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ENERGY RESEARCH

European Solar Markets Attractiveness Report

April 2023

This is a redacted sample of the European Solar Markets Attractiveness Report. If you are interested in the full report, contact Alex Hutcheson, (alex.hutcheson@auroraer.com).

European Battery Markets Attractiveness Report (BATMAR):
Inform your next business move in Europe with this comprehensive report

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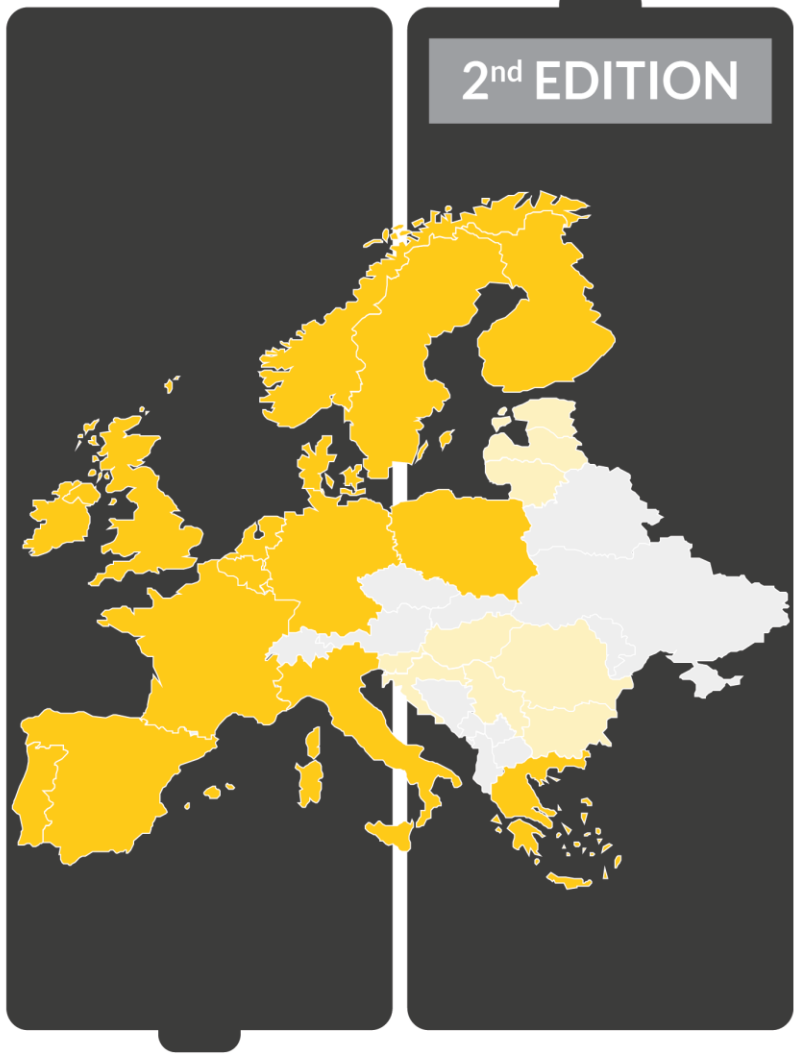
Analysis across 24 European countries:

- Great Britain*
- Ireland (I-SEM)*
- France*
- Belgium*
- The Netherlands*
- Germany*
- The Nordics* (Denmark, Finland, Norway, Sweden)
- Iberia* (Portugal, Spain)
- Italy*
- New Poland*
- New Greece*
- Hungary
- Romania
- Bulgaria
- New Serbia
- New Slovenia
- New Croatia
- New The Baltics (Estonia, Lithuania, Latvia)



With over 100 analysts and modellers working across our European Flexibility Energy Market Services, this report provides you with a summary of our credible, reliable, and bankable forecasts.

Access this report for:

- **European Battery Market Trends – Market Size and Opportunity**
  - Installed capacity, battery investment trends, and near-term pipeline
  - Forecast volumes for battery deployment by year and country
- **Policy and Regulatory Environment analysis**
  - European and national battery strategies, targets and plans
  - Analysis of anticipated regulatory changes impacting battery markets
  - Assessment of policy risks including aggregation of demand side assets, and grid connection
- **Battery Storage Business Models and Value Drivers**
  - Summary of attainable markets and revenue stacking opportunities
  - Comparison of value drivers across markets including RES penetration and daily wholesale market spreads, balancing services and capacity market auctions
  - Assessment of saturation risk for each country
- **Battery Economics and Business Cases. See above plus:**
  - Revenue stacking opportunities and normalised gross margins (1, 2 and 4 hours)
  - Investment cases (estimated IRR ranges) for hybrid business models (optimised between energy arbitrage and ancillary services)

New features:

- 6 new regions covered
- Business cases for 2 new markets: Greece and Poland
- Updated BESS cost projections
- Analysis of recent EU market reforms

Get in Touch to Find Out More

For markets (*) Flexible Energy Market Services with detailed forecasts & business case analysis are available

Source: Aurora Energy Research

Executive Summary

- Europe currently stands as one of the leading regions for solar PV investments globally and, driven by ambitious decarbonisation targets, is expected to see exponential growth in solar PV in the coming years
- Aurora's European Solar Markets Attractiveness Report provides an overview of European solar PV markets and the key underlying value drivers
- Key highlights from the report include:

- The top markets for solar PV in Europe are [redacted], [redacted] **and** [redacted];[redacted] leads due to strong policy support for solar and large market size despite average project economics

**The information in this report is taken from a range of Aurora's Power and Renewables market subscriptions to provide you with a high-level understanding of European solar 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.*

Source: Aurora Energy Research

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Aurora's rating combines nine robust metrics to derive an overall attractiveness score for 24 European solar markets

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The overall market attractiveness score for each European solar market covers three categories and eight metrics, which are set out in detail in this report.

Categories and metrics	Weighting	Rationale	Source of data
Market size, composition & outlook	**40%**		
1 Solar deployment to 2030	*40%*	Indicates expected future market size in the medium term	Aurora fundamental modelling*
2 PPA[1] market potential in 2030	*20%*	Indicates expected availability of commercial off-takers in the medium term to mitigate merchant risks	Aurora databases*
3 Solar buildout in 2022	*40%*	Reflects recent trends and market activity	Aurora databases and analysis*
Policy environment	**40%**		
4 Announced solar[2] targets in 2030	*20%*	Demonstrates policy ambition for RES deployment over the medium term	Aurora analysis*
5 Historical auctioned capacity	*10%*	Indicates track record of government support for RES build-out (and market size for refinancing)	Aurora analysis*
6 Planned auctioned solar capacity until 2030	*20%*	Indicates expected government support for RES build-out	Aurora analysis*
7 Policy risks - support schemes, permitting, grid connection	*50%*	Reflects effect of key policy and regulatory risks on project development	Aurora analysis*
Project economics	**20%**		
8 Indicative fully merchant net[3] IRR for project starting in 2025 and 2030	*40% each*	Captures the commercial viability of new build fully merchant projects for final investment decisions in three years' time and in 2030 to capture cannibalisation effects in different markets	Aurora fundamental modelling*
9 Attractiveness of co-location with batteries	*20%*	Reflect ability to pursue innovative business models to improve project economics	Aurora analysis*

(*) Detailed country data available in Aurora's Power Markets subscriptions.

1) Aggregated PPA potential for all RES technologies 2) Only utility-scale solar 3) Includes guarantees of origin and imbalance costs

Source: Aurora Energy Research

The most attractive European market for solar PV is [redacted], followed by [redacted] and [redacted]

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Installed capacity of solar PV across Europe currently stands at [redacted] GW, making up [redacted] % of total installed capacity. It is projected to grow by more than [redacted] by 2030, requiring a cumulative investment of EUR [redacted] billion CAPEX until 2030.

Rank	Region	Market attractiveness score
1	[redacted]	
2	[redacted]	
3	[redacted]	
4	[redacted]	
5	[redacted]	
6	[redacted]	
6	[redacted]	
7	[redacted]	
8	[redacted]	
9	[redacted]	
10	[redacted]	

Market size, composition & outlook Policy environment Project economics

Top markets

[redacted]

Markets to watch

[redacted]

Source: Aurora Energy Research

Due to policy changes [redacted], and [redacted] have improved in the ranking, while [redacted] has dropped

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Region	Current rank (Apr-23)	Previous rank (Mar-22)	Highlights and key changes
			
			
			
			
			
			
			
			
			
			
			

Source: Aurora Energy Research

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Solar capacity buildout is driven by four key factors which cut across government policy and market forces

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1 Increasing power demand

- \+ As Europe looks to decarbonise and reach Net Zero emissions by 2050, it seeks to achieve this in large part through electrifying its economy, creating additional power demand that can be met by renewables to reduce emissions
- \+ Additionally, increasing demand for PPAs drives investment in renewables
- − Improvements in energy efficiency put downwards pressure on power demand

2 Strong policy support and Government ambition

- \+ Government ambition through renewables deployment targets and strong policy support drives investor confidence and ultimately investment in renewables
- − Lack of policy support, or sudden changes in policy, can negatively impact investor confidence in renewables in a country

More in section IV of this report.

3 Rising fuel and carbon prices

- \+ Electricity prices in most markets across Europe are set by the marginal producing plant, which is most often gas CCGTs, such that the power price is highly correlated with the short run marginal cost of a CCGT
- \+ Therefore, the gas price is directly related to the baseload power price, and to the capture price of renewables
- − Some countries in Europe, such as Spain, have introduced caps on the price of gas that can be passed through to the consumer when used to generate electricity, lowering renewable capture price for merchant projects

4 Phase out of thermal capacity

- \+ As Europe phases out traditional thermal capacities such as coal and older, unabated gas assets in its push to meet ambitious decarbonisation targets, this makes way for alternative, low-carbon generating capacities to fill the gap in order to meet Europe's increasing power demand.
- − Accelerated retirement of thermal capacity places greater strain on managing system parameters such as frequency and voltage which cannot be provided by renewables alone.

Source: Aurora Energy Research

Power demand in Europe is expected to increase by [redacted]% to 2050, driven by increased electrification across sectors

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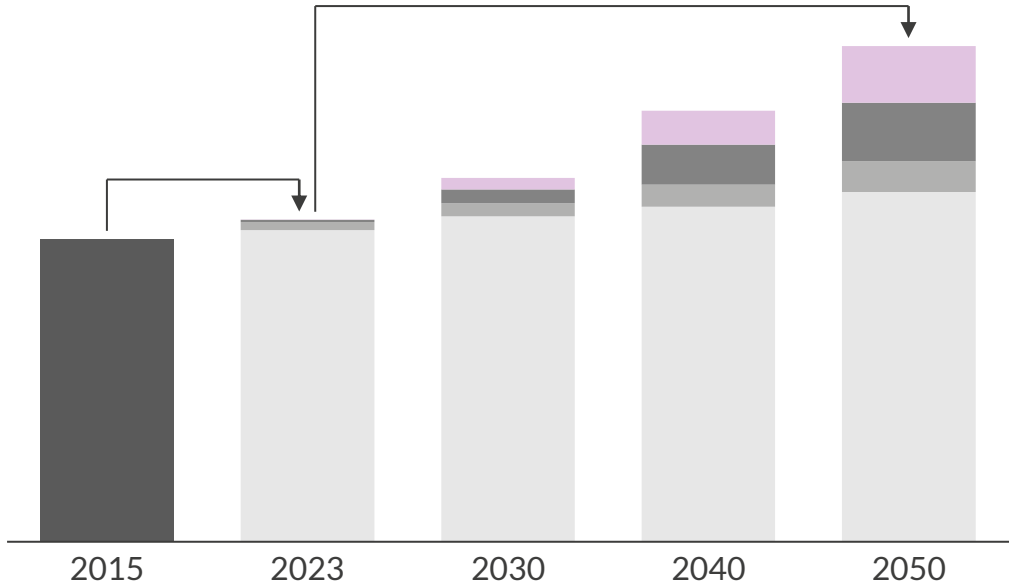
Annual power demand in Europe[1]

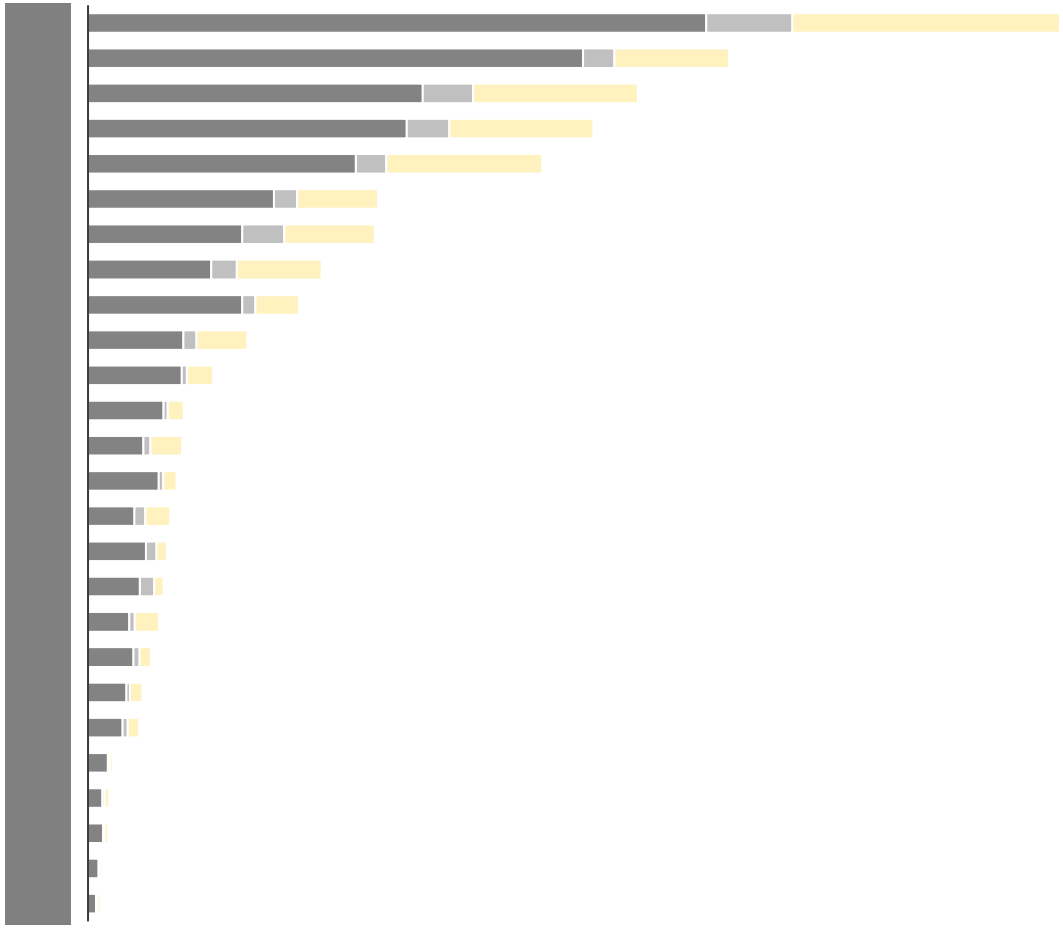
TWh



- In Aurora's Central outlook, power demand across Europe increases by [redacted]% between 2023–50. Electric vehicles make up the largest share of new demand, followed by hydrogen, electrification of industry (included in base demand), and heating.

Annual country level power demand

TWh



Hydrogen | Road transport | Heat | Base power demand[3] | Historical

2023 | 2030 | 2050

1) EU27 plus UK and Norway, minus Malta and Cyprus. 2) Demand for green hydrogen production from electrolysis. 3) Underlying demand excluding heat and EVs.

Sources: Aurora Energy Research, Eurostat

The key objectives of EU's energy policy framework have long supported the buildout of renewables across the continent

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2 Strong policy support

Part of overarching EU Green Deal framework

	2014 Climate & Energy Framework 2030	2019 Clean Energy for all Europeans	2021 'Fit for 55'	2022 REPowerEU
Key objectives	*Set out the EU's climate targets for the period 2021-2030*	*Regulatory framework to decarbonise the EU's energy system in line with its Green Deal objectives*	*Proposed package reflecting a ratcheting up of climate ambition and energy-related targets by 2030*	*Strategy to reduce reliance on Russian gas and mitigate impacts of high power prices on consumers*
Emissions reduction	▪ 40% reduction in GHG emissions by 2030 relative to 1990 levels, in anticipation of 2016 Paris Agreement	▪ Part of wider EU Green Deal strategy to reach net zero by 2050, no increase in emissions reduction targets	▪ 55% reduction in GHG emissions by 2030 relative to 1990 levels	▪ Heightened ambition to electrify industry and buildings via renewables to lower gas demand
Renewables deployment	▪ 27% share of renewable energy in EU gross final energy consumption by 2030	▪ Binding target of 32% of renewable energy sources in EU energy mix by 2030	▪ 40% share of renewable energy in EU's overall energy mix by 2030	▪ Targets 589 GW of solar PV by 2030 ▪ Includes EU solar strategy and EU Solar Rooftop Initiative ▪ Provisional agreement to raise targeted share of renewable energy to 42.5% by 2030[3]
Energy efficiency	▪ 27% improvement in energy efficiency by 2030 compared to current levels	▪ 32.5% increase in energy efficiency by 2030 over current levels ▪ Increase efficiency of buildings[1]	▪ 36% and 39% energy efficiency improvements in final and primary energy consumption, respectively	▪ Increase energy efficiency of buildings (e.g. greater heat pump deployment)
Security of supply	▪ Interconnector capacity to reach 10% of installed generation capacity by 2020 and 15% by 2030 ▪ Implement North-South/Southern gas corridors, increase gas storage and regasification capacity	▪ Re-design of electricity market to accommodate high renewables capacities, including separation of the procurement of balancing capacity and balancing energy	▪ Increase share of sustainable fuels in aviation and shipping to decarbonise and reduce reliance on fossil fuel imports	▪ Reduce gas demand and diversify supply to reduce EU dependence on Russian gas by 90% by 2030 ▪ Investment in LNG infrastructure ▪ Increase domestic production of green hydrogen and biomethane

1) Energy Performance of Buildings Directive (EU 2018/844). 2) Versus "Fit for 55" baseline buildout rate. 3) As of 30 March 2023, includes additional 2.5% top up to reach 45%

Sources: Aurora Energy Research, European Commission

Rising fuel and carbon prices increase the costs of thermal assets and due to current price setting nature this drives higher market prices

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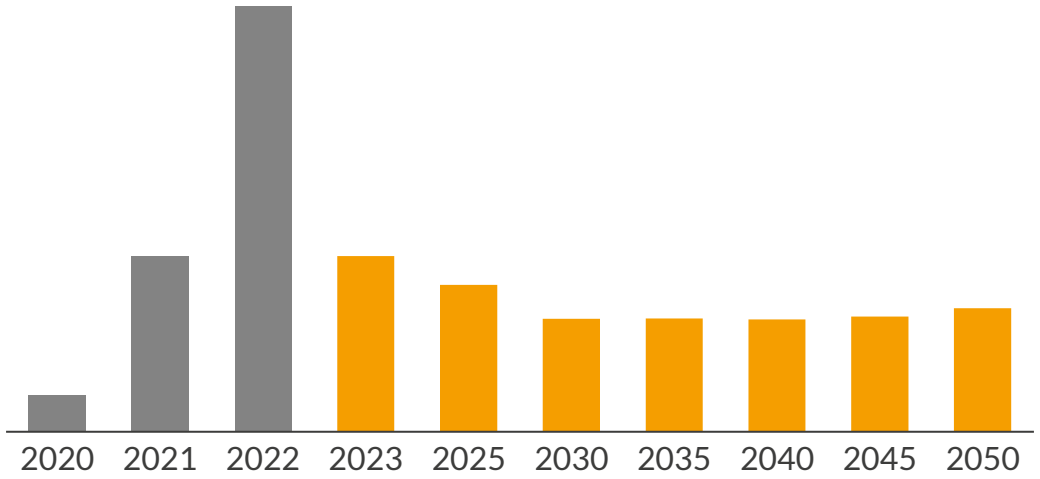
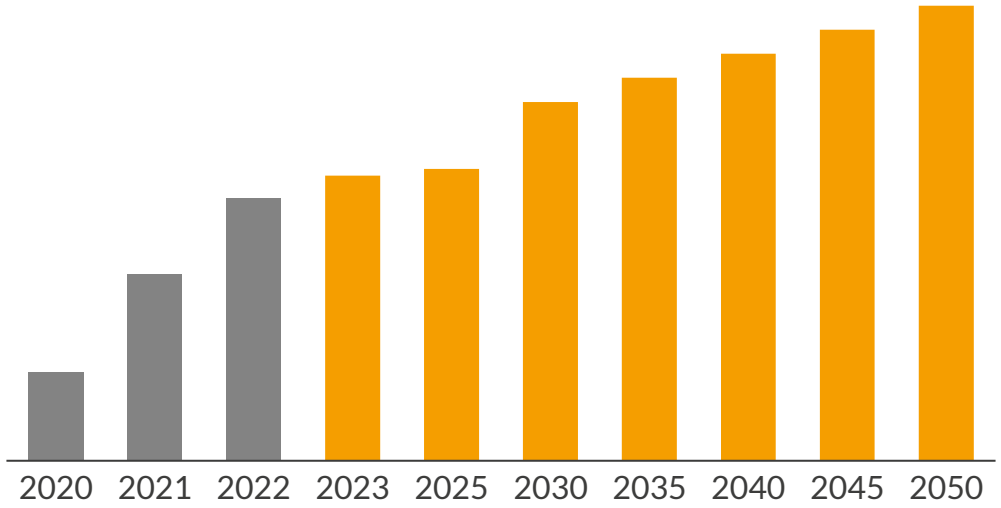
3 Rising fuel and carbon prices

Gas prices[1]*
EUR/MWh (real 2022)



- Gas prices spiked in 2022 as Russia's invasion of Ukraine led to a drastic decrease of Russian gas to Europe
- Gas prices rebalance by 2026 as Russian dependence is reduced, and then increase to 2050 due to rising global gas demand and declining indigenous production

Carbon prices[1]*
EUR/tCO_2 (real 2022)



- EUA prices rose to record highs early 2022 as traders anticipated natural gas prices remaining high. EUAs faced a sudden sell-off following Russia's invasion of Ukraine but have since recovered as the economic outlook improved and EU Trilogue negotiations ended with slightly higher ETS ambition .
- After rebalancing from current highs by 2025, prices are expected to increase out to 2050. Rising prices reflect the expectation of stricter annual emissions limits as the EU increases decarbonisation efforts towards legislated targets.

