AURORA ENERGY RESEARCH

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European Renewable Co-Location Report

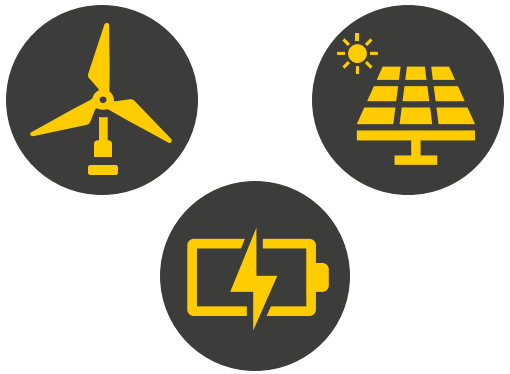
June 2024

European Renewable Co-Location Report

Explore opportunities and benefits for co-locating renewable projects with battery storage across Europe

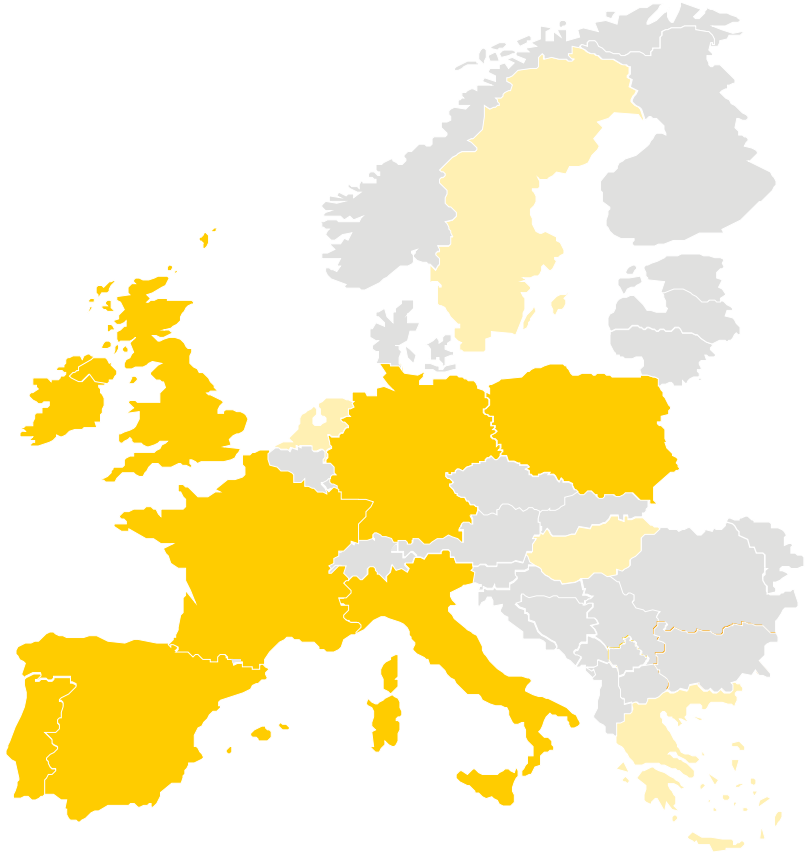
Access this report for:

- Clustering of 12 European markets into 'high', 'medium' and 'low' attractiveness for co-location
- Comparative analysis of business case risks for intermittent renewables
- Overview of regulatory and subsidy landscape for physically co-located projects
- Key considerations for co-location, including technology costs and configurations
- Expert assessments on trends to watch for co-location
- IRR for co-located business cases vs. standalone renewable assets for 8 countries



For more information about this report, contact:

Mrunal Karnik – mrunal.karnik@auroraer.com



Aurora European Co-location Markets Attractiveness Report: *How to use this report*

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This report is divided into 6 sections:

- **Section I [*Executive summary*]** gives an overview of the full report, highlighting the most attractive markets for co-location, details of how we cluster the 12 markets covered into categories, as well as an overview of the total ratings and market-based summary slides for all countries.
- **Section II [*Introduction to co-location*]** gives a general introduction into the topic of co-location and outlines the current operational capacity across Europe.
- **Section III *[Drivers for co-location]*** provides insights into the current risks for intermittent RES assets, both in 2030 and in 2050, as well as ways in which co-location with battery assets could help mitigate these.
- **Section IV *[Policy & Regulation]*** explores the key policy drivers for co-located assets and government commitments and regulation. It also details the various markets and revenue streams available to co-located assets and how co-location can enable faster grid connections compared to standalone RES.
- **Section V [*Technology trends*]** supplies extensive background on the technologies considered in this report, particularly cost assumptions, and how these differ in selected co-located setups.
- **Section VI [*Project economics*]** introduces the investment cases for merchant co-located solar PV and BESS assets, comparing the revenue split between both over time and IRRs for representative assets.

If you are looking for…

- ***Country summaries:*** *read through Section I [Executive summary]*
- ***A high-level explanation of co-location:*** *go to Section II [Introduction to co-location]*
- ***Which risks to RES co-location can help you mitigate and where:*** *go to Section III [Drivers for co-location]*
- ***An explanation of the markets and detailed policy analysis for a specific market:*** *see Section IV [Policy & Regulation]*
- ***Aurora's investment case numbers for a particular asset:*** *see Section VI [Project economics]*

If you are using this report…

- **For project financing:** See sections I and VI to get a summary of the overall markets and where co-location can boost IRRs most.
- **As an OEM**: See section IV to understand favourable regulation across all markets covered.

Source: Aurora Energy Research

Modelling storage is complex. Aurora's forecasts have underpinned the deployment of over 2.5GW of operational battery assets globally

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What is the challenge?

- Modelling a consistent set of day-ahead, real-time and Ancillary service prices accounting for opportunity costs
- Understanding and modelling detailed rules in AS[1] markets, including responding to market changes
- Capturing the role of weather in driving scarcity and AS[1] procurement – annual averages are irrelevant to storage economics, especially as renewables penetration increases

Future of the market (difficult to model)

- Dispatching assets against multiple price series accounting for imperfect foresight, degradation, warranties, route to market, and asset characteristics

Future of the asset in the market (easier to model)

How do we address it?

- ✓ Offer valuations for a range of standard and bespoke market scenarios
- ✓ Work closely with clients to ensure the valuation is specific to their asset or portfolio characteristics
- ✓ Model storage margins for all major business models including arbitrage, Ancillary Services, and hybrid
- ✓ Dispatch against consistent day-ahead, real-time and AS prices
- ✓ Account for degradation and imperfect foresight
- ✓ Present results in slides and cashflow model at monthly, quarterly and annual granularity

Example transactions

2018
- Banked by Santander on first project financing of battery storage in the UK for 100MW Zenobe portfolio
- Sell-side market advisory for then-largest operational battery storage portfolio in Europe, STEAG's 90MW bid into the FCR market

2019
- Supported Pivot Power on sale of company and 2GW portfolio to EDF
- Supported PE fund on $50m acquisition of storage developer; bidding support for large developer for DS3 auctions

2020
- AUS $50m in debt financing for 50MW extension of Neoen's Hornsdale battery – first battery project financing in Australia
- Debt and equity raise for 100MW battery portfolio

2021
- Development/financing of 150MW Hazelwood BESS project

2022
- Sell-side advisor for 1.1GW of battery storage from BMES to UBS Asset Management and Cypress Creek Renewables

2023
- Buy-side advisor for Engie's acquisition of Broad Reach Power

1) Ancillary Services.

Source: Aurora Energy Research

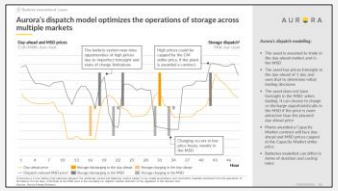
Flexibility Market add-on service: Provides detailed power market analysis and investment cases for batteries in 14 European markets

Flexibility Market add-on service

Forecast reports & data

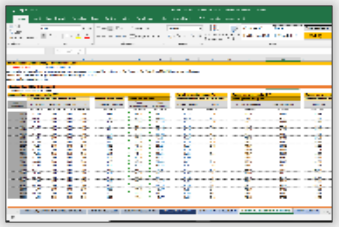
Technology and market development reports

- Overview of battery pipeline development
- Overview of regulatory framework for batteries
- Revenue stacking models for batteries
- Projections for battery CAPEX and OPEX by delivery year
- Reports and datasets follow the same format with content tailored to specific markets



Forecast data

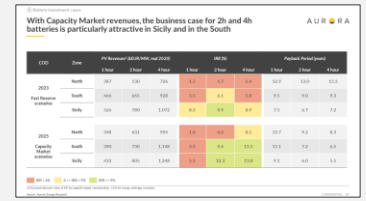
- Central case forecast prices provided at settlement period granularity until 2050
  - Wholesale power prices
  - Balancing market prices
  - Ancillary services prices



Investment cases

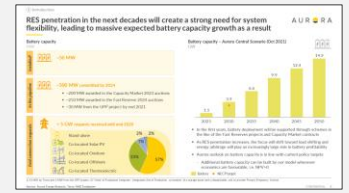
Standalone Battery

- At least six investment cases per country or zone including:
  - Arbitrage of wholesale market and balancing market
  - Focused participation in frequency control market (if applicable)
- Annual project margins to 2050. IRR and NPV for at least two entry years



Co-location

- Provided in markets with favourable economic or regulatory opportunities
- At least two investment cases for battery co-located with solar PV and/or onshore wind
- Annual project margins to 2050. IRR and NPV for at least two entry years



Ongoing analyst support

Throughout the year you can contact us to discuss questions related to our analysis and our thoughts on flexibility market and policy developments.

