

Can batteries supercharge the SEE energy transition?

Public webinar

April 2023



- I. About Aurora
- II. Southeastern Europe's energy transition
- III. The battery storage landscape
- IV. Battery storage economics
- V. How Aurora's analytics could contribute to this new era

Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

A U R  R A

Power markets



Renewables



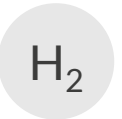
Storage



Electric vehicles



Hydrogen



Carbon



Natural gas



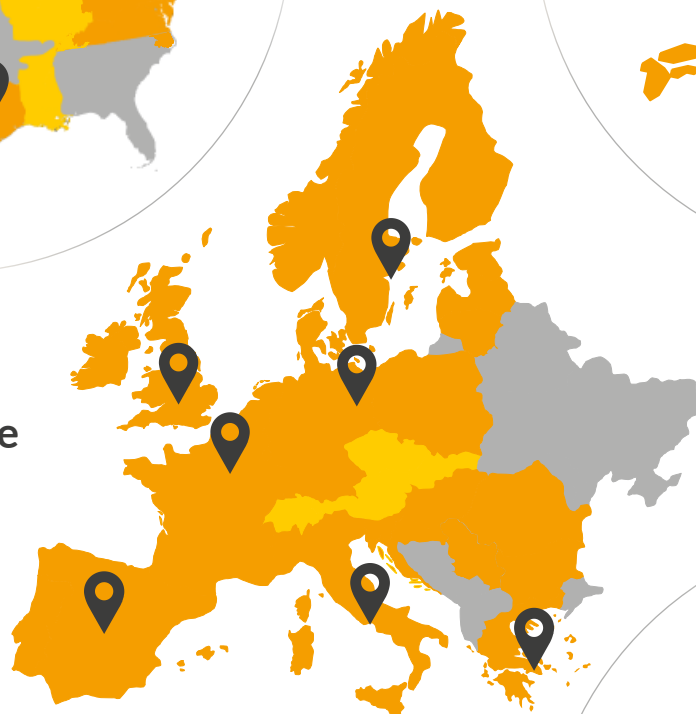
United States



Japan



Europe



Australia



 Regular detailed coverage  Analytics on demand



11 Offices

Oxford | Berlin | Madrid | Athens
Paris | Sydney | Austin | Oakland
Stockholm | Rome | Tokyo



350+

market experts



600+

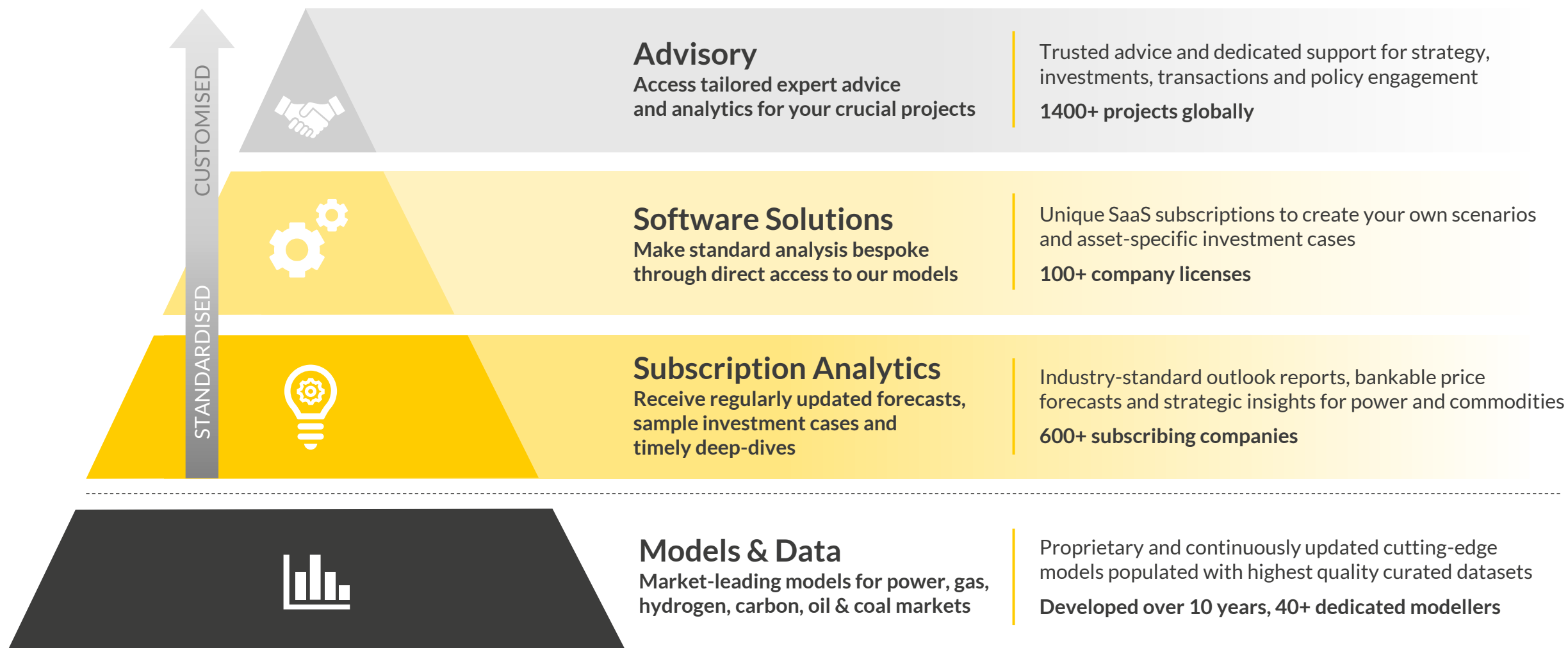
subscribing companies



150+

transactions supported in 2022

Our market leading models underpin a comprehensive range of seamlessly integrated services to best suit your needs



The study was conducted by a team of international, and on-the-ground, power market specialists



Dr Evangelos Gazis
Head of SEE

- 8 years of consulting experience at Aurora and Imperial College Consultants
- PhD and MSc in Sustainable Energy Systems, MEng in Electrical Engineering



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Senior Associate

- 4 years of energy markets experience; Previously at Sweco
- MSc Sustainable Energy Systems, University of Edinburgh, BSc in Power Engineering



Dr Stavros Skarlis
Senior Analyst

- Formerly a Senior consultant, MD of Exothermia GmbH and e-Kinesis PC
- MBA, PhD in Chemistry, MSc in vehicles exhaust aftertreatment systems, MEng in Mechanical Engineering



Petro Ylli
Commercial Associate

- Formerly at Scientia Consulting and Create and Act Consulting
- MSc in International Business Development, MA in Global Sales and Marketing



Louiza Moutafi
Senior Analyst

- 4 years of energy market experience; Previously at IPTO
- MSc in Energy Systems from West Attica University of Athens, MEng in Chemical Engineering



Julia Szabo
Analyst

- Working student at Resonanz Energy and Enpal
- MSc in Global Energy Transition and Governance from CIFE - European Institute



James Haynes
Energy Modeller

- 3 years of energy modelling experience at Aurora; formerly at ITO World
- MSc in Science in Operational Research with Risk from Edinburgh University



Joe Lloyd
Energy Modelling Analyst

- Experience using data analysis and graphing software
- MSc in Physics, University of Oxford