Aurora April 2023 Central forecast[2] Historical

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) Dutch TTF gas price, for years 2023-2027, the prices shown take into account current futures prices for the years in question, with declining weights 2) Other forecasts in the report are based on Aurora's January 2023 forecast

Source: Aurora Energy Research

Increasing marginal costs for thermal plants will drive them out of merit in favour of additional renewables capacity buildout…

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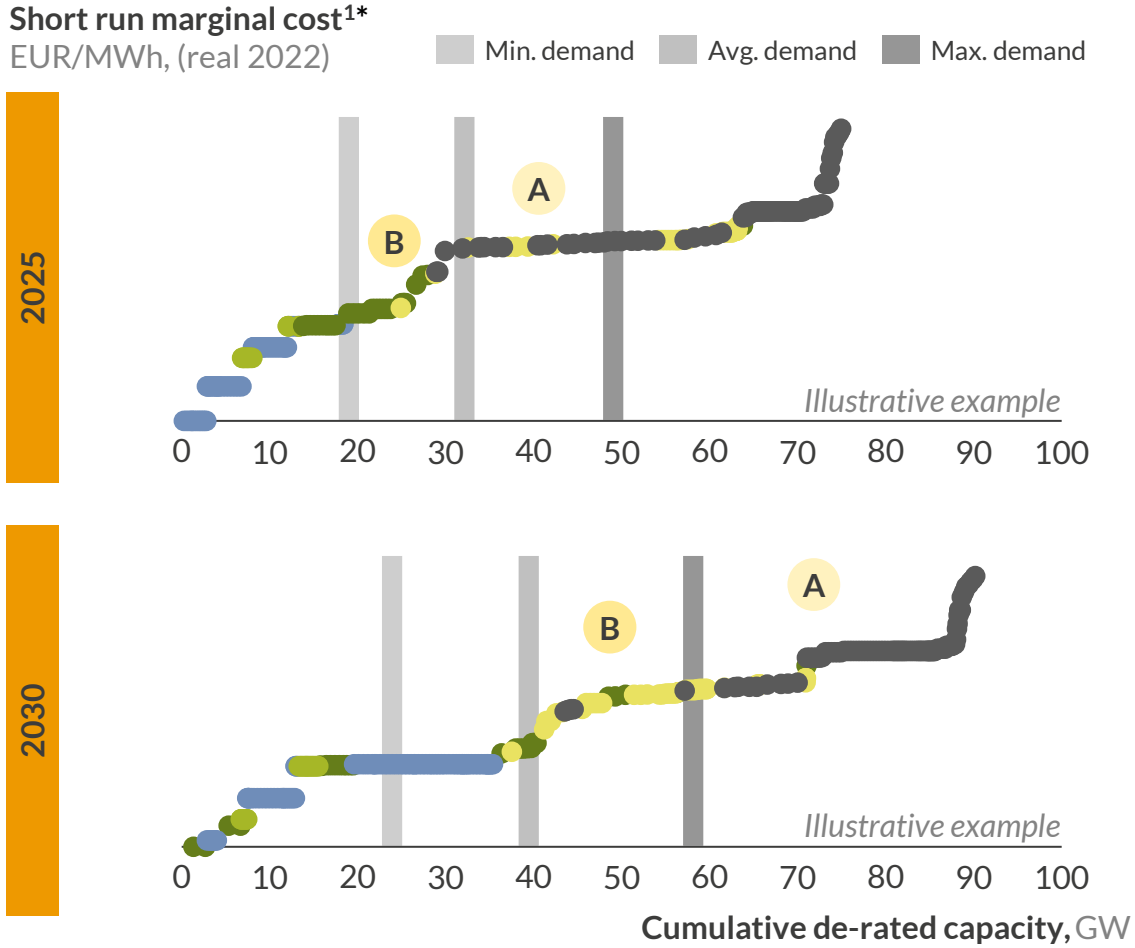
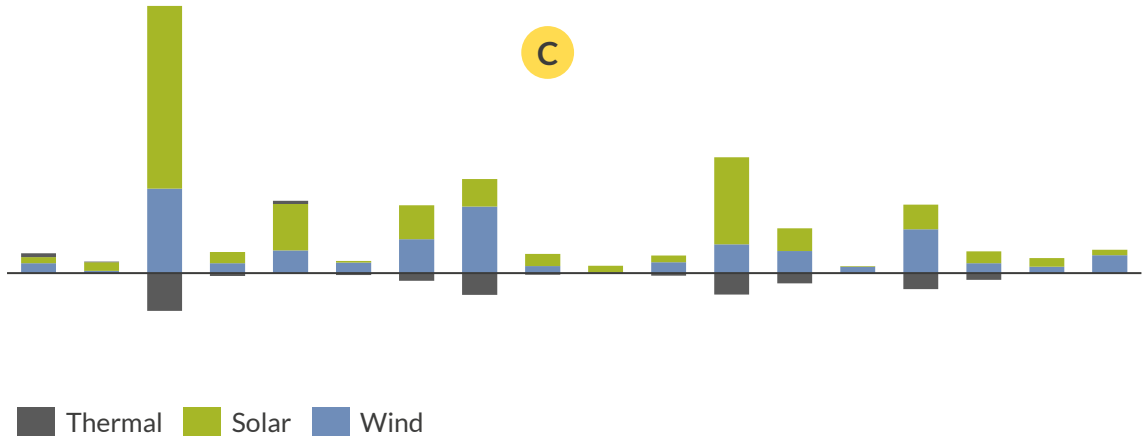
4 Phase out of thermal capacity

Short run marginal cost[1]*
EUR/MWh, (real 2022)



Capacity changes (2023 – 2030)*
GW



- **A** Increasing marginal costs for thermal plants will drive them out of merit, causing them to fulfil less demand and only be dispatched in periods of high demand
- **B** The rapid growth in renewables results in low-cost assets fulfilling more than the average demand by 2030
- **C** Across Europe, ▮ GW thermal assets are expected to fall out of merit and retire by 2030 due to a combination of worsening economics and ageing
- The reduction in capacity of these assets in turn supports the buildout of further renewables capacity

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) Shown for a representative country in Europe. 2) Includes biomass, hydro, nuclear, CCS and hydrogen. 3) Includes interconnectors and storage. 4) Includes unabated gas and coal plants.

Source: Aurora Energy Research

...but even in a Net Zero scenario, dispatchable technologies exposed to commodity prices will set the price more than half of the time

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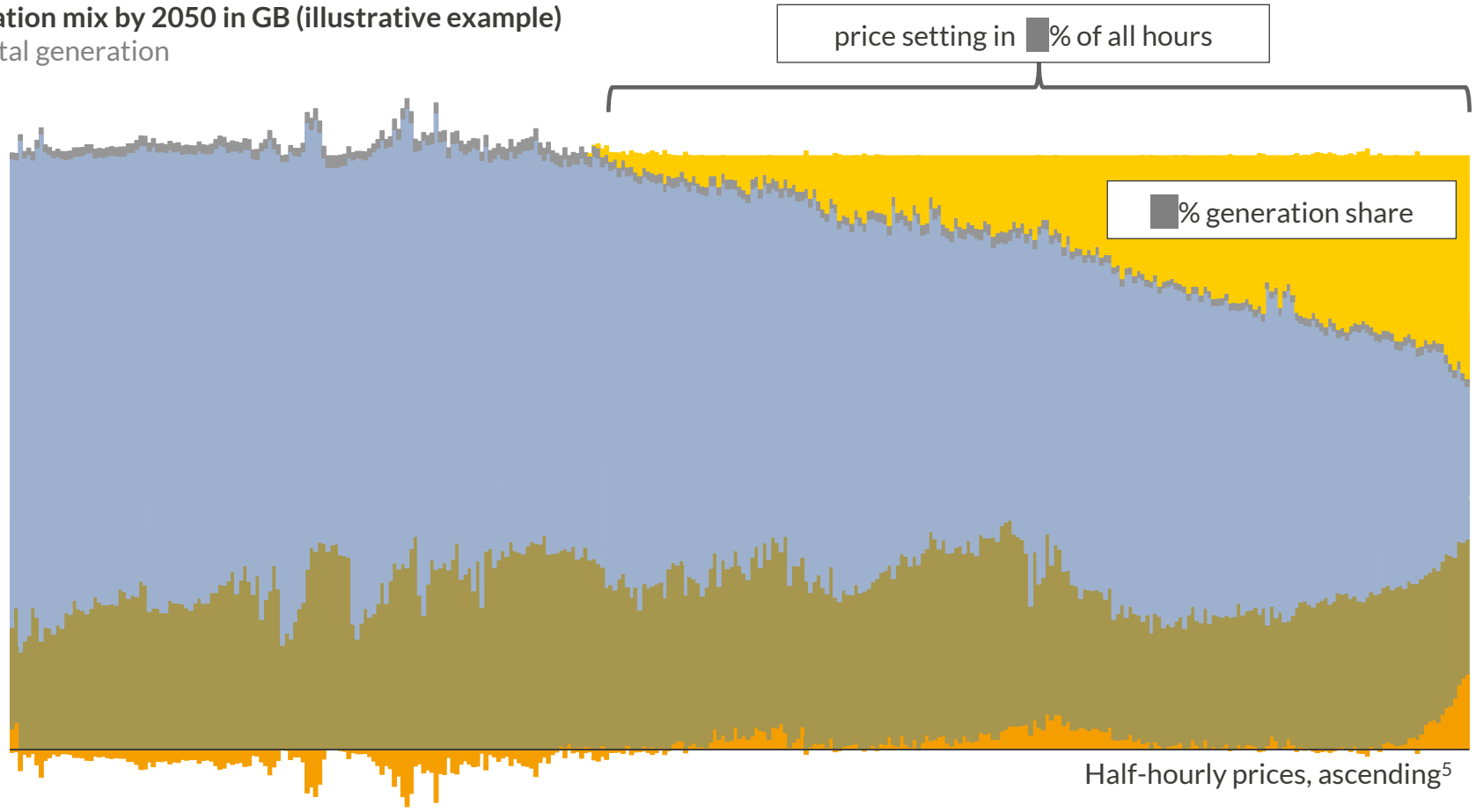
4 Phase out of thermal capacity (cont.)

Generation mix by 2050 in GB (illustrative example)
% of total generation



1) Includes CCGT and peakers 2) Mainly CHP 3) Includes wind, solar and other renewables 4) Includes batteries and pump storage 5) Grouped into periods of 25 hours

Sources: Aurora Energy Research, European Commission

Government support schemes are still the biggest driver of solar build-out across most of Europe, with varying degrees of merchant exposure

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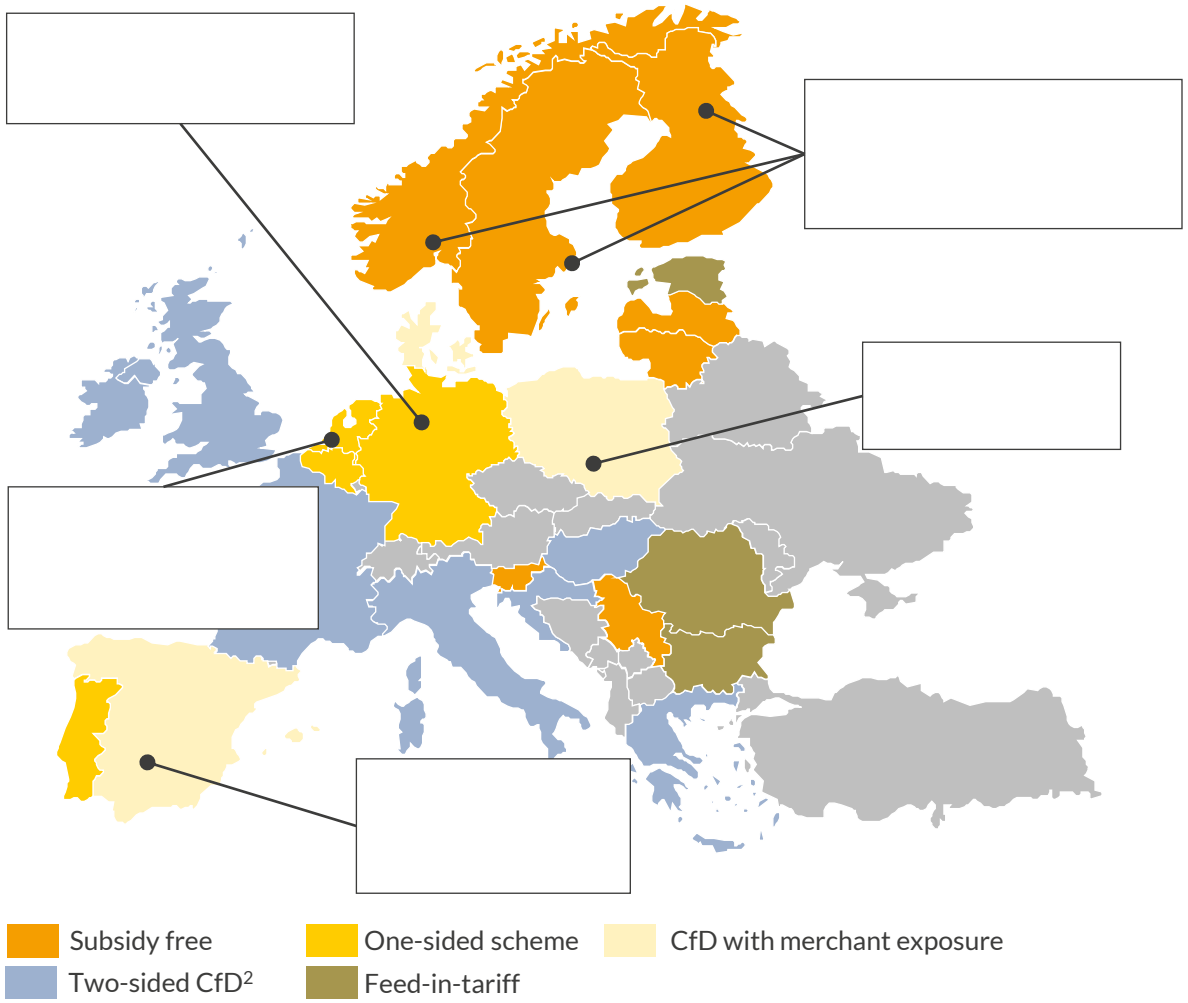
Renewable support schemes for utility-scale solar: some markets allow for merchant exposure



Impact of support schemes on buildout of solar PV

Sources: Aurora Energy Research

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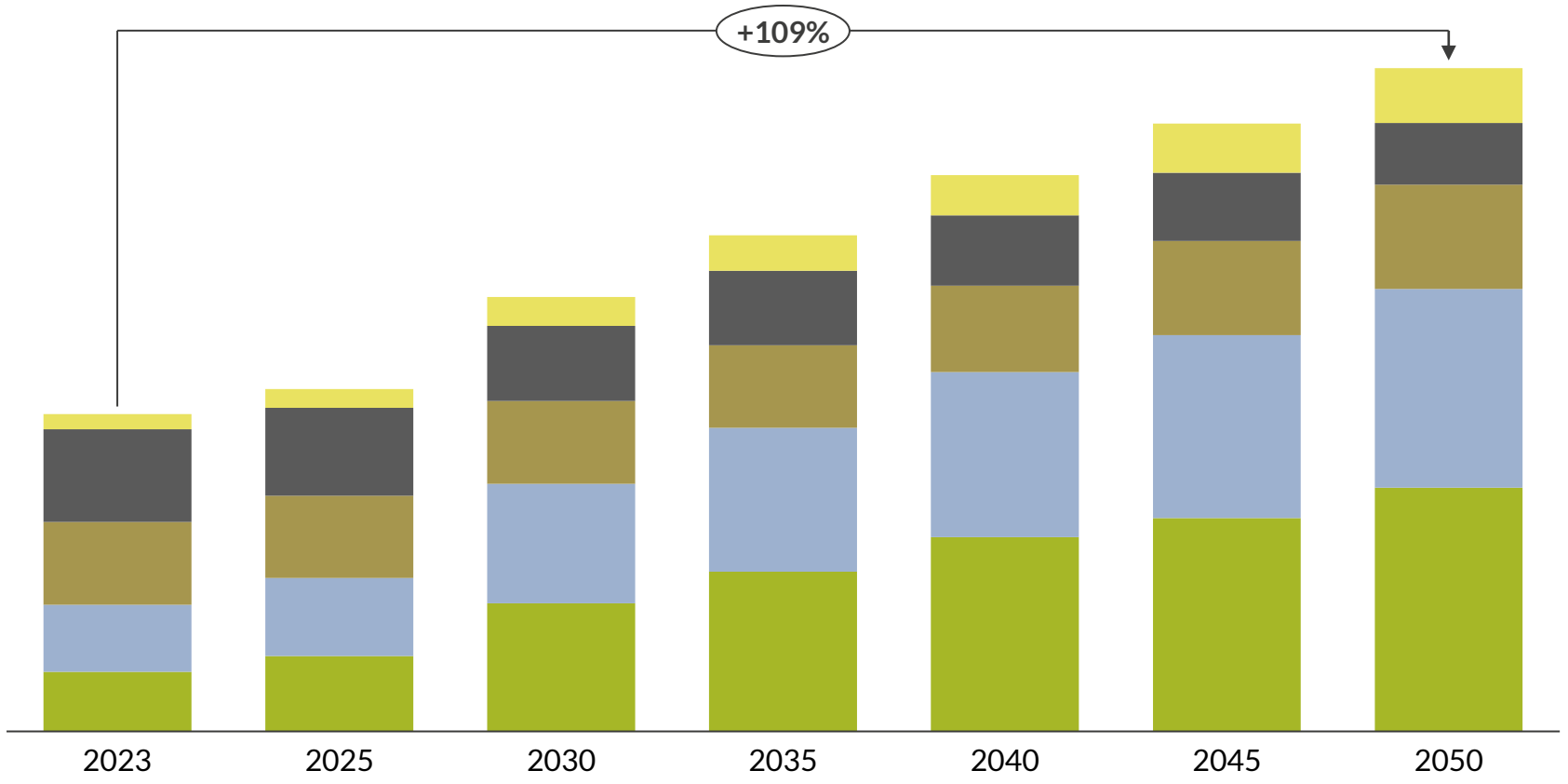
Decarbonisation efforts drive strong growth in renewables capacity, with solar reaching [redacted] GW by 2030 in Aurora's Central case

Installed generation capacity in Europe[1] (Aurora Central Scenario)*
GW



(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

Flexible[2] Fossil[3] Other low carbon[4] Wind[5] Solar

1) Europe defined as EU27 plus UK and Norway, and Serbia minus Cyprus and Malta. 2) Includes interconnectors and storage. 3) Includes gas and coal plants. 4) Includes nuclear, hydrogen, biomass, hydro, EfW,and CHP. 5) Includes solar and wind technologies.
Sources: Aurora Energy Research, European Commission

- Total power generation capacity across Europe roughly doubles by 2050, due to increasing demand from electrification of sectors as a means to decarbonise, coupled with a shift away from thermal generation to lower load factor renewables
- Renewables dominate the growth in capacity, with solar increasing by [redacted] GW by 2030
- However, in Aurora's Central scenario, Europe falls [redacted] GW or [redacted] % short of the REPowerEU target of [redacted] GW solar 2030
- Furthermore, despite significant reductions, unabated fossil capacities still comprise around [redacted] % of total capacity by 2030, requiring further regulatory intervention if climate targets are to be met

The share of solar generation in Europe [redacted] by 2030 and [redacted] by 2050 as renewables continue to displace thermal plants

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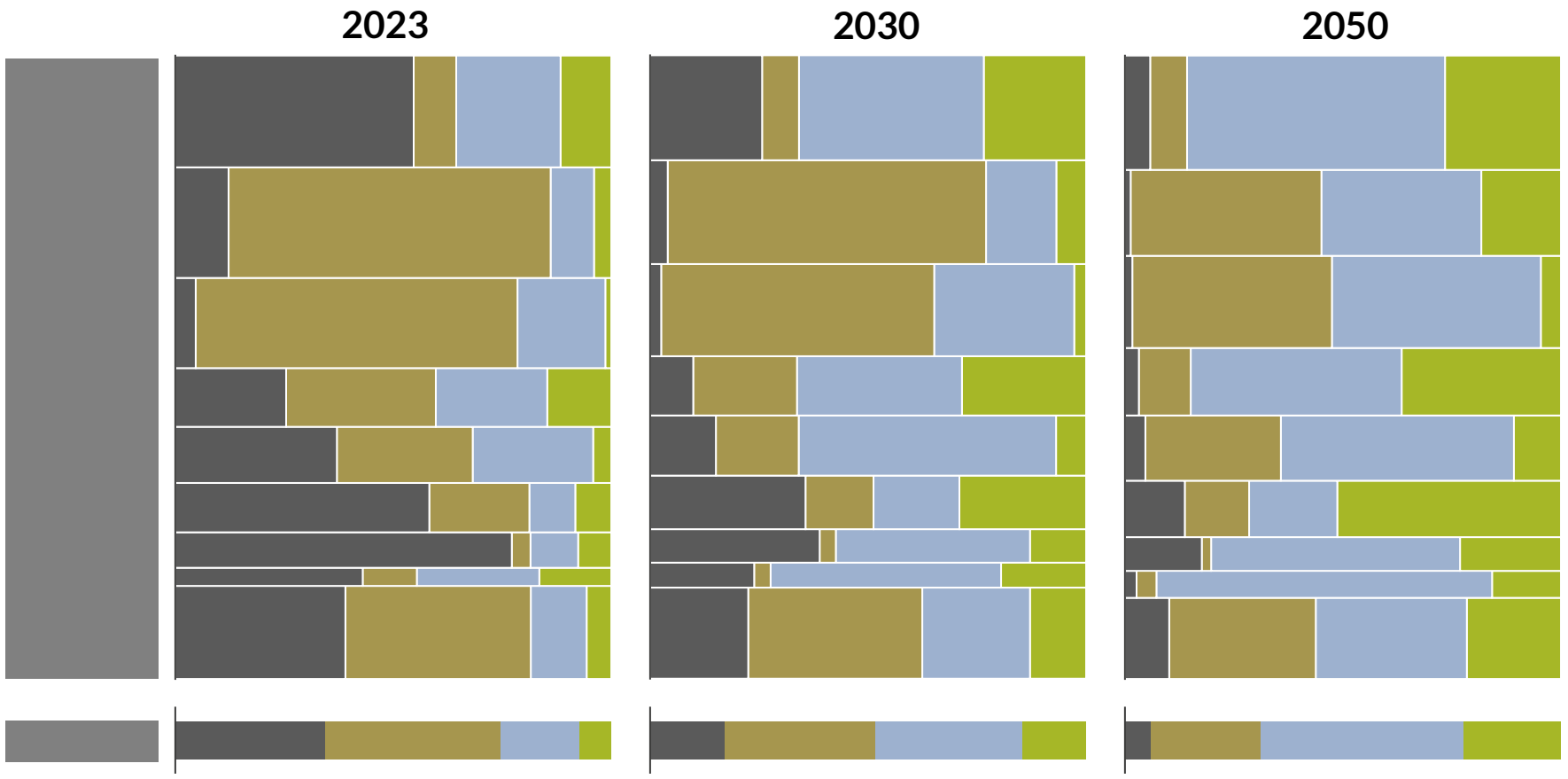
Share of total generation (TWh) in Europe[1] (Aurora Central scenario)*

%



Fossil[2] Other low carbon[3] Wind Solar

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

Vertical axis scaled by each country's share of Europe's total power demand in relevant year. 1) Europe defined as EU27 plus UK, Norway, and Serbia, minus Cyprus and Malta. 2) Includes gas and coal plants. 3) Includes nuclear, hydrogen, biomass, hydro, EfW,and CHP.