Source: Aurora Energy Research

Agenda

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I. **Executive summary**
   1. Rating results
   2. Market summaries

II. **Introduction to co-location**

III. **Drivers for co-location**
   1. Risk to renewable assets
   2. Benefits of co-location

IV. **Policy & Regulation**
   1. EU Policy
   2. Targets
   3. Grid access
   4. Revenue streams
   5. Subsidy support
   6. Ongoing Regulatory Developments

V. **Technology trends**
   1. Renewables
   2. Lithium-ion batteries

VI. **Project economics**
   1. Country market economics
   2. Variables affecting co-location economics

VII. **Appendix**

For more information about this report, contact:

Mrunal Karnik – mrunal.karnik@auroraer.com

Executive Summary

**The information in this report draws on Aurora's 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 Alex Hutcheson (alex.hutcheson@auroraer.com) about finding a solution relevant to your needs.*

- With renewable energy sources (RES) becoming an ever more important part of the European and global energy landscape, corresponding changes in the market environment and to business cases, such as the increasing risk of falling capture prices, lead to market players looking for ways to mitigate these risks and to secure business cases.
- Although the battery industry in Europe is still nascent, the potential for co-locating intermittent RES assets with Battery Energy Storage Systems (BESS) is increasingly considered by both policymakers and suppliers, as these setups can harness multiple revenue streams and provide much needed system services.
- Aurora has a strong track record working on flexible energy markets and providing business cases for flexible technologies as well as RES assets across the globe. This report explores potential drivers for co-location and the current policy landscape for 12 European markets, as well as showing merchant business cases for co-location for eight of these markets.
- Markets are not scored quantitatively, but due to the nascent state of most policy measures, grouped into one of three categories outlining their attractiveness for co-located business cases: High, Medium and Low.
- The three most attractive markets for RES and BESS co-location in Europe are [redacted]. These come out on top due to [redacted]
- Additional key insights include:
  - [redacted]
  - [redacted]

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

Aurora's rating combines 11 metrics to derive an overall indication of where single markets provide a good environment for co-location

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The overall market attractiveness rating for each European battery market covers the following four categories and 11 metrics, which are set out in detail in this report.

Categories and metrics	Weighting	Rationale	Source of data
A Market size			
1 Currently operational, co-located RES capacity	*100%*	Demonstrates market size and interest	Aurora analysis
B Drivers for co-location			
2 Capture price discount in 2030 and 2050	*50%*	Captures risk to renewables from increasing market saturation	Aurora modelling
3 Imbalance costs to RES in 2030 and 2050	*20%*	Indicates potentially increasing costs due to higher system dependence on RES	Aurora modelling
4 Curtailment rates in 2030 and 2050 and remuneration	*20%*	Incorporates potentially lost revenue from curtailment schemes	Aurora modelling
5 Remuneration of curtailment due to grid constraints	*10%*	Risk of losing out on revenues due to increasing risk of grid congestion	Aurora analysis
C Policy environment			
6 Is co-location explicitly part of the national energy strategy?	*10%*	Demonstrates policy ambition for battery and renewables deployment	Aurora analysis
7 Existence and efficacy of subsidy schemes open to co-location	*30%*	Outlines potential for co-location projects to come online at lower risk	Aurora analysis
8 ▪ Improvement of grid access by co-locating?	*30%*	Outlines potential for faster grid access to co-located vs. standalone RES projects	Aurora analysis
9 ▪ Market access for merchant co-located projects	*30%*	Indicates availability and long term contractability of revenues	Aurora analysis
D Project economics			
10 ▪ IRR increase from standalone RES to co-located projects	*50%*	Captures the financial upside for retrofitting BESS with solar PV assets	Aurora modelling
11 ▪ Total project IRR for co-located projects	*50%*	Captures the commercial viability of new build projects	Aurora modelling

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Source: Aurora Energy Research

Different markets emerge across the four categories, with [redacted] and [redacted] rating high in at least two

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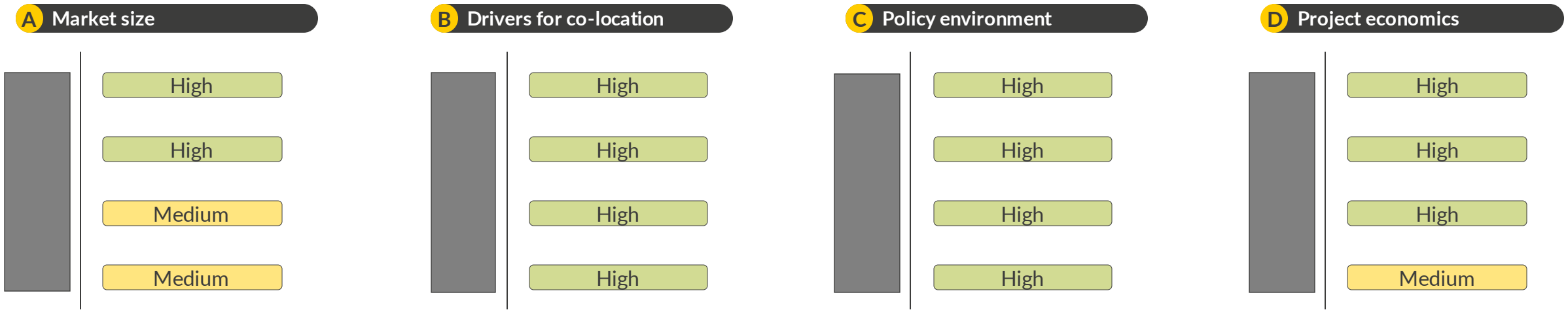

- [redacted]
- [redacted]
- [redacted]

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

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

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

The markets rated as having 'High' attractiveness in Europe are [redacted] and [redacted]

A market is rated as High in the 'Total' category if they are rated High in at least two of the subcategories. A total rating of Low is assigned if a market scores Low in at least two subcategories and does not have any High rating. The markets are sorted alphabetically within the total qualitative rating.

	A	B	C	D	Total
[redacted]					High
[redacted]					High
[redacted]					High
[redacted]					High
[redacted]					Medium
[redacted]					Medium
[redacted]					Medium
[redacted]					Medium
[redacted]					Medium
[redacted]					Medium
[redacted]					Low
[redacted]					Low

Top markets

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

Markets to watch

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

High Medium Low

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Source: Aurora Energy Research

Subsidies exist specifically for co-located projects in [redacted]; high co-located IRRs are achievable, however [redacted]

One-slide summary summarizing the key findings is available for every market in the full report

Overall attractiveness

High

[redacted] rates high on [redacted]. While the policy situation has been constrained by [redacted], recent changes including [redacted] will make [redacted] one of the key markets to watch going forward.

A Market size

High

B Drivers for co-location

High

- [redacted]
- [redacted]

C Policy environment for co-location

Medium

- [redacted]
- [redacted]

D Project economics

High

- [redacted]
- [redacted]

Potential upcoming developments

- [redacted]
- [redacted]

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Source: Aurora Energy Research

Renewables and batteries can be co-located in multiple technical configurations, with AC co-location being the most prominent

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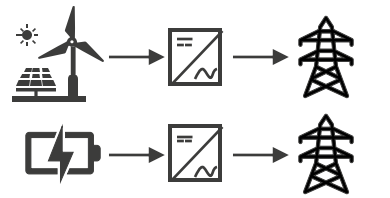
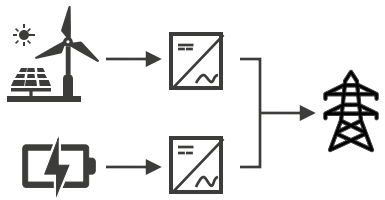


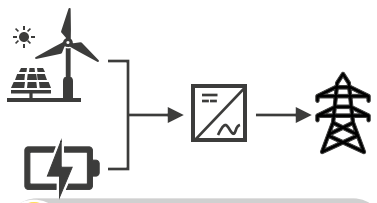
I Standalone

Assets are two different sites, therefore are metered and managed individually



II AC co-location

RES and battery require separate inverters to connect to the grid



III DC co-location

RES and battery share a single inverter connected to the grid

Costs
CAPEX & OPEX

Portfolio diversification
Diversification of risk and revenue

Asset oversizing
Oversize renewables asset relative to grid connection

Battery dispatch
Charging/discharging profile of the battery asset

Inverter losses
Avoiding losses from AC/DC conversion

Other aspects

Full benefit | Partial benefit | Partial downside | Full downside

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

The majority of operational projects is located in [redacted] and [redacted], with the market still [redacted] in most of Europe

