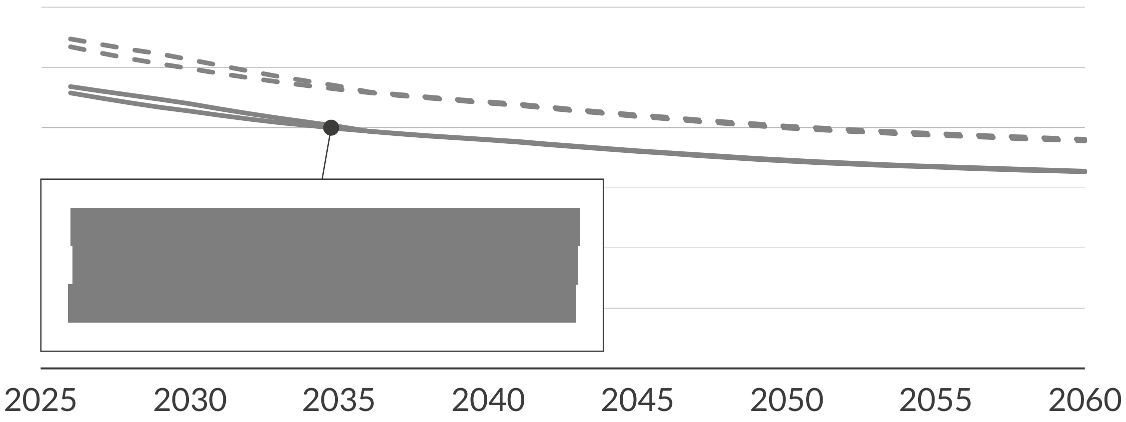
- Horizontal single-axis trackers orient solar panels to follow the sun's movement along an east-west trajectory.
- This tracking mechanism enables a broader production profile compared to fixed solar assets and increases full load hours, as the modules can generate higher energy yields throughout the day.
- However, solar tracking systems come with higher CAPEX compared to standard fixed solar PV installations.

Capture price discount to baseload price in 2030 vs 2050 - Central scenario[1]

€/MWh (real 2023)

Renewable LCOE trajectories (COD year)[2]

€/MWh (real 2023)



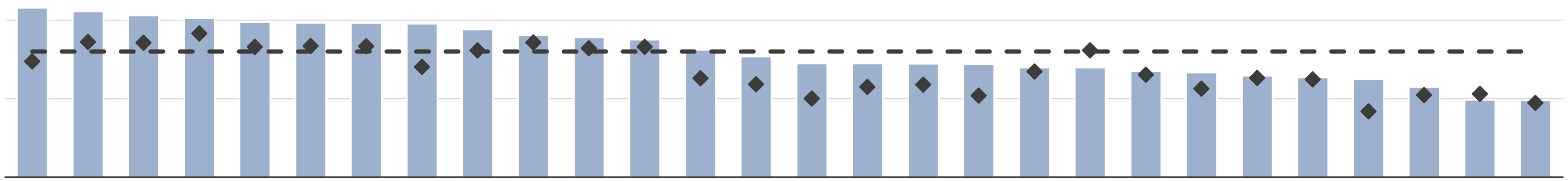
Source: Aurora Energy Research

Onshore wind economic curtailment [redacted]

AURORA

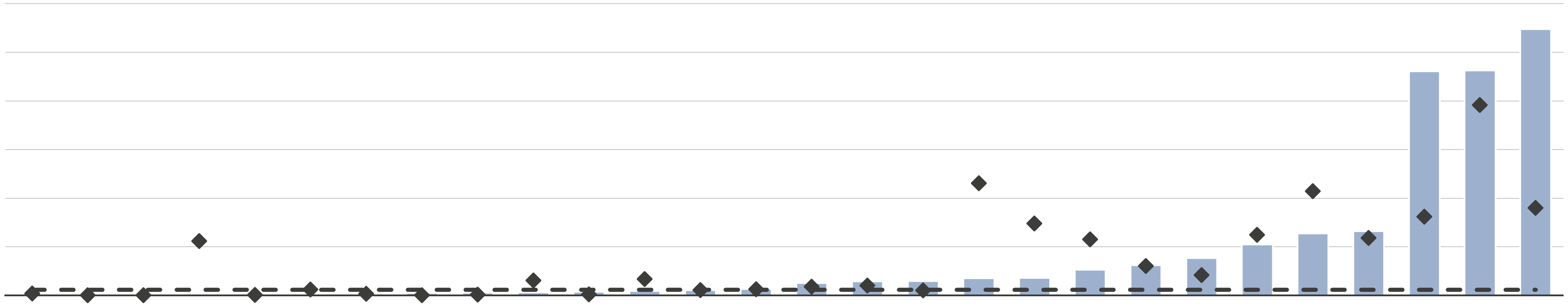
Onshore wind capture prices[1,2] in 2030 vs 2050

€/MWh (real 2023)



Onshore wind economic curtailment[2] over generation by region (2030 vs 2050)[2]

%



Sorted by decreasing capture prices and increasing economic curtailment in 2030

2030 ◆ 2050 – – European average of displayed regions (2030)

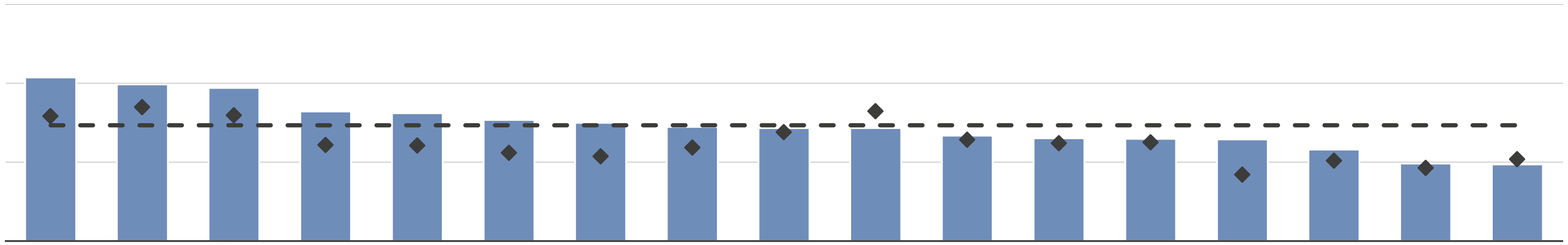
- Onshore wind sees higher capture prices [redacted]
- [redacted] sees the highest onshore wind capture price in 2030, as permitting restrictions limit buildout in the short-term.
- [redacted]
- [redacted]
- [redacted]

Source: Aurora Energy Research

Offshore wind demonstrates [redacted]

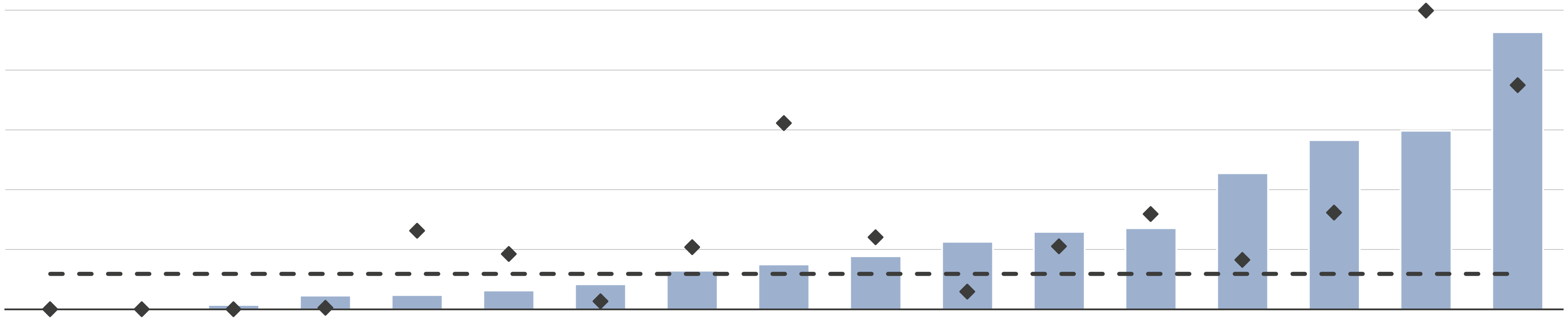
Offshore wind capture prices[1,2] in 2030 vs 2050

€/MWh (real 2023)



Offshore wind economic curtailment[2] over generation by region (2030 vs 2050)[2]

%



Sorted by decreasing capture prices and increasing economic curtailment in 2030

2030 ◆ 2050 – – European average of displayed regions (2030)

- Offshore wind capture prices on [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

In the short term, floating offshore wind [redacted]

AURORA

Example from [redacted]

Technology overview

Fixed offshore wind

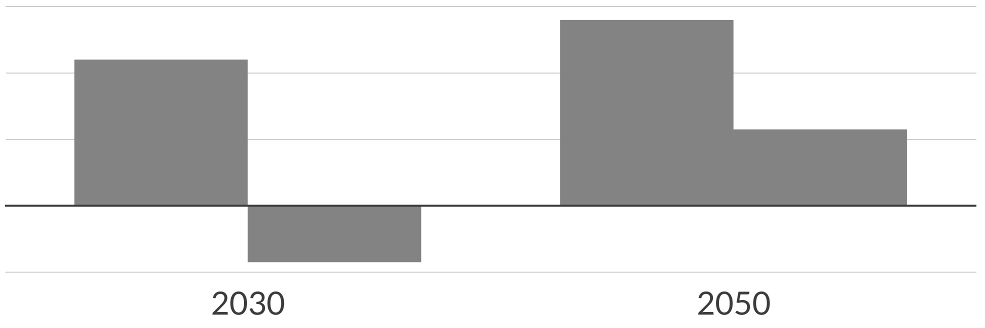
- Fixed offshore wind systems are anchored directly to the seabed through fixed foundations, typically installed in waters less than 100 meters deep.
- Fixed offshore plants tend to have higher load factors than onshore wind due to higher wind speeds.
- As 80% of global offshore wind resources are in locations too deep for fixed foundations to be financially viable, future fixed projects will face increasingly limit areas for development.

Floating offshore wind

- Floating offshore wind plants use various flotation technologies to anchor wind turbine foundations in waters at depths up to or even greater than 1000 meters. This requires installing dynamic and mooring cables.
- Floating offshore wind plants can access remote locations in deeper seas, allowing for access to higher and more consistent wind speeds, resulting in higher load factors compared to fixed offshore wind. Additionally, since floating plants can access new regions in deeper seas, they can have less correlation generation profiles relative to fixed offshore.
- However, these advantages come with significantly higher CAPEX compared to standard fixed offshore installations.

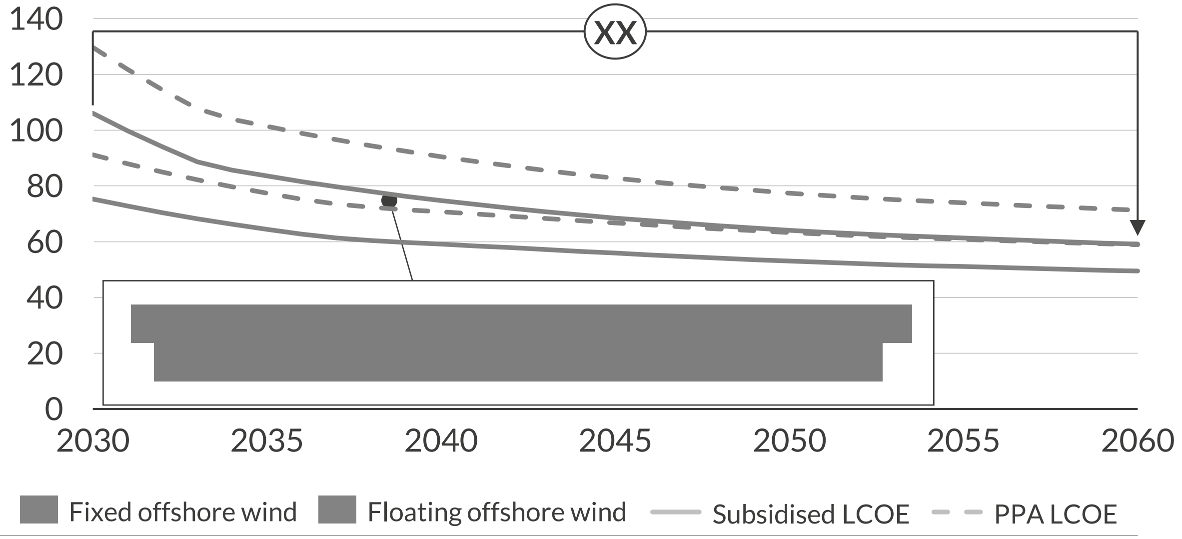
Capture price discount to baseload price in 2030 vs 2050 - Central scenario[1]

€/MWh (real 2023)



Renewable LCOE trajectories (COD year)

€/MWh (real 2023)



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Imbalance costs for 2025-2050 are expected to be highest in [redacted] for solar PV and in [redacted] for wind

AURORA

Aurora's imbalance cost methodology is covered in detail in the Appendix.

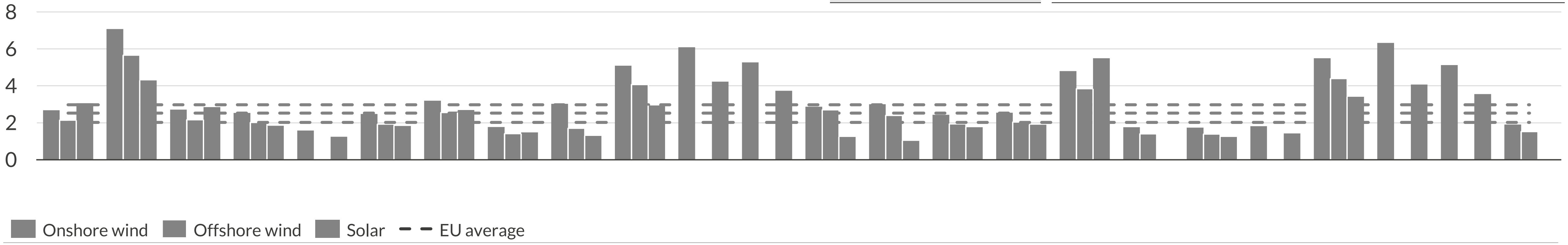
What are imbalance costs?

- Imbalance costs for renewables assets arise from the variable nature of most renewable technologies; due to imperfect foresight, the realised generation at time of delivery will deviate from the submitted schedule.
- These deviations are compensated on the intraday and balancing markets, where different energy prices apply depending on whether the production was above or below the submitted schedule.
- Prices on the intraday and balancing markets differ from wholesale prices and have to be paid by the renewable assets – the incurred costs are called imbalance costs and are usually expressed in €/MWh generated.
- To forecast imbalance costs, we combine historical developments with an estimate of future demand, supply and settlement prices.

Main drivers for imbalance costs in different countries

Value driver	Description	Likelihood	Effect
[redacted]	[redacted]	◕	↑
[redacted]	[redacted]	◕	↑
[redacted]	[redacted]	◔	↓
[redacted]	[redacted]	◕	↑
[redacted]	[redacted]	◑	↓
[redacted]	[redacted]	◑	↓

Average imbalance cost by region and technology (average 2025-50)
€/MWh (real 2023)



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

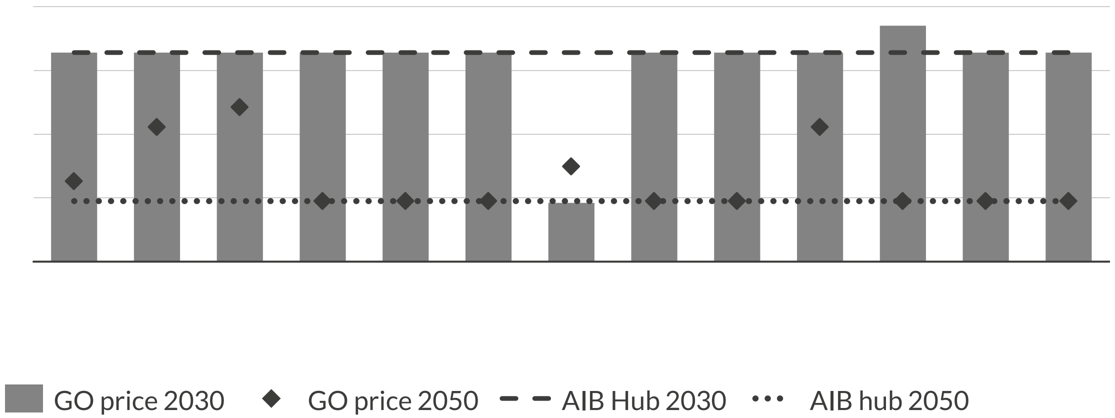
Aurora uses country-specific Guarantees of Origin prices where available and the AIB Hub reference price for other markets

Aurora's GO price methodology is covered in detail in the Appendix.