Source: Aurora Energy Research

- In Aurora's Central scenario, renewables share of generation increases to [redacted]% by 2030 and [redacted]% by 2050 across Europe, mainly at the expense of fossil generation (gas and coal) but also nuclear
- Although solar represents almost [redacted]% of total installed capacity in Europe by 2050, it only comprises [redacted]% of total generation due to relatively low load factors
- The increase in renewables is largely driven by ambitious decarbonisation policies across Europe, such as [redacted] target of [redacted] GW solar by 2030, combined with continued cost declines in renewables and increasing carbon price that together help to make renewables increasingly competitive with conventional generation

Rising PPA demand from utilities & corporates provides an opportunity for new build renewables to secure stable revenues

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PPA supply and demand methodology

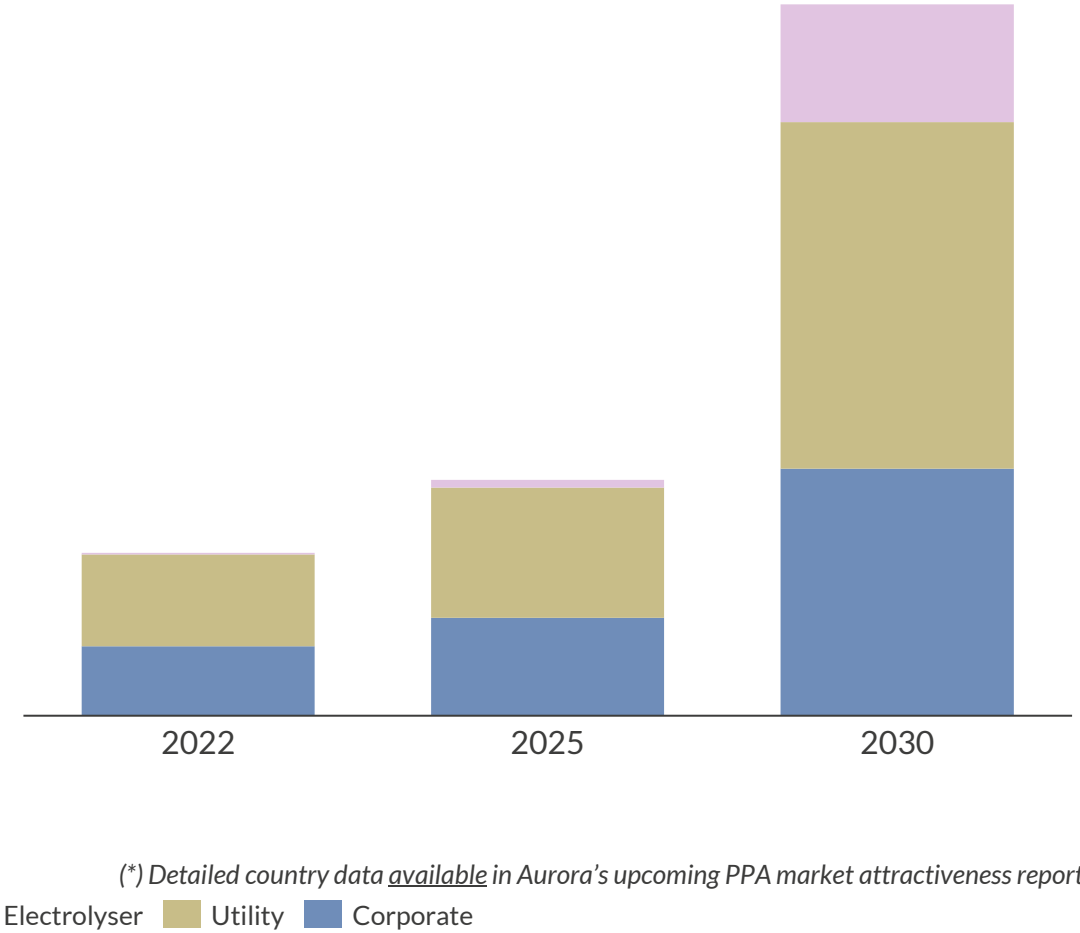
PPA supply

- In most markets PPA supply is primarily driven by merchant buildout of renewables, of which [redacted]% is expected to be wind and [redacted]% solar
- Another component are PPAs that have already been signed, but are yet to enter into force
- In some countries assets in subsidy schemes may also close PPAs, such as zero-bid offshore wind projects in the Netherlands
- Assets falling out of subsidies and at the end of their lifetime may also close a PPA to finance their repowering. These assets would otherwise be decommissioned

PPA demand

- PPA demand today is derived from Aurora's own PPA database, while future demand is estimated based on Aurora's forecast of sectoral power demand growth combined with assumptions around the share of each sector that will require a PPA and have the necessary creditworthiness ratings
- PPA demand is expected to quadruple over the next decade, rising from [redacted] TWh in 2022 to [redacted] TWh 2030, driven by Europe's strengthening decarbonisation targets and an increasingly discerning green consumer base

New build renewables PPA demand in Europe*[1]
TWh



(*) Detailed country data available in Aurora's upcoming PPA market attractiveness report.

1) Across 18 modelled countries in Europe. Electrolyser demand estimated based on country targets.

Source: Aurora Energy Research

[redacted] and [redacted] PPA markets expected to be most undersupplied, with [redacted] and [redacted] most oversupplied

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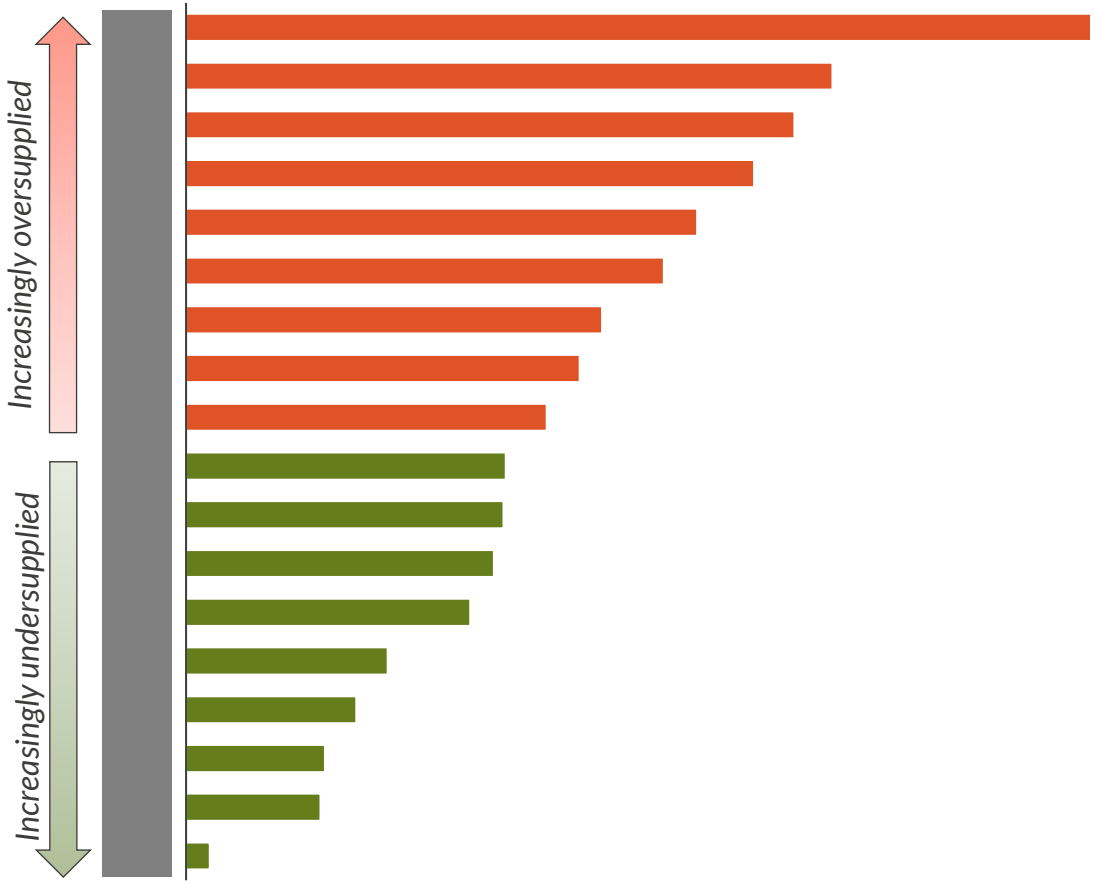
PPA supply as a share of PPA demand in 2030*

%



Oversupplied PPA markets

[redacted]

Undersupplied PPA markets

[redacted]

(*) Detailed country data available in Aurora's upcoming PPA market attractiveness report.

Undersupplied Oversupplied

Source: Aurora Energy Research

This is a redacted sample of the report. For the full report, contact Alex Hutcheson,

Europe could see [redacted] GW increase solar PV capacity by 2030 in a Central scenario, accounting for [redacted]% of total generation

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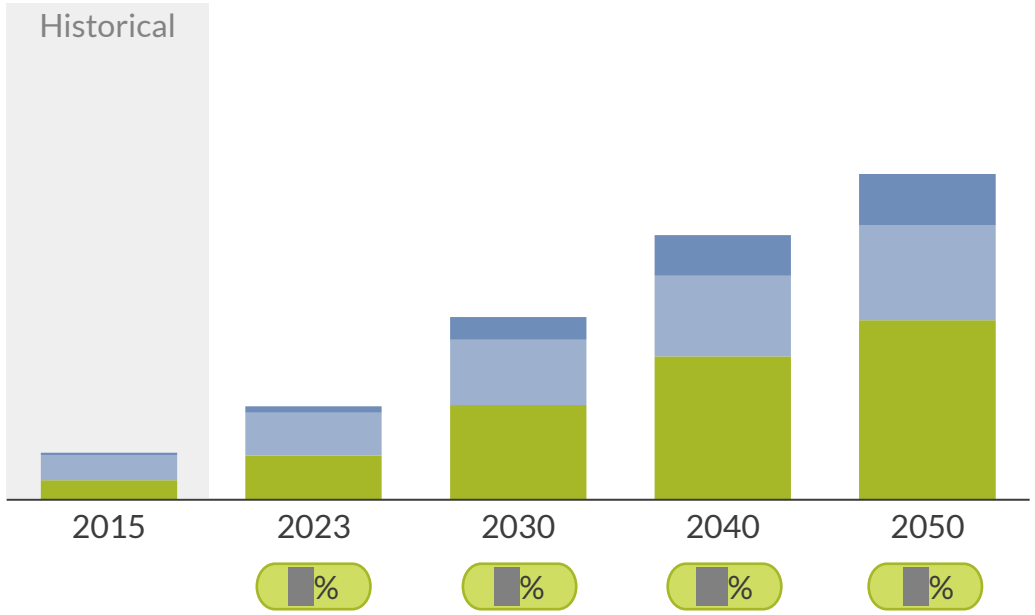
European installed variable renewable[1] capacity (Aurora Central scenario)

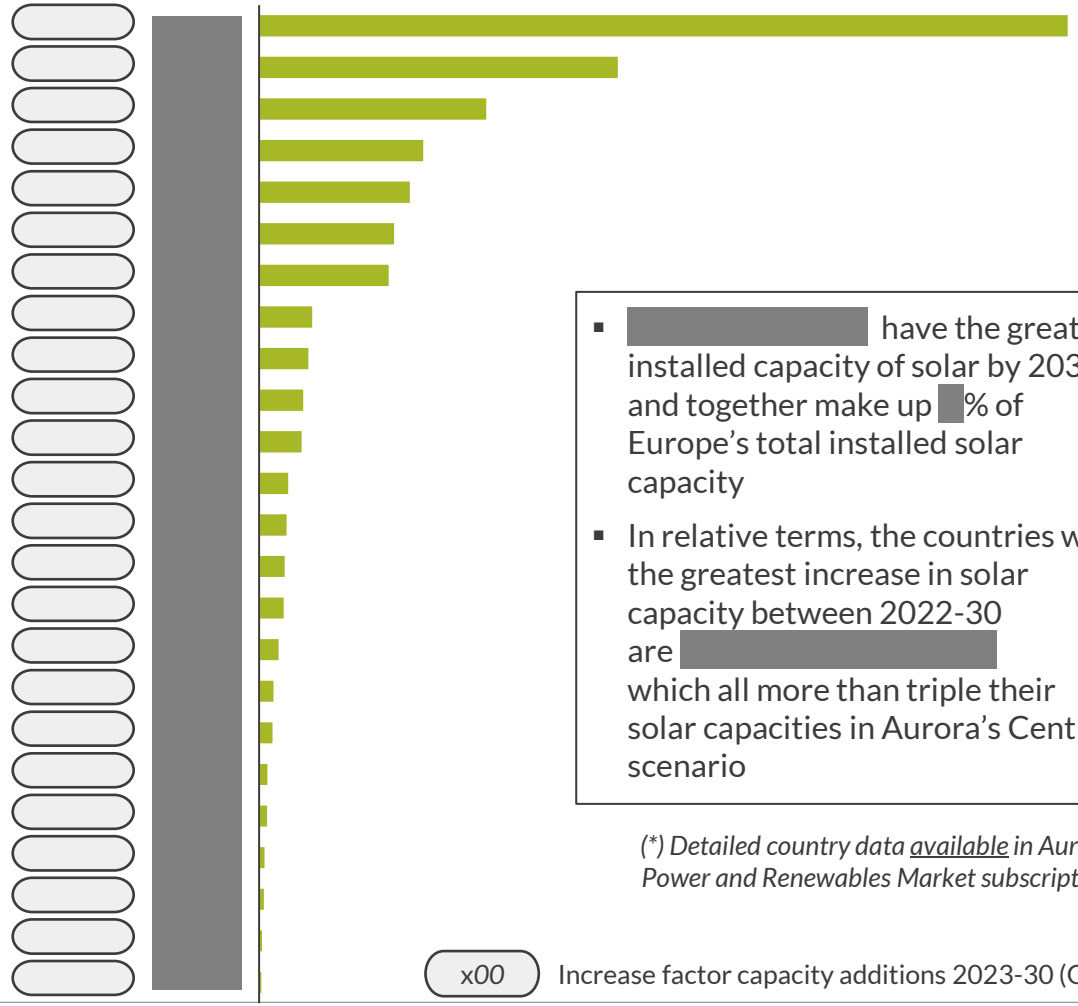
GW



- Europe's installed capacity of solar PV increases by more than [redacted] times between 2023-2050, in Aurora's Central scenario
- Although solar comprises around half of installed renewables capacity, the share of total generation is only [redacted]% and [redacted]% in 2030 and 2050 due to relatively low load factors compared to offshore and onshore wind

Installed solar PV capacity in 2030 (Aurora Central scenario)[3*]

GW



- [redacted] have the greatest installed capacity of solar by 2030, and together make up [redacted]% of Europe's total installed solar capacity
- In relative terms, the countries with the greatest increase in solar capacity between 2022-30 are [redacted] which all more than triple their solar capacities in Aurora's Central scenario

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

xx% Solar share of total generation

x00 Increase factor capacity additions 2023-30 (GW)

1) Defined as solar PV, onshore wind and offshore wind. EU27 plus UK and Norway, and Serbia minus Malta and Cyprus. 2) Includes fixed bottom and floating offshore wind. 3) Includes utility and small-scale solar capacities

Sources: Aurora Energy Research, Eurostat

These new capacity additions represent a cumulative investment opportunity in solar PV of [redacted] billion EUR between 2023-50

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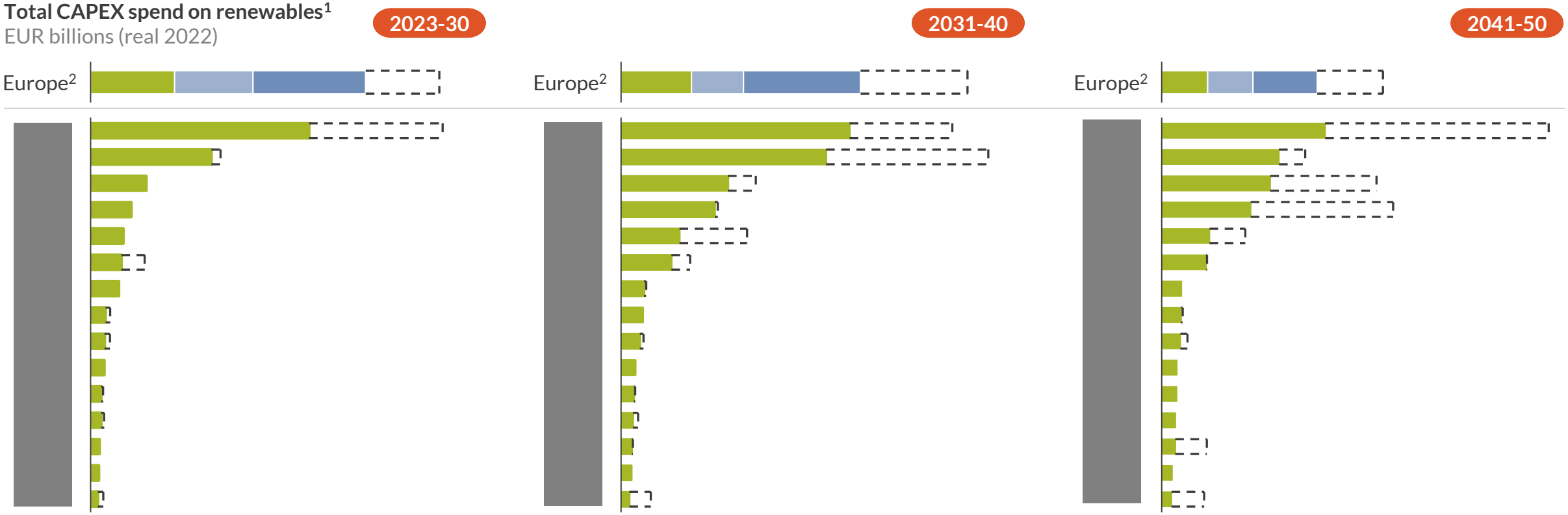
Total CAPEX spend on renewables[1]
EUR billions (real 2022)



- [redacted] dominates CAPEX spend on solar PV until 2030 due to strong buildout driven by support from subsidies
- Relative to its size, the [redacted] also sees a high CAPEX spend on solar buildout

- CAPEX spend between 2031-40 decreases compared to 2023-30 despite similar levels of buildout due to decreasing CAPEX
- [redacted] overtakes [redacted] in total spending as high load factors drive a strong buildout of solar

- CAPEX spend between 2041-50 is significantly lower than in the previous decades due to a combination of lower buildout and decreases to CAPEX
- [redacted] reaches second place in CAPEX spend due to higher buildout of solar compared to

1) Refers to net additions, excludes repowering 2) EU27 plus UK, Norway, and Serbia minus Cyprus and Malta

Source: Aurora Energy Research

Small-scale solar comprises [redacted]% of total installed solar capacity in Europe

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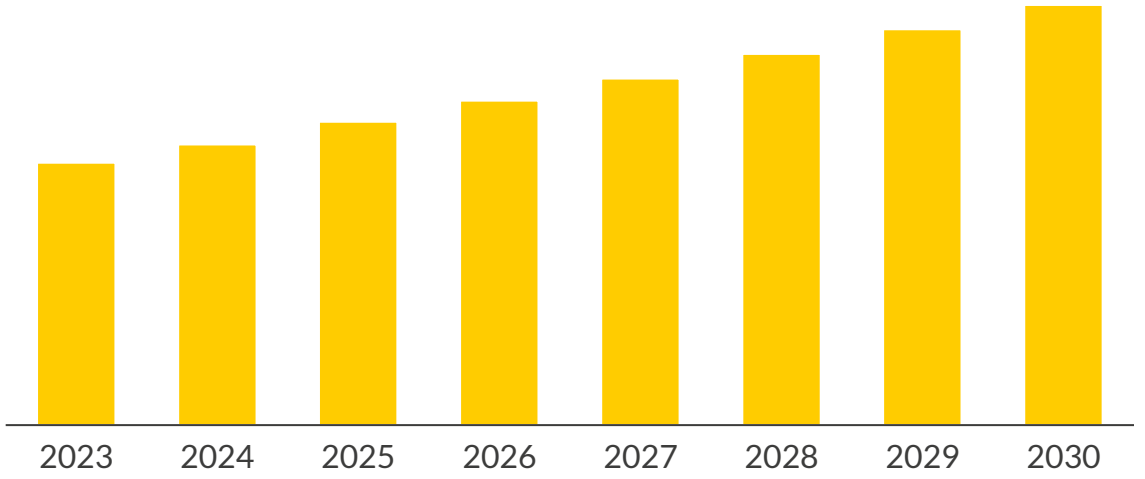
Installed utility and small-scale[1] solar 2022
% installed solar PV

Installed small-scale[1] solar in Europe[2]
GW



- Across Europe small-scale solar (residential rooftop solar and commercial-scale solar) comprises [redacted]% of total installed solar as most countries offer some incentives to install e.g. residential rooftop solar
- The share of small-scale solar is particularly high in [redacted], [redacted], [redacted] and [redacted] due to strong support e.g. through

- Across Europe small-scale solar capacities are expected to increase by around [redacted]% by 2030

Utility-scale Small-scale[1]

1) Includes residential rooftop solar and commercial-scale solar 2) EU27 including GB and Norway

Sources: Aurora Energy Research, IEA

Deployment of solar PV reached a record high in 2022, driven by high power prices and strong policy support