Agenda

I. About Aurora

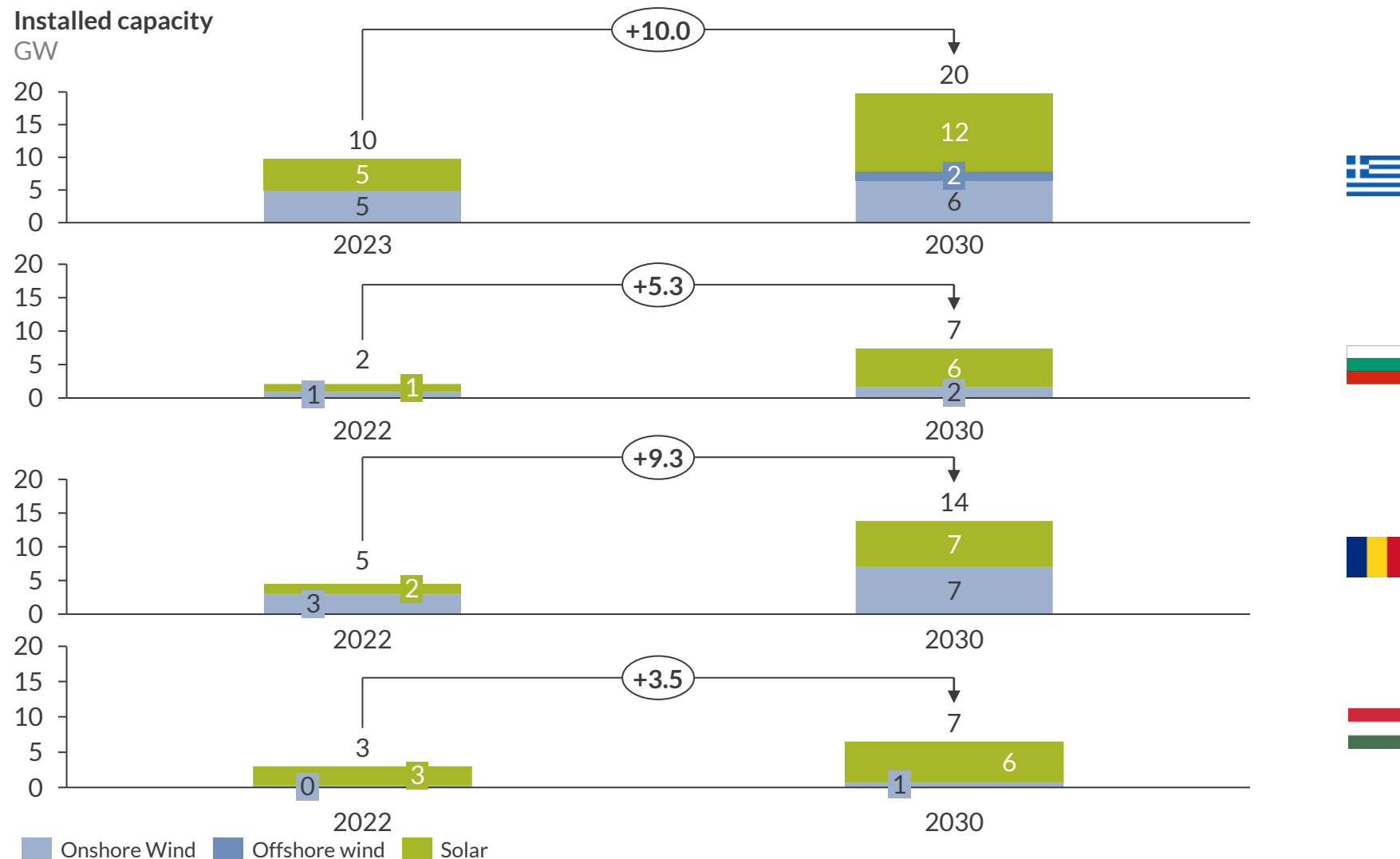
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The coal exit plans and increasing commodity prices lead to a large, renewables growth which will increase the system's intermittency



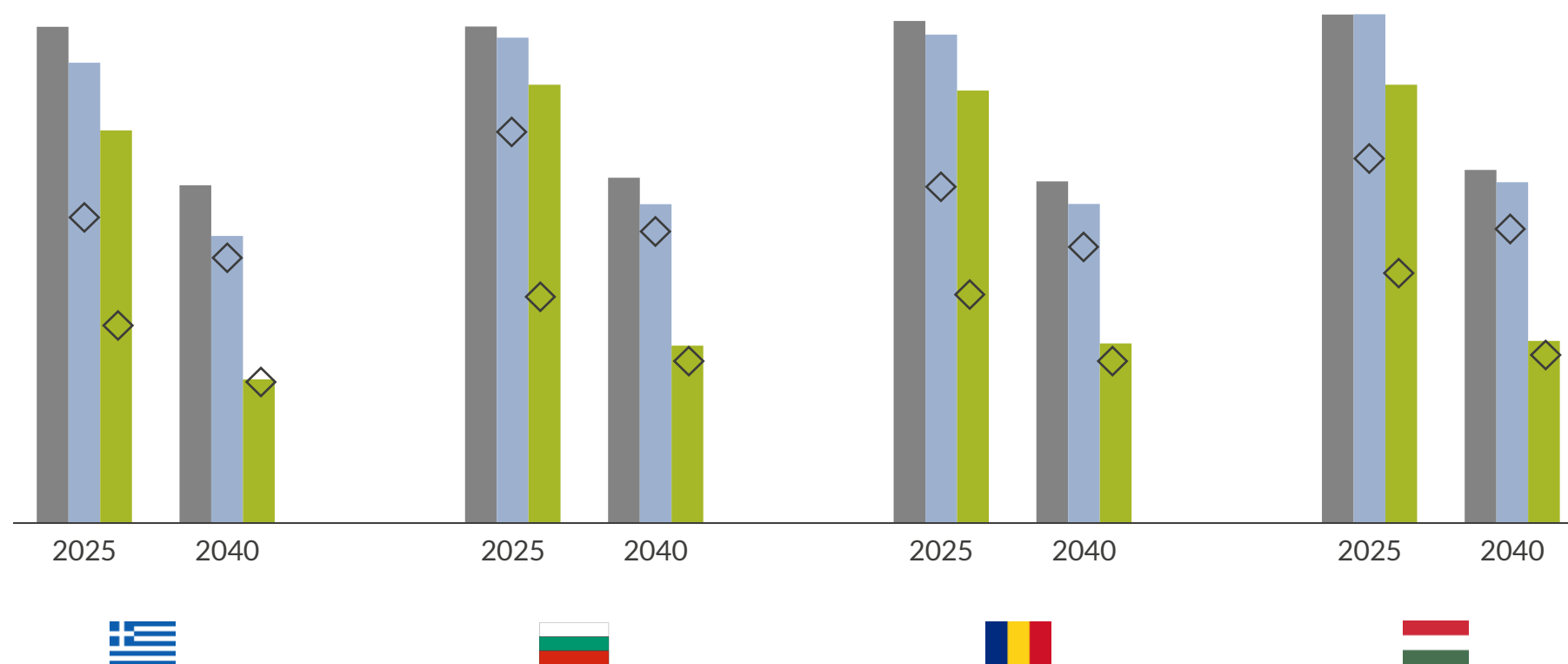
Comments

- Over 28 GW of new renewables capacity could be installed in Greece, Bulgaria, Romania and Hungary over the next 8 years, placing South Eastern Europe as a hot market for investors
- Renewables growth is expected to be higher in Greece followed by Romania, Hungary and Bulgaria
- The vast majority of new capacity is expected to come from solar PV as merchant economics appear more attractive than those of onshore wind
- These levels of RES penetration lead to high instances of excess generation but also of more tight periods as dispatchable capacity decreases – batteries are crucial for supporting this transition

On top of subsidized renewables, capture prices for wind and solar appear attractive for large amounts of merchant deployment

Baseload and uncurtailed capture prices¹

EUR/MWh



■ Baseload ■ Capture price Wind ■ Capture price Solar ◇ LCOE - 10% discount rate

1) Average capture price for each MWh produced of theoretical generation.