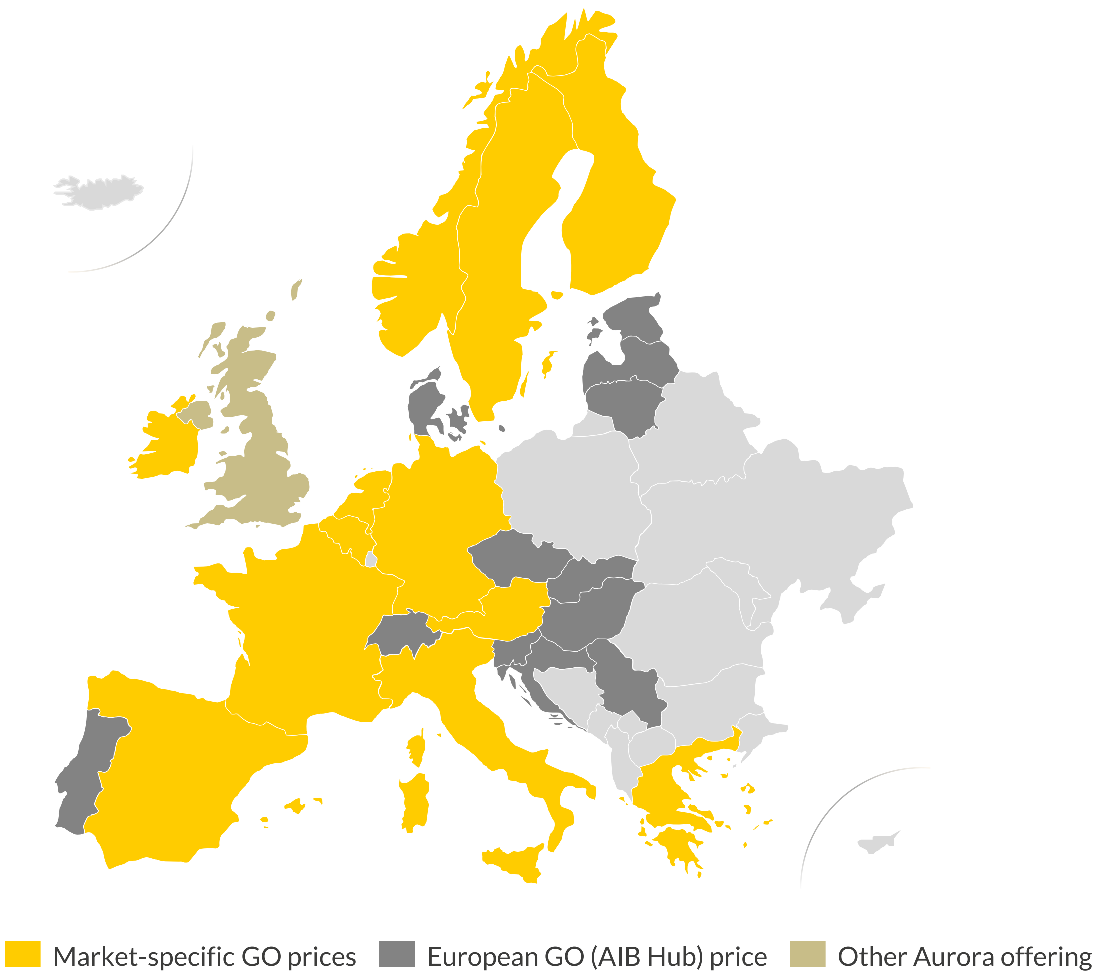
Background on Guarantees of Origin

- Guarantees of Origin (GOs) are the key energy certification system in Europe, used by energy consumers to certify the source of their consumption.
- Not all markets in Europe are part of the Association of Issuing Bodies (AIB)[1] and some markets see a price premium for regionality, which is why we are using different prices for different countries:
  - For the 13 markets which are covered in detail in Aurora's certificate modelling, we use market-specific prices[2].
  - For markets which are part of the GO scheme but for which Aurora does not provide detailed prices, we assume the average AIB / continental price.
  - For all other markets, we assume that GOs are not available.

Guarantees of Origin price
€/MWh (real 2023)



Visual representation of certificate prices used per market in this report



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

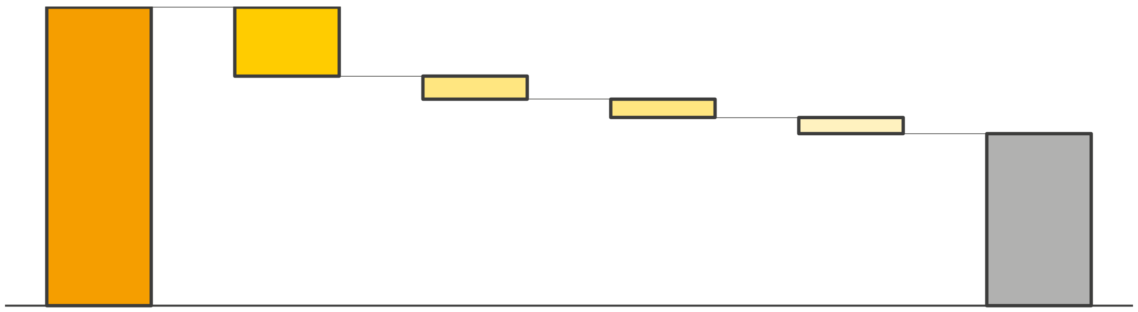
Aurora's utility PPA valuation accounts for price risks and hedging costs, resulting in a fundamental PPA reference price

AURORA

Aurora's PPA price methodology is covered in detail in the Appendix.

PPA reference price calculation: waterfall components

€/MWh (illustrative)



1 Expected revenues from baseload market prices[3]

2 Difference in asset's generation vs. baseload, incl. weather risk

3 Expected rolling losses given the market liquidity and strategy[4]

4 Risk discount reflecting uncertainty in market price[5]

5 Risk discount reflecting other risk factors not explicitly priced into risk factors above, calibrated with market price quotes

Selected drivers with the potential to affect fleet-wide PPA prices

Value driver	Description	Probability	Effect
[redacted]	[redacted]	◔	↑
[redacted]	[redacted]	◑	↓
[redacted]	[redacted]	◔	↑
[redacted]	[redacted]	◑	↓
[redacted]	[redacted]	◔	↑

↑ Effect on prices

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

In European markets, fixed-price long-term PPAs following a pay-as-produced pattern are most desirable for sellers

AURORA

Commercial clause	Description	Who holds the risk? *Seller* – *Offtaker*
Price clauses		
Fixed price	Fixed long-term price, offtaker takes on full price risk	[redacted]
Collared	Price follows capture price, contract guarantees a max/min price	[redacted]
Floating/Indexed price	Price linked to baseload index, offtaker only takes on capture price cannibalisation risk	[redacted]
Tenor clauses		
Short term (<=5 years)	Suitable if no debt financing required or secured differently (e.g. via CfD)	[redacted]
Medium term (6 - 9 years)	Allows debt financing for smaller merchant projects with low leverage	[redacted]
Long term (>9 years)	Allows for highly debt-leveraged finance	[redacted]
Volume clauses		
Baseload	Asset delivers power at a pre-agreed fixed pattern	[redacted]
Monthly % of P90	Asset(s) guarantees minimum pattern	[redacted]
As produced / as forecasted	Offtaker receives asset generation profile	[redacted]

Seller's perspective – desired clauses

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

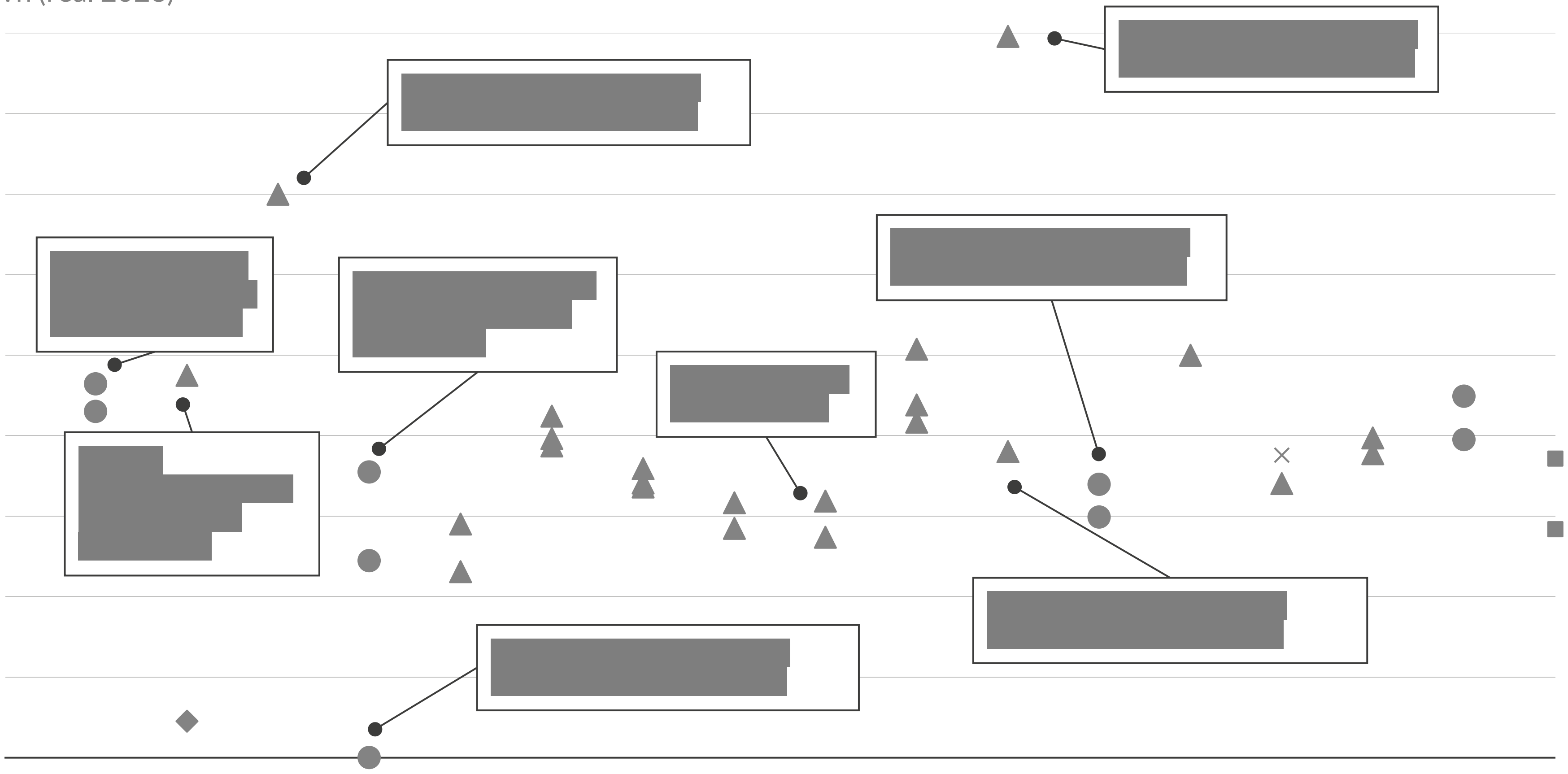
Source: Aurora Energy Research

Due to the variety in national subsidy scheme designs and technology requirements, RES auction strike prices differ strongly across Europe

AURORA

Historical auction strike prices per market and technology[1,2]

€/MWh (real 2023)



Solar PV Onshore Wind Offshore Wind

● Sliding feed-in premium ▲ Two-sided CfD ◆ Green certificates only ■ Fixed feed-in premium × CfD with merchant exposure

- Strike prices achieved vary strongly between markets and technologies, driven by competition levels, design and participants' strategic interests, potentially leading to counterintuitive results:
  - [redacted]
  - [redacted]
  - [redacted]
- Underlying auction volumes, which can strongly affect levels of competition, are ignored here.

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, national registries

Agenda

AURORA

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

1. Technology trends
2. Aurora outlook
3. **Routes-to-Market**
   i. Merchant
   ii. Subsidised
   iii. PPAs

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Contracts for Difference and Power Purchase Agreements are becoming the dominant route to market in Europe for renewables

AURORA

Subsidised

National subsidy schemes

Economic support implemented by governments to boost business cases of strategic technologies

- Subsidy schemes can take various forms and have changed severely in Europe over the past decades; current prominent ones include:
  - [redacted]
  - [redacted]
- Schemes change over time and available volumes differ based on government ambition.

PPA-backed

Power Purchase Agreements

Long-term contracts between producers and offtakers for a fixed energy price

- This setup ensures long-term revenue stability as well but has additional risks compared to subsidies, such as the offtaker's creditworthiness and legal constraints.
- Potential loss of capture price upside due to off-taker price discounts; compensated for by lower costs of capital and higher leverage.
- PPAs play significant role in financing in mature markets like [redacted]

Merchant

Reform of the electricity market

Assets fully rely on market developments and are exposed to market risks

- Fully merchant assets trade all their volume on the market and are exposed to all risks; financing is solely dependent on how attractive market prices are expected to be.
- [redacted] markets already see merchant buildout.
- Uptake might increase if developers hedge against some merchant risks with innovative set-ups such as BESS co-located projects.

Representative hurdle rates for solar PV and onshore wind in Europe[1]

%, real, pre-tax, unlevered

[redacted]% [redacted]% [redacted]%

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

While subsidised assets offer the lowest risk of all routes to market considered, this is partly outweighed by lower potential revenues

AURORA

As part of this report, we generally classify the routes to market into distinct categories. In reality, mixed options are possible and often in use. This can include subsidy schemes which allow for capacity to be contracted under PPAs or PPAs with varying degrees of merchant exposure, leading to a mix of the results below.

Consideration	Description	Subsidised	PPA-backed	Merchant
Financing conditions	[redacted]	◕ [redacted]	◑ [redacted]	◔ [redacted]
Ease of market entry	[redacted]	◑ [redacted]	◑ [redacted]	◔ [redacted]
Potential revenues	[redacted]	◑ [redacted]	◕ [redacted]	● [redacted]

Sorted by increasing risk →

● High attractiveness ◑ Medium attractiveness ◔ Low attractiveness

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

In order to make the business cases in this report comparable, we have made a series of uniform assumptions for the different routes to market

AURORA

All variables not explicitly covered here will be used as shown on the previous slides and can be found in detail in the data book corresponding to this report.