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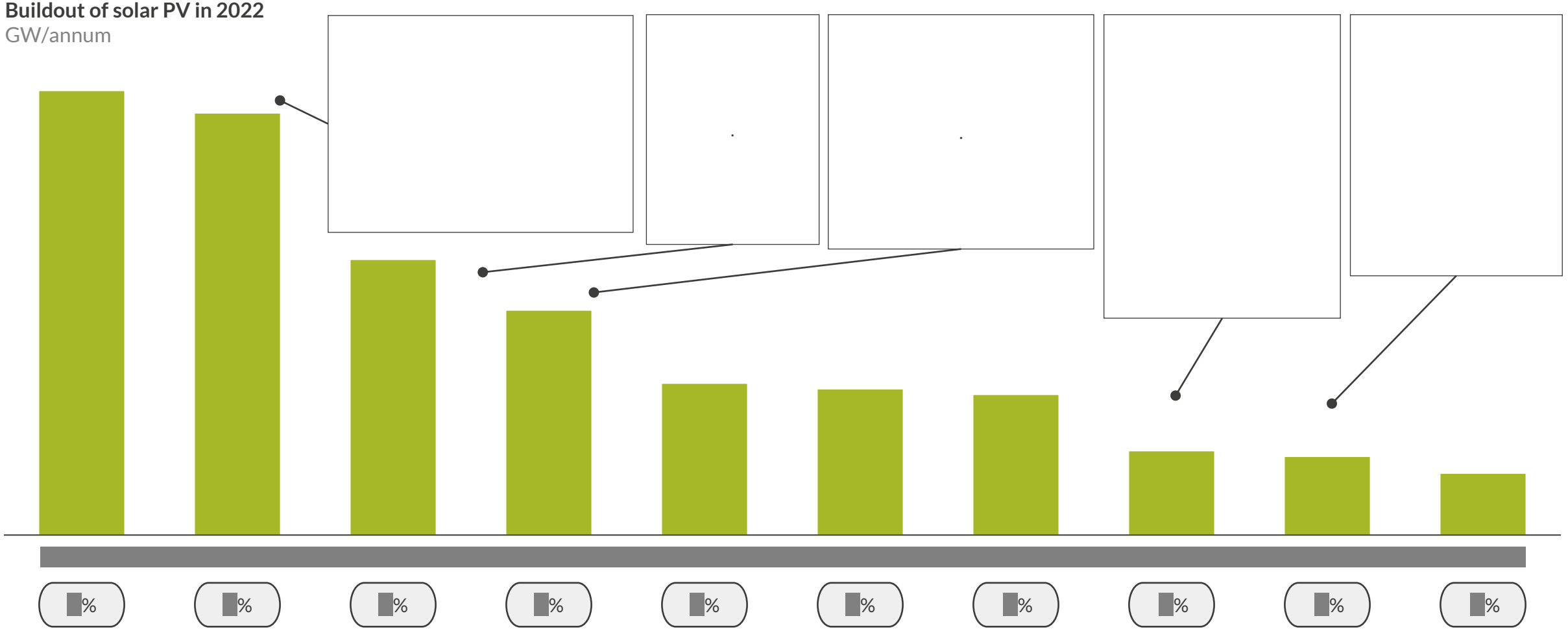
Buildout of solar PV in 2022
GW/annum



XX% Share of total installed capacity

Source: Aurora Energy Research, Solar Power Europe

[redacted] leads on market size followed by [redacted] and [redacted], [redacted] and [redacted] score high despite relatively small size

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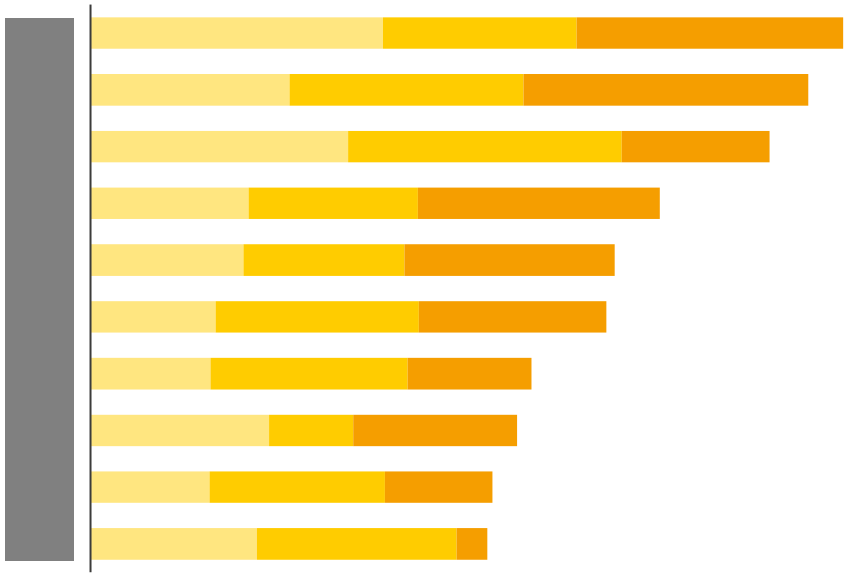
Market size, composition & outlook

Countries are assessed in terms of their market size and outlook for solar PV between 2023-2030, based on three metrics shown below. An overall score for the market size indicator is assigned between 0-10 reflecting the specified weighting of the three metrics.

Metric	Weighting	Rationale
1 Solar deployment to 2030	40%	Indicates expected future market size in the medium term
2 PPA market potential in 2030	20%	Indicates expected availability of commercial off-takers to mitigate merchant risks
3 Solar buildout in 2022	40%	Reflects recent solar market activity



Source: Aurora Energy Research

Agenda

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This is a redacted sample of the European Solar Markets Attractiveness Report.
If you are interested in the full report, contact Alex Hutcheson, (alex.hutcheson@auroraer.com)

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

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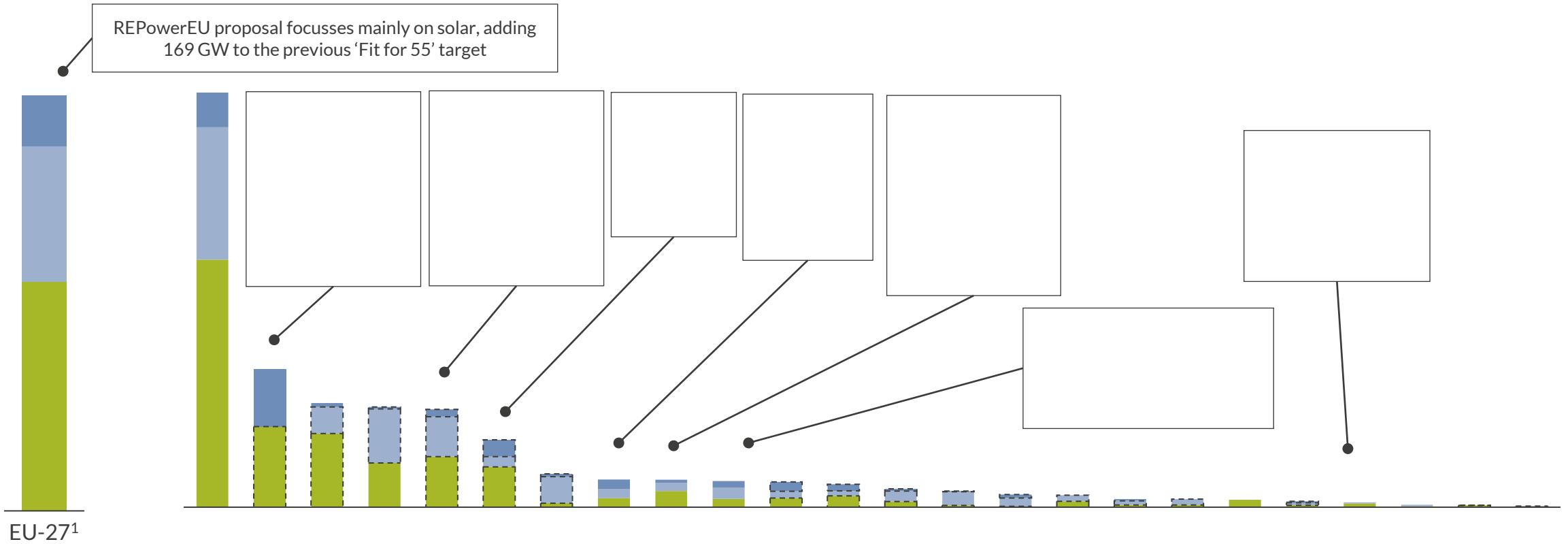
Target installed capacity by 2030

GW



Required solar additions as share of current installed solar capacity

%

Offshore wind | Onshore wind | Solar PV | Estimated[3]

Sources: Aurora Energy Research, European Commission, RTE, Nordic TSO, NECP, National energy strategies

The REPowerEU plan details key measures to reduce Russian reliance and fast forward the clean transition across five main pillars

The European Commission's REPowerEU plan was released on 18th May 2022 following the initial outline published in March. It is about rapidly reducing dependence on Russian fossil fuels by fast forwarding the clean transition and joining forces between Member States to achieve a more resilient energy system and a true Energy Union.

1. Boost energy savings

2. Diversify energy imports

3. Reduce fossil fuel use

4. Smart investment

5. Reinforce preparedness

1) Provisional agreement as of 30 March 2030, includes additional 2.5% indicative top-up to reach 45% 2) Recovery and Resilience Facility

Sources: Aurora Energy Research, European Commission

In 2022, the European Council provided for Member States to implement temporary revenue caps on renewable power producers

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	Measures to clawback windfall revenues from renewable power producers[7]			Other relevant measures
	How the clawback is calculated	Retroactive[8]	Which assets are most affected	
Greece				
Germany				
Poland				
Hungary				
Great Britain (non-EU)				
Netherlands				
France				
Spain				
Ireland				
Italy				

Sources: European government statements, Aurora Energy Research

The Commission has proposed to increase the renewables target to [redacted] GW of capacity by 2030, requiring [redacted]x faster deployment

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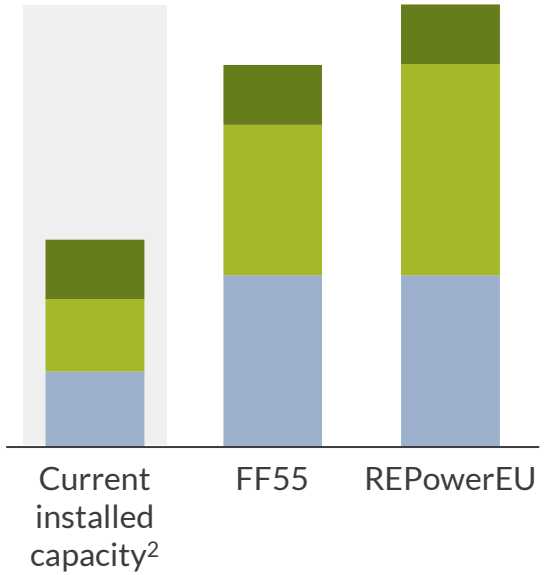
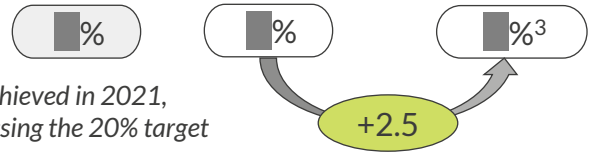
Target installed RES capacities by 2030[1]
GW

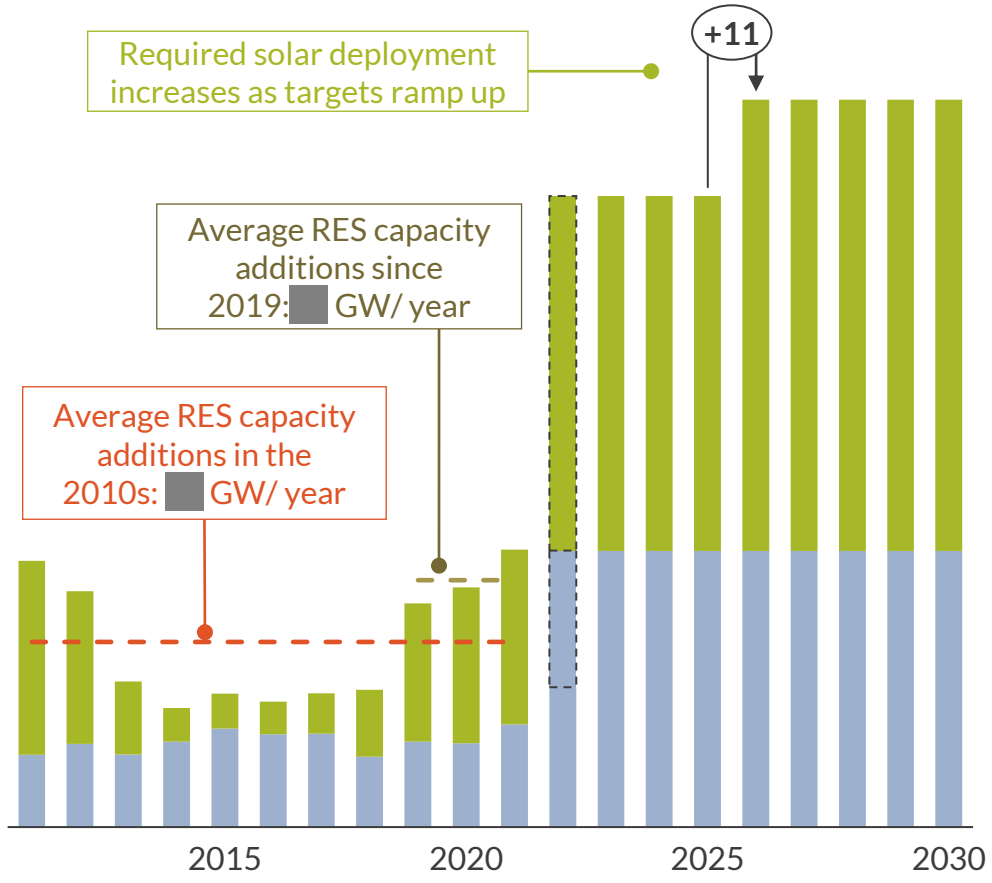


Target RES share of gross final energy consumption, %



Achieved in 2021, surpassing the 20% target

Wind and solar capacity commissioned per year[1]
GW



Other RES[4] | Solar | Wind | Buildout 2022 | Avg build rate (2011-2021) | Avg build rate (2019-2021)

1) Shown for EU-27 only. 2) Estimated capacities end of 2022. 3) Provisional agreement as of 30 March 2030, includes additional 2.5% indicative top-up to reach 45% 4) Other RES includes hydro and biomass.

Sources: Aurora Energy Research, European Commission, Eurostat, WindEurope, SolarPower Europe

The EU Solar Energy Strategy outlines a comprehensive vision to rapidly deploy solar energy

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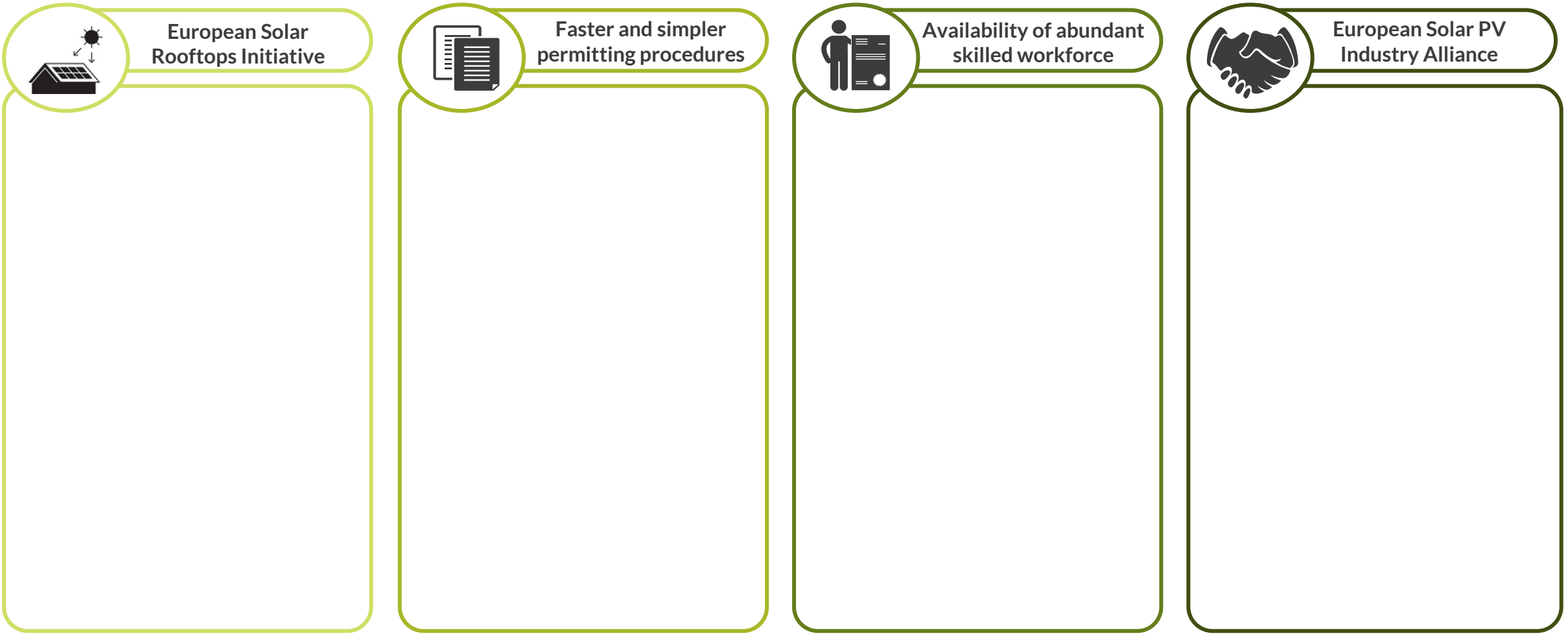
The EU Solar Energy Strategy outlines a comprehensive vision to swiftly reap the benefits of solar energy, and presents four initiatives to overcome key challenges faced.



Sources: Aurora Energy Research, European Commission

Utility-scale solar in Europe has historically been brought to market by three main support schemes; most countries have shifted to CfDs

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Direct subsidies

FiPT Feed-in/Premium tariff

- Under an FiPT, renewables generators sell power either directly to the market or through a direct marketer
- A feed-in premium[1] is paid to the generator to top up wholesale revenues
- Support levels are determined by government policy or competitive auctions

FiT Feed-in-tariffs

- Long-term premium payment for small scale renewables
- Generators are paid a generation tariff rate per kWh produced and an export tariff for each kWh exported to grid

CfD Contracts for Difference

- Guarantees a price for generators – they receive a 'top-up' payment equal to the difference between an awarded strike price and market reference price
- Scheme could operate as a fixed price contract or utilise a price floor

Additional / indirect support

GC Green certificates

- Green certificate scheme – designed to provide transparency to consumers who purchase renewable electricity from their suppliers
- Guarantees of Origin (GoOs) serve as a tradeable EU wide instrument

ETS EU-Emission Trading Scheme

- Cap and trade scheme obligating eligible emitters to present one carbon allowance (EUA) for each tonne of CO_2 emitted
- In 2022, prices averaged [redacted] EUR/tCO_2

Further details on country specific support schemes are available in the following slides

Region	Main scheme[2]	*Pricing regime*	*Negative price risk*	*Price floor*	*Merchant exposure*

Subsidies are not offered in [redacted]

Source: Aurora Energy Research

Key nuances and support scheme rules across different regions have impacted the deployment of utility-scale solar (1/2)

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Region	Current main scheme	Positives and nuances
Belgium	✓ ✗	
Bulgaria		
Croatia	✓ ✗	
Denmark	✓ ✗	
Estonia	✓ ✗	
Finland		
France	✓ ✗	
Germany	✓ ✗	
Great Britain	✓ ✗	
Greece	✓ ✗	
Hungary	✓ ✗	
Ireland	✓ ✗	

Source: Aurora Energy Research

Key nuances and support scheme rules across different regions have impacted the deployment of utility-scale solar (2/2)

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Region	Current main scheme	Positives and nuances
Italy	✓ ✗	
Latvia		
Lithuania		
Netherlands	✓ ✗	
Norway		
Poland	✓ ✗	
Portugal	✓ ✗	
Romania		
Serbia		
Slovenia		
Spain	✓ ✗	
Sweden		

1) Solar PV projects must be completed within 24 months. For each month delay awarded subsidy tariff decreases by 0.5%, up to a maximum of 6 months (after which the project loses all subsidies 2) Following DL 17/2022 Agrivoltaic plants are now allowed to access subsidies, without the restrictions on development applied to traditional solar PV 3) 400MW wind tender announced for 2023, no tenders announced for solar 4) Applies to utility-scale feed-in premium available for installations up to 10MW

Source: Aurora Energy Research

Subsidy schemes have brought forward [redacted] GW of solar in Europe, comprising almost [redacted] per cent of total solar capacity installed

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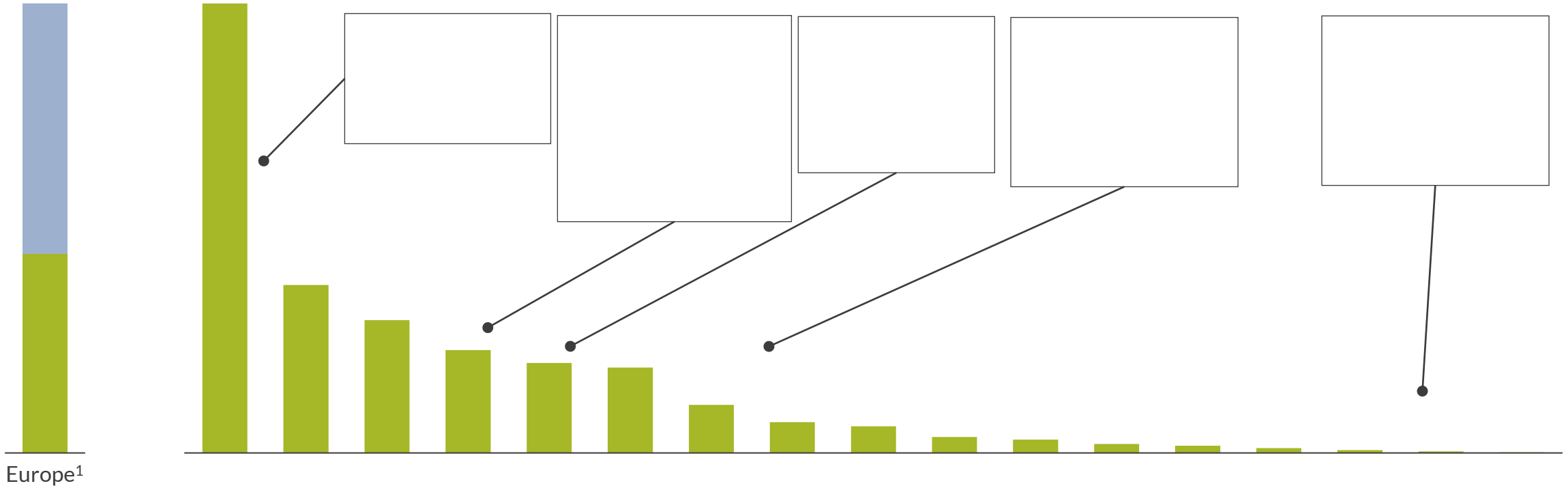
Total historical capacities procured through government support schemes
GW



Procured solar capacity as share of total solar capacity installed
%

Solar PV

1) Represents Aurora's 24 modelled countries.