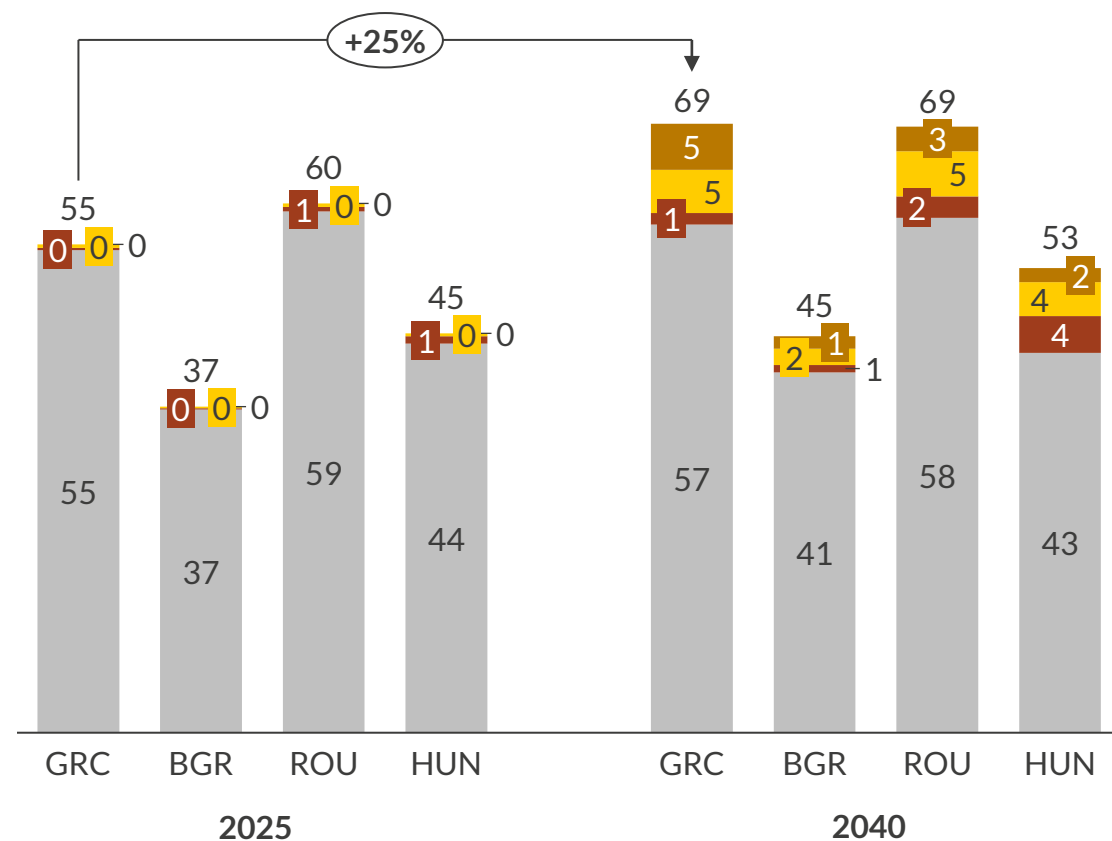
Comments

- The largest difference between capture prices and the LCOE for both wind and solar appears in 2025 due to high baseload prices which have not recovered fully from the gas price rally
- While the difference between capture price and LCOE reduces over time, there a healthy margin all the way to 2040
- Onshore wind prices are expected to see much reduced cannibalisation compared to solar both due to its more diverse profile but also due to the lower deployment as offshore wind becomes a part of the generation mix

We also expect a larger system size due to electrification of heat, transport but also green hydrogen production

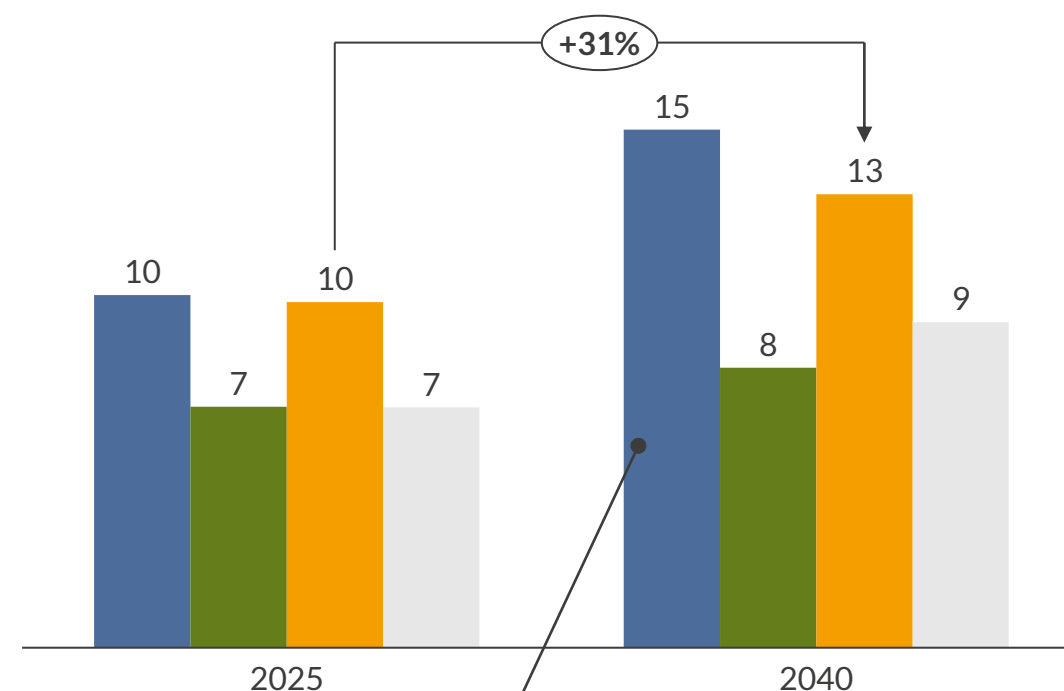
Annual demand demand in 2025 and 2040

TWh



Annual peak demand in 2025 and 2040

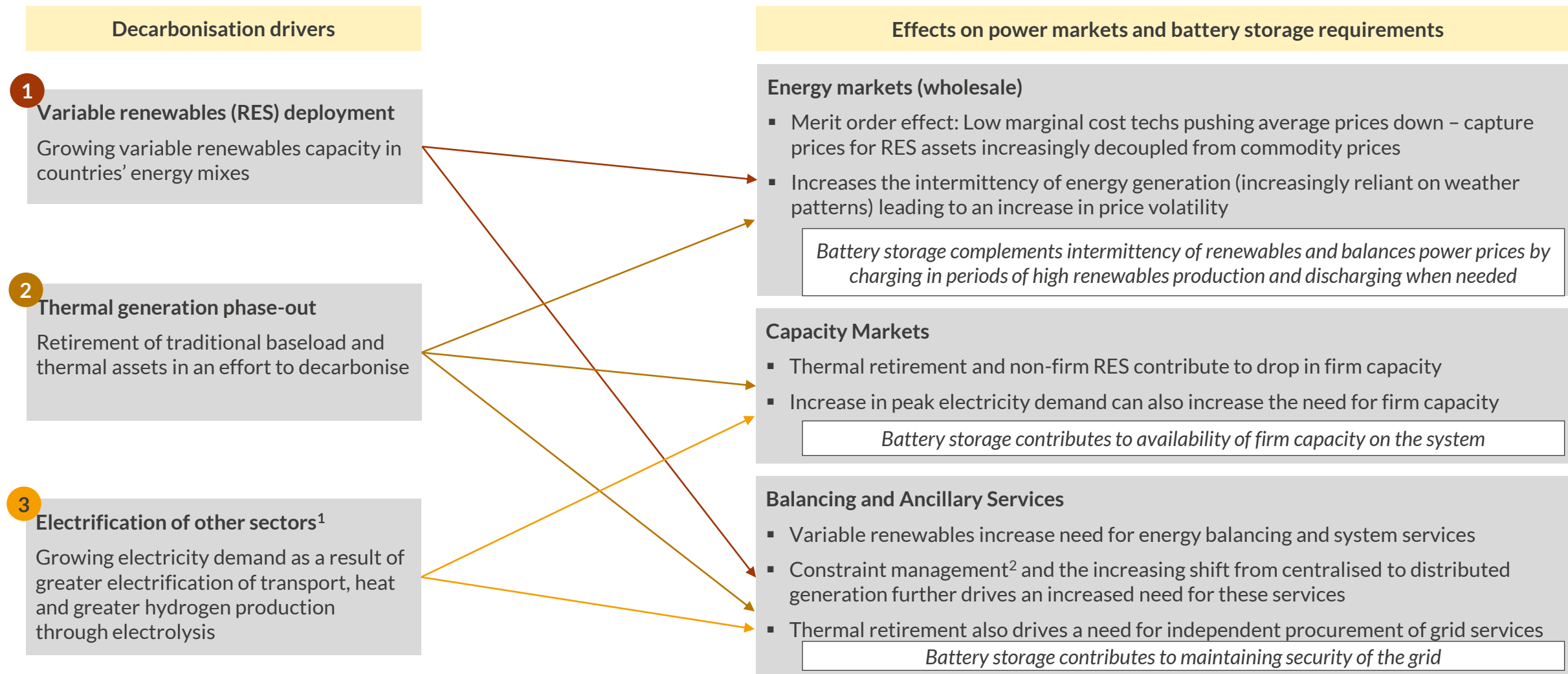
GW



The peak demand of the future is expected to grow significantly. At the same time, existing thermal dispatchable assets are expected to be history by 2040. Therefore, batteries alongside other cleaner dispatchable sources are expected to be key for keeping the lights on

1) Data up to Sep 2022.