Parameter	Description	Value
COD[1] merchant case	Start year of operations for merchant analysis	2028
Aurora Scenario	Aurora in-house modelling scenario	Aurora Central
Asset lifetime	Assumed economic lifetime of the asset	27-32 years (depending on the country)
Technology	Exact technology setup assumed if multiple options are available	Fixed solar PV, Onshore wind, Fixed offshore wind
Curtailment	Types of curtailment accounted for in energy volumes and capture prices	Economic curtailment[2]
Subsidy strike price	The strike price assumed for the subsidised business case	Strike price of the last national auction
PPAs	Specifics of the PPA contract	Representative of country specifics, all entry year 2025
Capacity market price	Source of capacity market prices where available	Based on Aurora's modelling (depending on the market)

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

AURORA

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

1. Technology trends
2. Aurora outlook
3. Routes-to-Market

V. Risks & Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Merchant business cases for solar PV projects, with entry year in 2028, is viable in [redacted]

AURORA

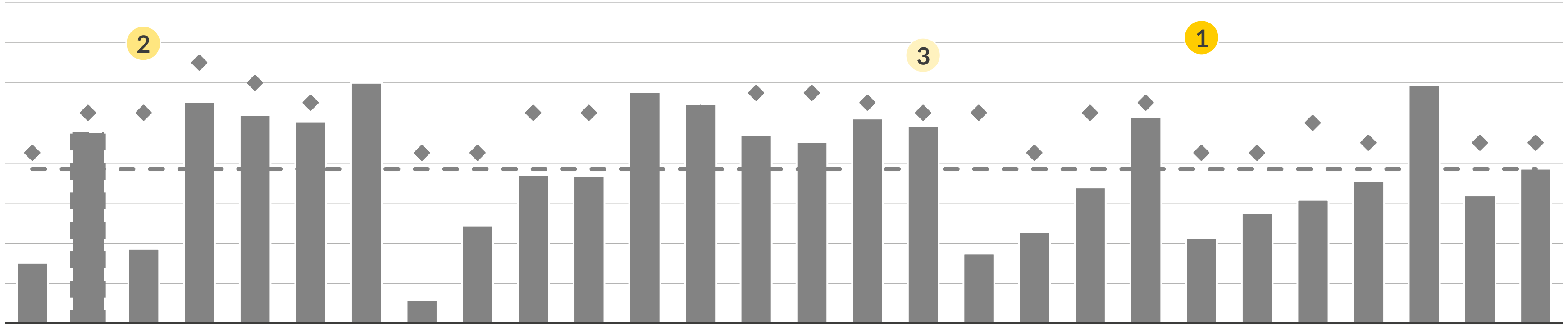
Solar PV

Merchant

The numbers on this slide display reference values for the respective technology, route-to-market and market. The results for individual projects can differ significantly, i.e. due to regional cost differences, load factors and financing structuring.

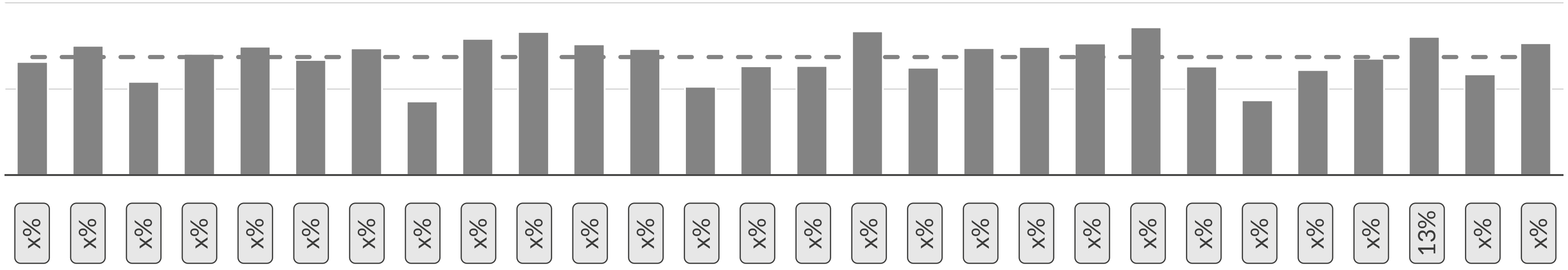
Project IRR, entry year 2028[1]

%, pre-tax, unlevered, real 2023, Central scenario[2]



LCOE, entry year 2028[1]

€/MWh (real 2023), Central scenario[2]



Reference IRR – – Average IRR ◆ Reference hurdle rate LCOE x Load factor[1] x Three highest reference IRRs

- [redacted] benefit from load factors between [redacted]–[redacted]%, whilst [redacted] has significantly high capture prices in the market, leading to IRRs clearing the hurdle rate in these markets.
- [redacted], have a significant pipeline of merchant projects exists in the market despite not reaching desired hurdle rates in this analysis.
- In most instances, the merchant projects in these markets are reflective of the premium sites in the region, which benefit from favourable load factors, costs and lower cost of capital as a result of larger utilities financing off balance sheets.
- [redacted] see low reference IRRs for solar PV because of low overall load factors, particularly in winter.

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

However, in all markets with subsidy schemes, despite the lower revenues, subsidies provides a viable route-to-market for solar PV

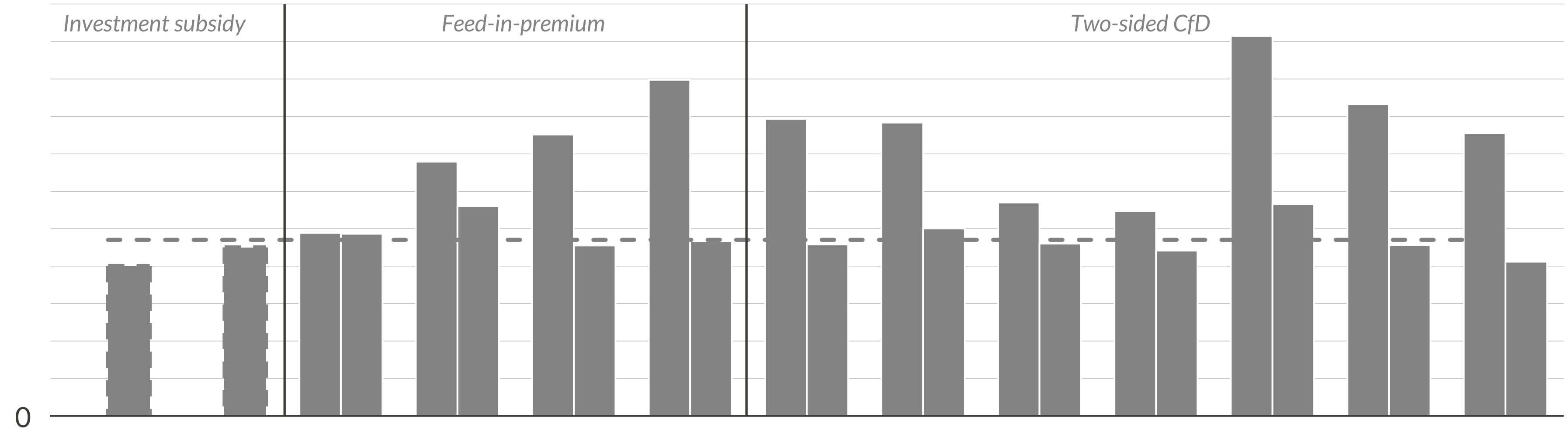
AURORA

Solar PV

Subsidised

The numbers on this slide display reference values for the respective technology, route-to-market and market. The results for individual projects can differ significantly, i.e. due to regional cost differences, load factors and financing structuring.

LCOE for COD 2028 and most recent auction strike price[1]
€/MWh (real 2023)[2]



Costs of capital assumed
%, real, unlevered, pre-tax

x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%

Annual asset load factor
%

x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%

Auction strike price | LCOE | Average LCOE | x Costs of capital | x Load factor[1]

- Developers, when bidding into subsidy support auctions, will bid in at least at their minimum economic strike price to achieve the desired hurdle rate over the project lifetime.
- Strike prices in markets like [redacted] are only partially indexed against inflation, requiring a premium in bids to account for inflation risk.
- In addition, markets with high curtailment need to factor in this generation risk to their bids, which materially increases bid prices in [redacted]
- Investment subsidies in [redacted] could provide attractive routes to market, but projects face regulatory hurdles.
- Additional markets, i.e. [redacted], might develop new auctions for co-located solar PV, which could offer attractive opportunities.

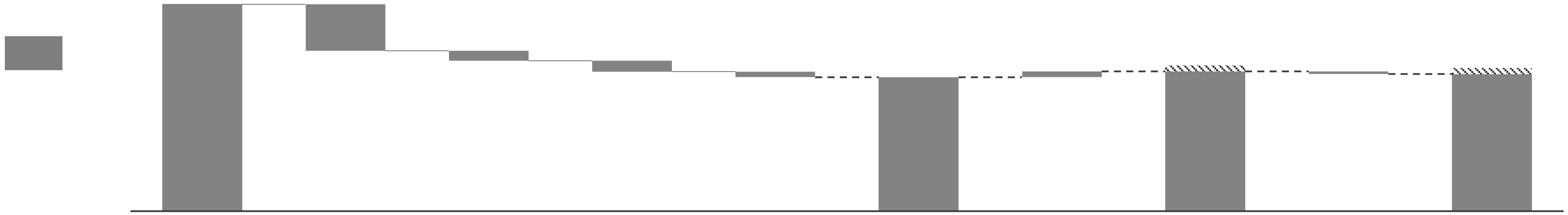
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

PPAs can offer an alternative route to market for Solar PV projects in Europe, with PPA prices between [redacted]-[redacted] €/MWh for select regions

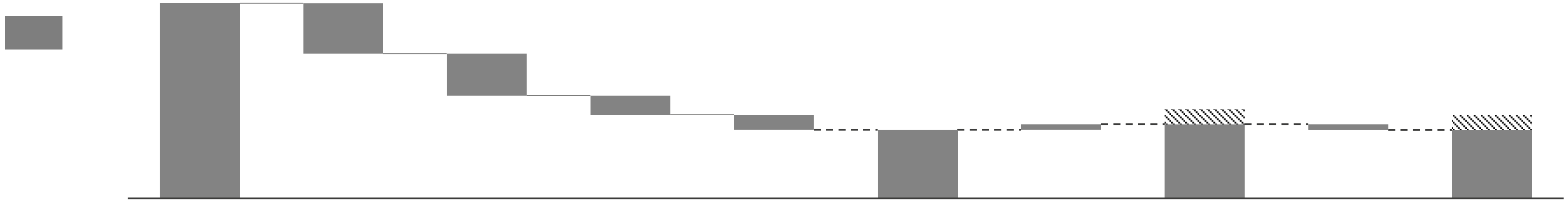
Solar PV

PPA-backed

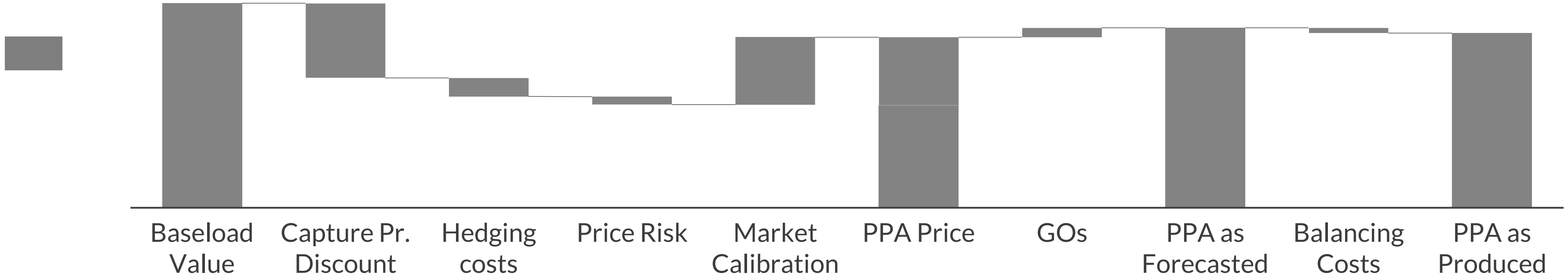
PPA Price benchmark for solar PV, 10-year contract starting in 2025
€/MWh (Nominal values)



PPA Price benchmark for solar PV, 10-year contract starting in 2025
€/MWh (Nominal values)



PPA Price benchmark for solar PV, 20-year contract starting in 2025
€/MWh (Nominal values)



- The largest factors driving the price of a pay-as-produced PPA are baseload prices and the capture rate of the contracted technology.
- Solar PV sees [redacted]
- [redacted]
- [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research

AURORA

Onshore wind

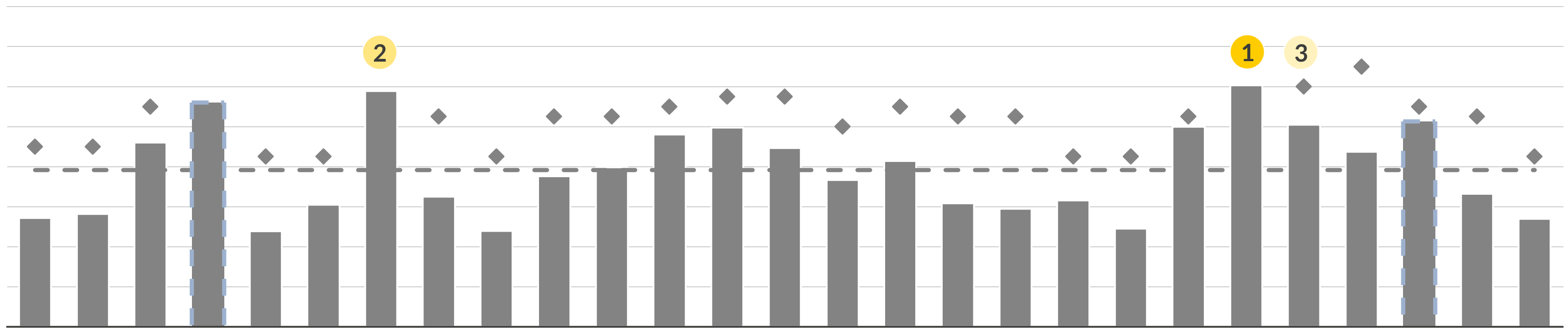
Merchant

Merchant business cases for onshore wind projects, with entry year in 2028, is only viable in [redacted]

The numbers on this slide display reference values for the respective technology, route-to-market and market. The results for individual projects can differ significantly, i.e. due to regional cost differences, load factors and financing structuring.

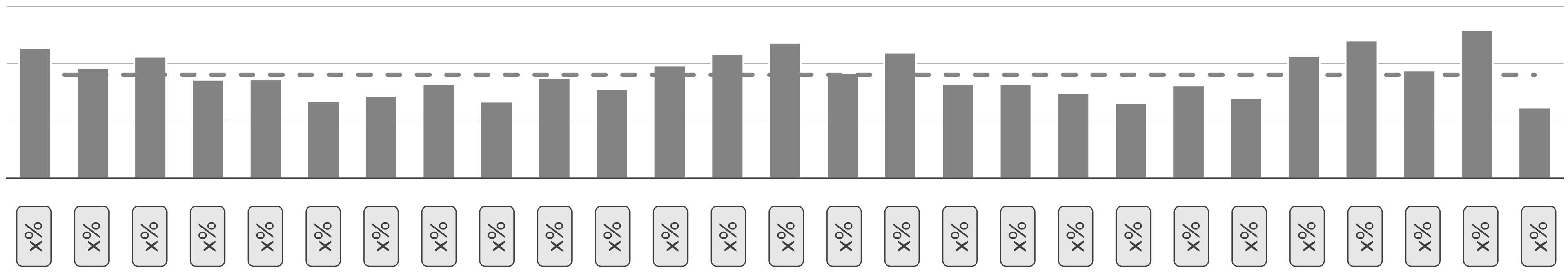
Project IRR, entry year 2028[1]

%, pre-tax, unlevered, real 2023, Central scenario[2]



LCOE, entry year 2028[1]

€/MWh (real 2023), Central scenario[2]



Reference IRR – – Average IRR ◆ Reference hurdle rate LCOE x Load factor[1] x Three highest reference IRRs

- [redacted] see the highest merchant project IRRs, driven by low CAPEX and high load factors, [redacted]
- [redacted]
- Markets in [redacted] see high IRRs driven by low costs, but hurdle rate ranges differ severely, hampering project feasibility.
- Switzerland is not included in this analysis because, although there is some theoretical possibility for onshore wind, development can take 20+ years in current regulation and the technology is not expected to play a major role.