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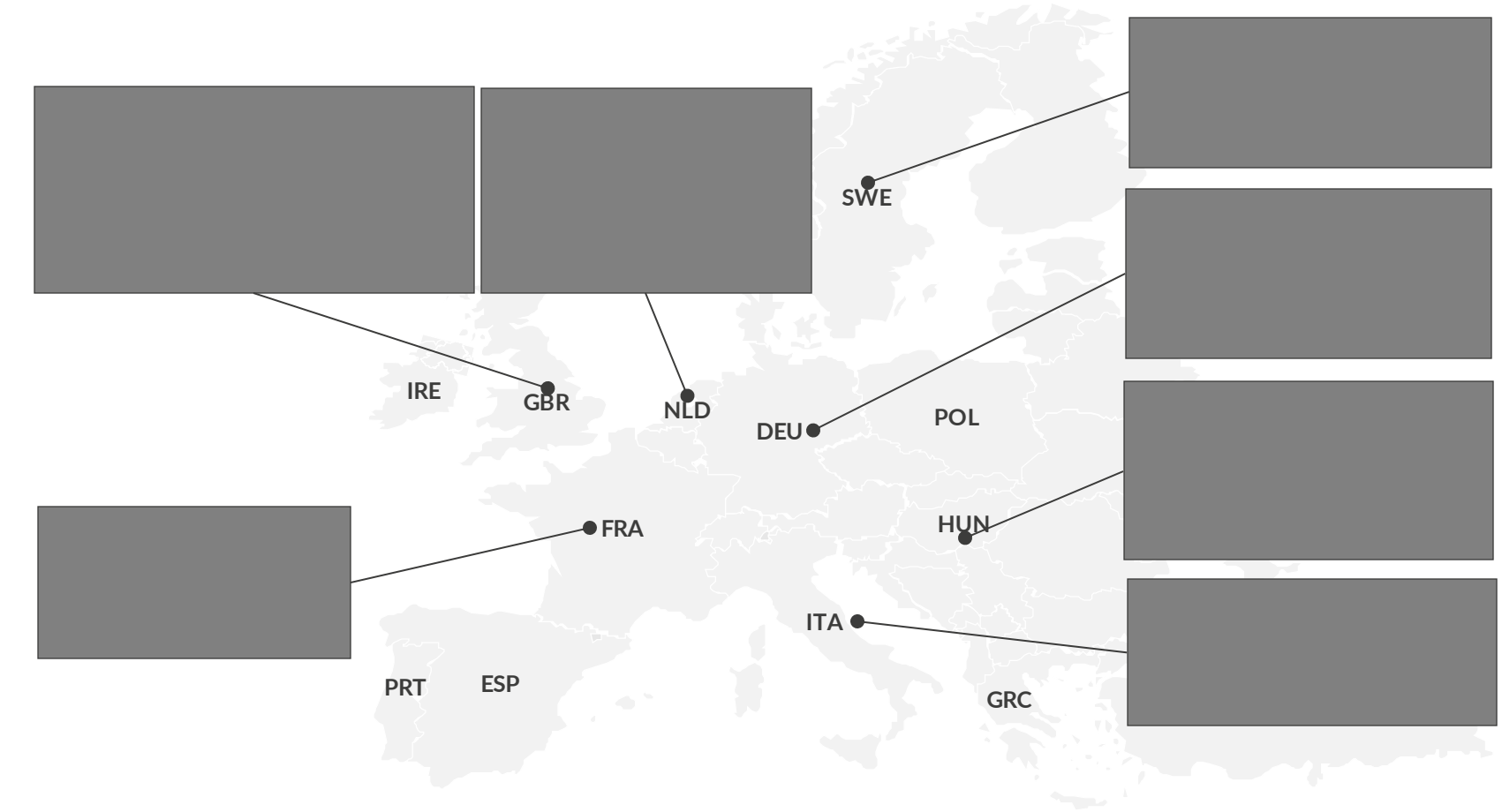
Operational co-located projects (utility-scale solar or wind with batteries)



No operational projects <100 MW of operational RES capacity >100 MW of operational RES capacity

- [redacted] and [redacted] account for the majority of operational co-located projects in Europe.
- Out of the 12 countries considered, the vast majority of the operational RES capacity in a co-located setup is currently concentrated within [redacted], making them the most developed markets for co-location.
- [redacted], constitute a significant proportion of the overall capacity.
- Projects in [redacted], [redacted], and [redacted] tend to be co-located with solar PV, while [redacted] and [redacted] have a greater focus on wind co-location.

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Source: Aurora Energy Research, IJ Global

Increasing renewables deployment leads to three key risks to profitability: [redacted], [redacted] and [redacted]

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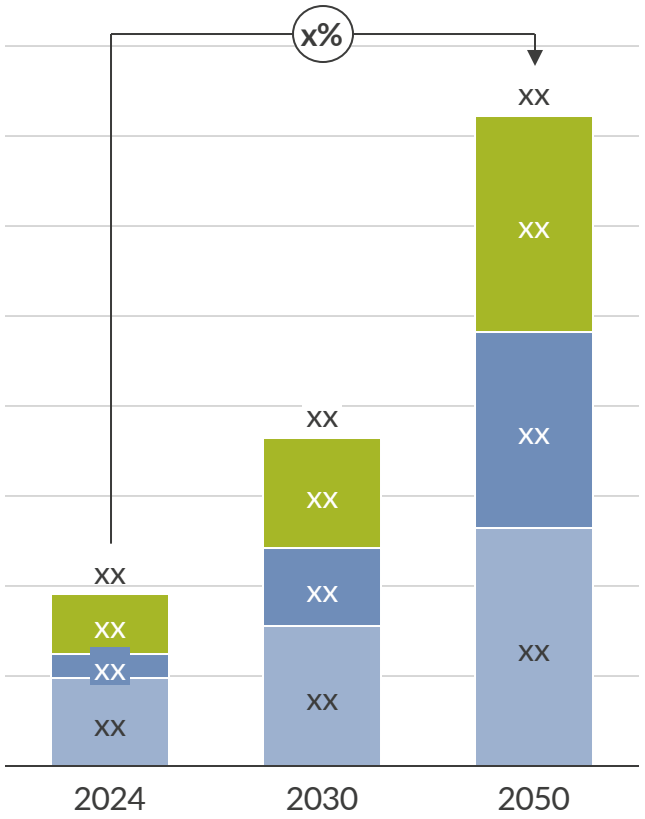
Renewables generation is expected to [redacted]

Annual renewable generation across Europe[1]
TWh/year



…which results in [redacted]

	Risks	Details	Implications for RES
1	[redacted]	[redacted]	[redacted]
2	[redacted]	[redacted]	[redacted]
3	[redacted]	[redacted]	[redacted]

Onshore wind | Offshore wind | Solar | X Deep dive on following slides

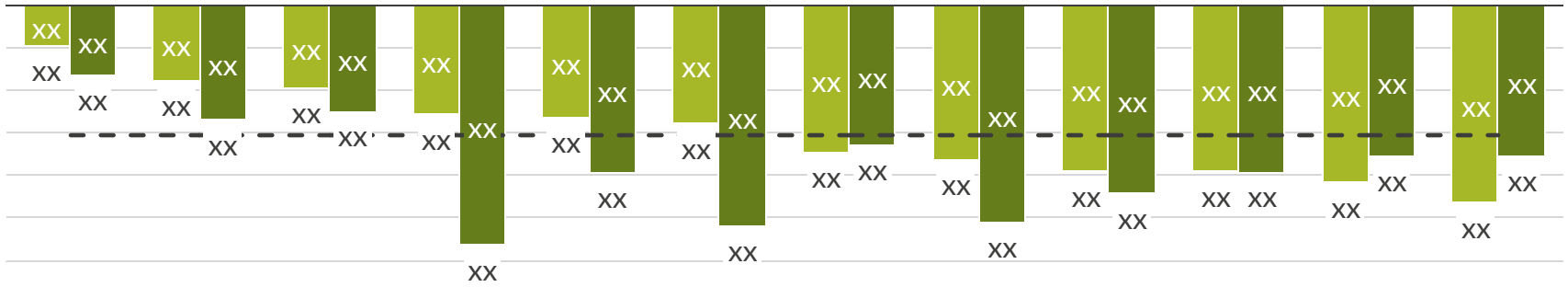
This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

Capture price discounts across Europe average [redacted] for solar and [redacted] for wind in 2030, worsening in [redacted] by 2050

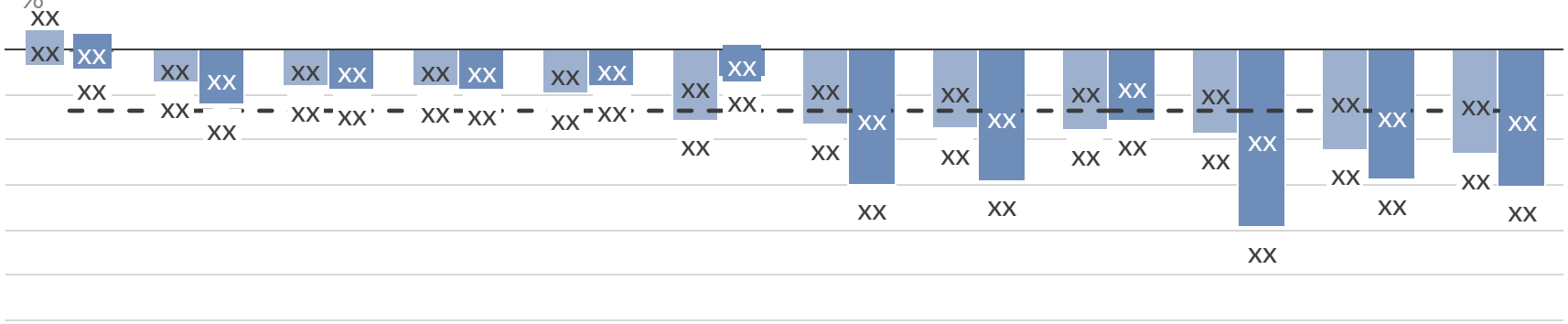
Solar capture price discount to baseload price[1] in 2030 vs 2050

%



Onshore wind capture price discount to baseload price[1] in 2030 vs 2050

%



Increased cannibalisation risk

2030 2050 European average of displayed regions (2030)

- Solar load factors are more correlated compared to wind, generally leading to [redacted].
- In [redacted] and [redacted], solar sees ~2x higher capture price discounts by 2050 as its penetration reaches over [redacted] driving high cannibalisation.
- Similarly, price cannibalisation effects from [redacted] (reaching [redacted] by 2050) contributes to the doubling of wind discounts in [redacted].
- Despite high RES penetrations, solar price discounts [redacted] in [redacted] mainly due to [redacted]
- Limited build-out potential in [redacted] and downwards pressure on baseload prices from [redacted] in [redacted] leads to smaller capture price discounts for wind by 2050.