Rising flexibility needs and corresponding battery storage buildout is primarily driven by decarbonisation and its underlying drivers



1) Growing demand could improve business case for storage if it is inflexible demand; but if it is flexible demand then detracts from business case for grid scale batteries. 2) Increase in constraint management is further driven by RES deployment outpacing grid capacity.

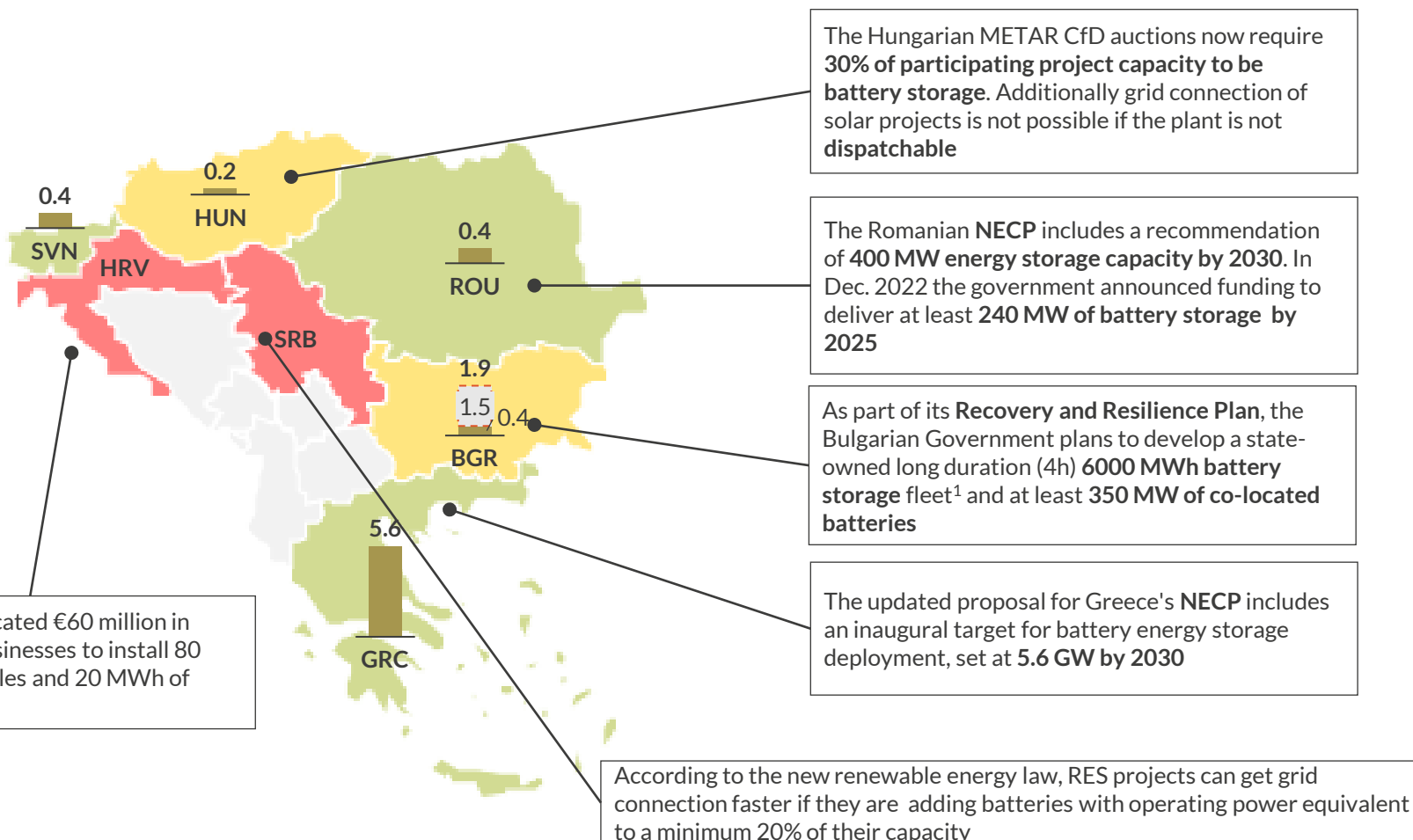
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Across Europe, a rising number of countries have introduced strategies and targets for energy storage deployment

National government policies and targets for capacity of energy storage (2030)

GW



- Increasing RES penetration requires improved power system flexibility, therefore accelerated storage uptake is key for the region's energy transition
- A substantial amount of public resources from the Recovery and Resilience Fund has been allocated to electricity storage investments in the SEE region
- Several SEE countries set ambitious national targets and are already planning auctions to support the construction of storage projects
- Battery auctions are expected in Greece and Hungary a this year, while Croatia has launched an auction this month

1) Project plan currently on hold. It is unlikely for the project to materialise in the form originally envisioned

Subsidy support for batteries exists in most SEE regions, mainly from recovery and resilience funds deployed by the EU

	Support type	Projects size MW or MWh	Comments
Greece	Auctions with the following format: a. Investment grant b. Annual operating support in the form of a CfD contract	1000 MW	<ul style="list-style-type: none"> The official announcement of the auction structure is expected by mid May while the first auction before July 2023 The next auctions within the year as well
Bulgaria	<ul style="list-style-type: none"> A € 798 m worth national energy storage network is funded through the Recovery and Resilience Plan 	350 MW, up to 6,000 MWh ¹	<ul style="list-style-type: none"> Respective facilities to be located close to areas with RES plants First tenders were expected by Sept. 2022, yet are still pending
Romania	<ul style="list-style-type: none"> Auctions are planned for BESS projects deployment by 2025 € 103.5 m to be granted (€ 79.6 m from the National Recovery and Resilience Plan) 	240 MW (480 MWh)	<ul style="list-style-type: none"> The funding will cover reimbursement of expenses and may not exceed € 167,000 per MWh of storage and € 15 million per applicant Auctions dates have not been announced yet
Hungary	<ul style="list-style-type: none"> Auctions are planned for BESS projects deployment by 2025 A total budget of € 320 m to be allocated 	475 MWh ²	<ul style="list-style-type: none"> The first auction is expected to be launched this spring The battery must be operating for at least 10 years and participate in the balancing market

- Greece is the first SEE country that has a battery storage framework and the most mature market in the region
- Battery storage auctions are expected this year in Greece and Hungary, and by 2025 in Romania
- The subsidies are expected in the form of CAPEX-based investment grants and annual operating support

1) The 6,000 MWh centrally owned storage systems is a concept that was recently put on hold. It is unlikely the project would materialize as initially envisioned.

2) 164 MWh of batteries owned by the TSO and DSOs, as fully integrated assets, as well as 311 MWh owned by market participants, with the RRF covering 50% of investment costs

The first auction of the new Greek energy storage support scheme is expected in Q2 2023; up to 400 MW to be awarded in the near future

Participation criteria

- **Participating technologies:** Standalone BESS
 - The award of the contracts to the selected projects should take place before the end of 2023 and the storage facilities should be completed by the end of 2025
- **Competition regulation**
 - Maximum project size set to **100 MW**
 - A single company (including subsidiaries) won't be able to get more than **25% of the volume** (max of 250 MW)
- **Other requirements:**
 - Licensing maturity is expected be a requirement to participate in the auctions
 - Finalised connection terms may be also required (similarly to RES auctions)
 - Similarly to RES auctions, there will be a 100% oversubscription requirement (total bidding capacity = min of 2 times the auction volume)

Auction design

Expected timeline

First auction to be announced in **Q2 2023**

Second and third auctions planned by end of 2023

Budget:

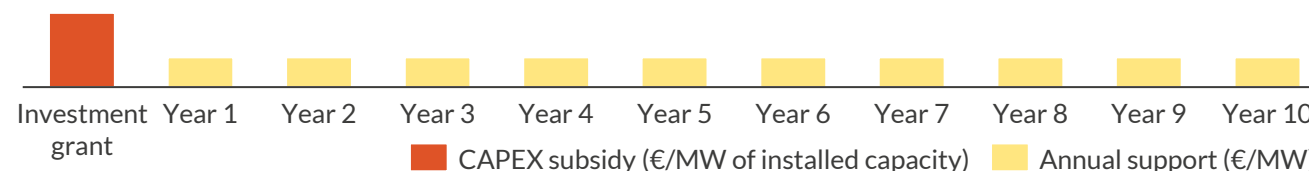
- 341 million € of grants are planned for the development of storage systems, **1000 MW in total**

Capacity to be awarded:

- 400 MW to be awarded in the first auction, 300 MW in the second and third each

Structure of the aid:

- Annual operating support plus CAPEX subsidy
- *"The aid will be granted, cumulatively, in the form of:*
 - *(i) an investment grant of 200,000 €/MW, which will be paid during the construction phase of all supported projects;*
 - *and (ii) an annual support in the form of a CfD contract for a 10-year period"*¹
- *"The total amount of annual support per beneficiary will be determined in a competitive tender and adjusted through a claw-back mechanism in case the project has excess market revenues from its participation to the market during the operations phase"*



1) The total amount of annual support per beneficiary will be determined in a competitive tender and adjusted through a claw-back mechanism in case the project has excess market revenues from its participation to the market during the operations phase.