However, in most markets with subsidy schemes, subsidies provide a viable RtM depending on the level of competition and strike prices

AURORA

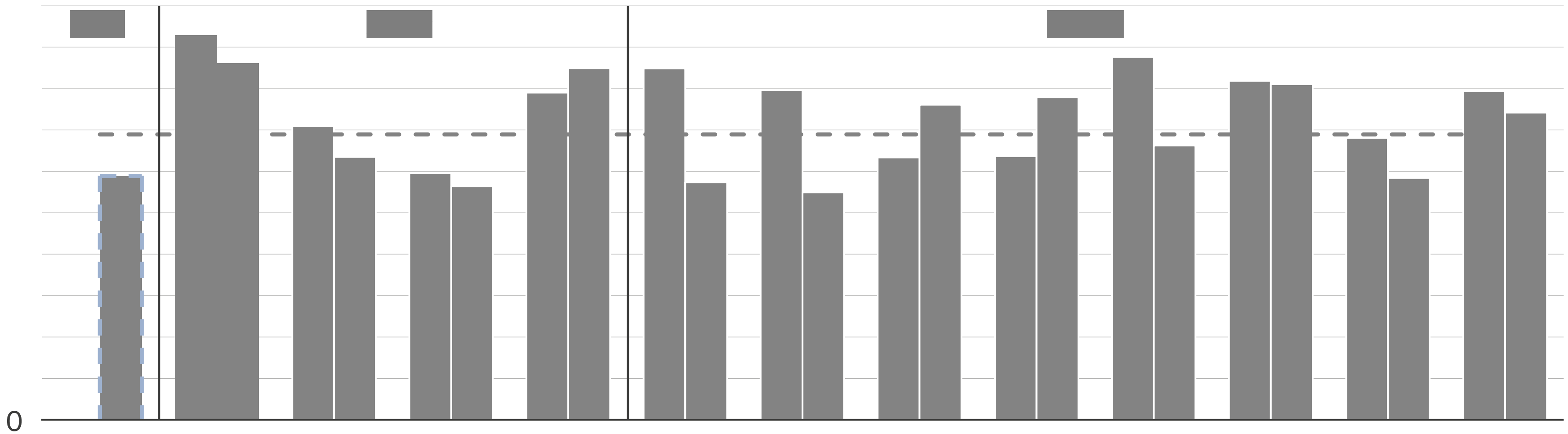
Onshore wind

Subsidised

The numbers on this slide display reference values for the respective technology, route-to-market and market. The results for individual projects can differ significantly, i.e. due to regional cost differences, load factors and financing structuring.

LCOE for COD 2028 and most recent auction strike price[1]

€/MWh (real 2023)[2]



Costs of capital assumed

%, real, unlevered, pre-tax

x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%

Annual asset load factor

%

x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%	x%

Auction strike price | LCOE | Average LCOE | x Costs of capital | x Load factor[1]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

- [redacted] and [redacted] saw recent auctions strike prices close to, or above, the LCOEs, indicating similar strike prices will be required for future auction years.
- In addition, depending on the future auction volumes and level of competition, it's likely that only the premium projects, with favourable wind conditions and costs will be successful in upcoming auctions.
- In all other regions, future prices could be lower but key factors such as indexation and curtailment need to be considered on top of LCOEs
- Strike prices in [redacted]

AURORA

Onshore wind

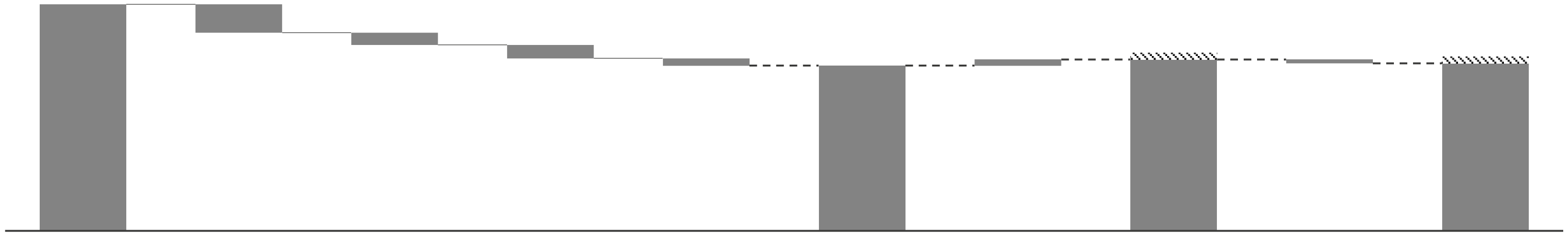
PPA-backed

PPAs can offer an alternative route to market for Solar PV projects in Europe, with PPA prices between [redacted]–[redacted] €/MWh for select regions

PPA Price benchmark for solar PV, 10-year contract starting in 2025

€/MWh (Nominal values)

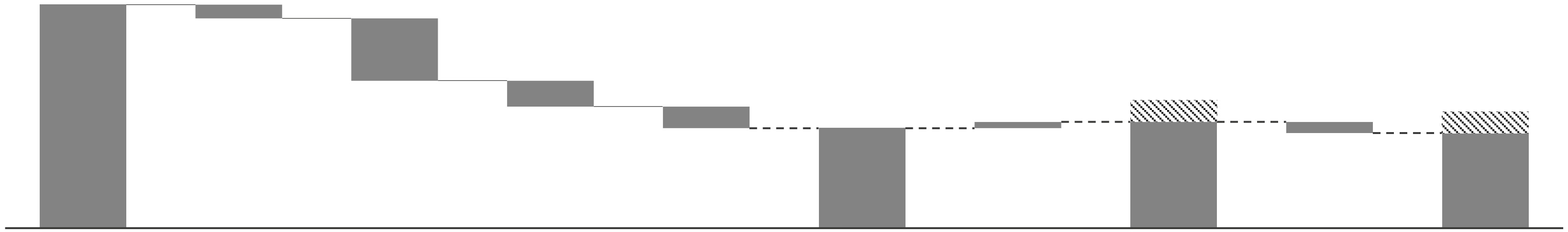
[redacted]



PPA Price benchmark for solar PV, 10-year contract starting in 2025

€/MWh (Nominal values)

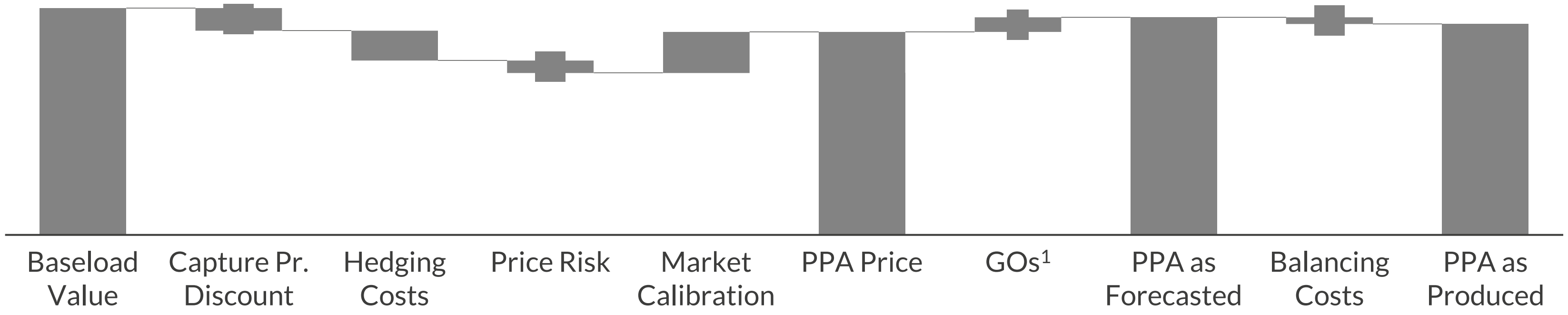
[redacted]



PPA Price benchmark for solar PV, 20-year contract starting in 2025

€/MWh (Nominal values)

[redacted]



- The largest factors driving the price of a pay-as-produced PPA are baseload prices and the capture rate of the contracted technology.
- Hedging costs and price risks vary across regions, based on level of uncertainty in the market and expected rolling losses based on liquidity and strategy.
- Combining PPAs with other Route to Markets, such as CfDs, provides an alternative route to market.
- In [redacted], the CfD scheme allows for the combination of subsidies and PPAs, which can lead to higher IRRs and lower hurdle rates required due to less assumed project risk, leading to project viability.

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

[redacted] are the key route-to-market for offshore wind in Europe [redacted]

Offshore wind

Subsidised

The numbers on this slide display reference values for the respective technology, route-to-market and market. The results for individual projects can differ significantly, i.e. due to regional cost differences, load factors and financing structuring.

LCOE for COD 2030 and most recent CfD auction strike price[1]
€/MWh (real 2023)[2]

Costs of capital assumed
%, real, unlevered, pre-tax

x%	x%	x%	x%	x%	x%

Annual asset load factor
%

x%	x%	x%	x%	x%	x%

Auction strike price · LCOE · Average LCOE · x Costs of capital · x Load factor[1]

- Offshore auction bids are often based on both fundamentals and strategic interests; the latter are not captured here. Whilst LCOEs represent an average reference project in the markets, with 2030 entry year.
- [redacted] saw recent auctions clearing at strike prices close to, or above, the LCOEs, indicating similar strike prices will be required for future auction years.
- In addition, depending on the future auction volumes and level of competition, it's likely that only the premium projects, with favourable wind conditions and costs will be successful in upcoming auctions.
- [redacted] and [redacted] could expect lower auction prices as a result of lower LCOEs, relative to recent auction strike prices.

Source: Aurora Energy Research

Agenda

AURORA

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

AURORA

Executive Summary

Risks & opportunities

- Renewables in Europe are facing a growing set of systematic and unsystematic risks, caused by global trends, as well as a reducing willingness by policy makers for the state to cover all risks, both for subsidised and merchant assets.
- As part of this report, Aurora has looked into three specific risks to the intermittent RES business cases which are of current interest in European markets:
  - **Market saturation:** [redacted]
  - **Negative prices:** [redacted]
  - **Grid congestion:** [redacted]
- Asset operators can look deeper into various options to make their assets more profitable and resilient against some of the prominent risks, of which we have investigated 3 opportunities in more detail:
  - **Portfolio diversification:** [redacted]
  - **Additional revenue streams:** [redacted]
  - **Co-location:** [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & opportunities

1. Risks
2. Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

Renewable projects are exposed to a variety of risks; this section will explore market saturation negative prices and congestion in detail

AURORA

Risk	Risk category	Description
1 Market saturation	Market	[redacted]
2 Negative prices	Market	[redacted]
Weather risk	Market	[redacted]
Lower demand growth	Market	[redacted]
Commodity prices	Market	[redacted]
Grid queues	Development	[redacted]
Construction risk	Development	[redacted]
Inflation	Development	[redacted]
Permitting risk	Development	[redacted]
Cost risks	Development	[redacted]
Supply chains	Policy	[redacted]
3 Grid congestion	Policy	[redacted]
Regulatory changes	Policy	[redacted]

X Deep dive on following slides

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

[redacted]

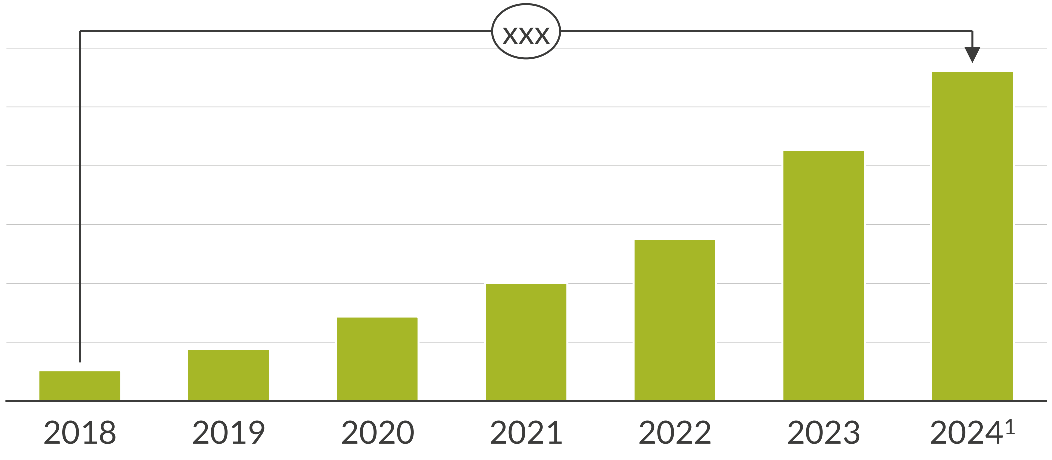
AURORA

1 Market saturation

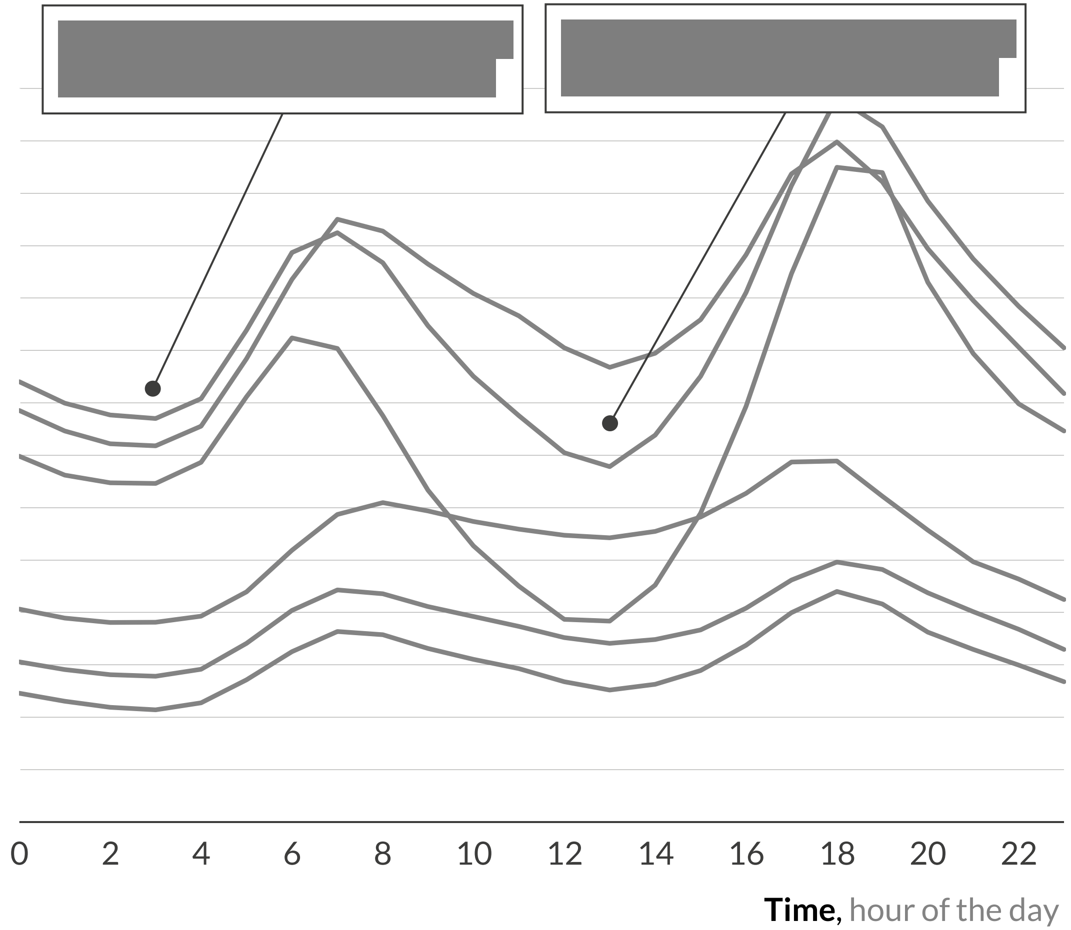
Countries speed up renewables deployment to strengthen energy security and meet climate targets, resulting in stronger-than-expected price pressure

- Large renewable capacities increase the risk of frequent periods of oversupply with simultaneous wind and solar generation pushing down market prices.
- Higher government ambitions or potentially more severe reductions in future CAPEX costs could lead to higher buildout volumes than anticipated.
- Market saturation emphasizes the need for energy storage and flexibility (e.g., demand response), though these technologies are not yet deployed at sufficient scale to cushion prize cannibalisation.