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Source: Aurora Energy Research

Non-remuneration of curtailment from local grid constraints poses a higher risk for renewables in some countries than others

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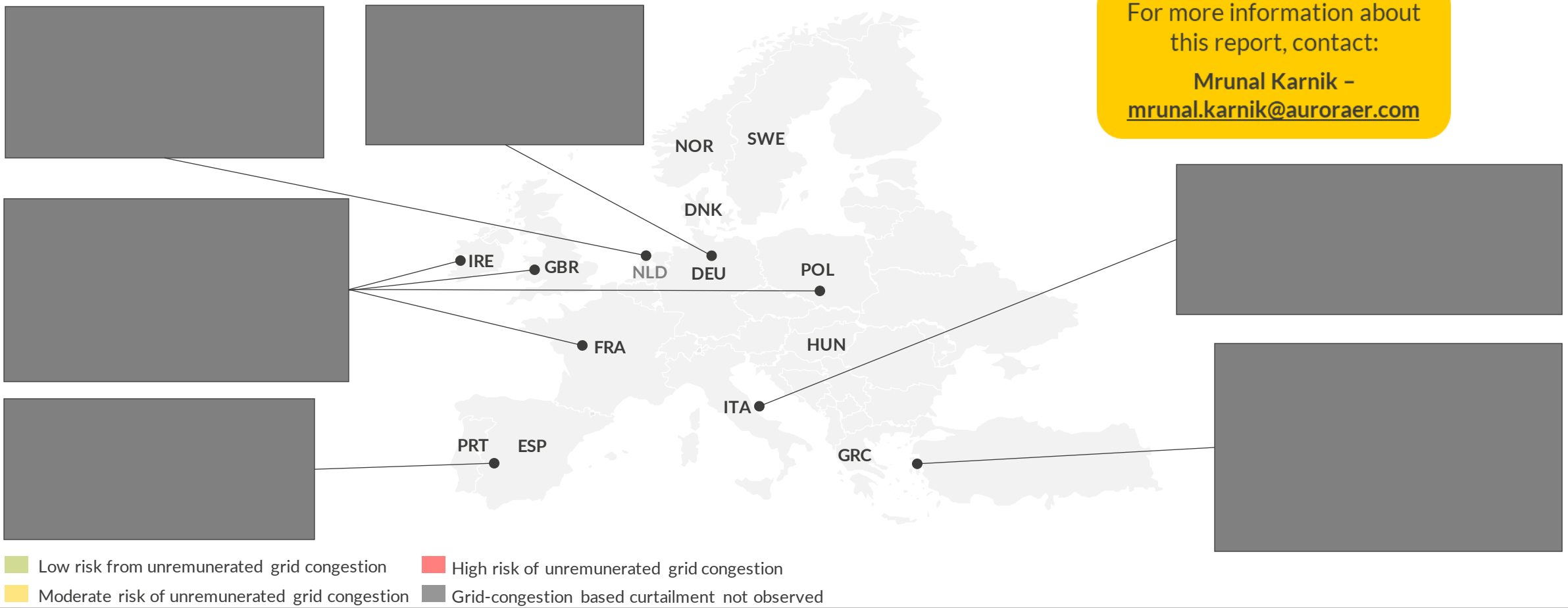
System-wide curtailment includes economic curtailment or regulatory requirements causing fleet-wide turn-down actions, while grid constraint-based curtailment is the result of insufficient local network capacity, limiting transfer of power across the network. Remuneration rules differ by country, type of connection and subsidy scheme.

Status of remuneration for grid congestion-related curtailment



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Source: Aurora Energy Research

Co-location on a single site allows for CAPEX and OPEX cost savings compared to the equivalent standalone projects

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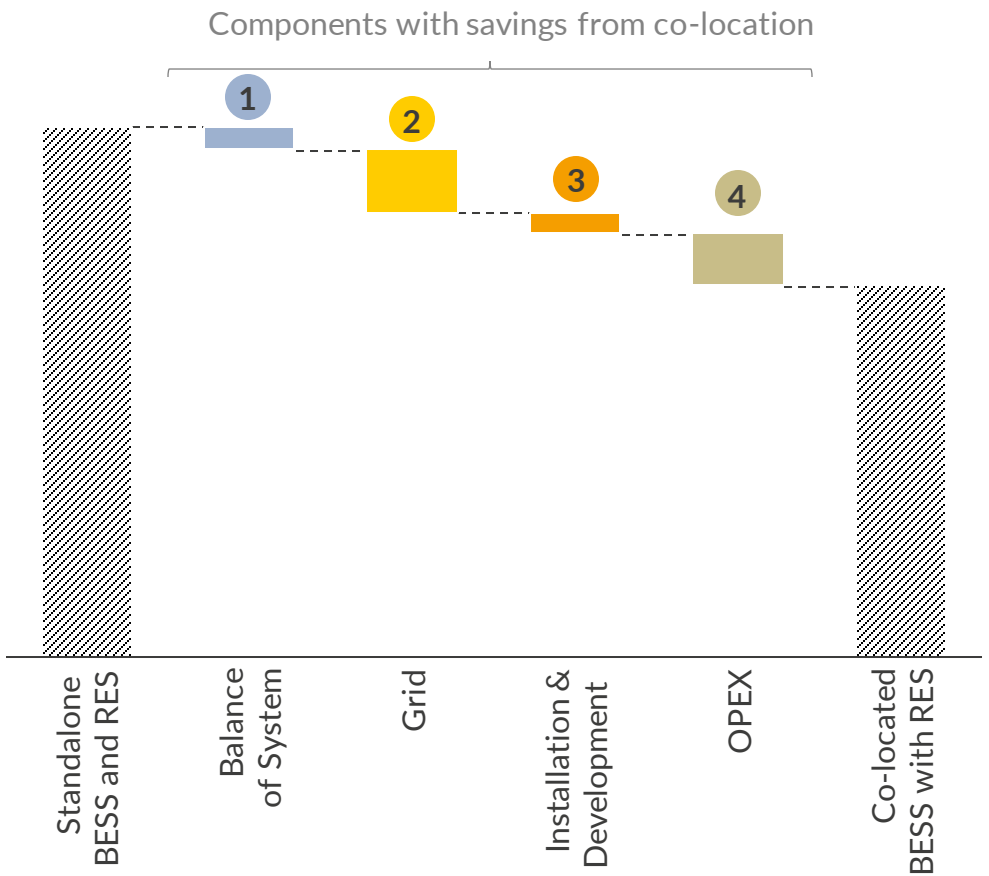
Illustrative standalone vs co-located project costs[1]
€/kW



1 **Electrical and Structural Balance of System savings** – Savings are achievable from synergies in shared cabling, control, protection and monitoring equipment as well as structural elements of the site (fencing, foundations, etc).

2 **Grid connection savings** – Shared grid connections can lead to significant cost savings, as costs[2] to set up an electrical connection to the distribution or transmission network only need to be incurred once.

- Oversizing of the RES plus battery capacity compared to the grid connection capacity leads to higher cost savings. The overall grid savings depend on the relative capacities of the RES and BESS asset.

3 **Installation and Development savings** – Cost savings can come from the synergies in the studies, permits or contracts required for BESS and RES on a single site rather than on two sites. These costs can include site appraisal, obtaining EIAs[3], planning and building permits, labour for installation, etc.

4 **OPEX savings** - Co-located projects can achieve O&M savings by having shared administrative costs (taxes or business rates) and shared personnel for general maintenance (e.g. cleaning, monitoring, security). There can be further OPEX savings from a shared land lease, depending on optimisation of land usage.