Most countries allow for batteries to stack various revenue streams, however contractual revenues are limited

Region	CM	WM	BS ¹	FR ²	OS ³	Availability of long-term contractual revenues
Greece						<ul style="list-style-type: none"> New auctions planned for 1000MW battery storage in a CAPEX based scheme that could cover up to 200,000 EUR/MW of the total CAPEX Greece expected to have a capacity market, but date of implementation is not finalised
Bulgaria						<ul style="list-style-type: none"> FCR and FRR ancillary services are available, yet there is neither a dedicated balancing services market, nor a legal framework for battery energy storage systems
Romania						<ul style="list-style-type: none"> € 103.5 m granted for battery projects to deploy 480 MWh battery energy storage projects First technical regulation on BESS installation have been published under the Order no 3/2023
Hungary						<ul style="list-style-type: none"> Contractual revenues are available through the METÁR CfD auctions for up to 15 years which now require 30% of the project capacity to be batteries FCR and FRR ancillary services available, however, there is still no framework for battery energy storage systems
Croatia						<ul style="list-style-type: none"> EU granted IE-Energy (operator) € 19.8 m to deploy a 50 MW BESS project mFRR balancing capacity/energy procurement via public tenders in HOPS (Feb. 23). Not clear which streams are available as there is no framework for storage
Slovenia						<ul style="list-style-type: none"> Sincro.Grid has launched trials of two BESS units of 10MW Not clear which streams are available as there is no framework for storage
Serbia						<ul style="list-style-type: none"> FCR and FRR ancillary services are available, yet there is neither a dedicated balancing services market, nor a legal framework for battery energy storage systems

Not available / relevant for battery storage
 Available/relevant and stackable for battery storage
 Partially available

1) Includes Balancing Mechanisms in Great Britain and Ireland and frequency products with full activation time > 10 mins such as mFRR, RR, and Secondary/Tertiary Reserves within Italy's MSD. 2) Includes frequency products with full activation time < 10 mins such as FFR, FCR and aFRR. 3) Other ancillary services and benefits such as black start capability, inertia, and local congestion mitigation services.









Sources: Aurora Energy Research, National Grid


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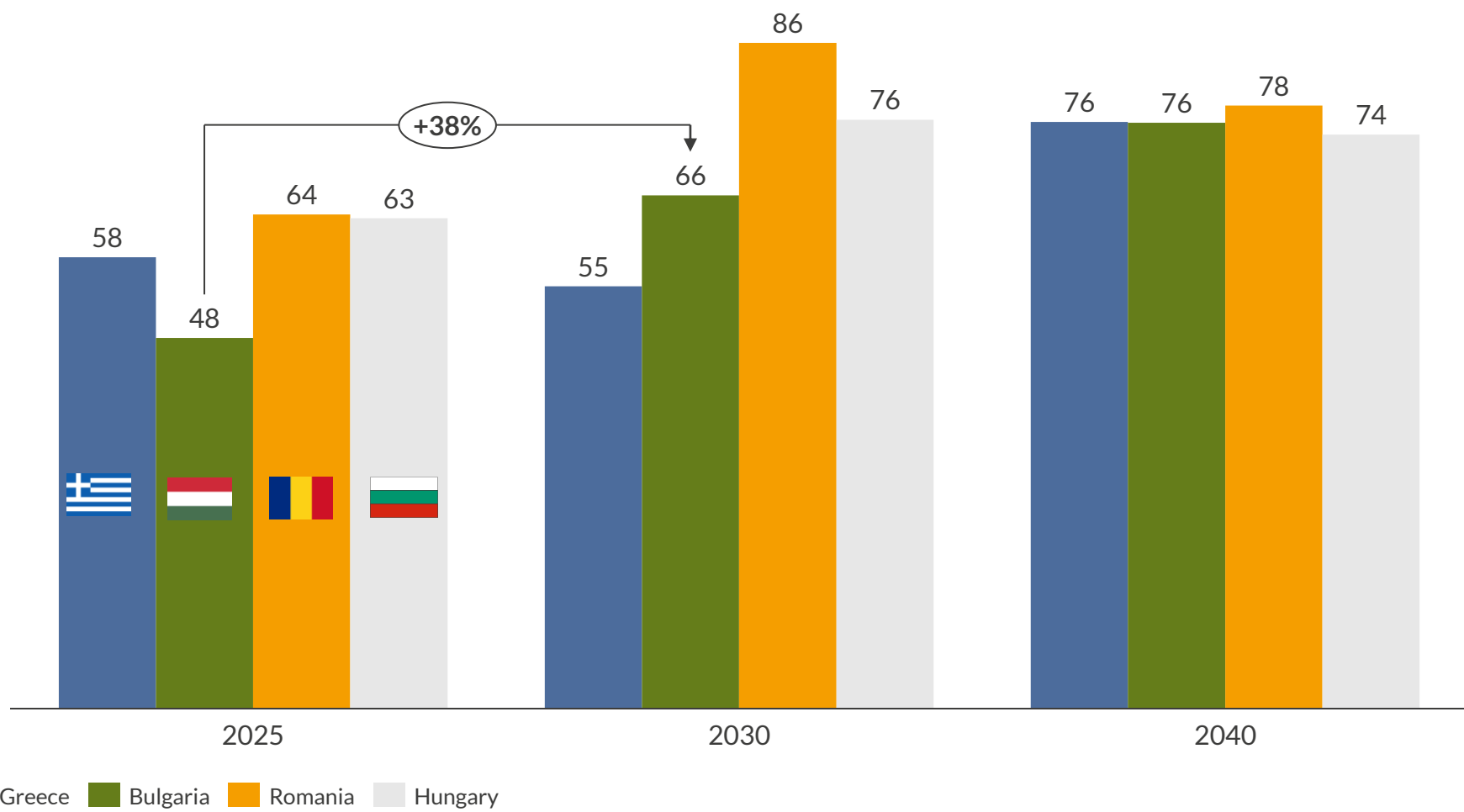
Battery storage system revenues are likely to be affected by commodity prices, intraday market spreads, as well as RES and batteries penetration rates

	Likelihood of materialisation	Impact on battery storage revenues	Comments
Commodity price increase			<ul style="list-style-type: none"> Higher commodity prices can result in higher power prices, which has the potential to provide enhanced revenues during energy discharging events
Renewables penetration increase			<ul style="list-style-type: none"> The expected increase in renewables penetration will on one hand increase the demand for balancing services and on the other hand allow for cost effective battery charging Both factors can potentially increase battery project revenue
Intraday market spread increase ¹			<ul style="list-style-type: none"> In case of increased prices volatility in the intraday market, batteries can benefit from both high power prices for discharging energy and low electricity prices during charging events
Battery capacity increasing ²			<ul style="list-style-type: none"> As deployment of battery assets increase, batteries participation in ancillary services markets will also increase, resulting in a collapse of respective prices and eventually limited revenues

 Further analysis is provided in the next slides

Intraday price volatility increases with penetration of intermittent renewables and higher commodity prices