Installed total solar PV capacity in Germany
GW



Average day ahead price per year[2] and hour of the day in [redacted]
€/MWh (nominal)



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research, ENTSO-E, Fraunhofer ISE

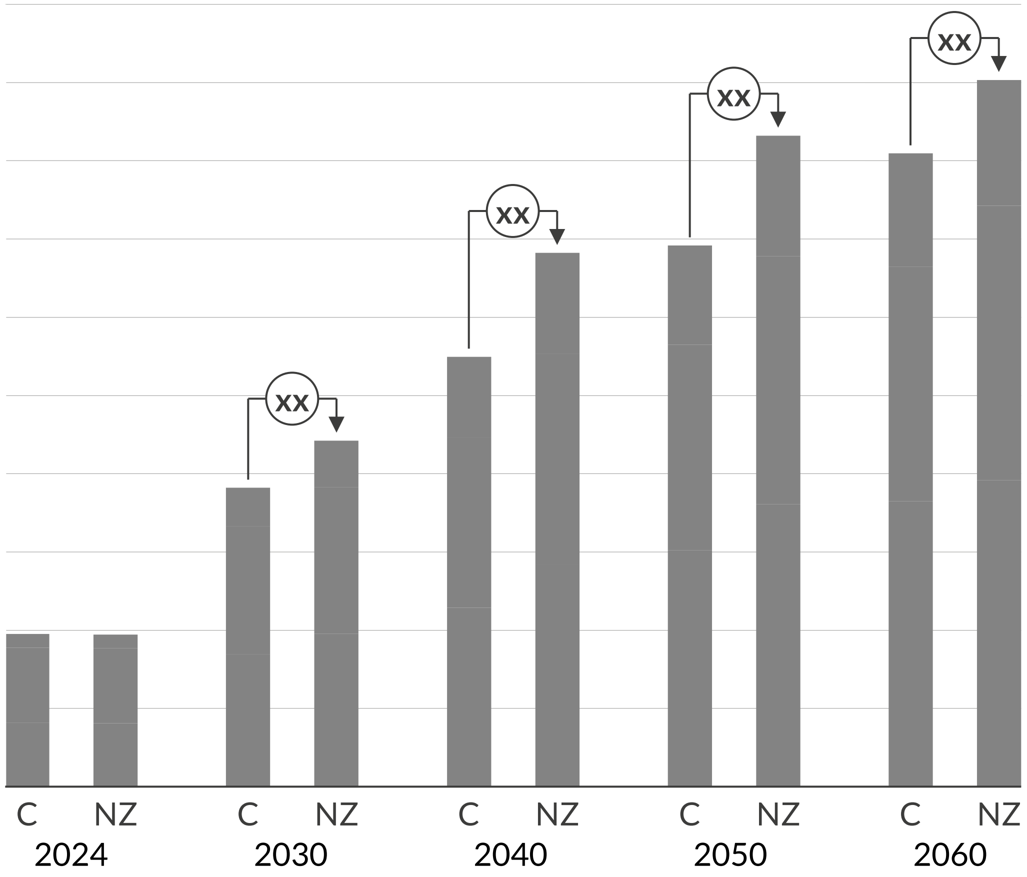
We use Aurora‘s Net Zero scenario to test the impact of a major acceleration of RES deployment, in line with government targets

AURORA

1 Market saturation

Installed renewable capacity in Europe Central (C) vs. Net Zero (NZ)[1]

TW

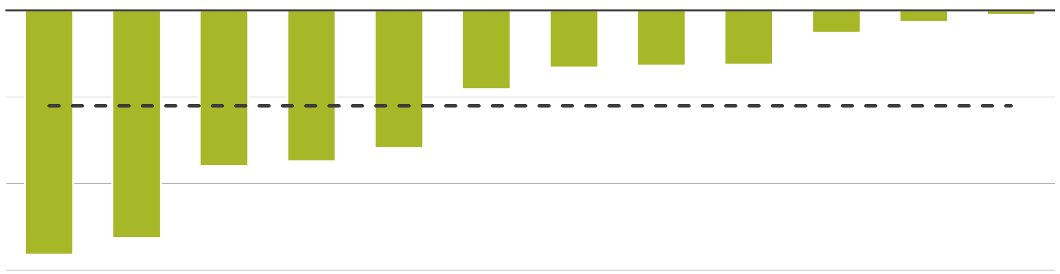


Policy support drives renewables expansion, but average capture prices decrease in the medium term due to lagging system flexibility

- Aurora Net Zero[1] anticipates policy support for carbon neutrality technologies and rising demand driven mostly by electrolysers and the electrification of heating and transport.
- In this scenario, variable renewable capacity in Europe is [redacted] higher than in Central by 2060, making up [redacted] of total system capacity. The biggest growth relative to Central is in onshore wind, which increases by [redacted]
- Along with accelerated buildout of renewables, Aurora Net Zero foresees a stronger growth of flexible capacities to support system integration.
- However, this will not fully offset price cannibalization, and we [redacted] compared to Aurora Central.

Average yearly difference in solar PV capture prices[2] - Central vs. Net Zero

%



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Markets most affected by the risk of [redacted] on the merchant side are [redacted]

1 Market saturation

The deltas show how assuming Aurora's Oct 24 Net Zero scenario instead of the Aurora Central scenario for merchant assets impacts IRRs for the 4 most affected markets per technology. While this scenario often sees higher RES buildout and lower capture prices, electrification leads to a hampered effect of more RES capacity coming online.

Delta in merchant IRR[1] – [redacted]
base percentage, real, unlevered, pre-tax

Delta in merchant IRR[1] – [redacted]
base percentage, real, unlevered, pre-tax

Delta in merchant IRR[1] – [redacted]
base percentage, real, unlevered, pre-tax

- The solar PV business case in this sensitivity is most affected in [redacted], where the reference IRR [redacted]%, as this scenario sees significantly higher auctioned RES capacities, exerting downward pressure on wholesale prices.
- [redacted] have higher installed solar PV capacity in Aurora's Net Zero scenario to make up for the combination of higher demand and faster decarbonisation timelines.

- Markets most affected for onshore and offshore wind are [redacted] and [redacted], resulting from the major role wind is playing in these markets in our forecast[5]:
  - [redacted]
  - [redacted]
- [redacted] sees a significantly higher deployment of onshore wind in the Net Zero scenario to reach government targets, with [redacted] installed in 2035, compared to [redacted] in Aurora's Central scenario.

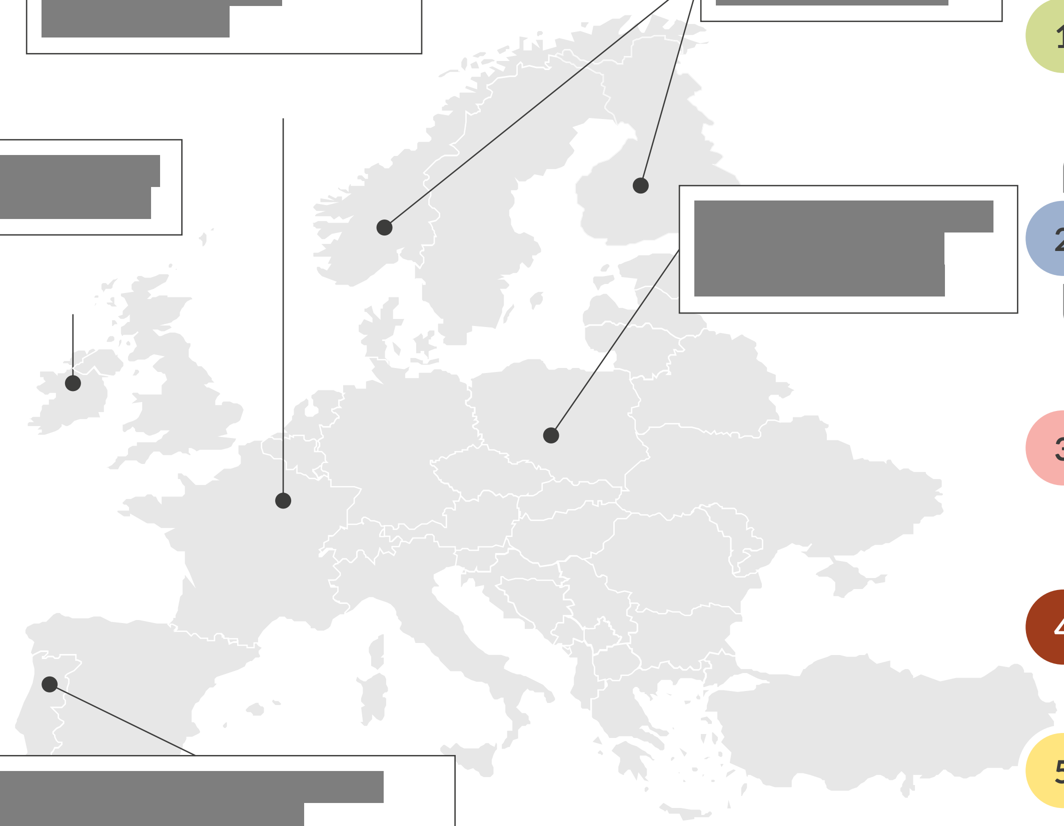
This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Over the past 5 years, negative prices have generally fallen into one of 5 categories, often acting at the same time

The drivers for negative prices shown here aim to outline the most relevant force on a higher level per market. In reality, several of them often occur together and are linked, leading to a single driver rarely being responsible for all negative prices in a market.

Key drivers for negative prices per market[1]



[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1 [redacted]

2 [redacted]

3 [redacted]

4 [redacted]

5 [redacted]

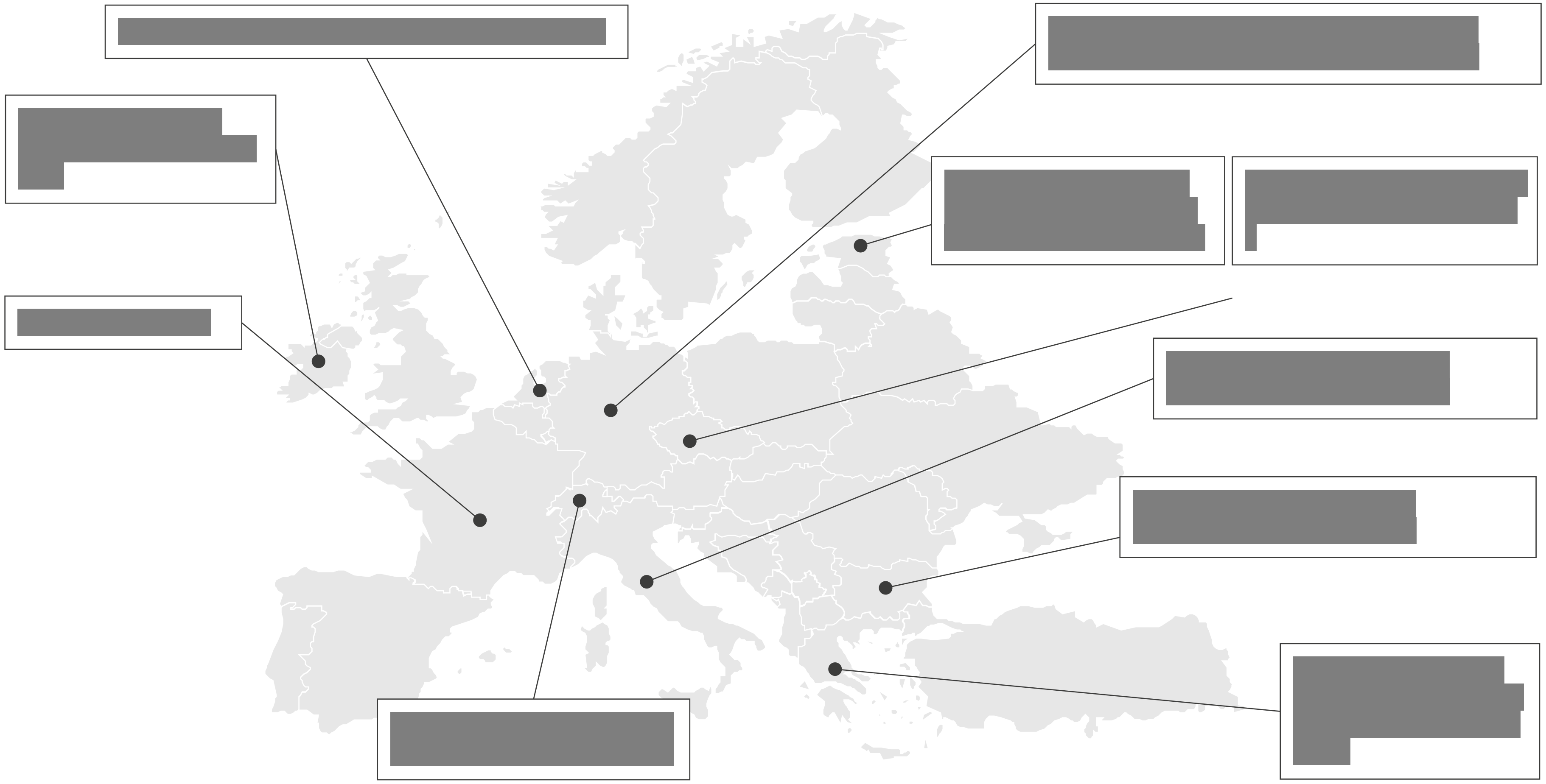
Source: Aurora Energy Research

Most European markets use [redacted] approach to protect RES assets under subsidies from negative prices

AURORA

2 Negative prices

Protection of solar PV and onshore wind assets from negative market prices in national subsidy schemes



No exposure | Some exposure | Full exposure | No subsidies, full exposure | No information | Some exposure (x-hour rule variation)

- Although multiple countries have offered protection against negative price hours in past iterations of their subsidy schemes, most governments have by now [redacted]
- A prominent approach is the [redacted]
- [redacted]
- [redacted]

Source: Aurora Energy Research

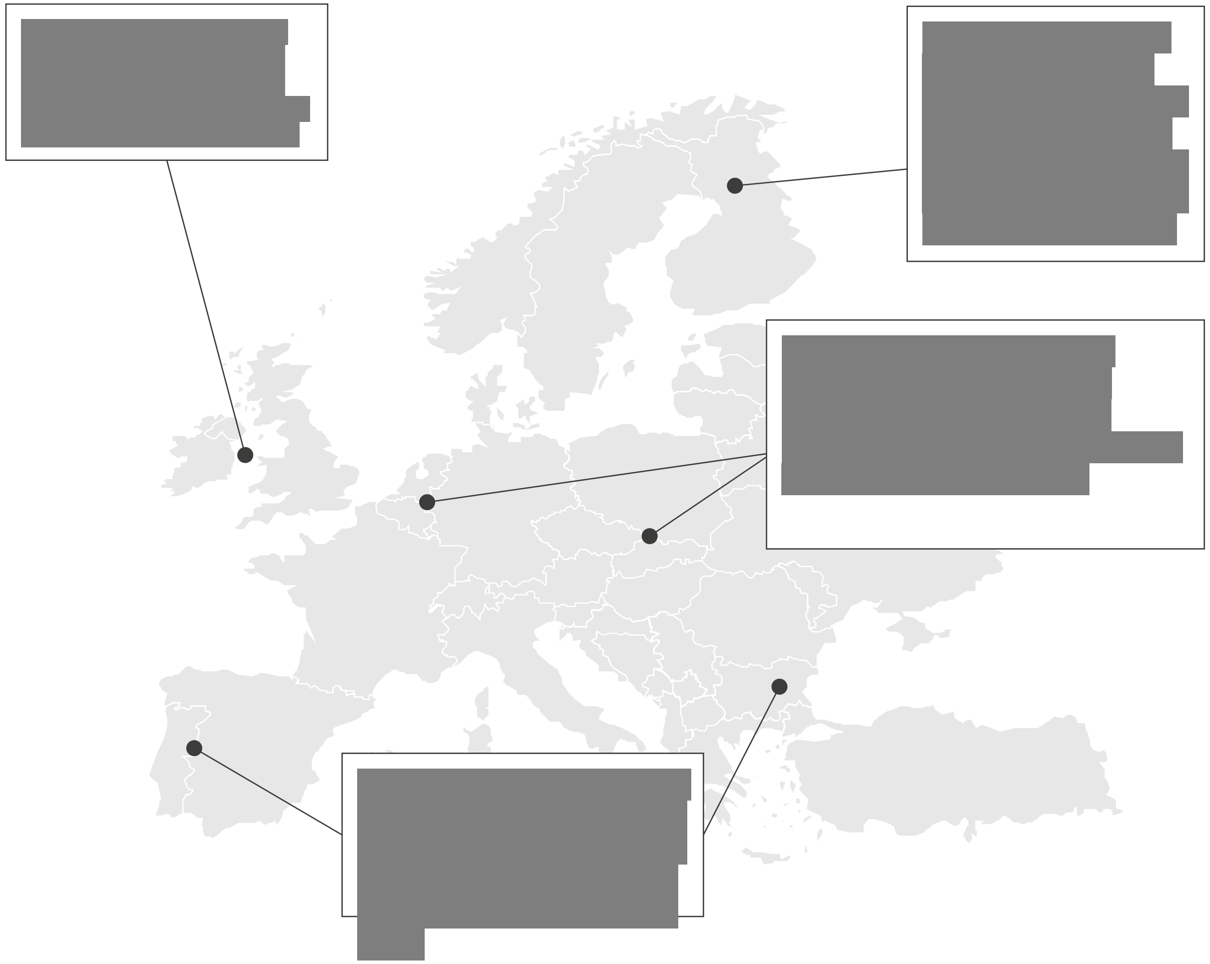
Negative prices pose a risk for non-shielded RES assets: While [redacted] see the lowest negative prices, [redacted] lead in frequency.