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Source: Aurora Energy Research

Adding a battery to RES assets can lead to CAPEX savings of up to [redacted]% and [redacted]% for AC-connected solar and onshore wind, respectively

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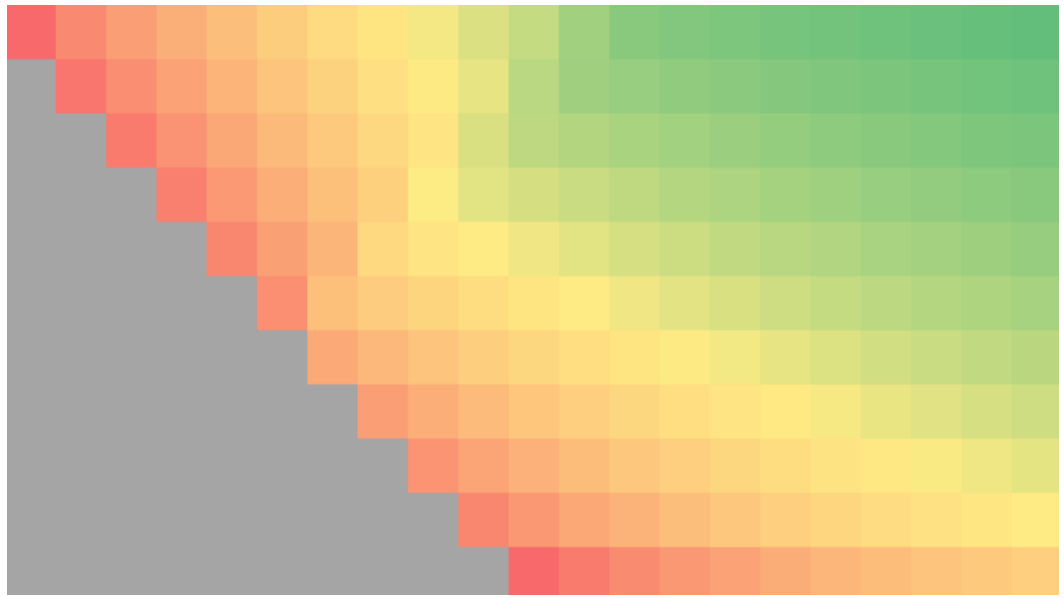
Savings for co-located solar PV and 2h battery[1]

Battery sizing
kW, relative to 1kW grid connection

AC setup



AC solar PV sizing
kW, relative to 1kW grid connection

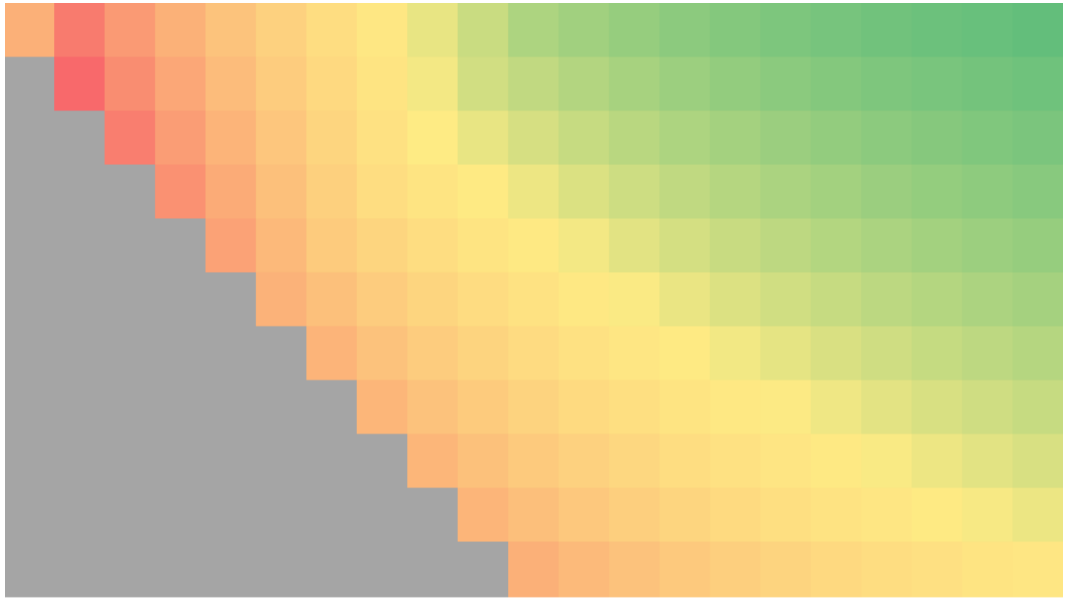
Savings of RES and battery, %

Key:

Savings for co-located onshore wind and 2h battery[1]

Battery sizing
kW, relative to 1kW grid connection

AC setup



AC wind sizing
kW, relative to 1kW grid connection

Savings of RES and battery, %

Key:

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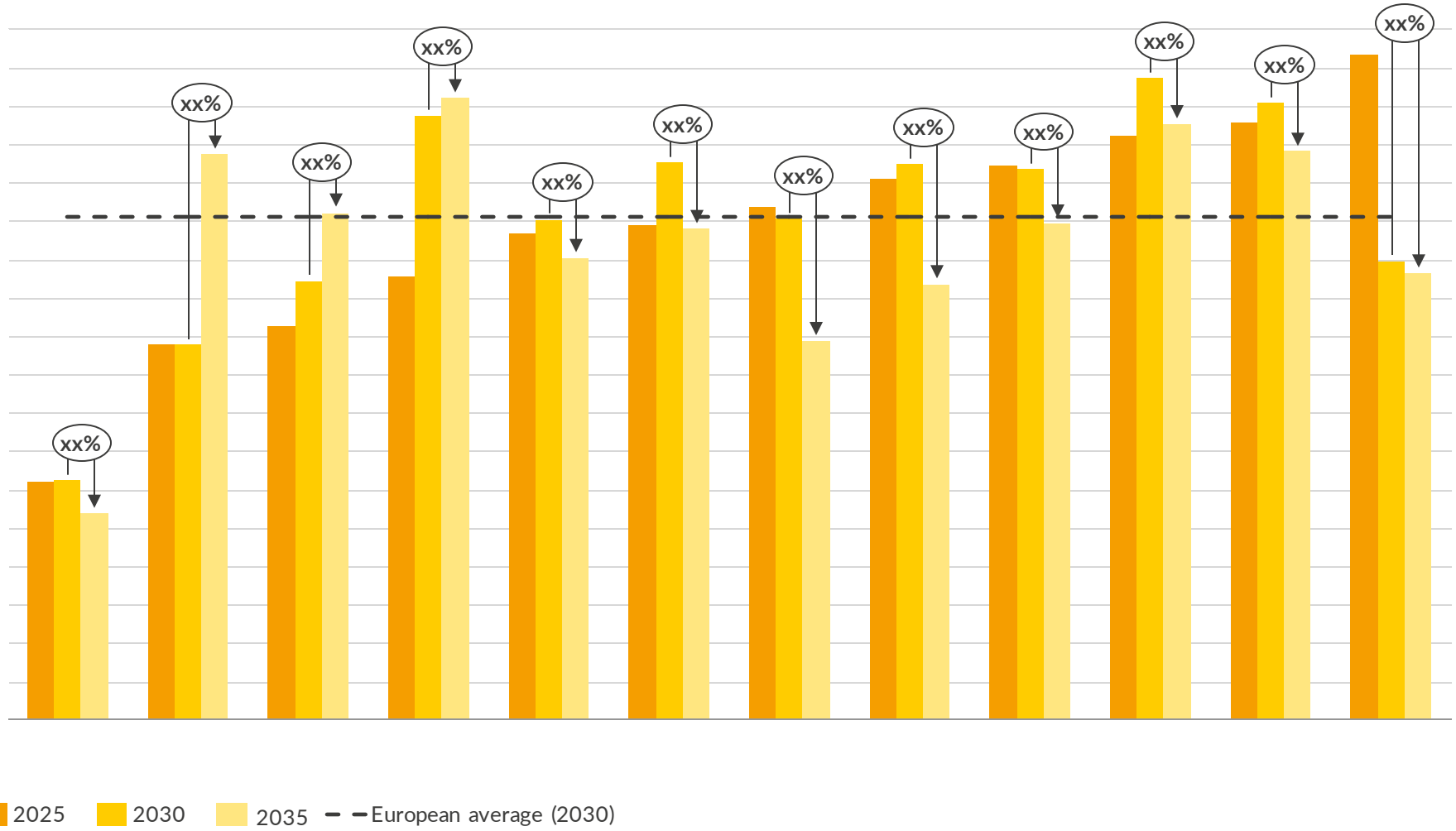
Source: Aurora Energy Research

Wholesale price spreads decease in [redacted] due to increased flexibility in the system from [redacted]

Average daily 1h[1] wholesale day-ahead market price spread
€/MWh (real 2023)



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Source: Aurora Energy Research