Source: Aurora Energy Research

At least [redacted] GW of solar is set to be procured through committed auctions to 2030

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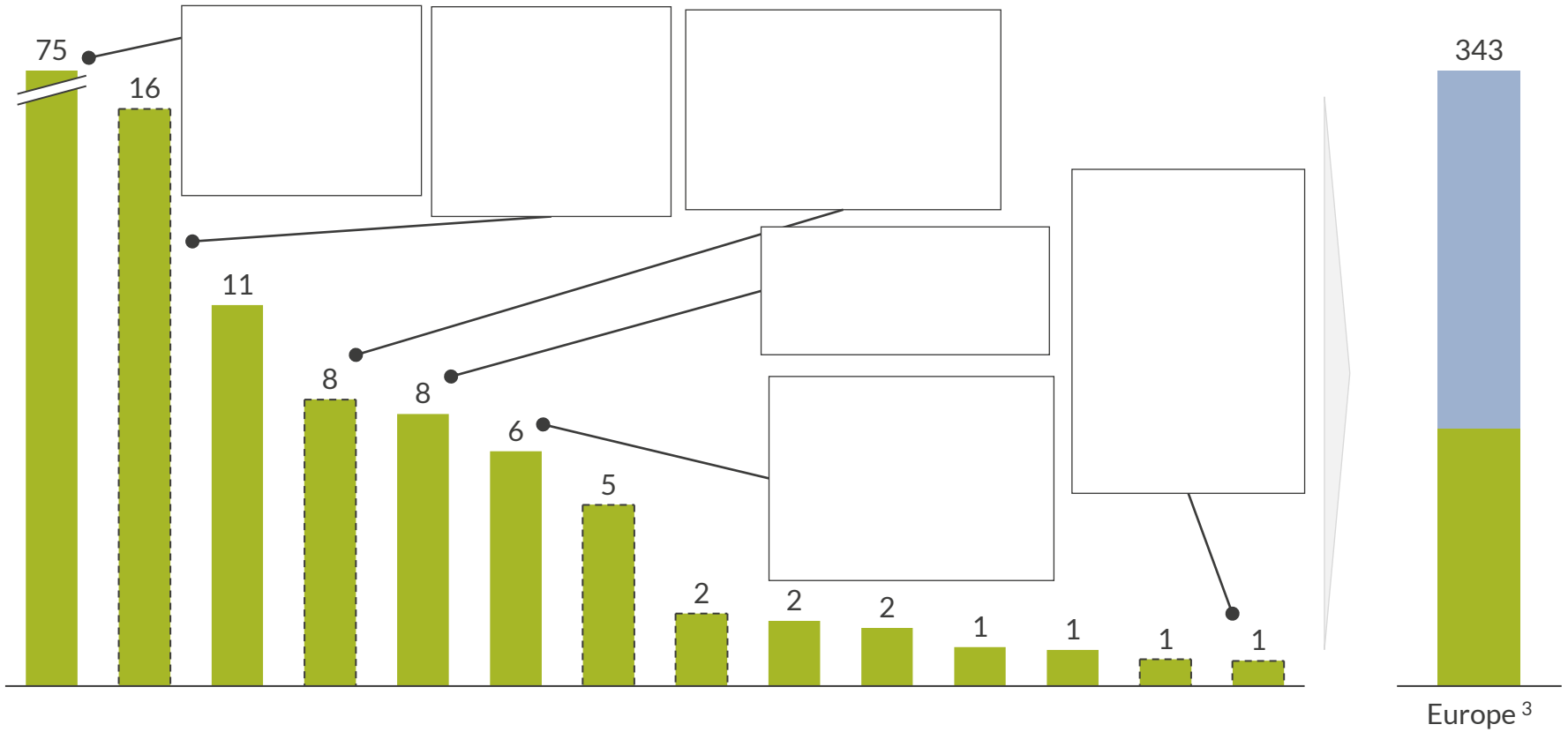
Planned capacity procurement of utility-scale solar through announced auctions until 2030
GW



Volumes shown represent announced and confirmed auctions as of February 2023 and do not reflect all potential auctions in the period to 2030. No auctions currently planned in

Wind Solar PV Estimated[4]

- Across Europe, auctions for subsidy schemes are estimated to procure [redacted] GW of large-scale solar through to 2030
- In 2022 multiple countries increased their planned capacity procurement, most notably [redacted] and
- The planned procurement represents [redacted]% of the additional capacity forecasted by 2030 in Aurora's Central scenario
- Planned procurement by EU countries represents only [redacted]% of additional capacity (387 GW) required to meet the RePowerEU target, suggesting further auctions may be required to meet the target
- Although subsidies will still be the main driver of solar buildout, planned capacity procurement is presently lower than historical trends, where [redacted]% of current capacity was procured through auctions

Source: Aurora Energy Research

Uncertainty around support schemes could stall deployment in regions where merchant projects are not fully viable e.g. in

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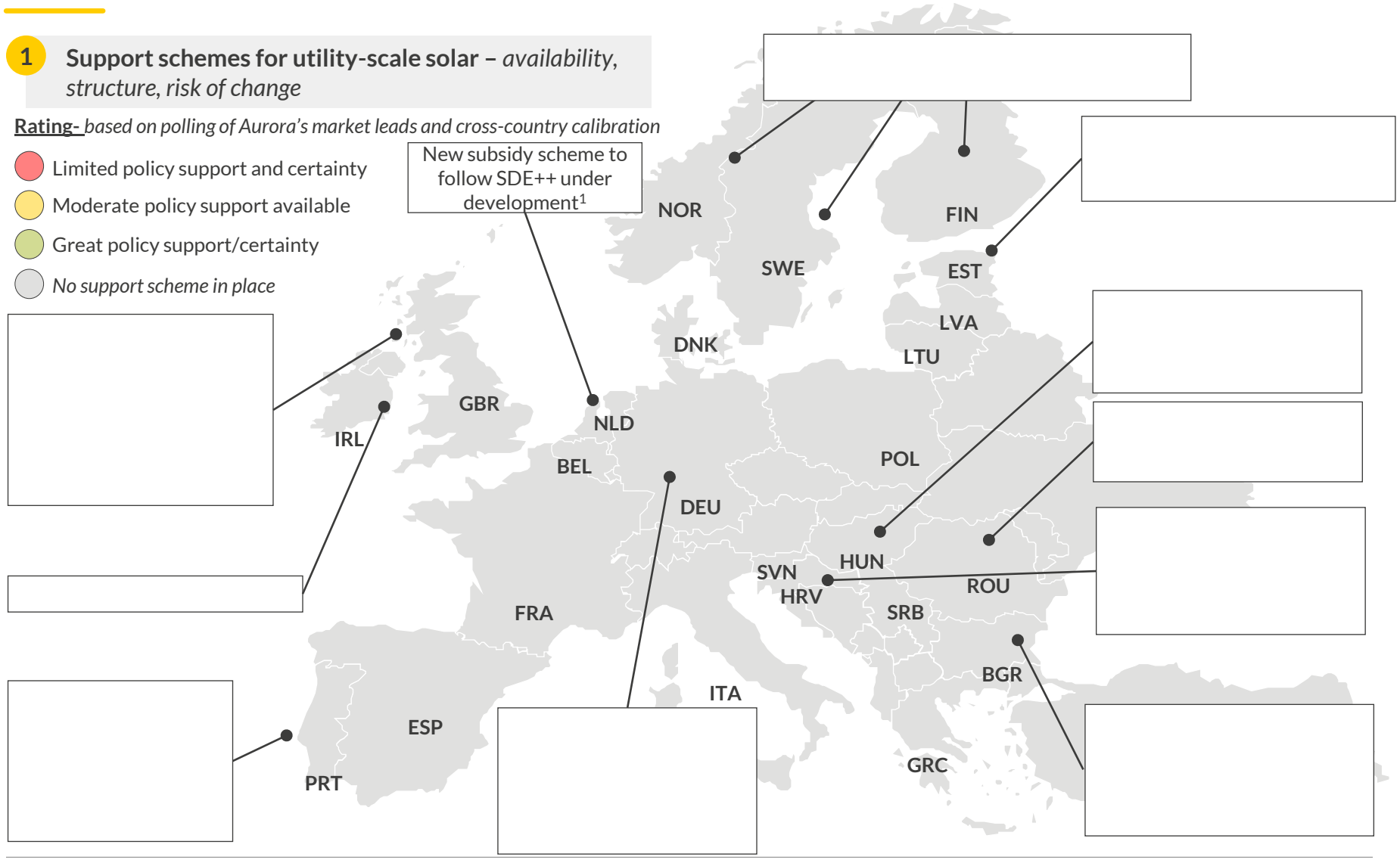
1 **Support schemes for utility-scale solar –** *availability, structure, risk of change*

Rating- *based on polling of Aurora's market leads and cross-country calibration*

- Limited policy support and certainty
- Moderate policy support available
- Great policy support/certainty
- *No support scheme in place*



Source: Aurora Energy Research, reNEWs

Lengthy and complex permitting procedures limit deployment of solar although permitting is generally quicker than for wind

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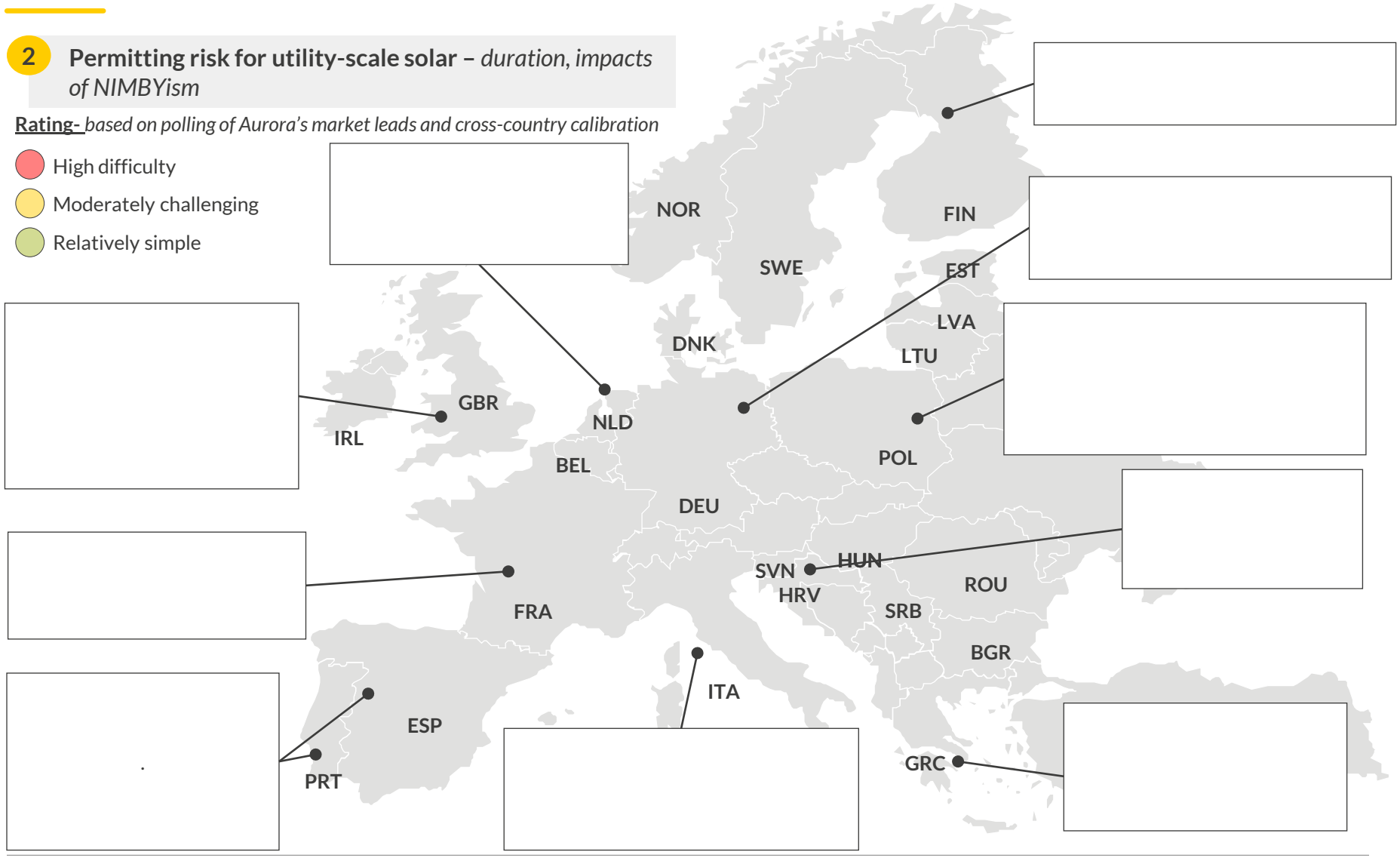
2 Permitting risk for utility-scale solar – *duration, impacts of NIMBYism*

Rating- *based on polling of Aurora's market leads and cross-country calibration*

- High difficulty
- Moderately challenging
- Relatively simple



Source: Aurora Energy Research

Both the EU and individual countries have passed significant regulation to speed up permitting, overall impact is not yet clear

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Region	Major regulation	Description of law	Likely impact
			
Greece			
France			
Italy			
Portugal			
Spain			

Likely to speed up permitting Impact unclear

1) Valid for 18 months, may be extended 2) Can be reduced to 10.8 kW in case of grid constraints 3) The emergency measure is intended to bridge the gap until the EU Renewables Energy Directive is updated and adopted. 4) As of 30 March 20235) Renewables deployment will be presumed to be of 'overriding public interest' to limit ground of legal objections

Sources: Aurora Energy Research, Reuters, Solar Power Europe

Scarcity and restrictions around grid connections further complicate solar deployment particularly in [redacted] and

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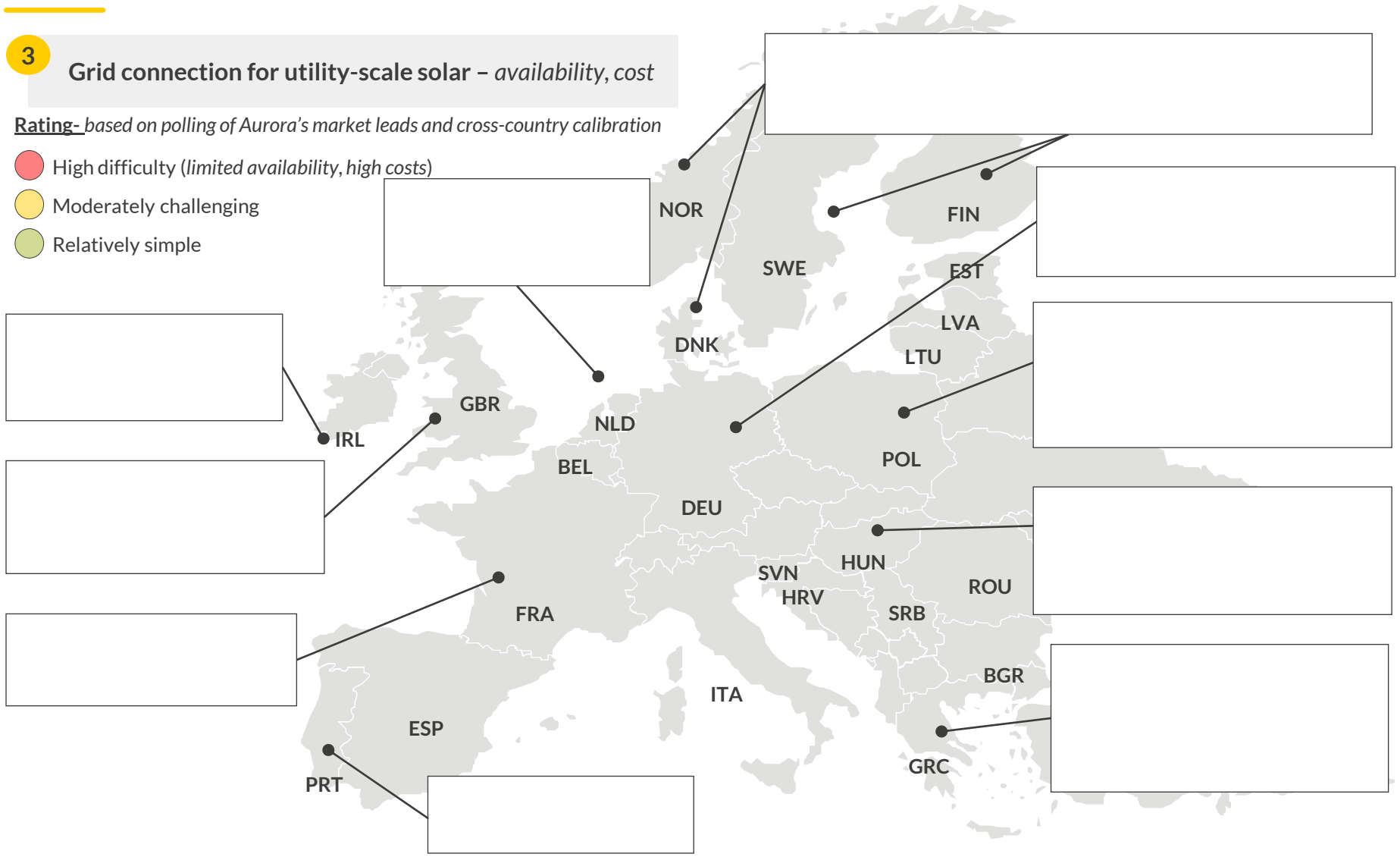
3 **Grid connection for utility-scale solar** – *availability, cost*

Rating- *based on polling of Aurora's market leads and cross-country calibration*

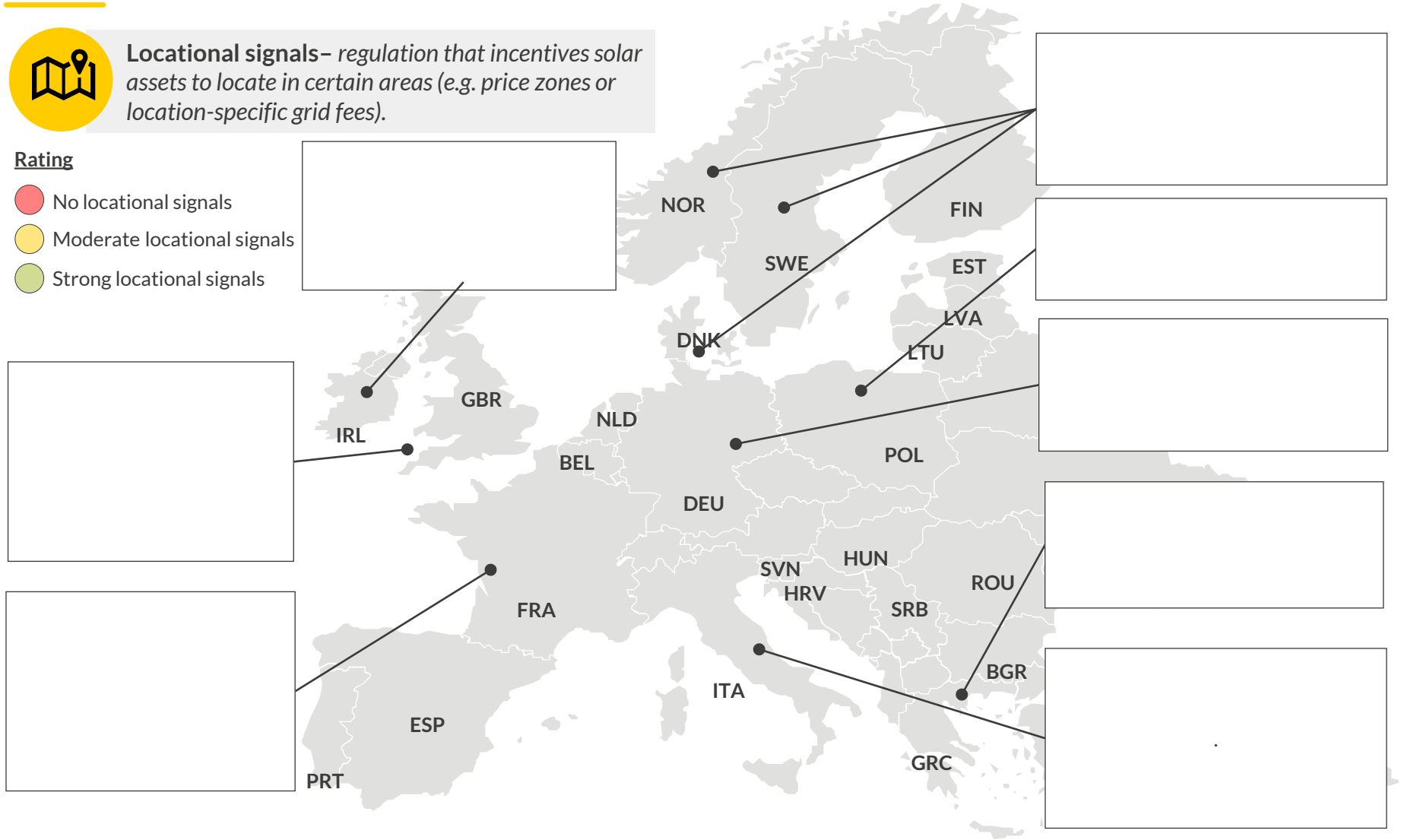
- High difficulty (*limited availability, high costs*)
- Moderately challenging
- Relatively simple



Source: Aurora Energy Research

Location-specific grid fees in [redacted] and [redacted] and price zones in [redacted] and [redacted] provide locational signals for the deployment of solar

Locational signals– *regulation that incentives solar assets to locate in certain areas (e.g. price zones or location-specific grid fees).*



Source: Aurora Energy Research

[redacted] sees the most attractive policy environment for solar deployment, followed by [redacted] and

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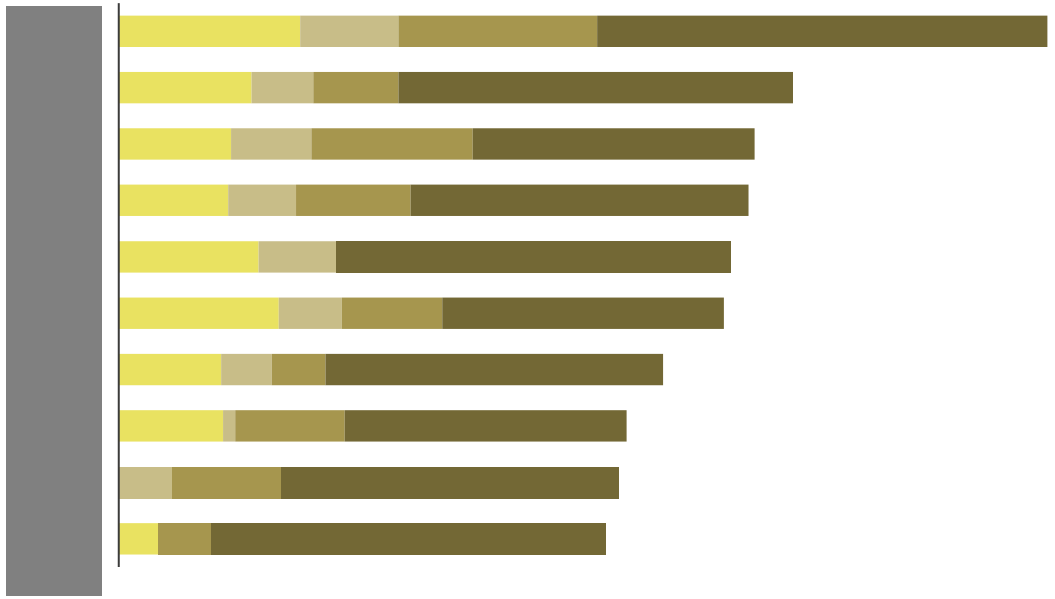
Policy environment

Countries are assessed in terms of their policy environment for renewables between 2022-2030, based on four criteria shown below. An overall score between 0-10 is assigned for each renewable technology reflecting the following weighting of assessment criteria.