AURORA

2 Negative prices

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

Number of negative price hours


[redacted]

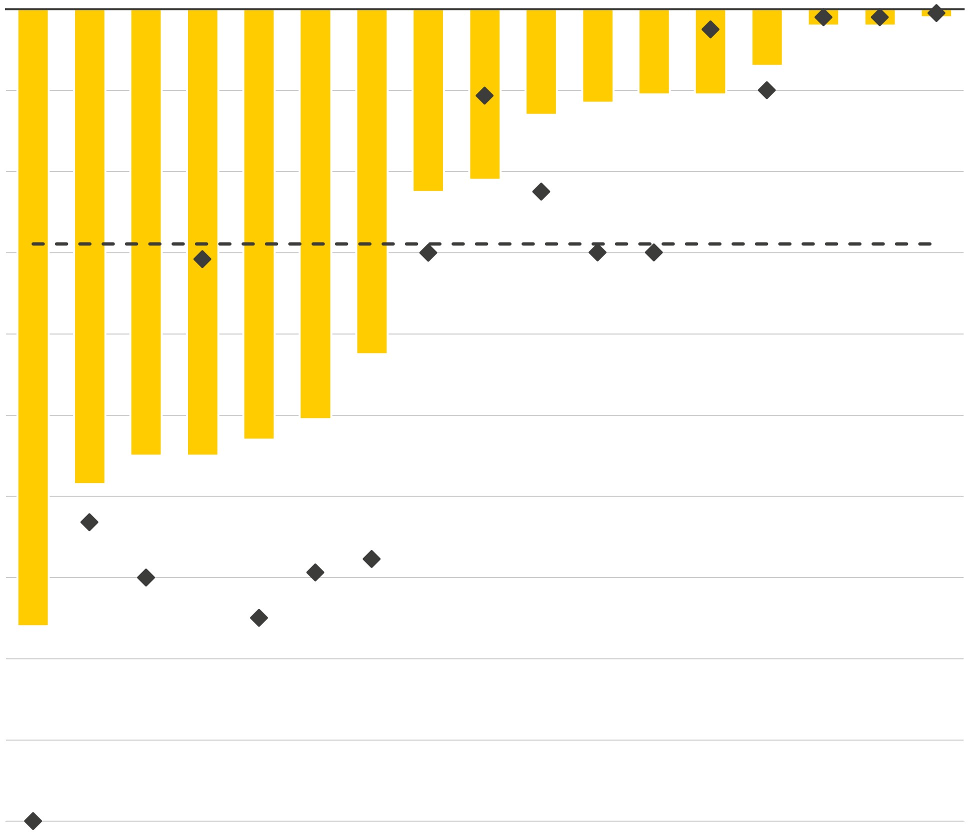
0-125 126-250 251-375 376-500 >500

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

€/MWh (nominal)

Lowest negative price[1,2]

€/MWh (nominal)



Average DA price - - Average ◆ Lowest negative price 2024

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research, ENTSO-E

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

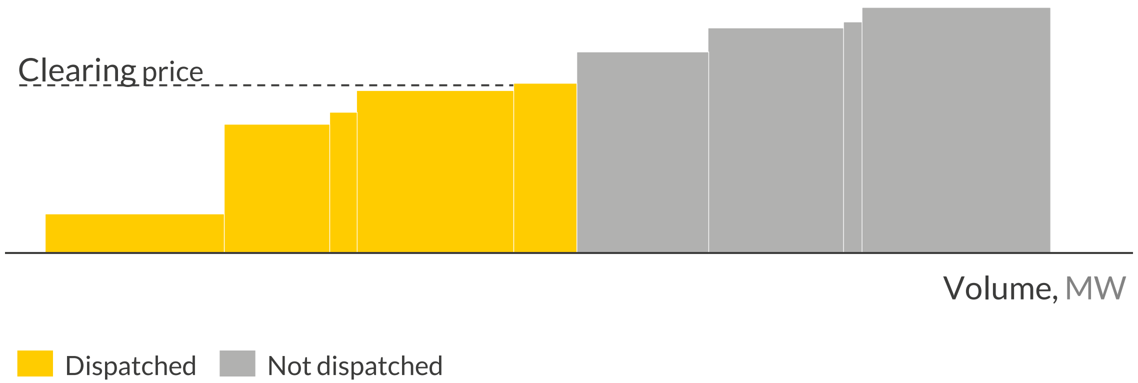
AURORA

3 Grid congestion

Economic curtailment

- Economic curtailment occurs when the cost of generating electricity exceeds the market price.
- The price at which a generator will curtail depends on its variable costs and the structure of its revenues:
  - Generators with higher variable costs will curtail first
  - Generators subsidised through a fixed Feed-in-Tariff scheme will choose to generate even when prices are below their variable costs.
- As wind plants tend to have slightly higher variable costs than solar, solar plants typically face lower economic curtailment when ignoring national subsidy schemes.

Bid price
€/MWh (illustrative)

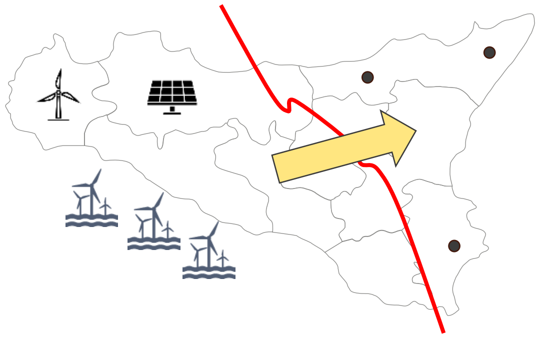


Focus of this subsection

Grid curtailment

- To ensure the safe operation of the power system, the network operators can curtail renewable production.
- Grid curtailment occurs when:
  - Grid capacity is insufficient to transport power from generation to demand
  - Conventional plants are required to run for the regulation of the system[1]
  - Intra-province bottlenecks or lack of DSO/TSO infrastructure
- Grid curtailment is most prevalent in times of high renewable production and low demand.
- Compensation of curtailed generation depends on a variety of factors, such as national regulation, the type of grid connection and the RES technology.

Illustrative limitations of electricity transported across the grid to demand



This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

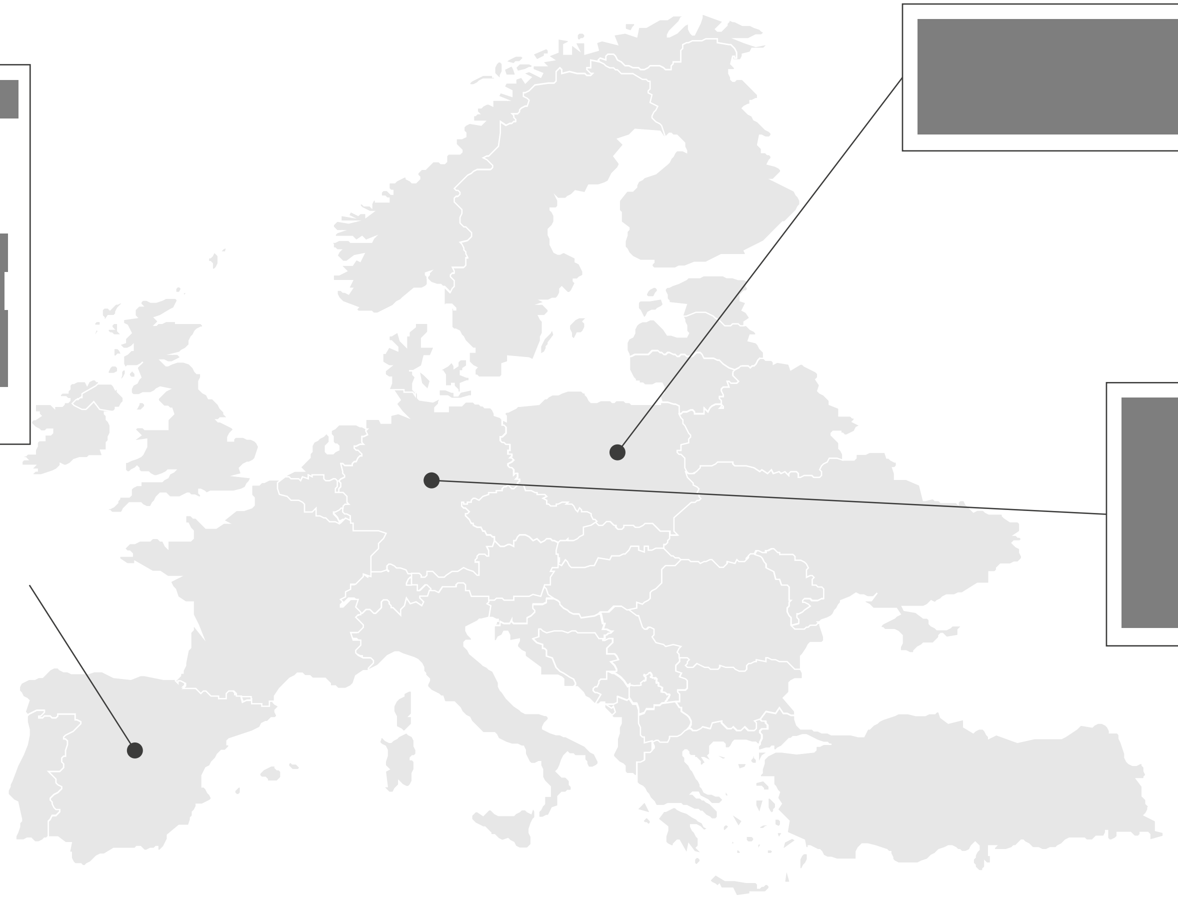
Source: Aurora Energy Research

[redacted] curtailed most energy generated by renewables in 2023

Volume of technical curtailment as a percentage of produced renewable energy – 2023

%

[redacted]



[redacted]

[redacted]

0%-1% 1%-2.5% 2.5%-5% 5%-10% >10%

- Across the continent, the total volume of remedial actions, including redispatching and countertrading, reached [redacted]
- While most countries curtailed significantly less than [redacted]% of renewable energy generation, [redacted] stood out with curtailments exceeding [redacted]
- In 2023, wind and solar curtailment were [redacted]
- Factors that typically reduce curtailment risk from a system-perspective include grid expansion, regulatory frameworks for system flexibility, interconnection and proximity of supply and demand.

Source: Aurora Energy Research, ACER calculation based on NRA and ENTSO-E Transparency Platform data, BNetzA, EirGrid, ENTSO-E, National Grid ESO, REE, RTE, PSE

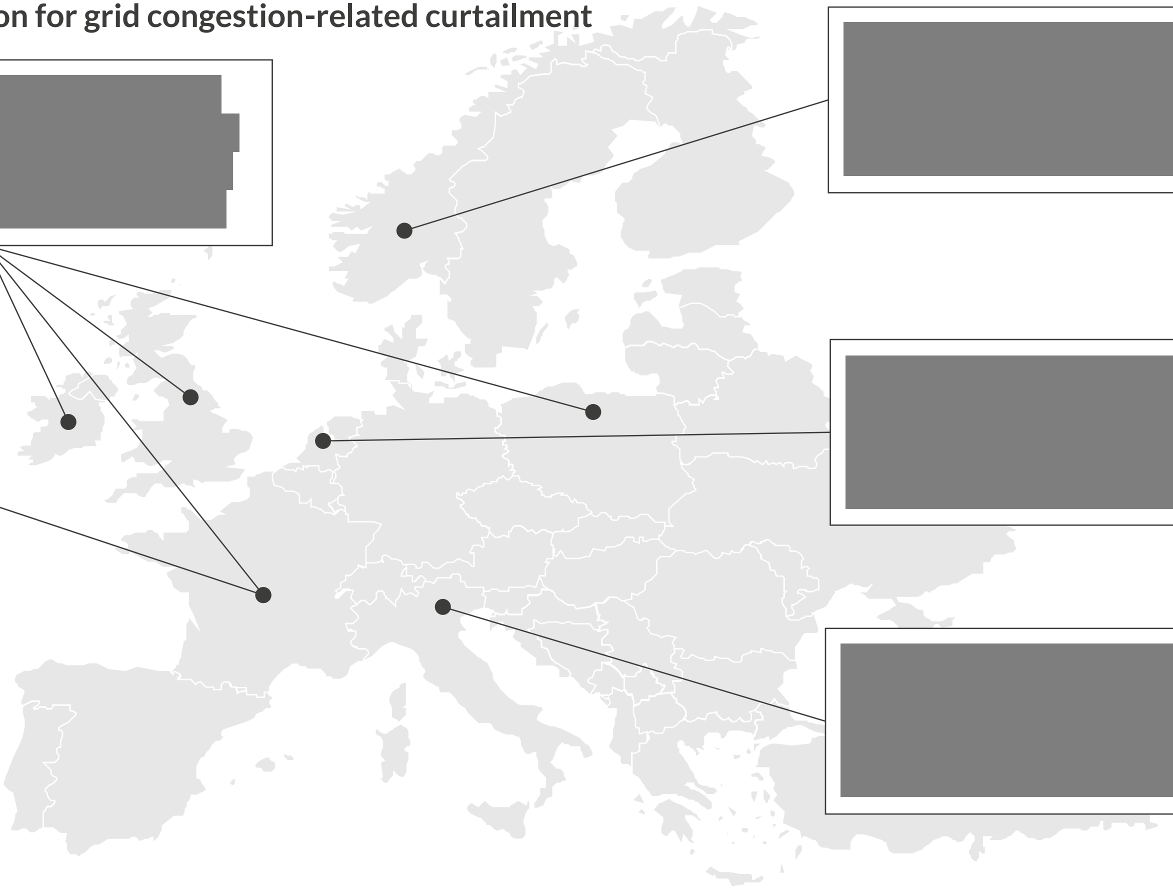
RES assets with non-firm connections are [redacted] not paid for grid congestion, but details vary significantly across countries

AURORA

3 Grid congestion

System-wide curtailment includes economic curtailment or regulatory requirements causing fleet-wide turn-down actions, while grid constraint-based curtailment is the result of insufficient local network capacity, limiting transfer of power across the network.