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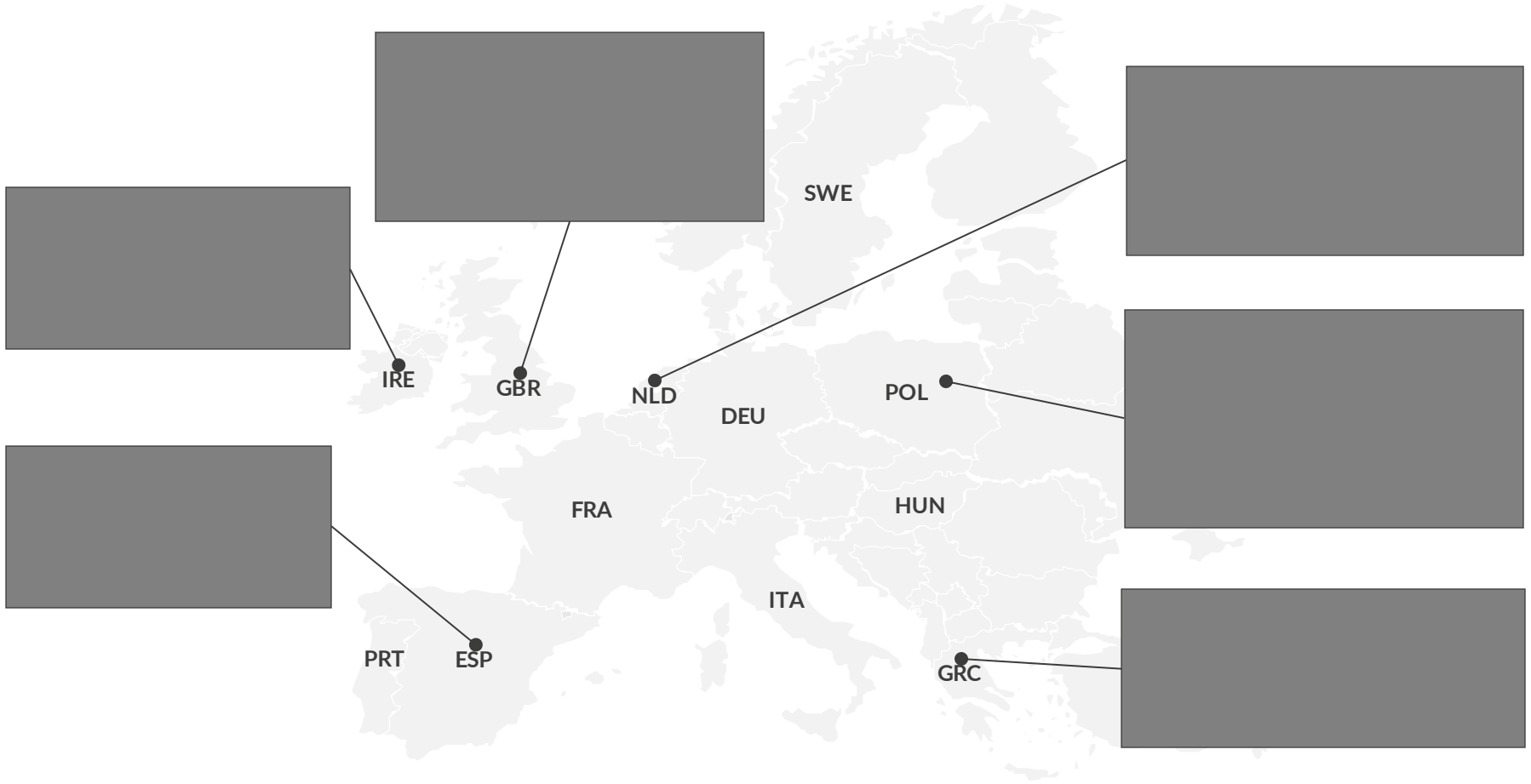
- Wholesale market price spreads signify the earnings battery assets can secure via energy arbitrage.
- Price spreads are expected to decrease in most countries by 2035 due to

- In high RES-penetrated markets, price spreads are expected to rise due to more frequent and prolonged low-price periods.
- Price spreads are expected to increase by 2035 in a few markets due to:

In [redacted], co-located projects can already receive priority for accessing grid connections, while others may follow suit

Speed of grid connections for co-located projects



Co-located projects are prioritised | Some benefit or future benefit | No prioritisation or benefit

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

AURORA

New build

- Regulation for co-located projects currently lags behind standalone projects, which is why grid connection for co-location is currently neither restricted nor prioritised in [redacted].
- In [redacted], there is existing regulation in place that prioritises battery co-located projects relative to standalone RES projects.
- This prioritisation is in place to address the limited availability of grid capacity due to congestion, which is seen as a key barrier throughout Europe including in [redacted].
- Co-location can help mitigate grid congestion and curtailment as batteries are able to store excess power in periods with high renewables generation.

Compared to standalone RES, co-located assets in [redacted] earn additional revenue through frequency response services

AURORA

The differences in revenue sources between a standalone RES and co-located asset will be explored in the country deep dives section

Region	CM	WM	BS[1]	FR[1]	OS	Availability of long-term contractual revenues
[redacted]	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Partially available	▪ [redacted]
[redacted]	Not available/relevant	Available/relevant and stackable	Not available/relevant	Partially available	Partially available	▪ [redacted]
[redacted]	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	▪ [redacted] ▪
[redacted]	Not available/relevant	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Not available/relevant	▪ [redacted]
[redacted]	Not available/relevant	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Not available/relevant	▪ [redacted]
[redacted]	Not available/relevant	Available/relevant and stackable	Partially available	Partially available	Partially available	▪ [redacted]
[redacted]	Available/relevant and stackable	Available/relevant and stackable	Partially available	Partially available	Not available/relevant	▪ [redacted]
[redacted]	Available/relevant and stackable	Available/relevant and stackable	Available/relevant and stackable	Partially available	Not available/relevant	▪ [redacted]
[redacted]	Not available/relevant	Available/relevant and stackable	Not available/relevant	Not available/relevant	Partially available	▪ [redacted]
[redacted]	Available/relevant and stackable	Available/relevant and stackable	Not available/relevant	Partially available	Not available/relevant	▪ [redacted]
[redacted]	Not available/relevant	Available/relevant and stackable	Partially available	Available/relevant and stackable	Not available/relevant	▪ [redacted]

Not available/relevant   Available/relevant and stackable   Partially available

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Ongoing regulatory developments within certain regions may have significant implications for co-located assets (1/3)

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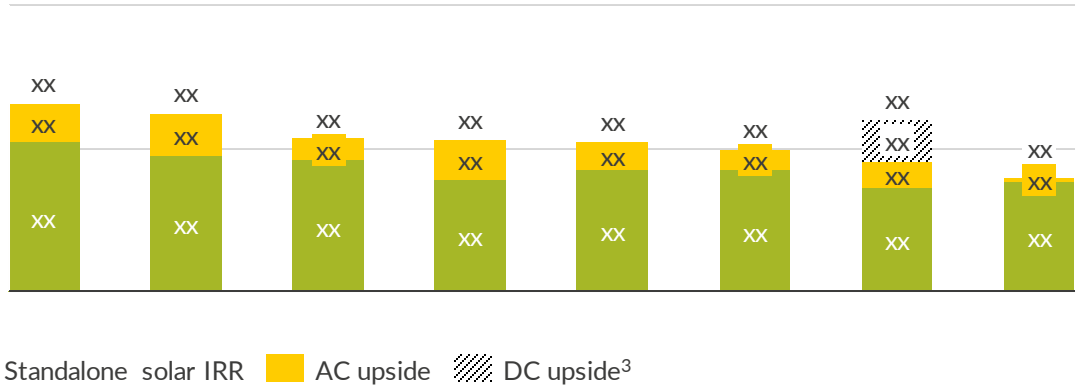
Sources: Aurora Energy Research, French Energy Regulatory Commission

AC co-location boosts standalone solar IRRs by [redacted]% in [redacted], [redacted] and [redacted]; [redacted] attains the highest co-located IRRs

Region	Status	Commentary
[redacted]	High	▪ [redacted]
[redacted]	High	▪ [redacted]
[redacted]	High	▪ [redacted]
[redacted]	Medium	▪ [redacted]
[redacted]	Medium	▪ [redacted]
[redacted]	Medium	▪ [redacted]
[redacted]	Medium	▪ [redacted]
[redacted]	Low	▪ [redacted]

Co-location IRRs relative to standalone solar

Percentage points



Key considerations on the IRR upside in certain markets

- Location plays an important role for co-location's potential benefits [redacted]
- Similarly, the strong upside in IRRs from co-location in [redacted] is location dependent [redacted]
- Additional upside cannot be gained for [redacted]

