

Flexibility for the energy transition: Battery economics

9th Annual EPRI-IEA Challenges in Decarbonisation Workshop

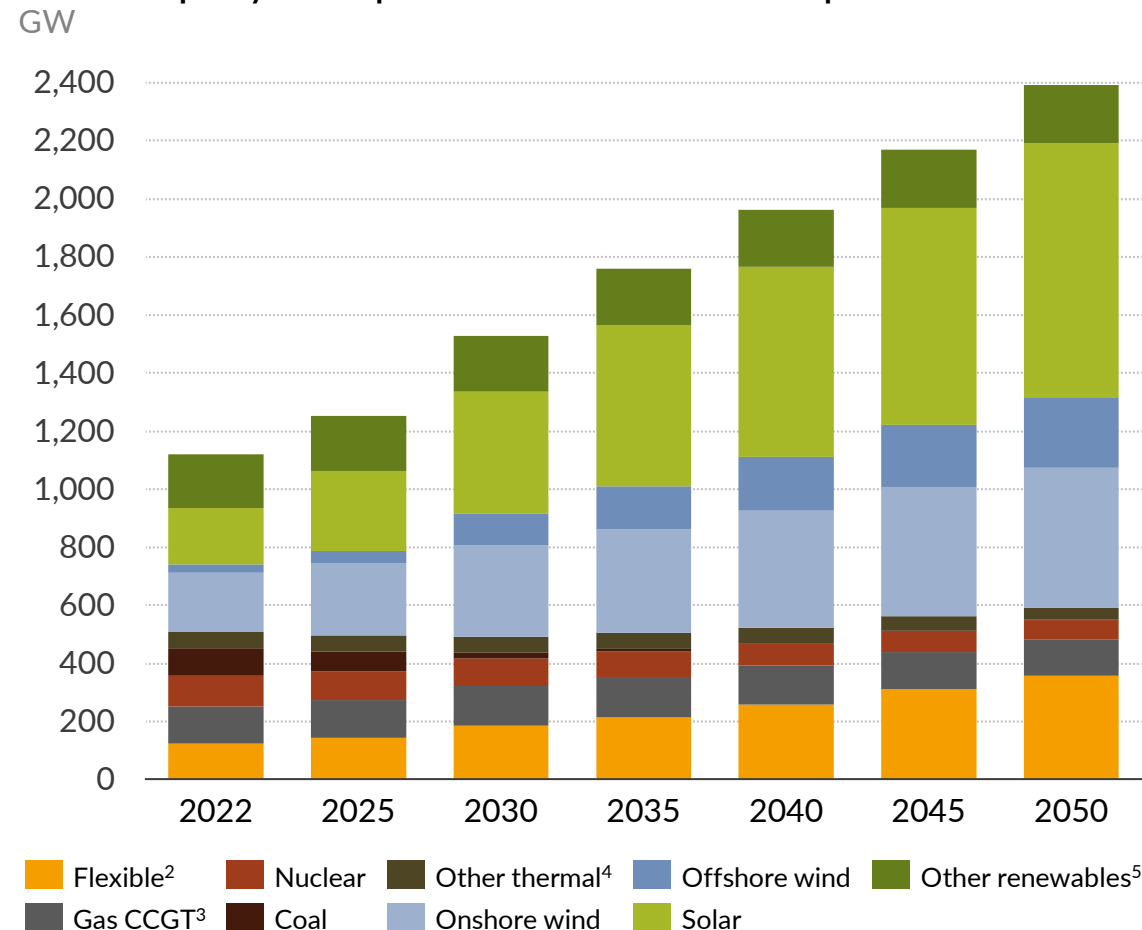
07th of October 2022



The increasing share of intermittent renewables leads to a higher need for dispatchable capacity in the system

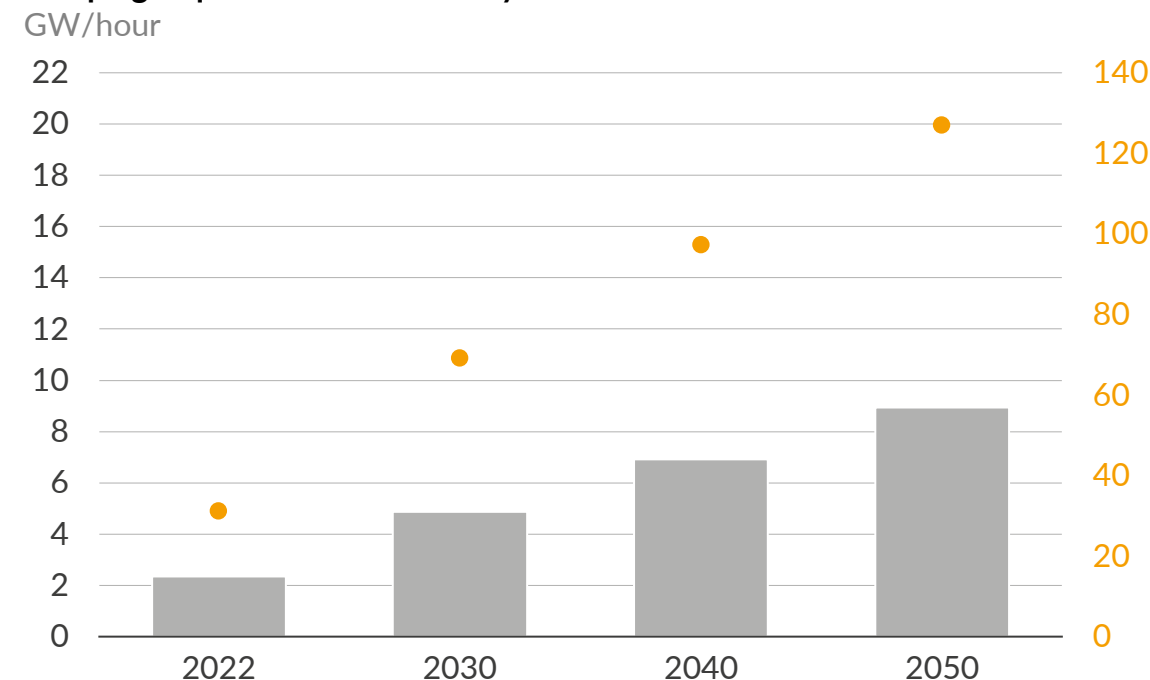
Europe's capacity mix sees a rapid buildout of renewables to meet rising demand, at the expense of coal and nuclear in Aurora's likeliest market view