Status of remuneration for grid congestion-related curtailment



[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Full remuneration | Partial or complex remuneration mechanism | No remuneration | Depends on firm or non-firm grid connections

- The compensation for grid congestion depends on various factors, i.e. the type of action taken and the asset's setup:
  - [redacted]
  - [redacted]
  - [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Sources: Aurora Energy Research, Council of European Energy Regulators: CEER Paper on Alternative Connection Agreements

Agenda

I. Executive summary

II. Market size & composition

III. Renewables policy environment

IV. Project economics

V. Risks & Opportunities

1. Risks
2. Opportunities

VI. Appendix

To get in contact about purchasing the full report, reach out to Bea Dunlop:

bea.dunlop@auroraer.com

This section explores three possible opportunities for renewables: geographical portfolio diversification, additional markets and co-location

	Opportunity	Details	Impact on business case
A	Portfolio diversification	[redacted]	[redacted]
B	Additional revenue streams	[redacted]	[redacted]
C	Co-location	[redacted]	[redacted]
	PPAs	[redacted]	[redacted]
	Aggregators	[redacted]	[redacted]
	Exchange hedging	[redacted]	[redacted]

X Deep dive on following slides

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

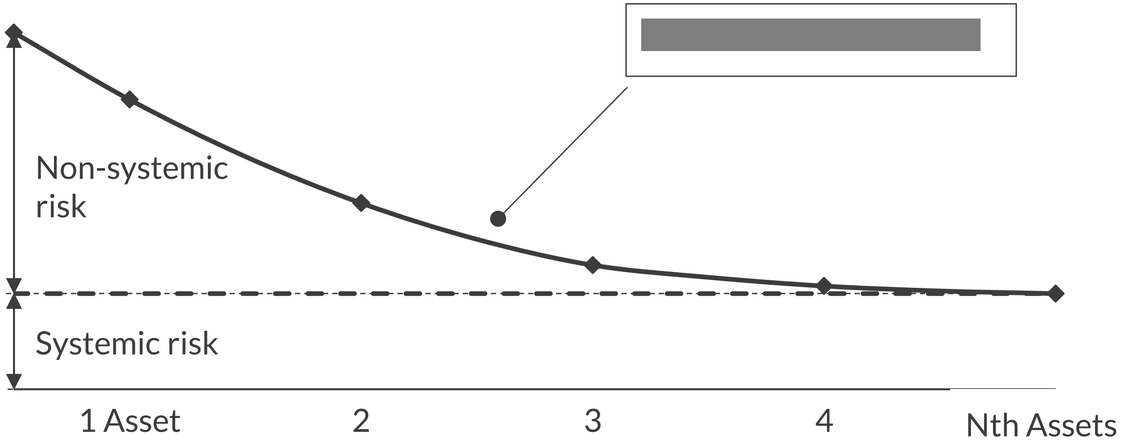
[redacted] can help mitigate country specific risk; however, [redacted]

AURORA

A Portfolio diversification

Risks can be classified into systemic and non-systemic risks; non-systemic risks can be mitigated by diversification.

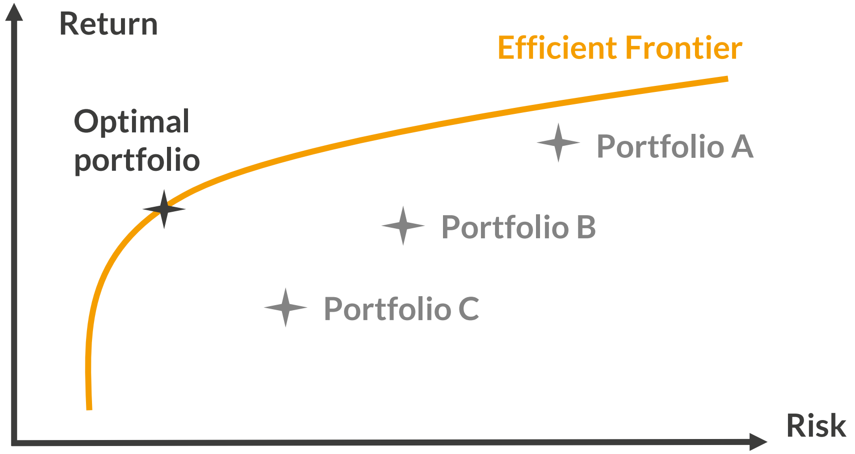
Risk level, illustrative



Risk in the context of portfolio management is associated with volatility and the potential for financial loss. It can be divided into:

1. **Systemic risk**[1] refers to factors that impact global markets uniformly, such as economic downturns or global energy price fluctuations. These risks cannot be eliminated through diversification.
2. **Non-systemic risk**[1] refers to factors that impact specific regions or industries, such as **competition, local regulatory changes, or weather patterns**. These risks can be mitigated through diversification, as they do not affect the entire market uniformly.

Portfolio theory suggests that it is possible to design an ideal portfolio which maximises investors' returns for any given level of preferred risks.



- The Efficient Frontier is the curve formed by the combinations that optimise returns for a given level of risk.
- The key benefits of portfolio diversification are:
  - ✓ Minimises the downside risk (in frequency and magnitude) of a portfolio
  - ✓ More opportunities for higher returns with the same level of risk
  - ✓ Helps reduce volatility of yearly returns
  - ✓ Lowers financial costs, and reduces the tax burden by allowing more debt (capital structure)
  - ✓ Similarly, decreases reliance on costly external funds for investments

Source: Aurora Energy Research

Low wind speed correlation across Europe can offer a natural buffer against weather risks

AURORA

A Portfolio diversification

Powered by AMUN

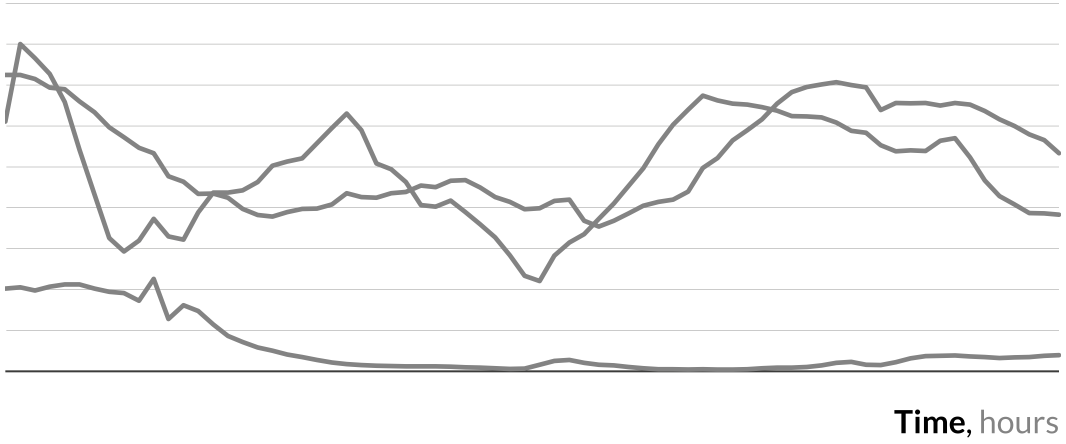
The data shown here on this slide is based on Aurora's in-house power market models and software tools operating in hourly granularity for every market.

Load factors for onshore wind across Europe

- The hourly generation profile of intermittent RES assets can vary significantly from one location to the other, as well as across different years.
- Combining assets with a high negative correlation in their profiles leads to complimentary dispatch profiles across the portfolio.
- Technological diversification, i.e. by using turbines for lower wind speed, is one of many other options for further diversification but not considered here.

Generation profiles of selected country-wide onshore wind fleets over 72h[1]

Hourly load factor



Correlation of hourly onshore wind load factors[2] to [redacted] fleet

Pearson correlation coefficient

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

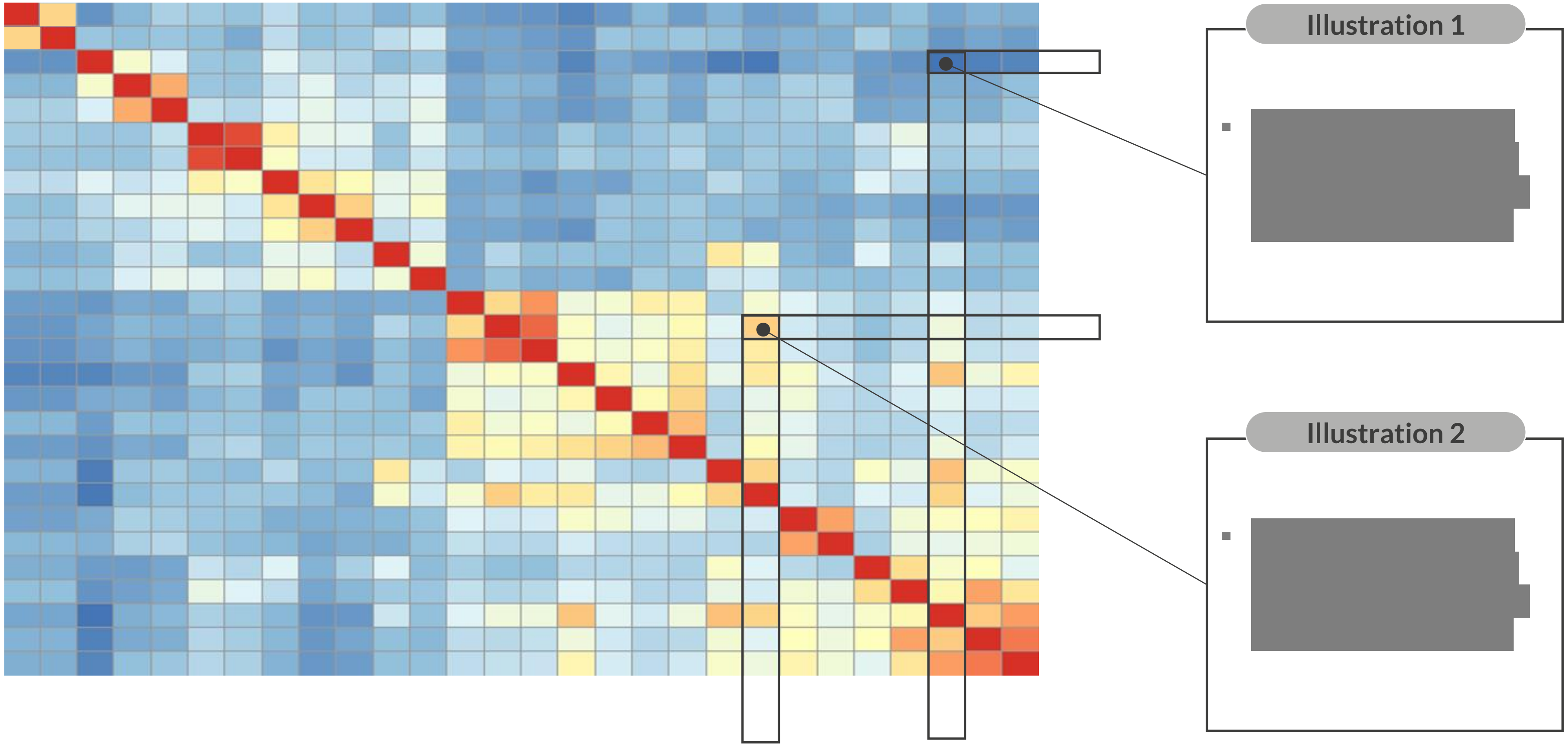
Complementary production profiles can be leveraged across countries to create robust portfolios

AURORA

A Portfolio diversification

Powered by AMUN

European onshore wind load factors in 2030 – hourly correlation matrix,
Pearson correlation coefficient



1 | 0.6-0.8 | 0.4-0.6 | 0.2-0.4 | 0-0.2 | <0

- We examine hourly uncurtailed, fleet-wide onshore wind load factors for the year 2030 and find that on average, onshore wind assets show a [redacted].
- The highest identified correlation of [redacted] exists between [redacted] and [redacted], while the lowest correlation observed is -[redacted] between [redacted] and [redacted].
- [redacted] wind assets have lower correlation with both [redacted] and [redacted] regions, providing an opportunity to stabilize generation through strategic asset allocation.

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Combining assets in different countries enhances overall predictability of returns by reducing generation volatility

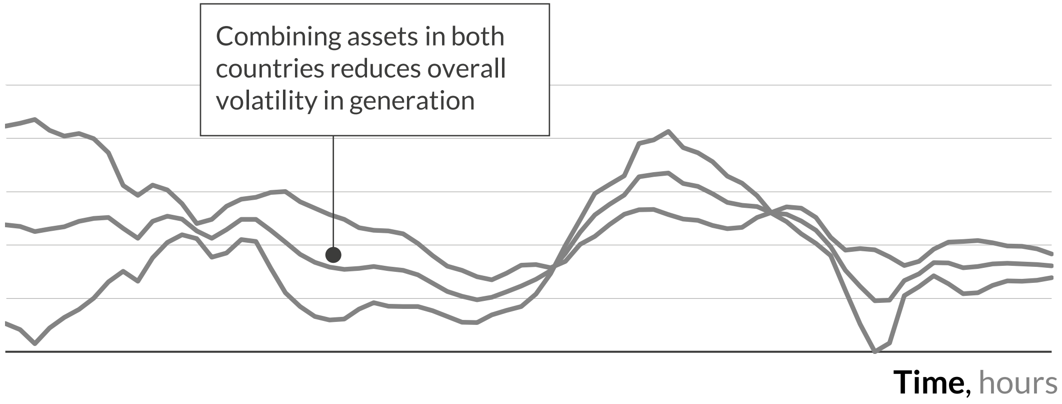
AURORA

A Portfolio diversification

Powered by AMUN

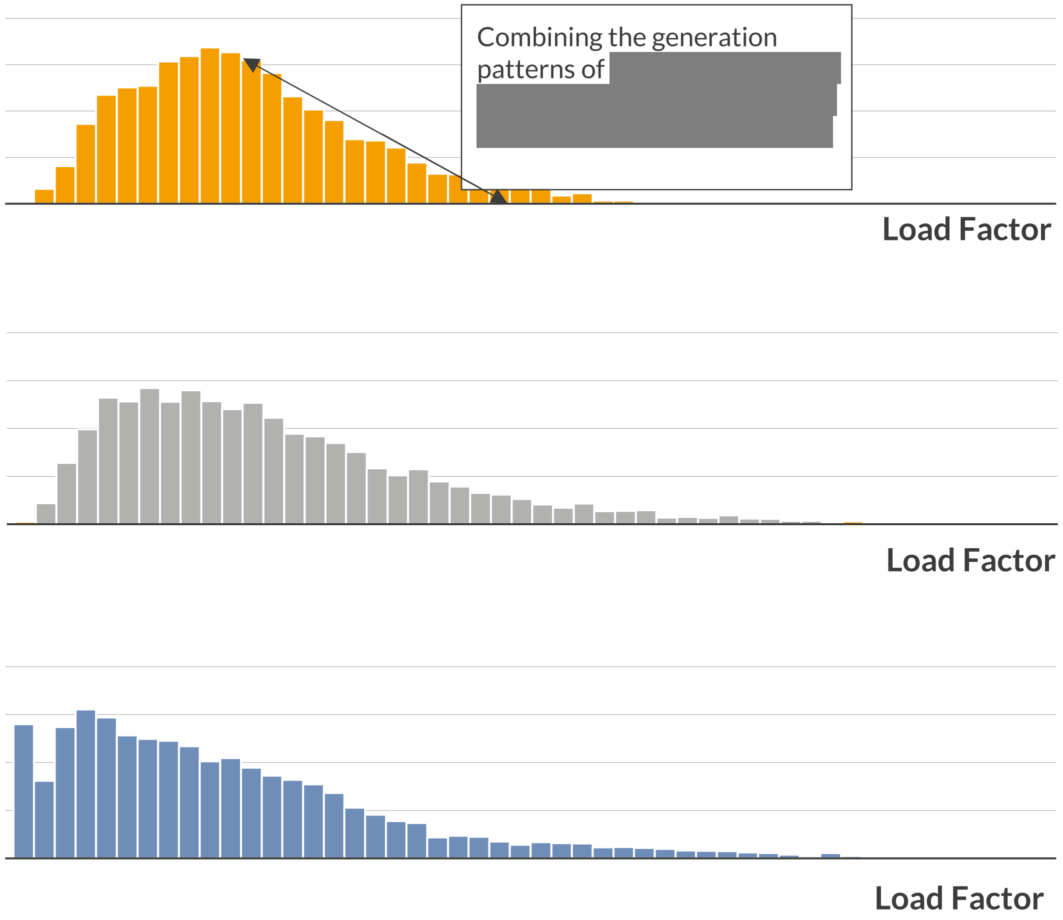
Load factor per hour in the first 3 days in 2030 in [redacted] and [redacted]

Hourly load factor



Distribution of hourly load factors in 2030 - Portfolio vs. individual countries

Frequency of hourly load factor



- Wind conditions vary across countries, resulting in different levels of steadiness, reflected in varying standard deviations of hourly load factors.
- A high standard deviation signals greater weather fluctuations, introducing uncertainty in energy production.
- Diversifying across countries with negatively correlated load factors reduces overall generation volatility, minimizing extreme variability compared to concentrating assets in one market.
- The combination of countries can impact the overall volatility of the aggregated portfolio generation profile - with some combinations being overall more volatile than others.