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

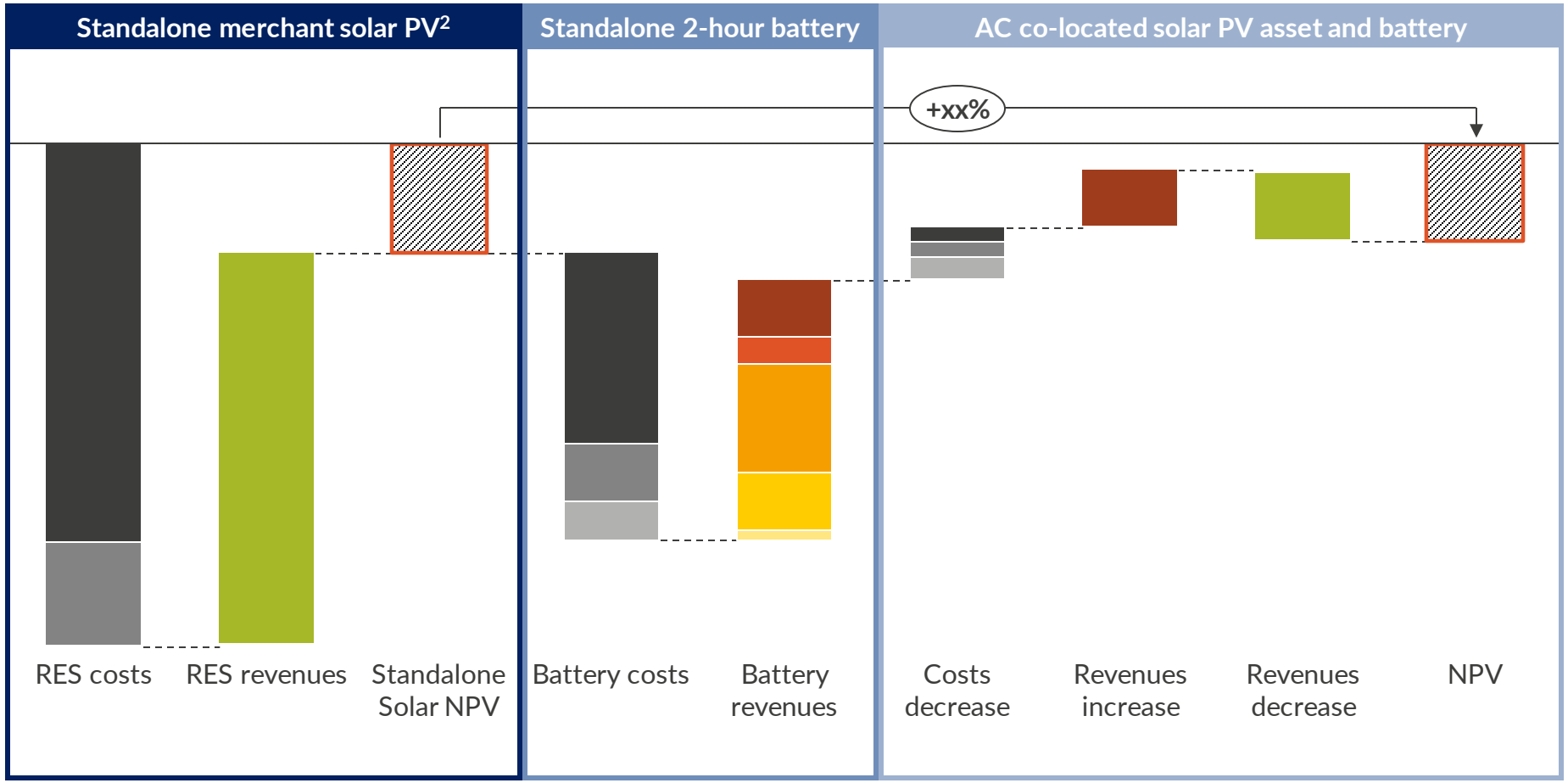
With full market access, AC co-location can provide an upside when compared to a fully merchant solar PV setup

AURORA

AC setup | New build

0.5 | 1.0 | 1.0

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



- 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]

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Source: Aurora Energy Research

High spreads in [redacted] mean co-located assets starting operation in 2027 can increase standalone solar IRRs by [redacted] pp

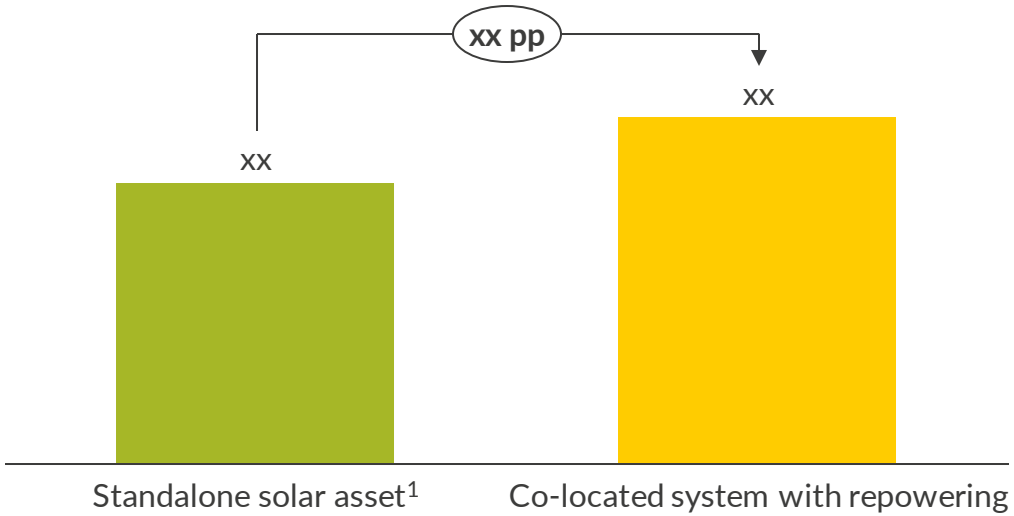
AURORA

AC setup | New build

Deep-dives on co-location business cases are included for 8 of the 12 markets covered in the report

Share of gross margins per asset in a merchant, co-located setup[1]
%

Project IRRs
% (pre-tax, nominal)



- Batteries in [redacted] can access the capacity market, ancillary service markets through the [redacted]
- [redacted]

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

Battery Solar PV

This is a redacted sample of the European Co-location Market Attractiveness Report. If you are interested in the full report, contact Mrunal Karnik (mrunal.karnik@auroraer.com)

Source: Aurora Energy Research

[redacted] provides the highest project IRRs across the 8 modelled markets due to strong combined battery and solar business cases

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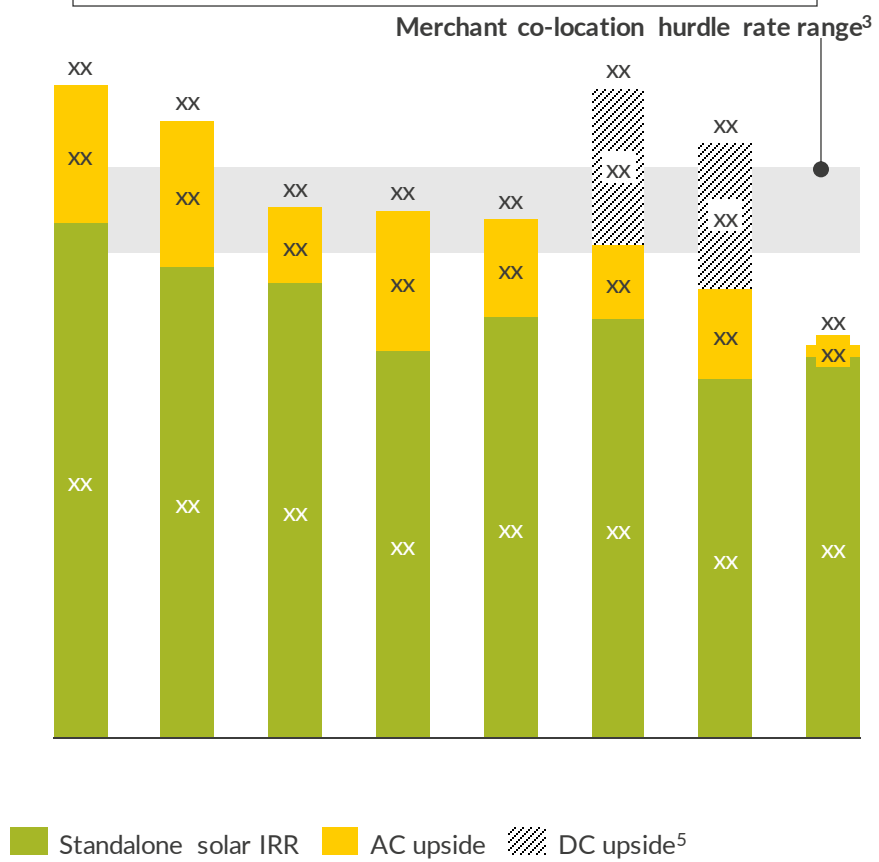
AC setup | New build

- High [redacted] revenue opportunities in [redacted] combined with [redacted] make for strong solar and battery business cases.
- High IRRs are driven by the battery in [redacted] and [redacted], both stemming from revenue stacking of ancillary markets, sizeable wholesale spreads in the wholesale and balancing markets, as well as capacity market payments.
- [redacted] sees lower co-located project IRRs owing to saturated ancillary markets and low wholesale spreads from sustained nuclear generation. Assuming a CfD setup, which is the most common for RES in [redacted], our modelling indicates project IRRs of up to [redacted]%.
- Co-location under DC set-ups can provide an additional upside to the AC case of up to [redacted]pp in available modelled regions[5].

Increase in standalone solar PV IRRs with co-location
Percentage point

AC co-located project IRRs[1]
%

AC co-location in [redacted] can push IRRs for standalone solar comfortably within range of co-location hurdle rates[3], though [redacted] solar PV business case already meets the standalone solar hurdle rates required.