Average daily price spread¹
€/MWh

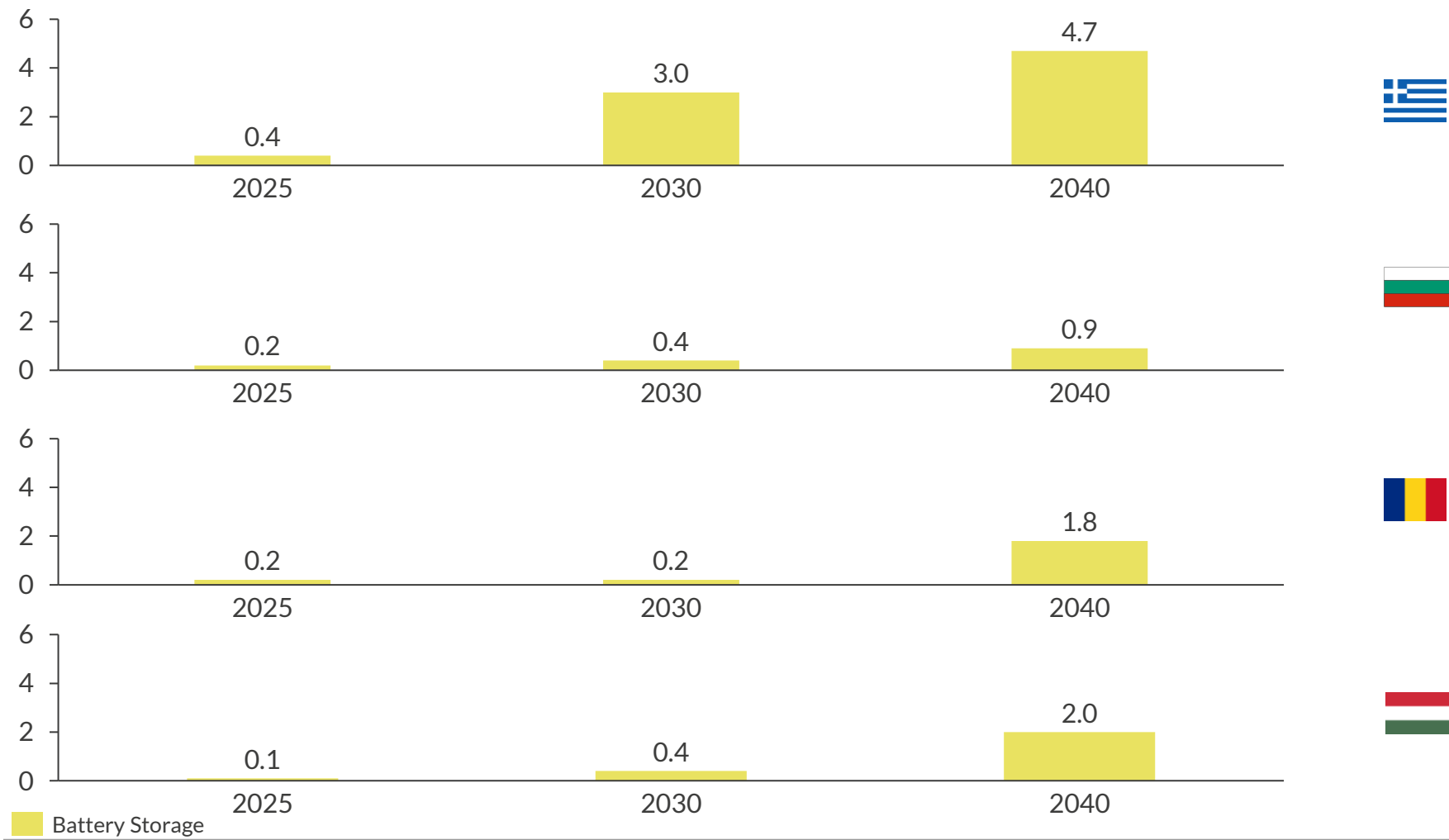


- This increase is the result of a growing share of renewables:
 - High solar generation during daytime hours and high wind generation during low demand hours lead to a decrease in prices
 - In hours with high load and low RES generation, prices increase as hydro and gas-fired technologies are price-setting in those hours (against a backdrop of higher gas and carbon price)

1) Average spread between the lowest and highest price during a day.

An accelerated batteries penetration is expected in major SEE markets resulting in over 9 GW of installed capacity by 2040

Battery installed capacity
GW



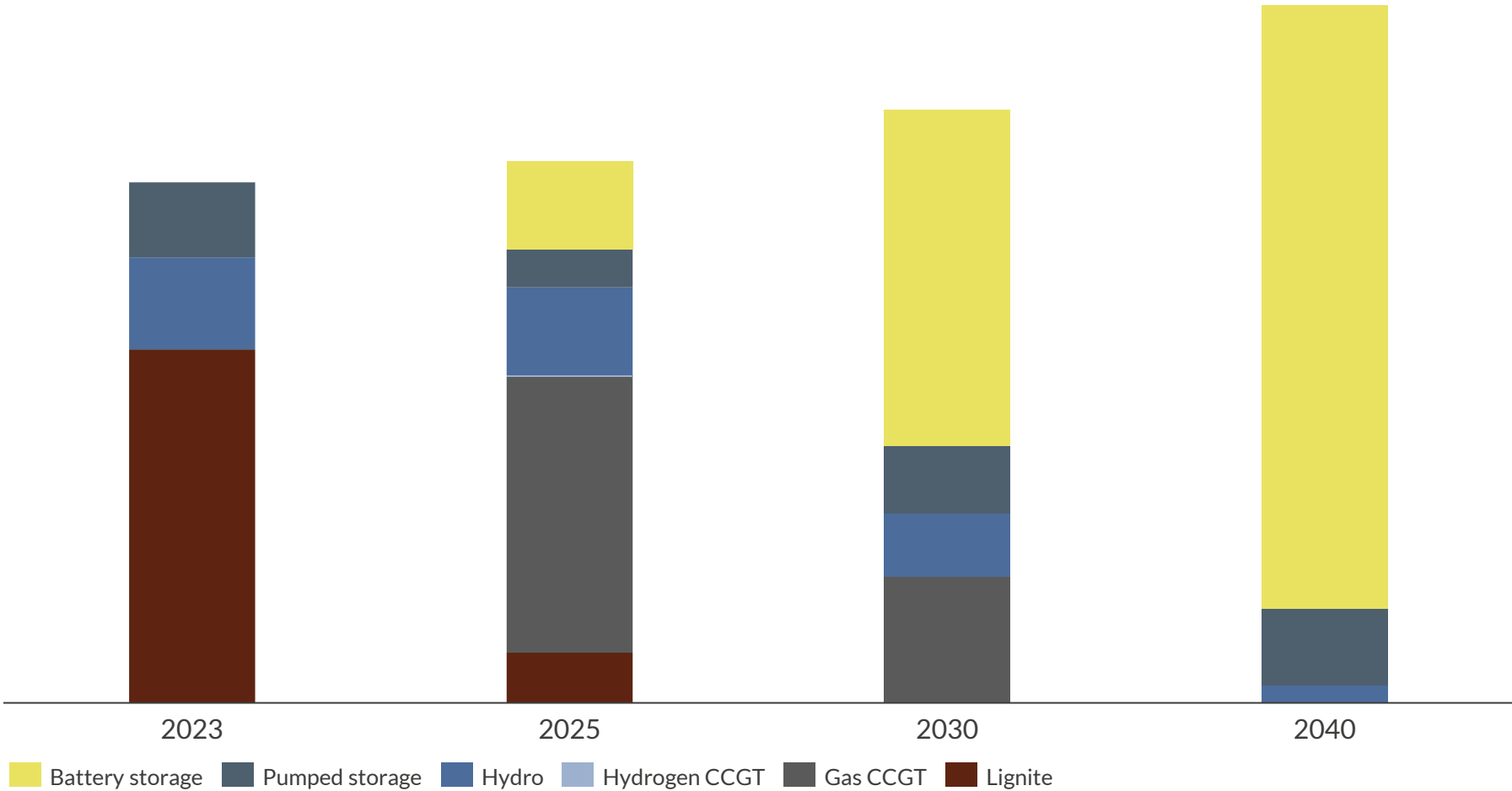
Comments

- A rapid penetration of battery storage systems is expected in major SEE markets, according to the Aurora's central view, resulting in a total 9.4 GW installed capacity by 2040
- Aurora's projections are affected by amendments in NECP targets, the existence of financial incentives, supporting respective assets built out, as well as favorable economics related to battery energy trading
- Greece appears to be the most rapidly growing market, due to recently announced auctions and the existence of a comprehensive legal framework for battery storage deployment
- Respective developments in the remaining countries are also expected beyond 2030