Metric	Weighting	Rationale
4 Announced RES targets in 2030	20%	Demonstrates policy ambition for RES deployment over the medium term
5 Historical auctioned capacity	10%	Indicates track record of government support for RES build-out (& market for refinancing)
6 Planned auctioned capacity till 2030	20%	Indicates expected government support for RES build-out
7 Policy risks - support schemes, permitting, grid connection	50%	Reflects effect of key policy and regulatory risks on project development



Source: Aurora Energy Research

Agenda

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Public and private offtake of revenue risks largely drives the cost of capital and business models for utility-scale solar PV

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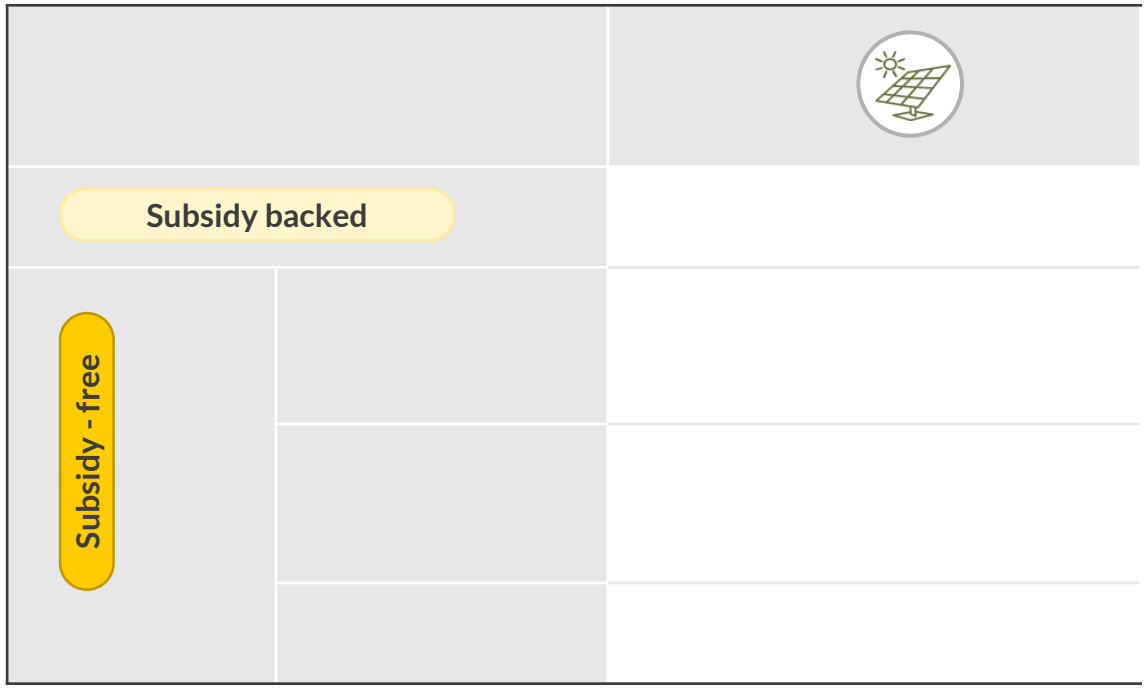
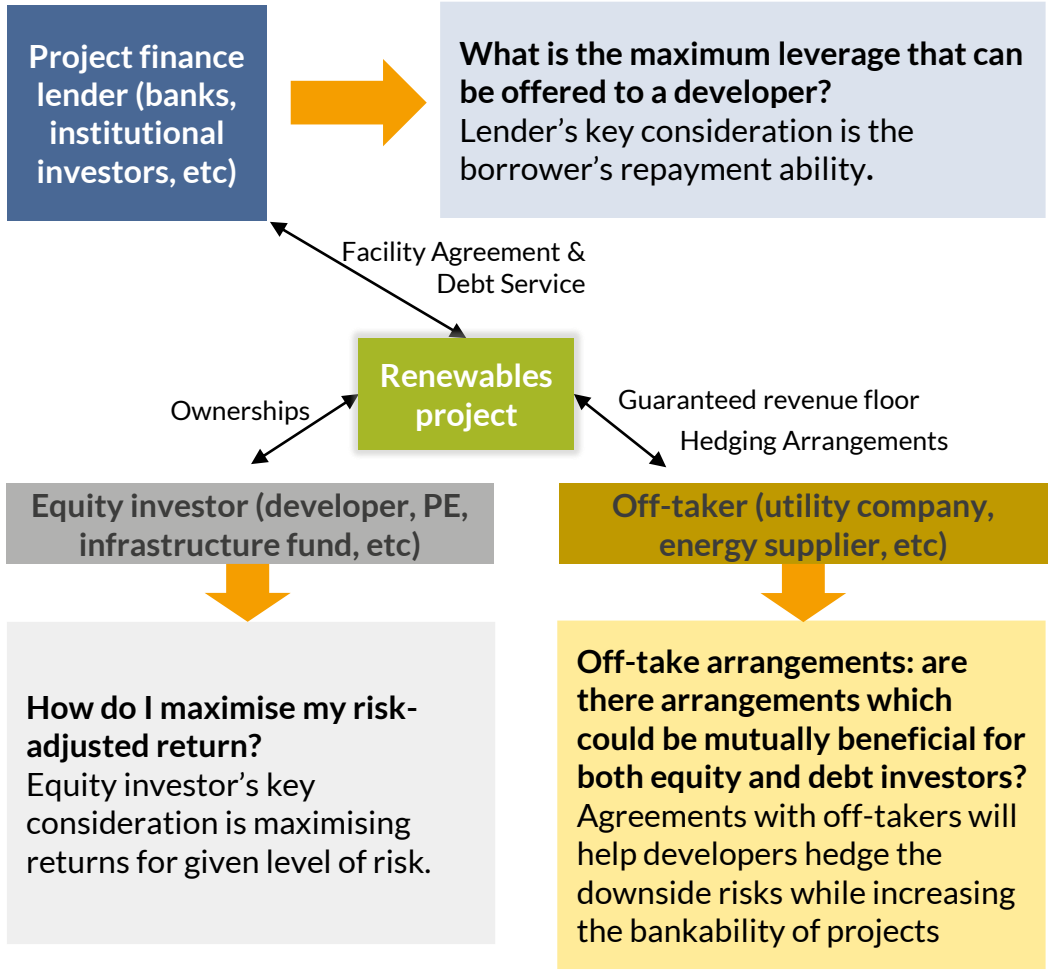
As renewable technologies mature, risks related to technology and deployment diminish. Revenue risks however become prominent with the advent of subsidy-free renewables.

Unlevered cost of capital for renewables at FiD, pre-tax, real



Ranges presented reflect a variety of factors, including project-specific characteristics, different revenue streams, investors' levels of comfort with price risks, PPA terms, portfolio considerations etc. As renewables "stack" revenues from different markets, it is important to assess the riskiness of each revenue stream individually.

There are several factors that should be considered when asset owners are assessing financing options



Source: Aurora Energy Research

A number of financial indicators can illustrate the financial performance of merchant solar projects

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VARIABLES

Costs

CAPEX – Initial capital costs. Includes grid connection, materials, transport, staff, and any environmental mitigation, professional fees and licensing costs

OPEX – Operating Costs. Includes operation & maintenance (transport, replacement parts, staff), and other costs such as insurance, grid use of system charges, imbalance costs

Other

Load factor – ratio of actual energy generation to rated output over a set period of time

Economic curtailment – ratio of actual energy generation to maximum potential generation, usually as a result of market prices being insufficient to cover variable or marginal cost

Discount rate based on risks associated with revenue stream

Operating lifetime

Construction duration

Decommissioning costs

Revenue

Subsidies – guaranteed by government policy

PPAs – Power Purchase Agreements

Wholesale market – where majority of electricity is traded between generators and suppliers

Capture price – generation weighted average price from the wholesale market

Balancing and ancillary services – services required to optimally manage the grid, includes frequency management and black start services

Guarantees of Origin (GoOs) – revenues from certificates guaranteeing each unit of clean energy

INDICATORS

LCOE

LCOE - Levelised cost of energy is the ratio of the total discounted costs and discounted energy production over the project lifetime

Enhanced LCOE – As LCOE above, but includes system integration costs, cost of intermittency

NPV

Net Present Value

IRR

Internal Rate of Return

Example common errors in discussing the economics of renewable energy projects

- LCOE are useful for indicatively comparing cost, but fail to capture the costs of integrating a technology into the system
- LCOE ignores very different revenue streams available to alternative technologies

Source: Aurora Energy Research

With raw materials making up over [redacted]% of total solar PV CAPEX, surging prices result in higher costs in the short term

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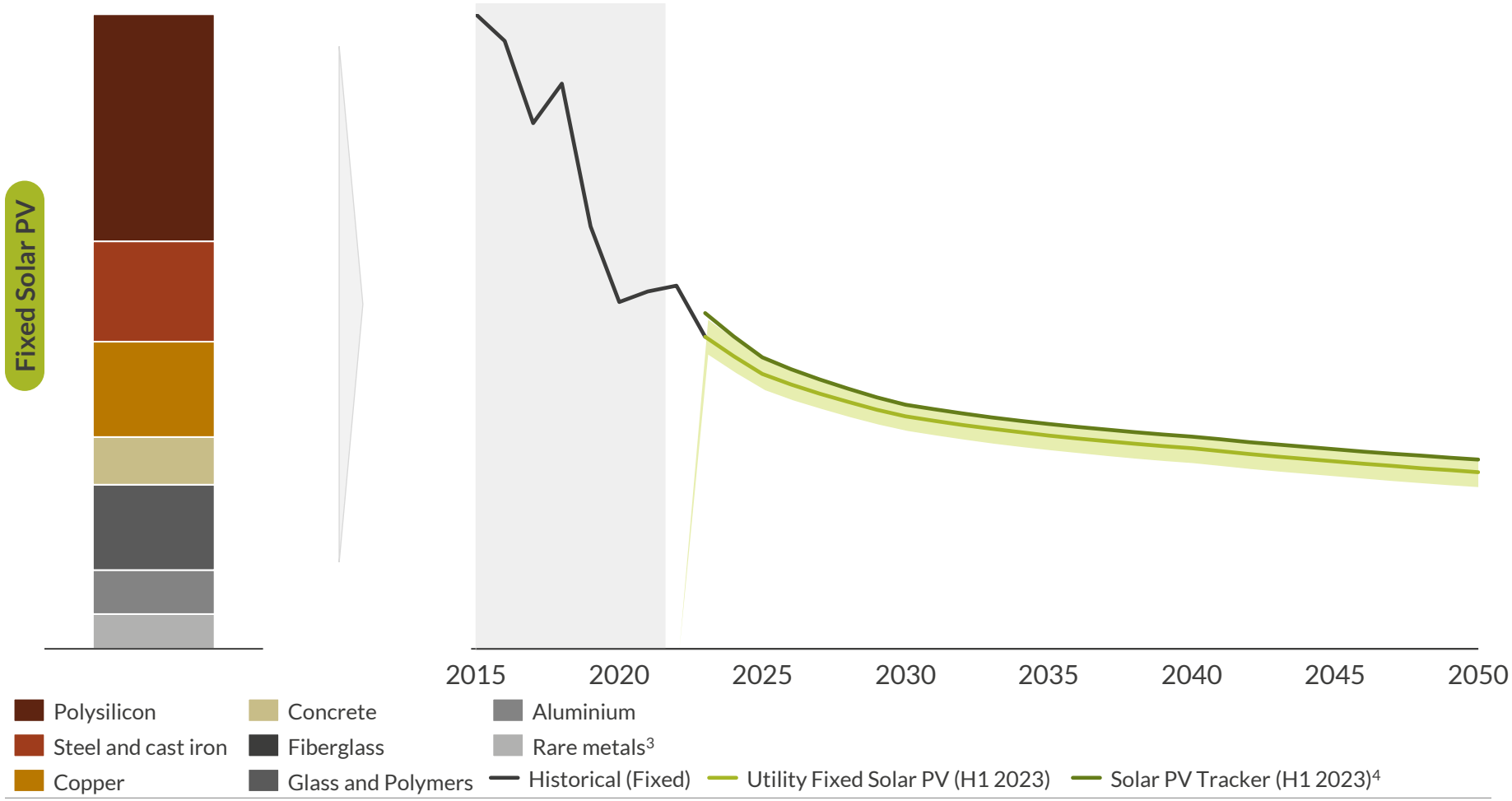
Share of total value of raw materials required[1,2]
%

Solar CAPEX trajectories[4]
EUR/kW (real 2022)



Sources: Aurora Energy Research, European Commission, IRENA,

The EU aims to match US and global low carbon industrial competition with its Green Deal Industrial Strategy (GDIS)…

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GDIS is based on five pillars	1 Create a simpler, targeted regulatory framework	2 Create high skilled Jobs	3 Speed up clean tech investment	4 Ensure access to critical materials	5 Ensure fair trade and competition
EU proposed acts/regulations	*Net-Zero Industry Act*			*Critical Raw Materials Act*	*Temporary Crisis and Transition Framework*
Key content and goals					

1) Solar power and solar thermal, onshore and offshore wind, batteries and energy storage, heat pumps and geotherma, electrolysers and fuel cells, sustainable biogas/biomethane, carbon capture and storage (CCS), grid technologies; 2) Depending on size and type of project, 9-12 months for RES (12, if > 1 GW), 12-18 months for factories (18, if output > 1 GW)

Sources: Nexus , European Commission, Aurora Energy Research

…however, in direct comparison, EU GDIS cannot match Inflation Reduction Act provisions on solar manufacturing

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Manufactured Technology	US: Inflation Reduction Act (IRA) manufacturing support	EU: Green Deal Industrial Strategy manufacturing support	Evaluation of competitive threat for the EU and impact on CAPEX in Europe
Solar			

<u>The EU aims to raise money from numerous sources:</u>

Existing sources: *Member States under relaxed State Aid rules, EU Recovery and Resilience Facility, EU Innovation Fund, InvestEU*

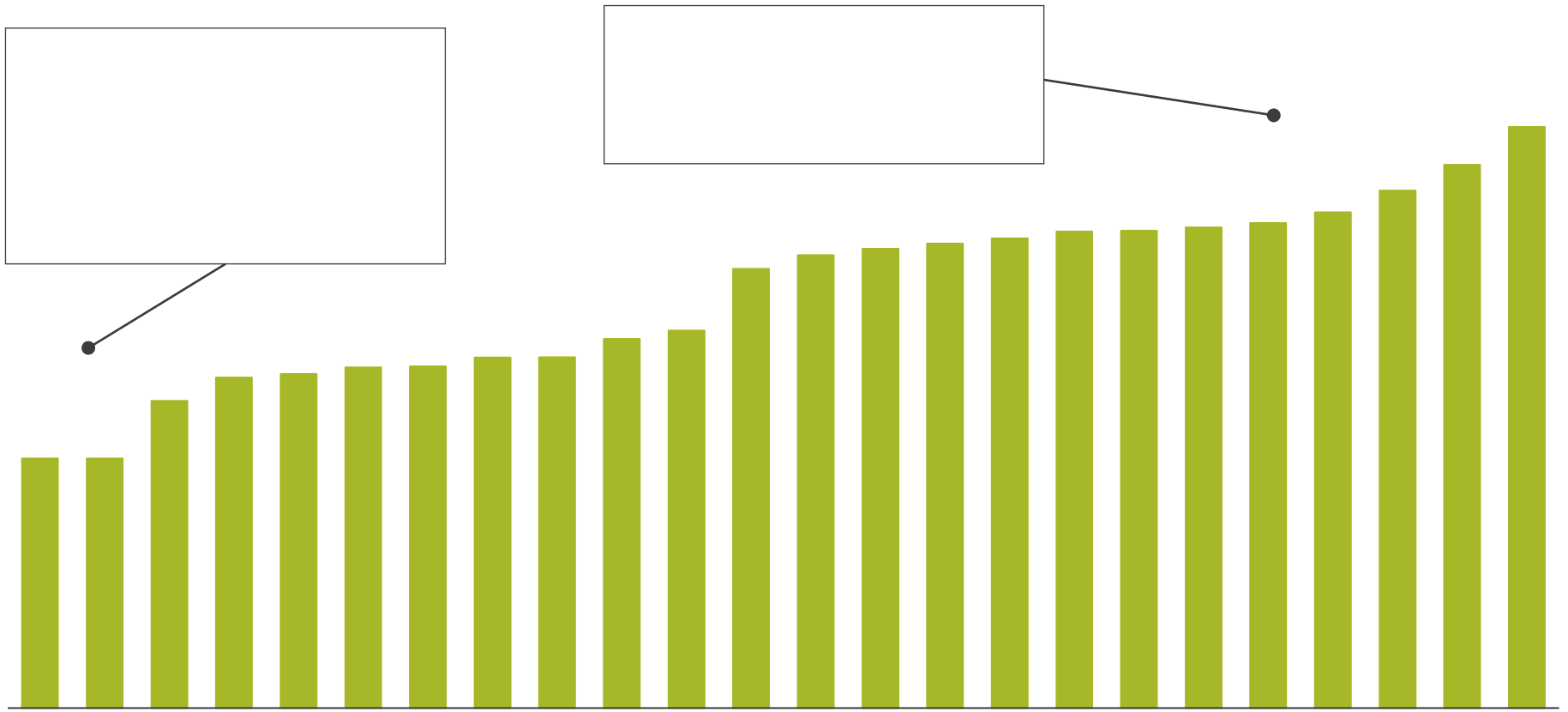
Additional options (currently discussed): *EU European Sovereignty Fund (not yet implemented), increased EU budget (paid by member states)*

1) Among others, Member states, EU Innovation Fund, Green Hydrogen Bank

Sources: Aurora Energy Research, European Commission, International Energy Agency, US Department of Energy

LCOEs vary materially across Europe due to regional differences in capital costs and load factors, [redacted] sees lowest merchant LCOEs

LCOEs for PPA-backed utility-scale solar in 2030[1]
EUR/MWh (real 2022), fleet average



(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) Assumptions detailed in appendix. 2) For Iberia a solar-tracker LCOE is shown 3) Shown for representative asset

Source: Aurora Energy Research

- Levelised cost of energy is the ratio of the total costs and discounted energy production over the project lifetime
- Load factors and CAPEX differences are the main determinants for LCOE variation across Europe.
- Due to high load factors countries in South (-Eastern) Europe have the lowest LCOEs in Europe
- PPA-backed projects have LCOEs around [redacted]% lower than merchant projects due to the lower cost of capital – but also see lower revenues due to PPA discount

Renewables capture price formation is based on marginal pricing and driven by several factors including demand and commodity prices

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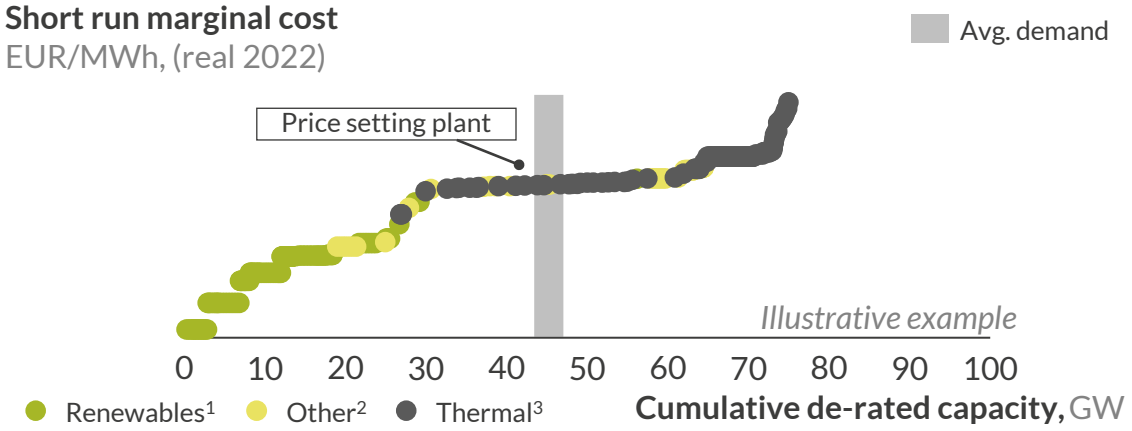
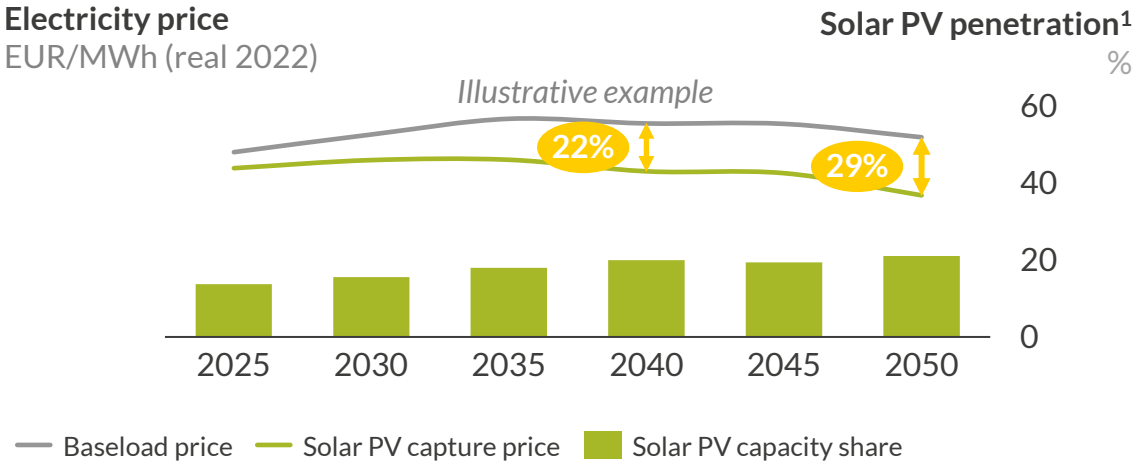
A Baseload prices are set based on marginal pricing – the marginal plant that meets the final demand sets the power price



B Renewables capture prices are set based on the baseload price and cannibalisation from renewables capacity buildout



What are the key factors that affect power prices?

1

2

3

4

1) Renewables includes wind, solar, biomass, hydro and EfW. 2) Other includes Nuclear, interconnectors and storage. 3) Thermal includes CCGTs, coal and peakers.