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Revenue split for the optimal sizing ratio per market is underpinned by the relative strength of standalone RES and battery economics

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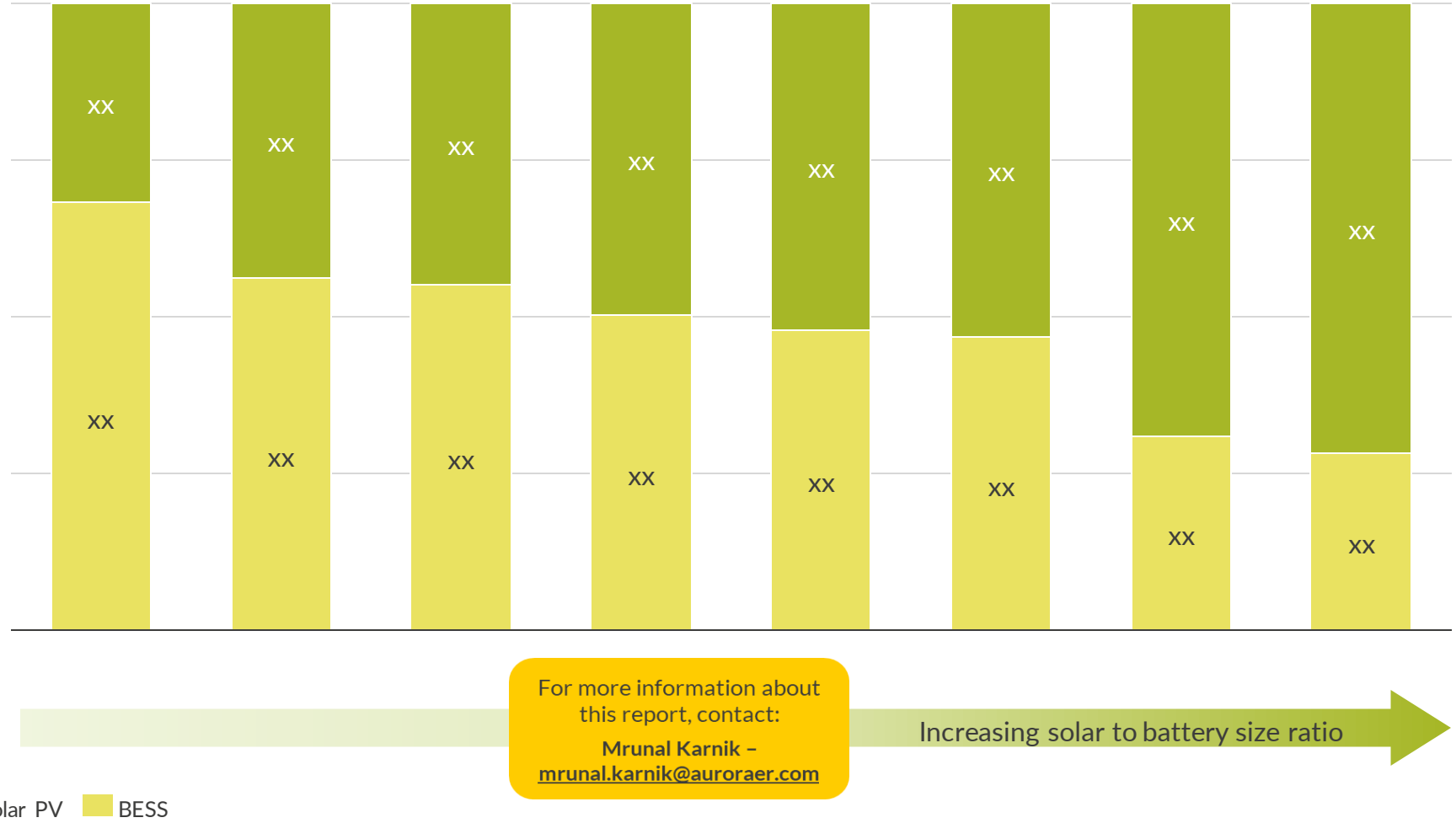
AC setup | New build

Share of gross margins[1] per asset in a co-located solar PV setup (2027 COD, average of 2027-2041)

%



- In markets with already favourable solar economics and high solar load factors (such as [redacted]), co-located project IRRs are maximised with higher solar to battery ratios as this minimises battery costs and allows access to revenue upside from flexibility markets, while maintaining high solar revenues.
- Optimal business cases tend towards a lower solar to battery ratio in other markets (such as [redacted]) where the battery business case is stronger, driven by greater revenue opportunities in energy arbitrage or ancillary services provision from the battery than from the solar generation.

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Source: Aurora Energy Research

BESS co-located with solar PV in DC configuration could yield a total gross margin up to [redacted]% higher than in AC configuration

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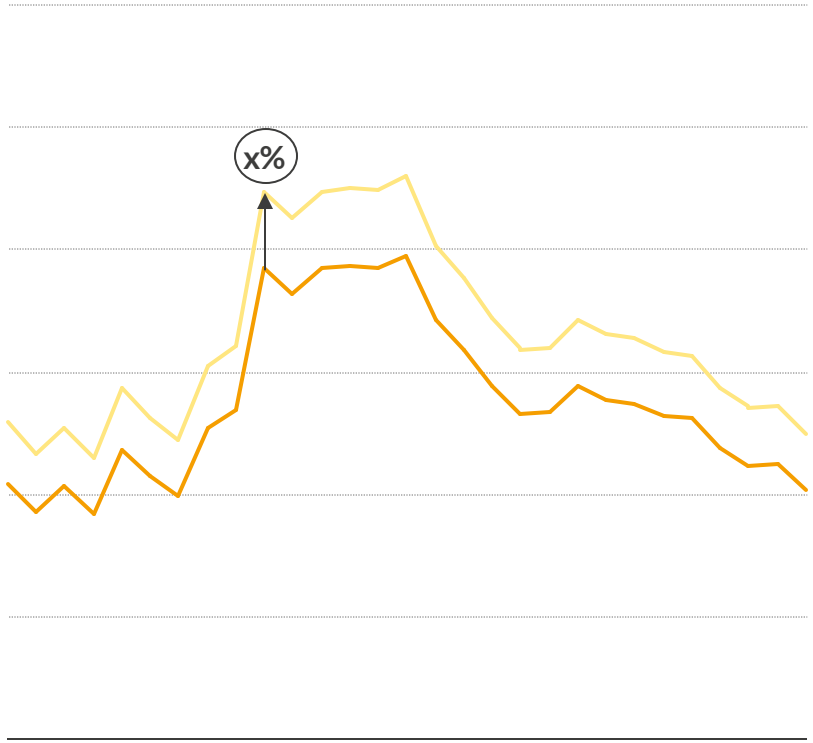
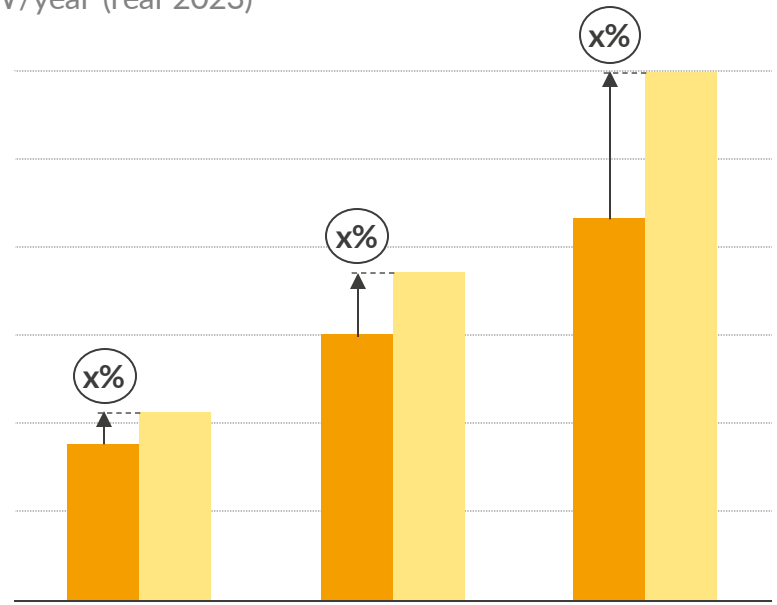
AC vs DC setup | New build

Co-located Solar PV and Battery asset in [redacted], AC vs DC configuration, 2027 entry, BESS duration of 1, 2, and 4 hours

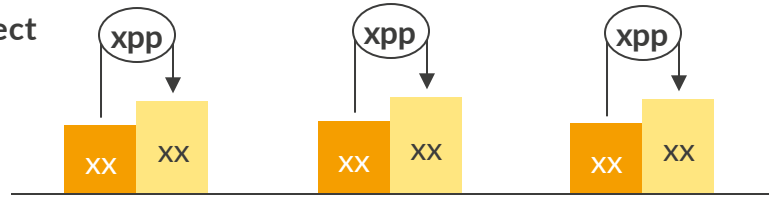
Solar gross margin
€/kW/year (real 2023)



Average total battery gross margins[1] (2027 – 2051[2])
€/kW/year (real 2023)



Project IRR[3]



AC DC

- DC consistently sees a higher total battery gross margin, and the advantage of a [redacted] grows with increasing BESS duration. This is because co-located batteries in a DC configuration are able to charge from the solar asset, and with increasing BESS duration they will be able to charge more hours from the solar asset.
- DC-configured co-location also has an advantage in terms of project IRRs, which are up to [redacted] percentage points above AC-configured projects in [redacted].
- However, the solar gross margin for the same co-location project is on average [redacted]% higher for an [redacted]-configuration.

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Source: Aurora Energy Research

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