Storage assets to dominate the ancillary services market from 2030 resulting in a collapse of respective prices; FCR is a simple example

FCR upward procurement volumes
MW

Qualitative example corresponding to the Greek FCR market



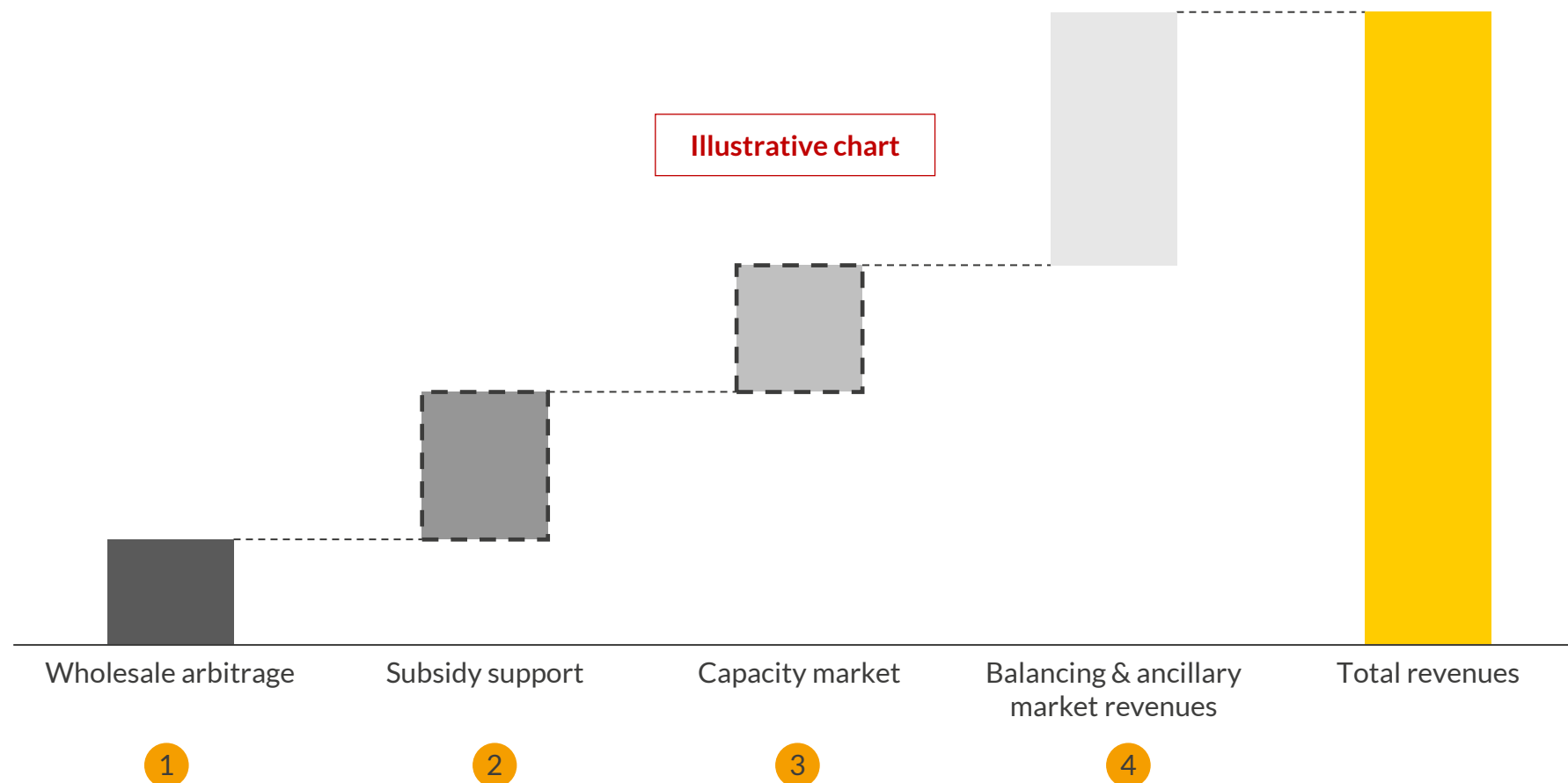
Evolution of upward FCR procurement

- Early capacity is primarily supplied by lignite and CCGTs but after 2025 the market is becoming increasingly saturated with batteries
- From 2030 batteries and dominate the upward FCR regulation; pump storage is increasing its role in the long-term
- As batteries participation in the FCR ancillary services market increase, respective **prices inevitably collapse**, which will eventually have a negative effect on batteries profitability

Fully understanding revenue stacking for batteries is crucial for developing battery projects; Aurora deep dives into these markets

Revenue stacking opportunities for batteries (illustrative)

kEUR/MW



Key Market Segments

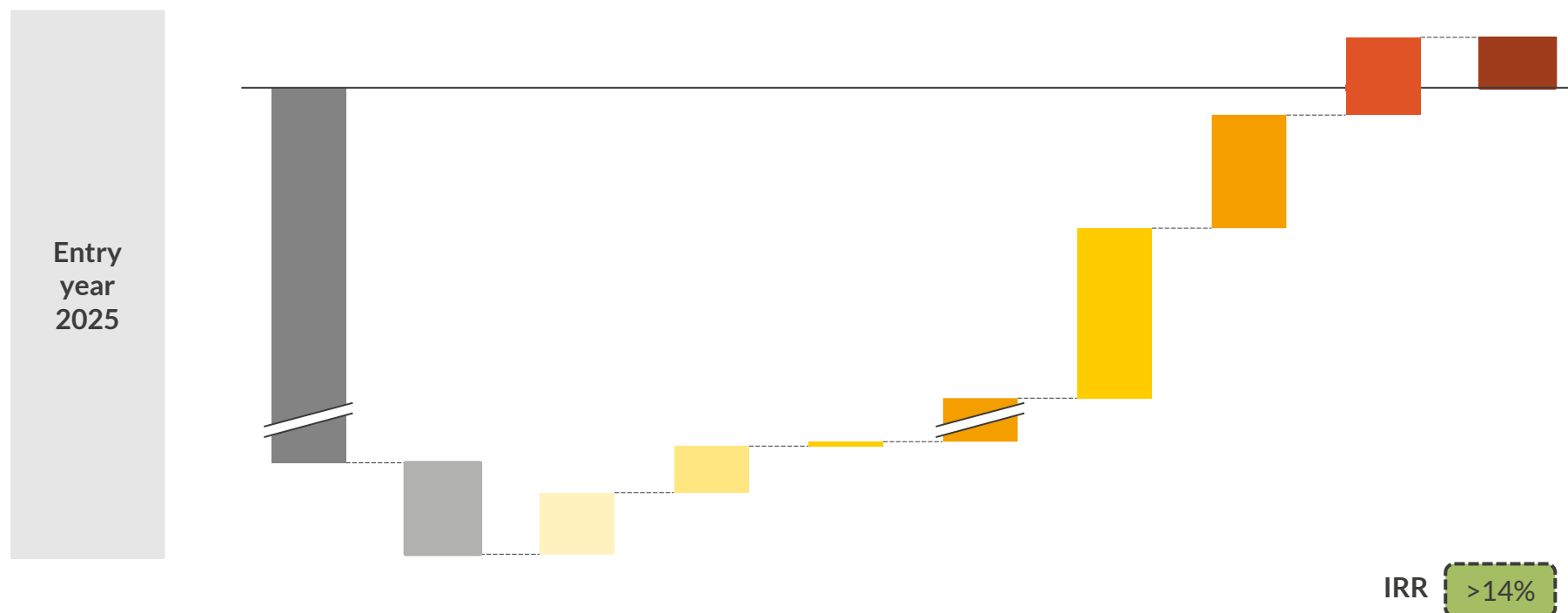
- 1 Wholesale market volatility is rising due to high commodity prices and fast renewable buildout and capacity tightness
- 2 The expected auctions and subsidy support are key to the first few projects that will enter the market in SEE
- 3 A potential launch of a **capacity market** could be a pillar for the deployment of merchant batteries. Such a market is expected to become increasingly necessary as large thermal capacity retirements take place in this decade
- 4 The participation of batteries in the balancing and ancillary services markets will provide additional revenue for battery projects and will be a key source of revenue for merchant assets