Source: Aurora Energy Research

The generation mix and load factors affect baseload market prices and capture price discounts across Europe

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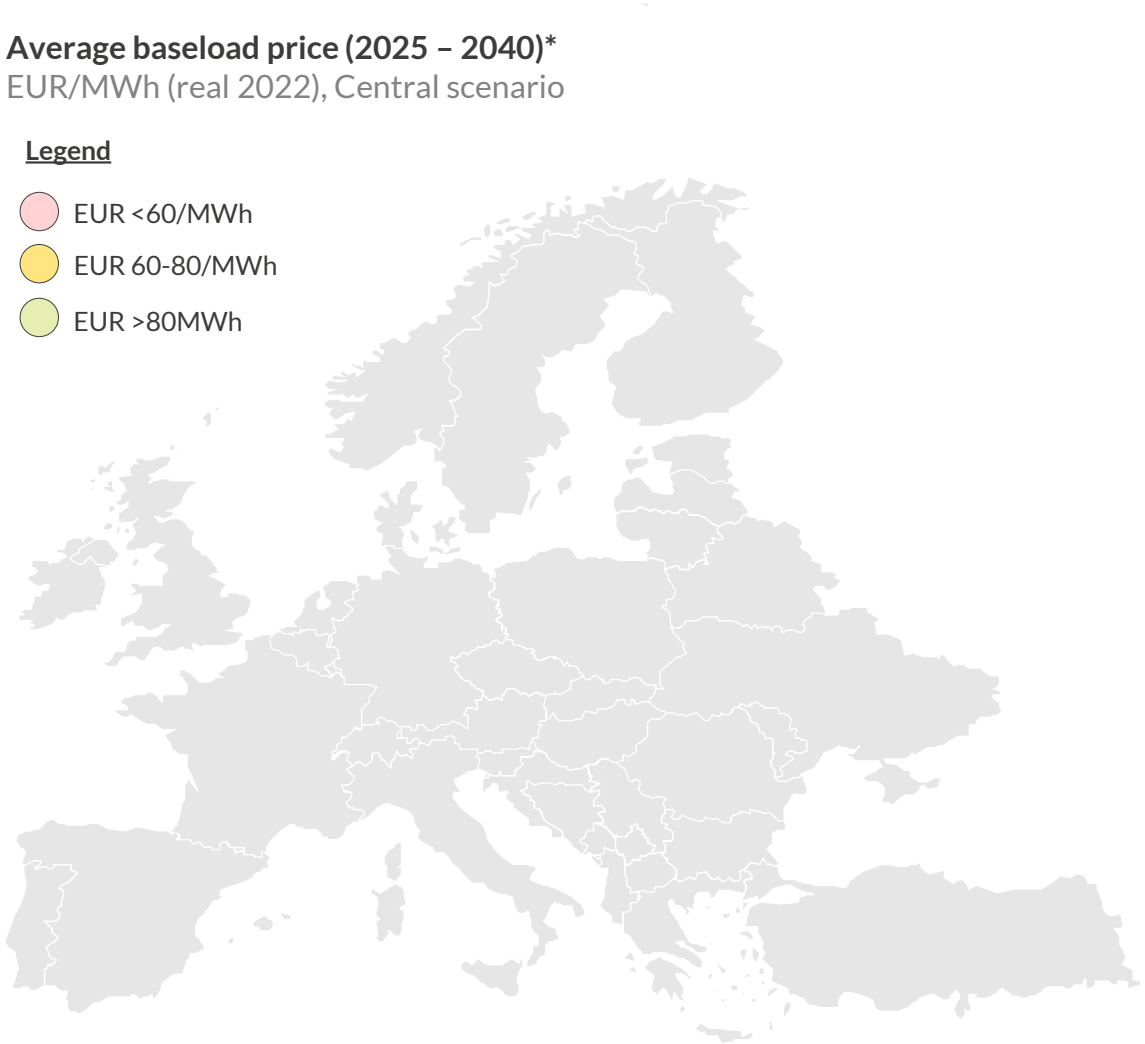
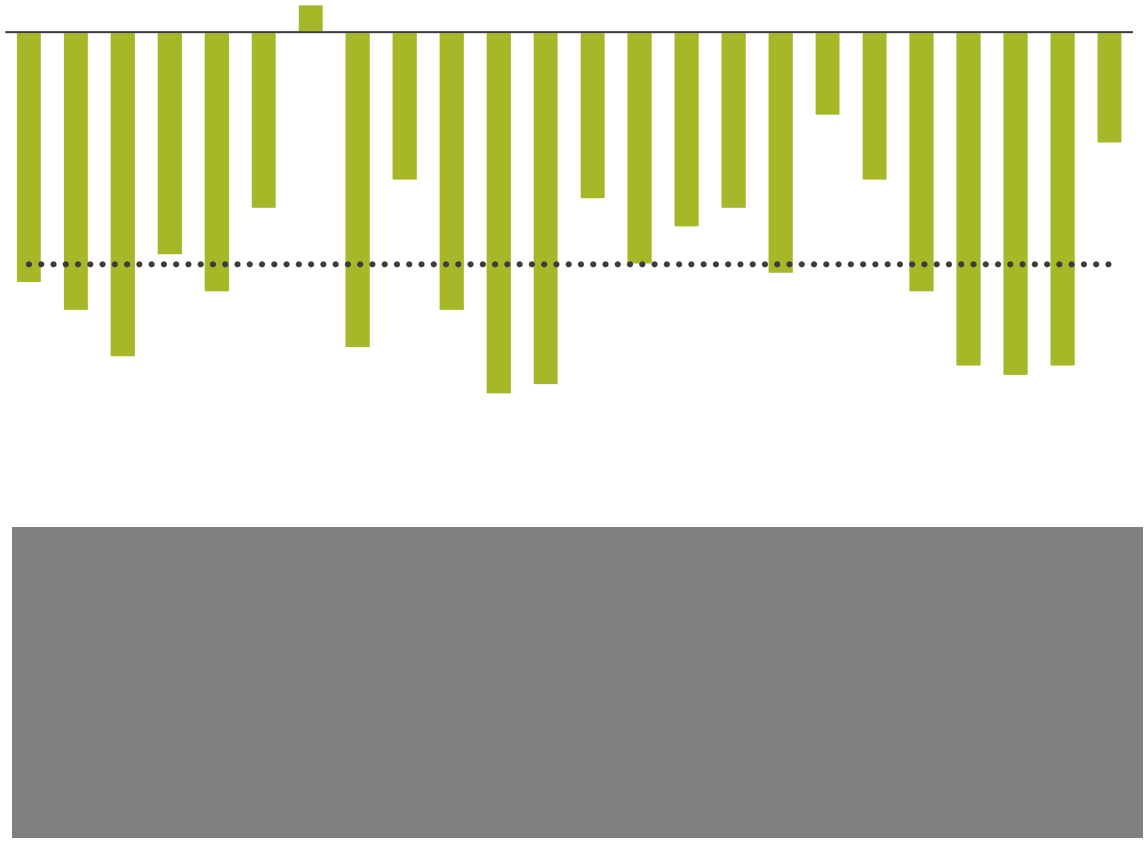
Average baseload price (2025 – 2040)*
EUR/MWh (real 2022), Central scenario



Solar capture price[1] discount to baseload price in 2030*
%, Central scenario



(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

••• European average[3]

1) Using capture prices assuming no economic curtailment i.e. plants continue to generate during negative price periods 2) Average across price zones 3) Average across Aurora's 24 modelled countries in Europe

Sources: Aurora Energy Research

On average solar PV capture prices decrease by [redacted]% between 2030-50 due to strong buildout and highly correlated generation

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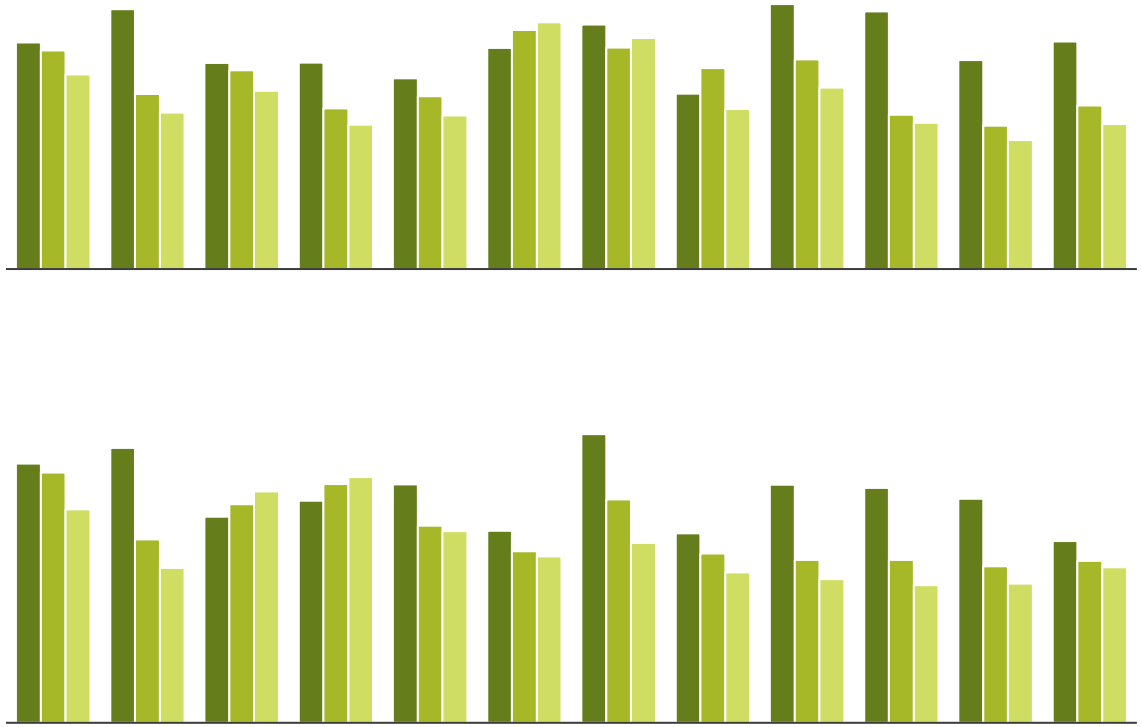
Solar capture prices* [1]
EUR/MWh, Central scenario



2030 2040 2050

Capture prices are projected to fall by a further [redacted]% between 2030-2050 across Aurora's 24 modelled regions in Europe, largely due to strong buildout of solar and the high correlation of solar generation

In each region, a variety of factors combine to determine the long-term trend in the power price captured by solar PV

+ Drivers of increasing capture prices

[redacted]

– Drivers of decreasing capture prices

[redacted]

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) Prices shown assuming no economic curtailment i.e. plants continue to generate during negative price periods 2) Average cross price zones

Source: Aurora Energy Research

Co-location with storage can improve the economics of a standalone renewables project through cost savings and additional revenues

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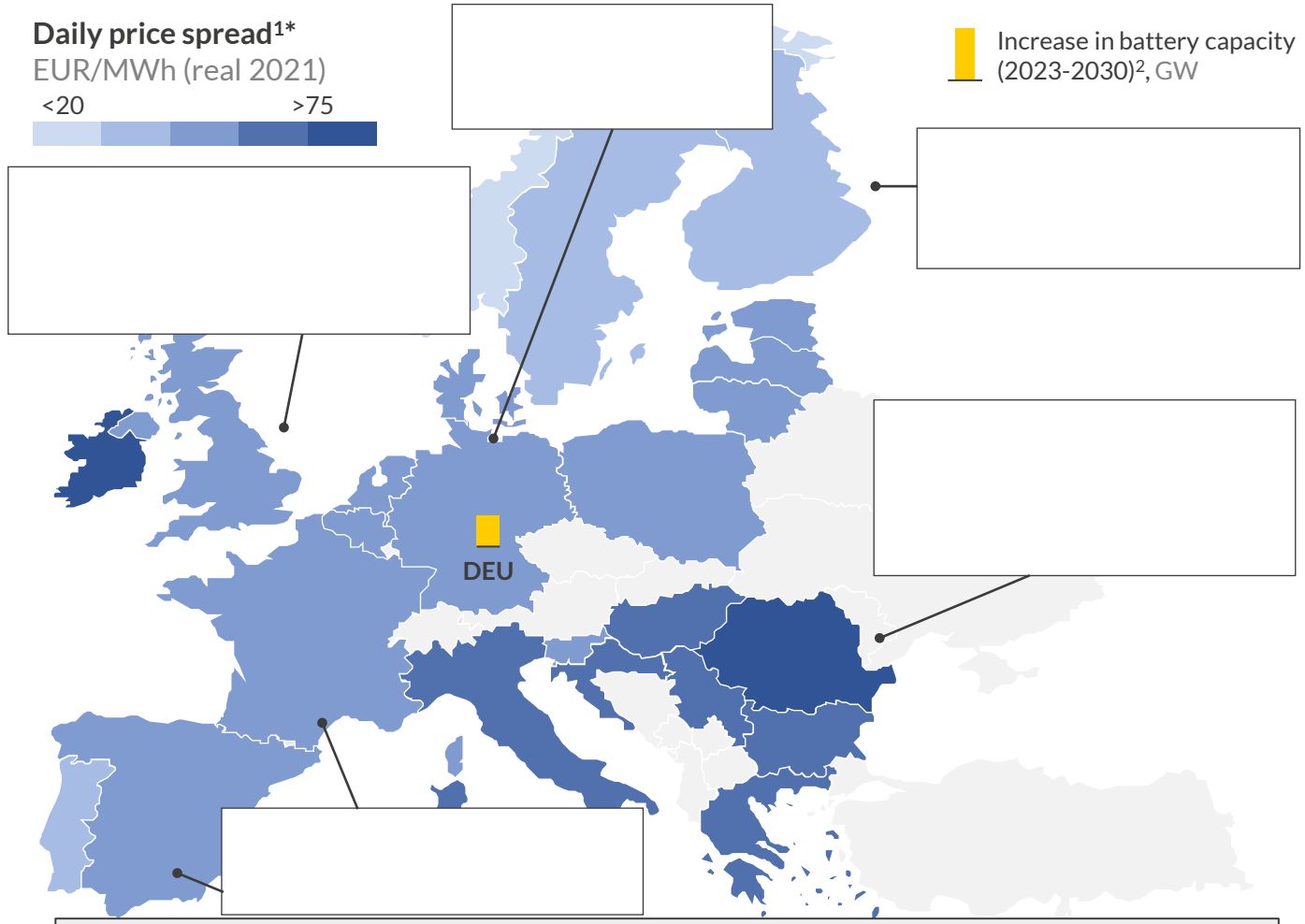
A few key drivers make storage assets attractive for investment…

- Availability of competitive ancillary services markets
- High balancing market returns and wholesale price spreads
- Availability of capacity markets or other Government support e.g. the innovation window in the DE auctions
- Increasing levels of renewables curtailment

…and co-location of storage assets with renewables can improve project economics through a host of benefits

- CAPEX savings realised by using the same grid connection and inverter for both assets
- Further CAPEX savings are achievable from shared Balance of System (BoS), installation, and development costs
- Assets also benefit from OPEX savings from optimisation of operational costs
- Co-location with storage assets creates additional revenue for renewables assets by utilising otherwise curtailed power



(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) Heat map based on average daily price spread between 2023 – 2030. 2) Based on Aurora's Central scenario. Only shown for countries with existing and forecasted battery capacities.

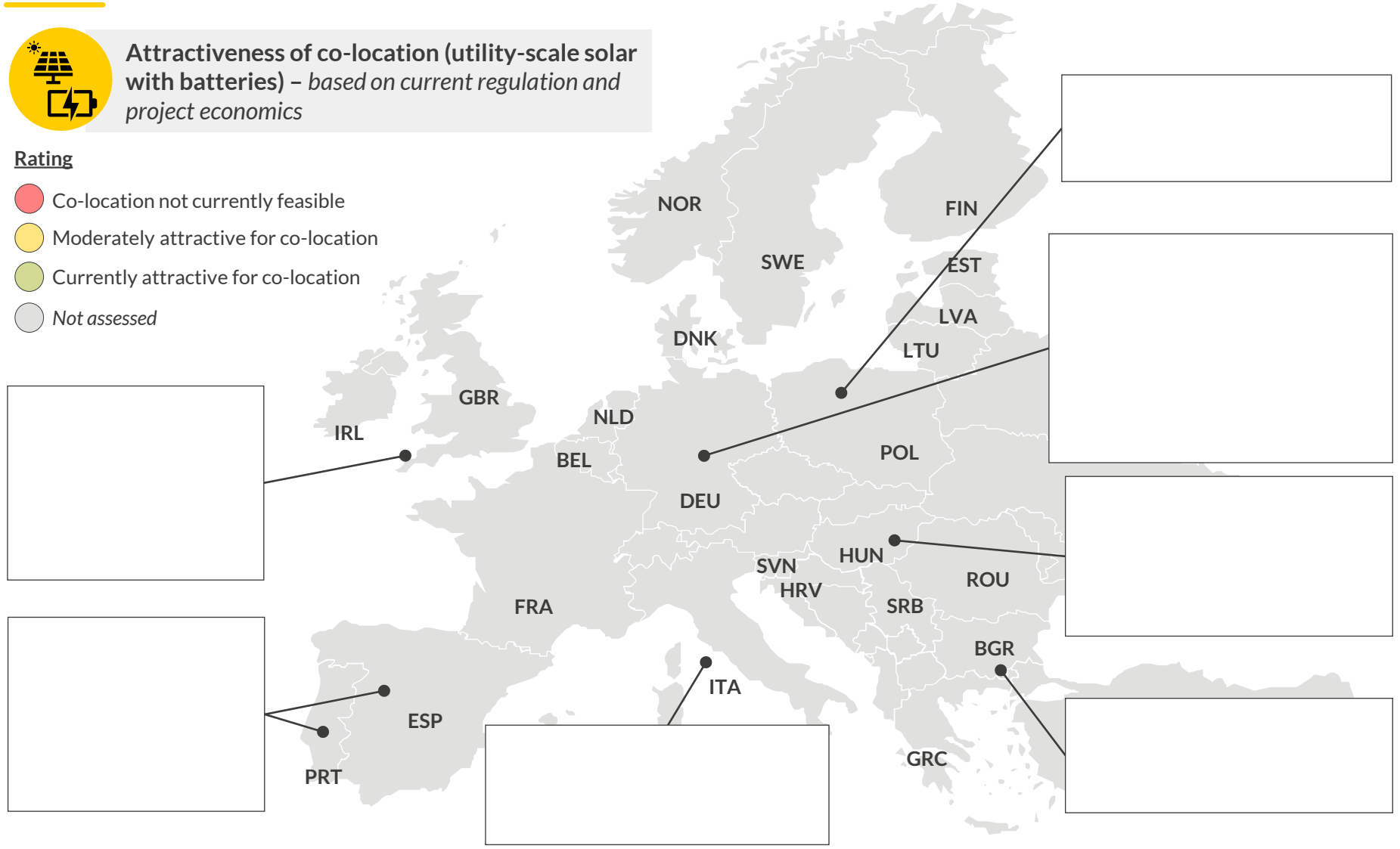
Sources: Aurora Energy Research

Favourable policy environment has enabled co-located projects in more mature markets such as

Attractiveness of co-location (utility-scale solar with batteries) – *based on current regulation and project economics*

Rating

- Co-location not currently feasible
- Moderately attractive for co-location
- Currently attractive for co-location
- *Not assessed*



Source: Aurora Energy Research

Imbalance costs vary across technologies and region, with [redacted] costs on average for wind than solar assets

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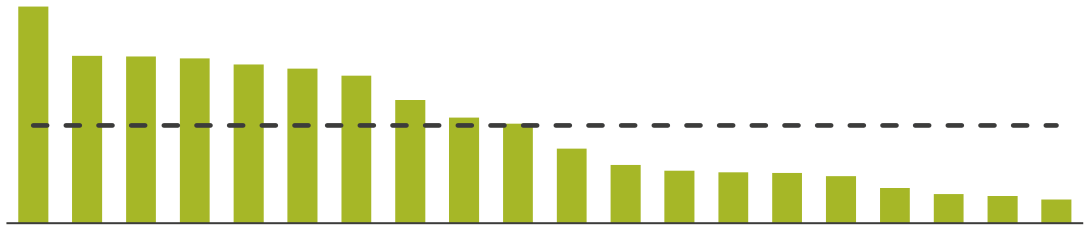
What are imbalance costs?

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

Average imbalance cost by region and technology

EUR/MWh (real 2022), average 2022-50*



Solar – – EU average

Main drivers for imbalance costs in different countries

Value driver	Description	Likelihood	Effect
		◕	↑
		◕	↑
		◔	↓
		◕	↑
		◑	↓
		◕	– [1]
		◑	↓

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

1) We expect balancing market energy prices to converge across countries. Whether this has a positive or a negative impact on prices depends on the individual country's price level in comparison to the European level.

Source: Aurora Energy Research

European Guarantees of Origin prices are expected to increase as demand outstrips supply

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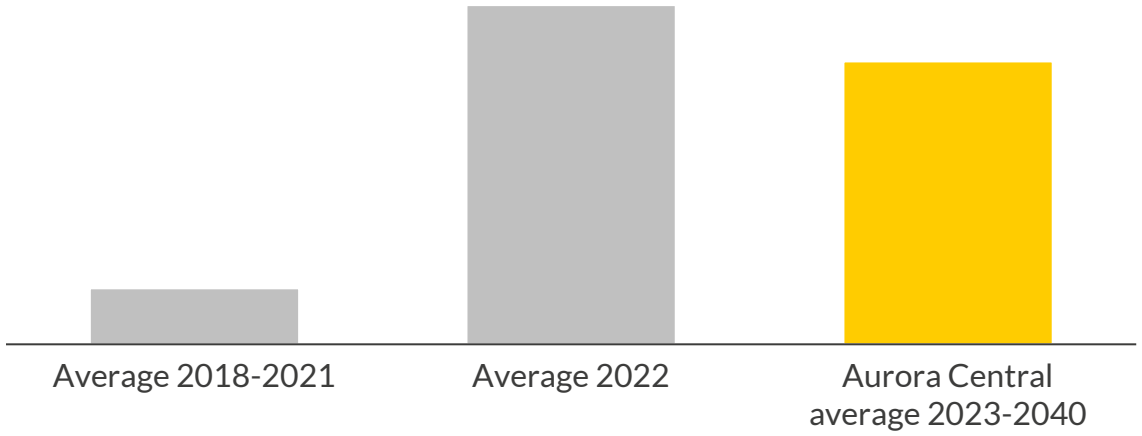
What are Guarantees of Origin?