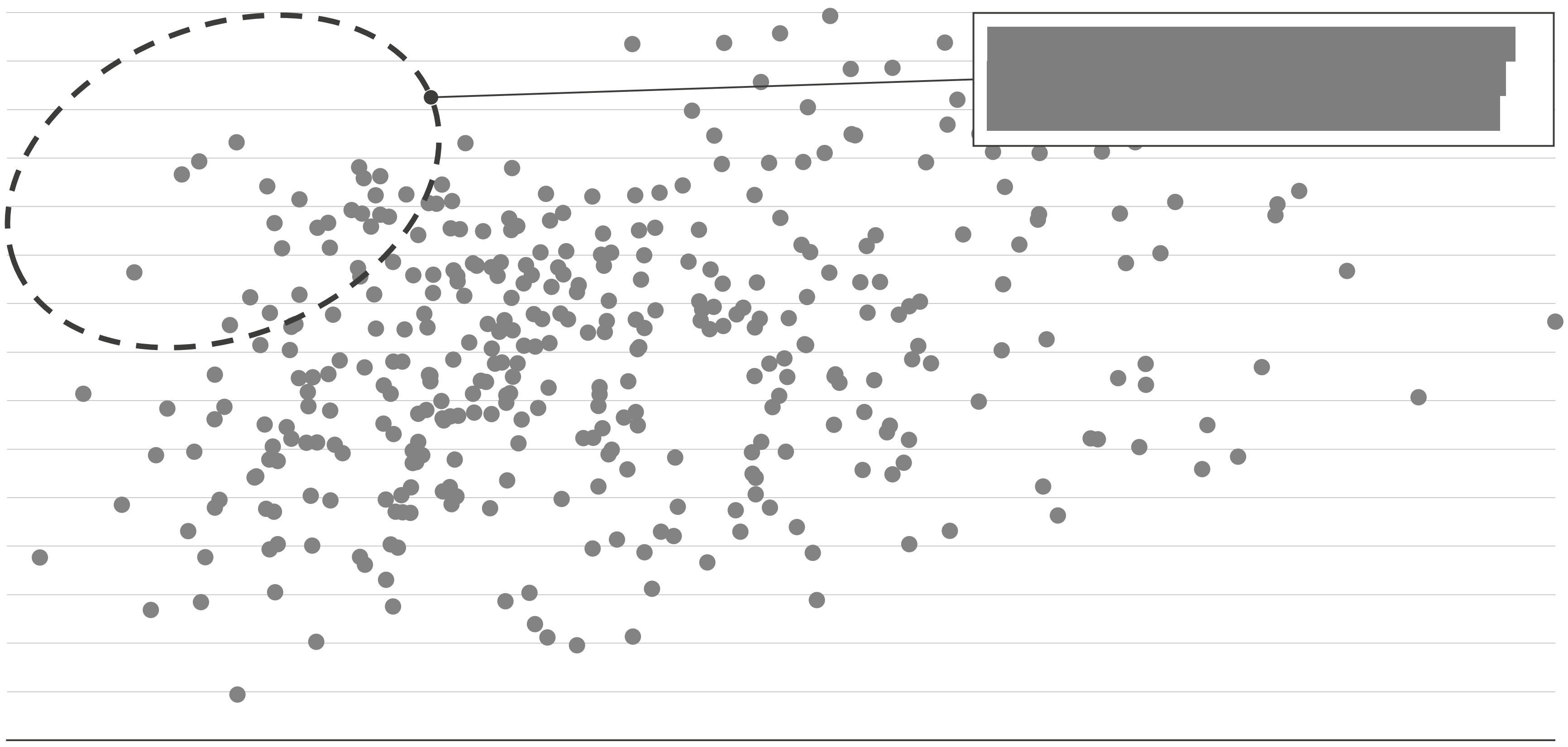
— XXX — XXX — Portfolio

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Among 300+ 2-country combinations, top portfolios can [redacted] sensitivity to weather risk by [redacted] in standard deviation

Distribution of hourly load factors in 2030 - Portfolio vs. individual countries
Portfolio load factor



Portfolio risk, standard deviation

● Other ● Highest Risk ● Lowest Load Factor ● Top 10 ● Lowest Risk ● Highest Load Factor

Source: Aurora Energy Research

AURORA

A Portfolio diversification

Powered by AMUN

Methodology and interpretation

- For this analysis, we looked at all possible 2-country portfolios, looking at country-average load profiles only.
- Each dot on the left represents one portfolio, both of which will consist of an even capacity split between both countries.
- A lower standard deviation in the hourly load profile, shown on the X-axis, can be interpreted in a few ways:
  - [redacted]
  - [redacted]

Additional markets available to RES on top of Wholesale and Intraday are often Capacity, Balancing and Ancillary Service markets

AURORA

B Additional revenue streams

Response time — Years → Hours → Minutes → Seconds → **Delivery**

CM Capacity Market

- Ensures security of supply by procuring a sufficient level of firm capacity to meet peak electricity demand
- Contracts are awarded either one or four years in advance for lengths of 1-15 years
- Payments are made on a capacity basis in kW/year and de-rated based on contribution to security of supply
- Although typically heavily derated, batteries can take advantage of the additional revenues without impacts to degradation

WM Wholesale & Intraday Markets

- The day-ahead market provides a platform to buy and sell power to meet demand every hour
- The intraday market procures continuous trading during the day
- Contracted from years ahead to T-1 hour trading
- Batteries can take advantage of arbitrage opportunities on both the day-ahead and the intraday markets

BS Balancing and Restoration Services[1]

- Balancing markets and slower frequency response services (e.g. mFRR and Replacement Reserve) ensure balance is maintained in the power system in each daily trading period
- Such services typically have higher and longer-lasting energy requirements
- Batteries can take advantage of arbitrage opportunities and revenues from provision of such services

FR Frequency Response Services[2]

- Maintains operational grid requirements and provides fast-acting power injection to arrest fast changes in system frequency, through sub-second to minutes long response
- Mostly procured on a capacity basis day ahead (e.g. FCR) or otherwise contracted in advance
- Batteries can gain revenues from the provision of frequency services

OS Other ancillary services and benefits

- Additional trading markets exist to procure non-frequency ancillary services to maintain grid operability such as inertia and local congestion mitigation services, which creates additional revenue opportunities for batteries
- Grid charge credits or avoidance in specific countries could potentially provide additional benefits for batteries

Sources: Aurora Energy Research, BEIS, National Grid, Ofgem

RES assets have access to ancillary service or balancing markets in [redacted] of 28 European markets, but limited participation to date

AURORA

B Additional revenue streams

Market access to balancing or ancillary service markets for intermittent RES[1]

Access to ancillary services / balancing markets | Access under certain conditions or under review | No additional market access

Current adoption and hurdles

- Participation of intermittent RES assets in balancing or ancillary service markets varies significantly across regions, resulting from late market design adjustments and high entry barriers:
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

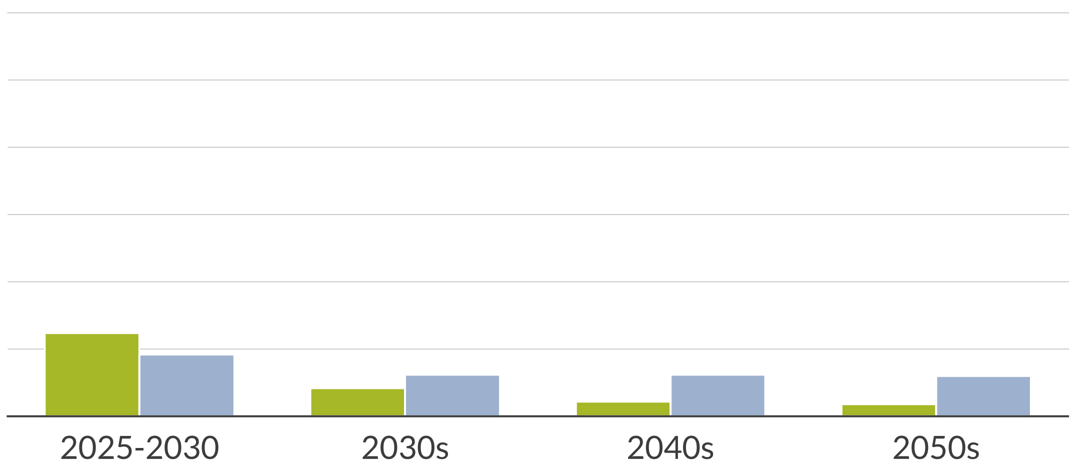
For the two markets investigated, a more sophisticated trading strategy accessing additional markets increased revenues by up to [redacted]%

AURORA

B Additional revenue streams

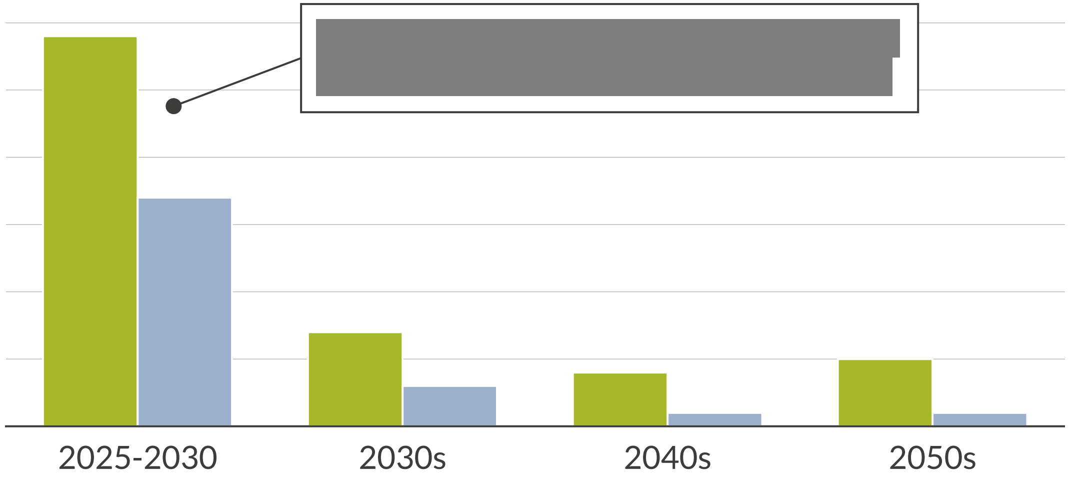
The exemplary upsides shown below compare the performance of typical assets with fleet-wide generation profiles per country. The trading strategies assume that the assets will reserve 20-30% of their capacity for participation in permitted Intraday, balancing or ancillary service markets.

Upside in revenues from advanced trading of exemplary asset in [redacted][2]
%



- [redacted]

Upside in revenues from advanced trading of exemplary asset in [redacted]
%



- [redacted]

Solar PV Onshore wind

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Co-location of RES with BESS can provide [redacted]

AURORA

C Co-location

Topic covered in detail in Aurora's European Co-location report.

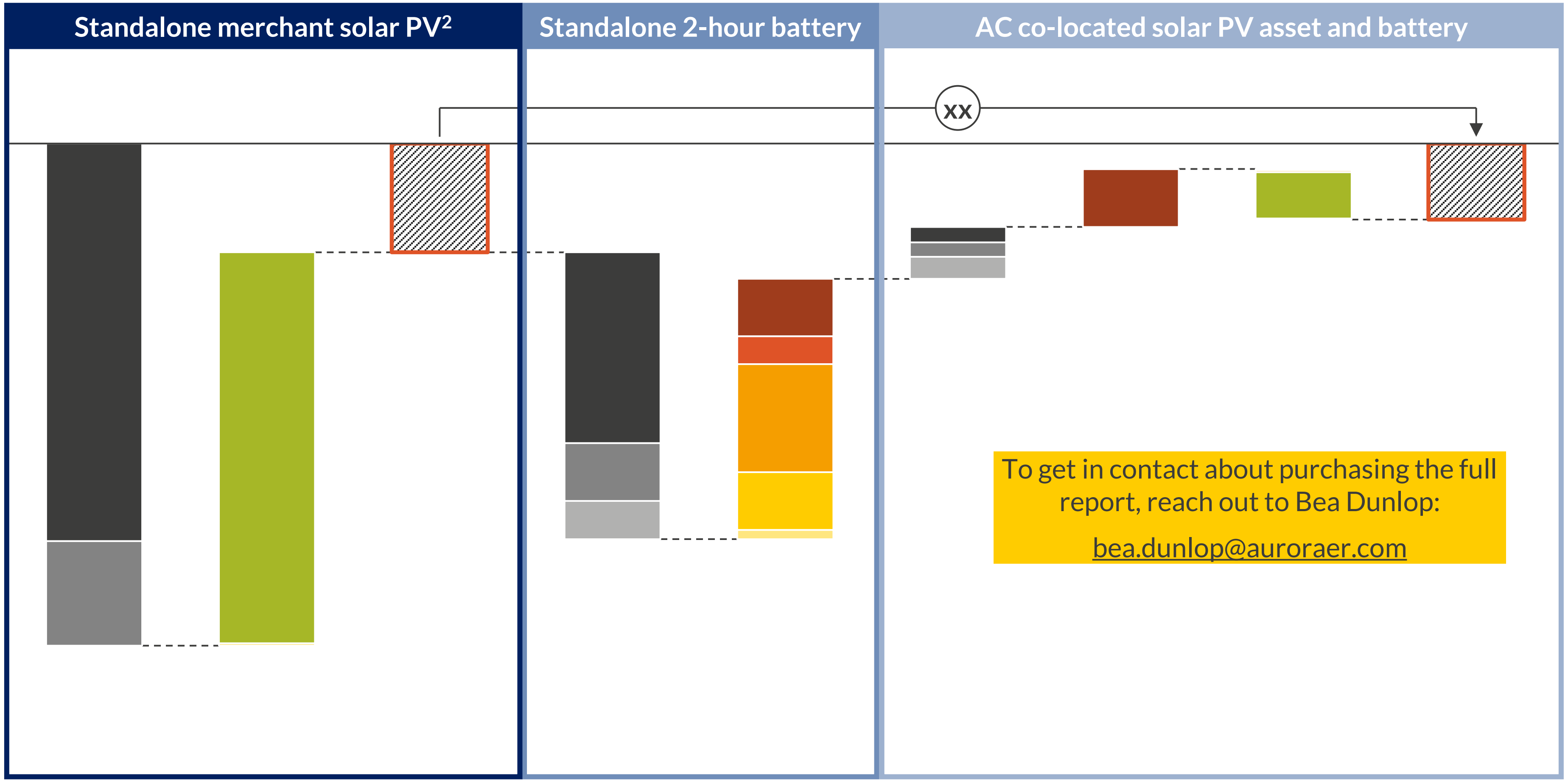
Benefits	Details	Implications for RES
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Source: Aurora Energy Research

With full market access, AC co-location can provide an upside when compared to a fully merchant solar PV setup

Illustrative NPV calculations of a new-built co-location project with COD 2025[1]
€/kW of grid capacity (real 2023)

AC setup | New build
0.5 | 1.0 | 1.0



AURORA

C Co-location

Topic covered in detail in Aurora's European Co-location report.

- For merchant, co-located projects, the battery can charge from [redacted]
- When looking at the economic impact of co-locating a battery with a PV asset, we observe a strong reduction of both the CAPEX and OPEX costs due to shared infrastructure.
- Charging from the renewable asset allows the battery to [redacted]
- Due to [redacted]

This is a redacted sample of the European Renewables Market Overview Report. If you are interested in the full report, contact Bea Dunlop (bea.dunlop@auroraer.com)

Source: Aurora Energy Research

Details and disclaimer

Publication
European Renewables Market Overview report (1st edition)

Date
January 2025

Prepared by
Lara Gohr
Konstantinos Myrianthefs
Sameer Hussain
Jannik Carl
(jannik.carl@auroraer.com)

Approved by
Rebecca McManus
(rebecca.mcmanus@auroraer.com)
Jörn Richstein
(joern.richstein@auroraer.com)
Richard Howard
(richard.howard@auroraer.com)

AURORA

ENERGY RESEARCH