For 2025 as entry year, 1-hour batteries could be highly profitable in a merchant configuration in Greece

Economics for new-build battery entering 2025

Net Present Value¹ EUR/kW (real 2021)

1 hour storage duration



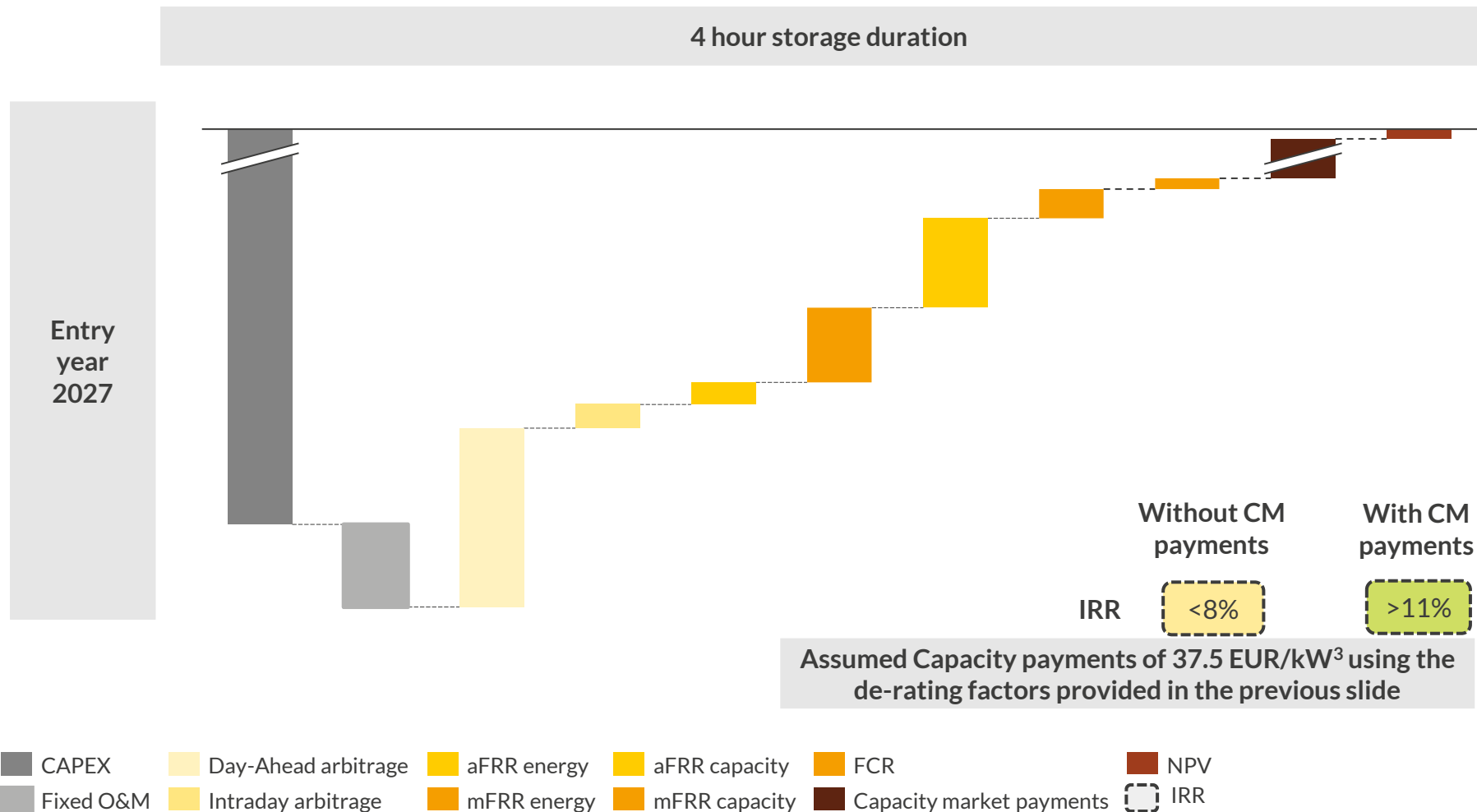
CAPEX Day-Ahead arbitrage aFRR energy aFRR capacity FCR IRR
Fixed O&M Intraday arbitrage mFRR energy mFRR capacity NPV

1) Assumed discount rate of 11% for all cash flows and a lifetime of 15 years.

Comments

- For 2025 as the entry year, 1-hour batteries achieve high IRRs due to moderate investment costs and high FCR and FRR capacity prices before market saturation
- Capacity revenues from the Balancing Market are the biggest components, representing almost 70% of the battery's revenues






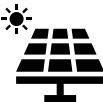

A long-duration battery entering in 2027, would require capacity payments to break; Capacity markets are crucial for the long-run



Comments

- In all SEE countries, a Capacity Market is still not available but in some regions they are expected before 2030 (Greece). In this respect, illustrated figures are only indicative and are used for a potential CM top up for the projects coming online post 2027
- The experience in other countries has shown that as more capacity of the same technology, with similar market behaviour (e.g. batteries) comes on to a system, the risk of non-delivery increases. This is then reflected by the System Operator through lower de-rating factors which affect the annual capacity payment

Different market reforms can impact future prices and increase market attractiveness for batteries

Key drivers and uncertainties	Effects on battery revenues and market attractiveness
 Changes in market design	The reform of ancillary services in Greece or EU-level changes in market design can impact batteries' revenue stacking
 Introduction of a Capacity Market	A well-functioning Capacity Market can be an important source of revenues for batteries
 Additional subsidies	New subsidy schemes, such as CAPEX-based subsidies or a MWh-based operating support make the installation of batteries more attractive
 MARI & PICASSO	European integration could help with extending the market size for balancing assets in Greece and increase price volatility
 Locational grid charges	Some locations can be more favourable for batteries in the future
 Co-location	Co-location can help reducing grid costs and CAPEX of the assets
 Quicker CAPEX reduction	A quicker CAPEX reduction makes battery deployment in the near future more attractive

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A new **Flexible Energy Market Service Add-On** will complement our comprehensive **Greek Power & Renewables Market Service**

Key information on Aurora's Greek subscription service

- Up-to-date report available (April 2023)
- Next update in Jul 2023
- Regular updates thereafter (quarterly)
- **Introductory workshop**, with insights on market and policy status quo, policy and market outlook, price curves, market scenarios and PPA analysis
- **Subscriber webinar**, Aurora's experts will be organising a webinar for each bi-annual update where we highlight key market developments as well as their impact on our modelling

All intelligence for a successful business, based on bankable price forecasts

1

Quarterly data and market report updates to assess business models

- **Forecasts of wholesale market prices along four scenarios** (Central, High, Low, Net Zero) until 2060
- **All the latest trends and forecasts**, recent market and policy developments
- **Price distributions**, capture spark spreads, peak prices
- **Capacity development**, generation mix, interconnector capacity, capacity buildout, exports
- **Capture prices** of key technologies (onshore, offshore wind, solar), load factors
- Imbalance cost analysis & forecast for wind and solar
- **Data in Excel**, all forecast data easily downloadable in Excel format
- **EU ETS carbon price & gas price forecasts**
- *Main reports are published in Q2 and Q4, with scenario updates in Q1 and Q3*

2

Interaction through workshops and ongoing support

- **Bilateral workshops** at your offices to discuss specific issues on the Greek market
- **Ongoing availability** (calls, access to market experts, modellers) to address any questions across European power markets
- Discounted invitations to Aurora's annual **Spring Forum**

Optional add-on

- **Granular data from our Power & Renewables Market Forecast report for Central, High & Low**
 - Hourly baseload prices
 - Monthly commodity prices

Access power market analysis and investment case data for batteries with our **Flexible Energy Market Service Add-On**

Flexible Energy Market service Add-On

Forecasts Reports & Data



Technology and market development reports

- 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 hourly granularity until 2060
 - Day-ahead and Intra-day (DAM & IDM) power prices
 - FRR market prices (both capacity and energy)
 - FCR market prices

Investment Cases



Standalone battery

- Multiple investment cases per country or zone including:
 - Arbitrage of wholesale market and balancing market
 - Focused participation in the frequency control market (if applicable)
- Annual project margins to 2060. IRR and NPV for multiple entry years

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