- Electronic certificate for the production of 1 MWh of electricity from renewable sources
- Introduced as European instrument for electricity disclosure to end-consumers and certified by a national scheme as well as the AIB[1]
- GoOs are recorded in national registries and have a yearly time stamp

Annual Nordic hydro benchmark GoO price*

EUR/MWh (real 2022), average 2023-40



Main drivers for Guarantees of Origin

	Description	Impact on prices
		↑
		↑
		→

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

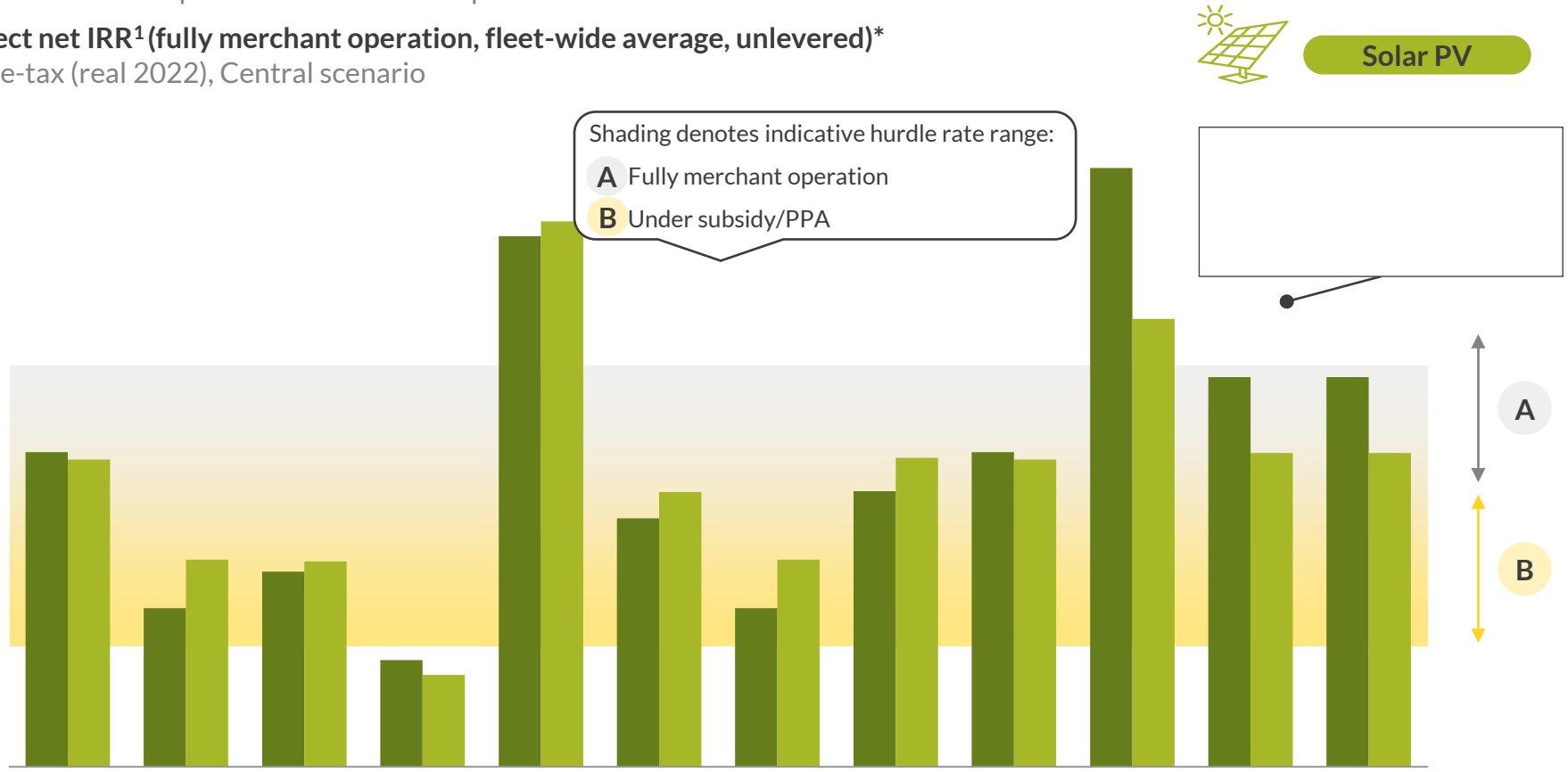
1) Association of Issuing Bodies

Sources: Aurora Energy Research, AIB

[redacted], [redacted] and [redacted] see the highest IRRs for solar PV in the short term due to high irradiation and low price cannibalisation (2/2)

IRRs presented reflect a typical, fully merchant project in each country (i.e. without subsidies or PPAs), such that individual sites will over- or under-perform based on site-specific considerations of load factor and locational benefits or costs.

Project net IRR[1] (fully merchant operation, fleet-wide average, unlevered)*
%, pre-tax (real 2022), Central scenario



First year of operation: 2025 2030

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

Source: Aurora Energy Research

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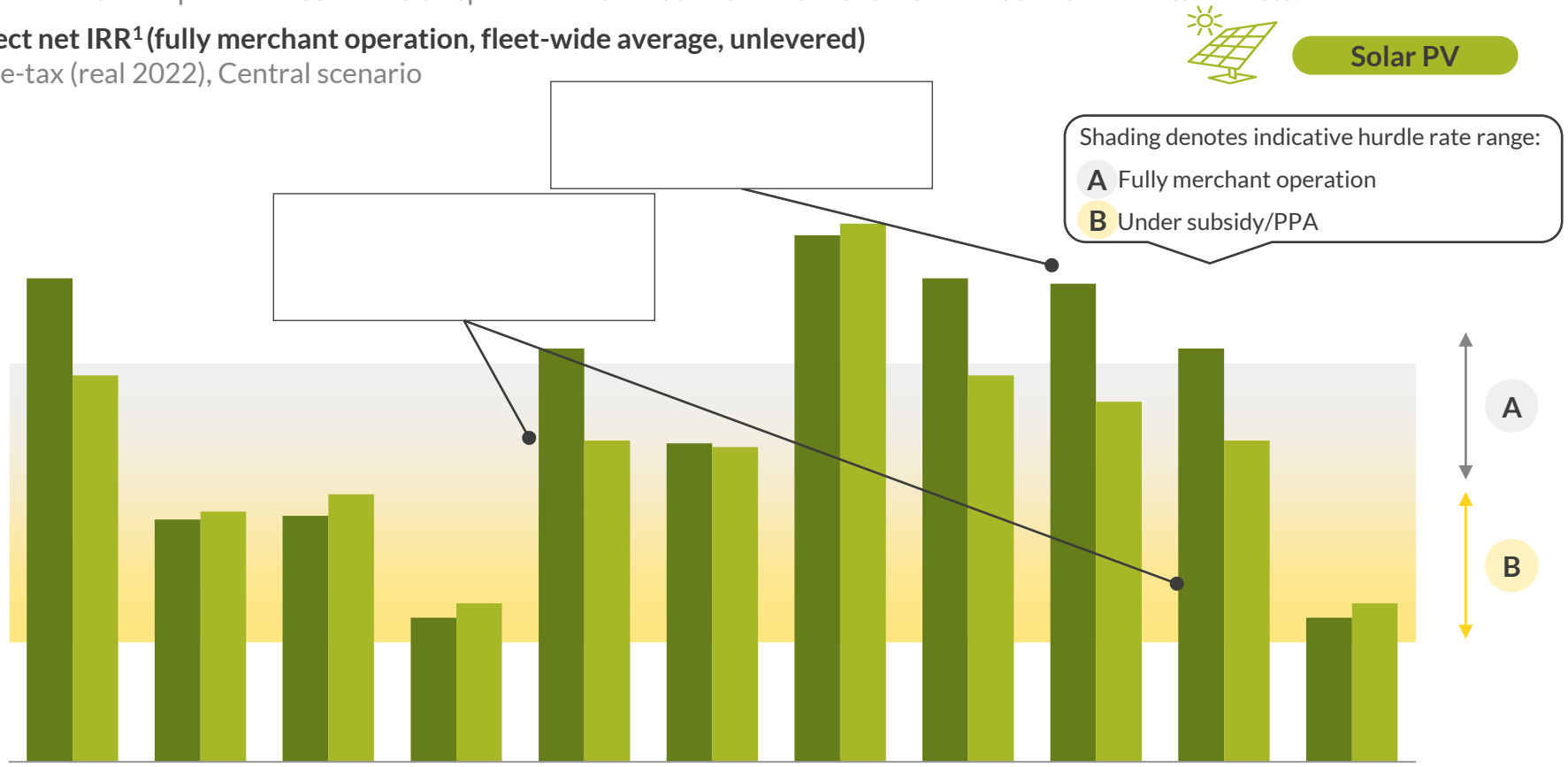

First year of operation: 2025 2030

(*) Detailed country data available in Aurora's Power and Renewables Market subscriptions.

Source: Aurora Energy Research

PPAs enable predictable revenue flows, allowing access to cheaper debt financing to improve risk-adjusted returns

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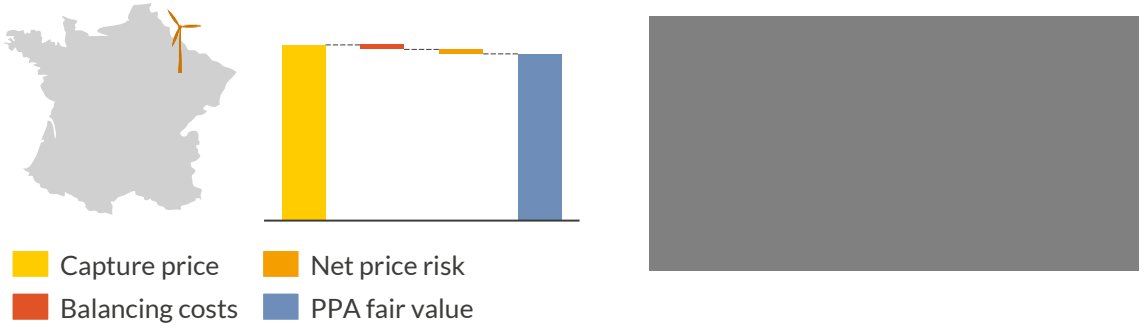
PPAs are a popular option for de-risking investments in renewable technologies, with much of Europe's merchant renewables capacity opting for this business model. Here we examine the impact of a fixed-price 10 year corporate PPA with a merchant tail on the IRR for an example onshore wind project in the North-east of France.

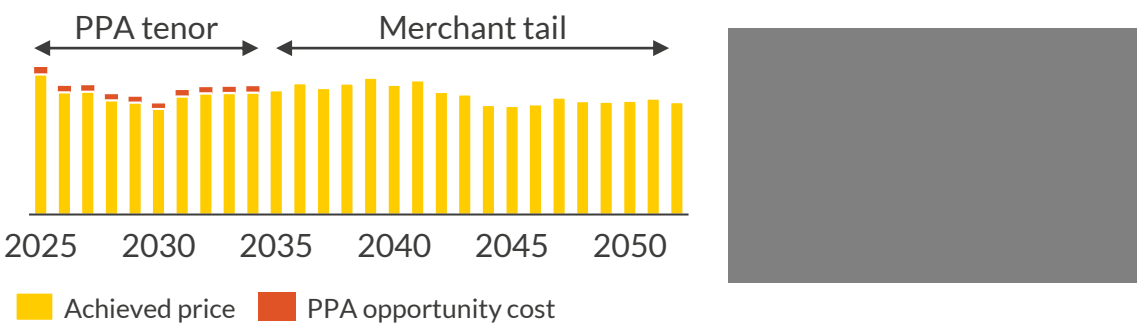
Illustrative fair value of 10-year, as-produced PPA for selected site (2025-34)

Illustrative PPA fair value estimation, EUR/MWh



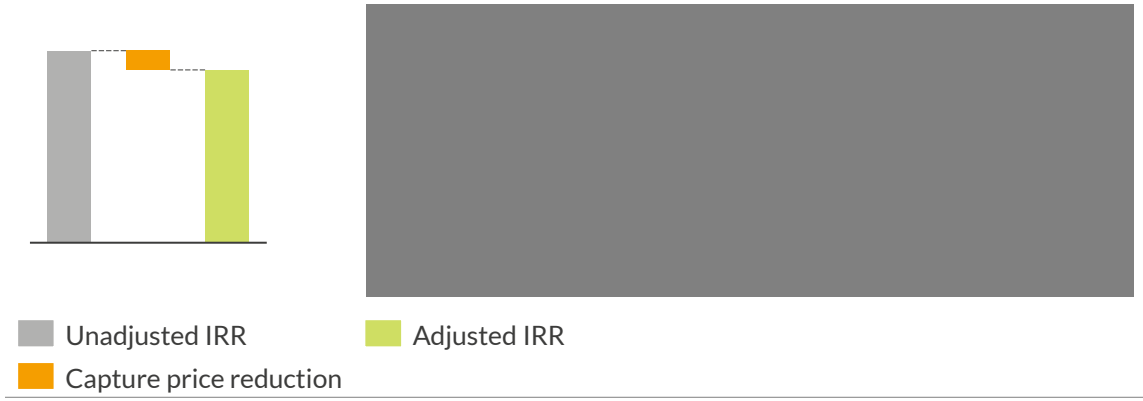
Effect on capture price revenues and merchant tail

Capture price revenues over the asset's lifetime, EUR/MWh (real 2022)



Impact on project IRR

IRR for example project, %, pre-tax (real 2022)



Considerations of WACC, hurdle rate and debt leverage

1) When discounted using a 6% discount rate

Source: Aurora Energy Research

Fluctuations in key drivers such as capture price and load factor are enough to tip projects above or below the hurdle rate

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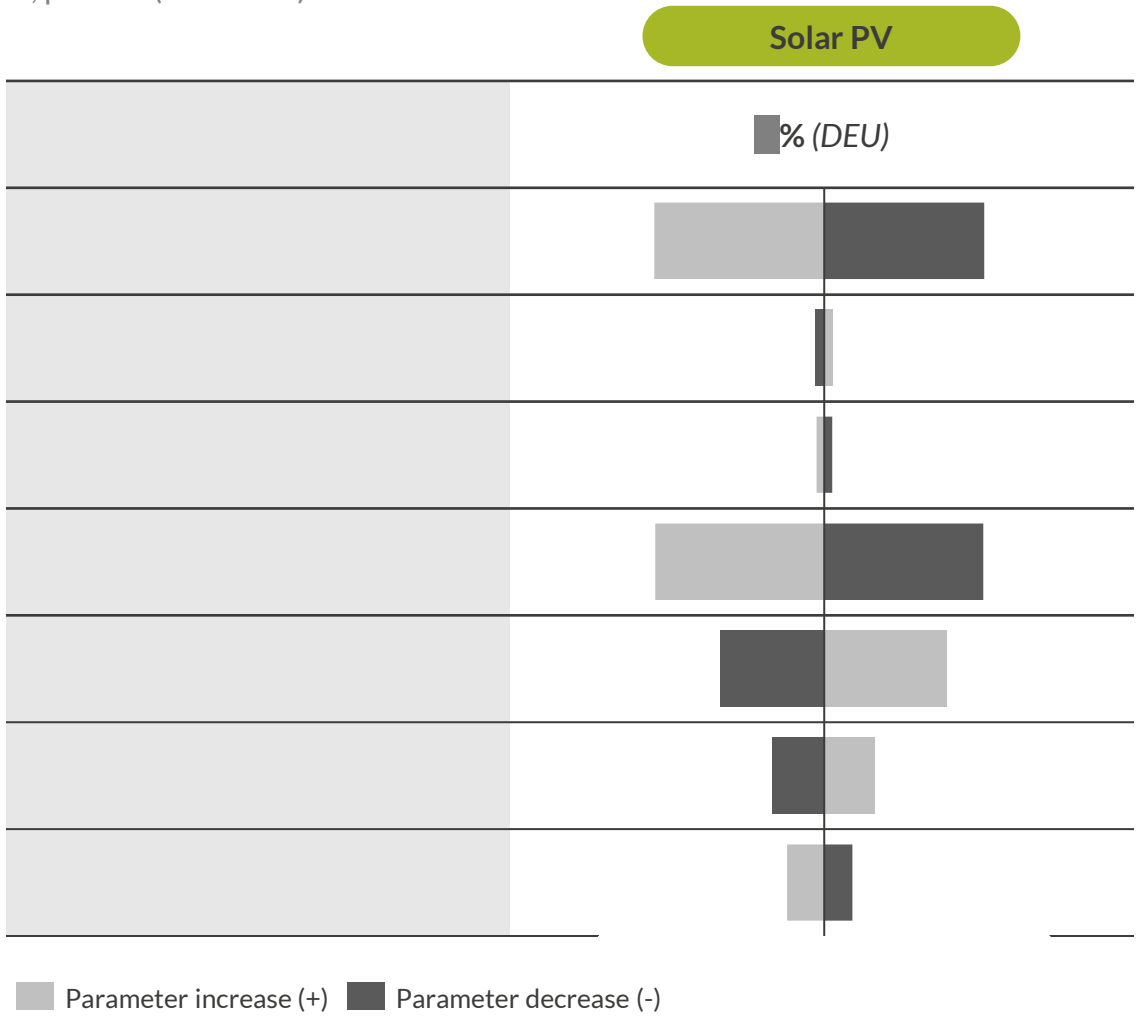
Project IRR sensitivities (in 2030)
%, pre-tax (real 2022)



Commentary

Source: Aurora Energy Research

has best projects economics due to high IRRs and attractiveness for co-location business models

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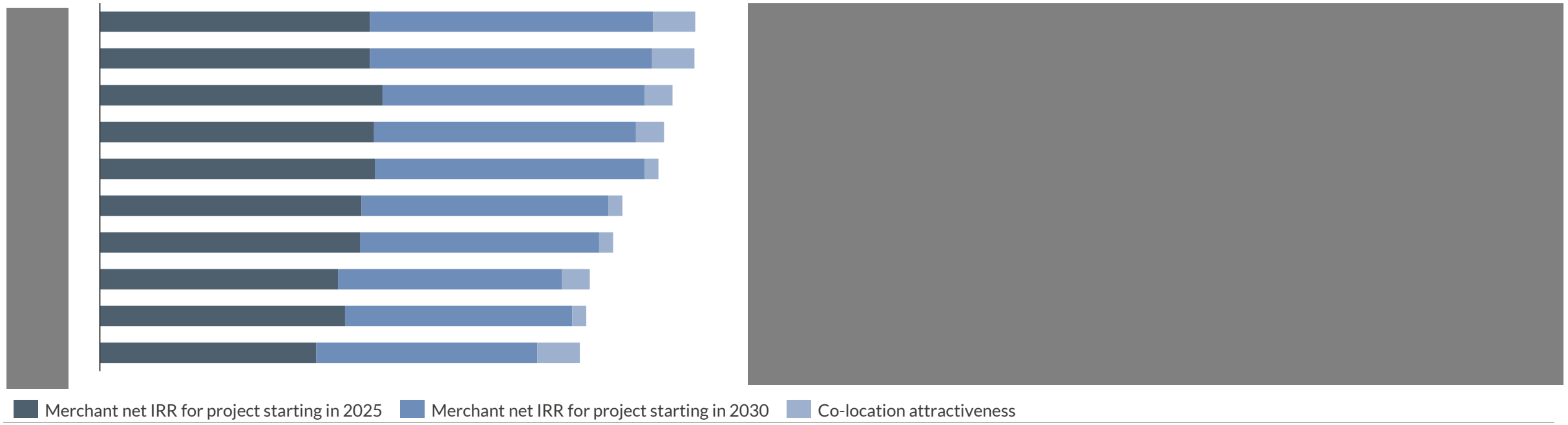
Project economics

Countries are assessed in terms of their economic outlook for solar, reflected through indicative fully merchant IRRs and attractiveness for co-location, with scores assigned between 0-10 where the maximum IRR = 10 and minimum = 0.

Metric	Weighting	Rationale
8 Indicative fully merchant net[1] IRR for project starting in 2025	40%	Captures the commercial viability of new build projects for final investment decisions in three years' time based on fully merchant business models
9 Indicative fully merchant net[1] IRR for project starting in 2030	40%	Captures the commercial viability of new build projects for project starting in 2030 to capture cannibalisation effects across markets
10 Attractiveness for co-location with batteries	20%	Reflect ability to pursue innovative business models to improve project economics



Source: Aurora Energy Research

Agenda

This is a redacted sample of the European Solar Markets Attractiveness Report.
If you are interested in the full report, contact Alex Hutcheson, (alex.hutcheson@auroraer.com).

Lifetime and WACC assumptions for project IRRs

	Asset lifetime (years)	WACCs	
Country/region	Solar PV	Fully merchant	PPA
BEL			
BGR			
DEU			
DNK			
ESP			
EST			
FIN			
FRA			
GBR			
GRC			
HRV			
HUN			
IRL			
ITA			
LTU			
LVA			
NLD			
NOR			
POL			
PRT			
ROU			
SRB			
SVN			
SWE			

Source: Aurora Energy Research

Load factors are another key determinant of solar PV LCOEs but can vary substantially between and within markets

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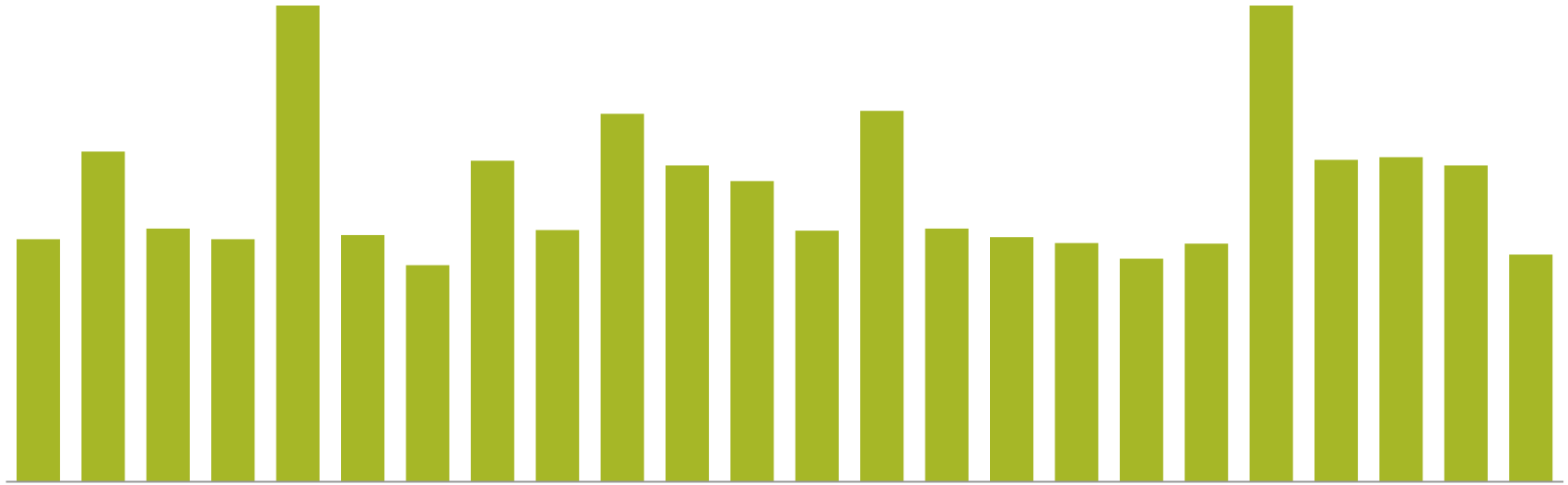
Solar load factors in 2030*

%



Fleet wide average[1]

Source: Aurora Energy Research

Details and disclaimer

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