Installed capacity in Europe in Aurora Central Scenario April 2022¹



The increase in intermittent renewables will lead to more sudden changes in output, creating a need for flexible capacities

Ramping requirements in Germany⁶

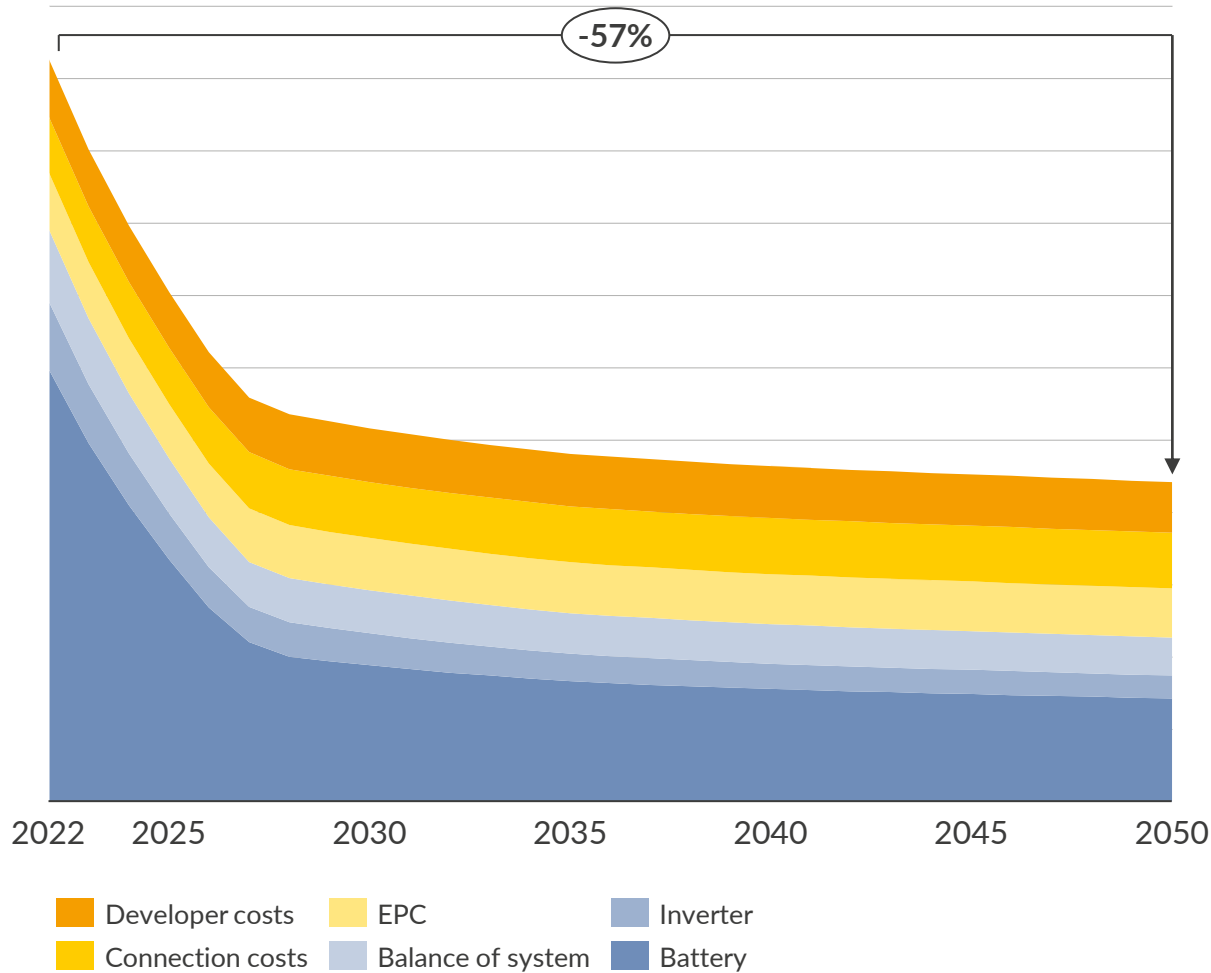


- With increased renewables deployment more flexibility will be required to tackle increasing imbalances. This will in turn exacerbate the need for flexibility markets
- Batteries are well suited to provide the needed flexibility

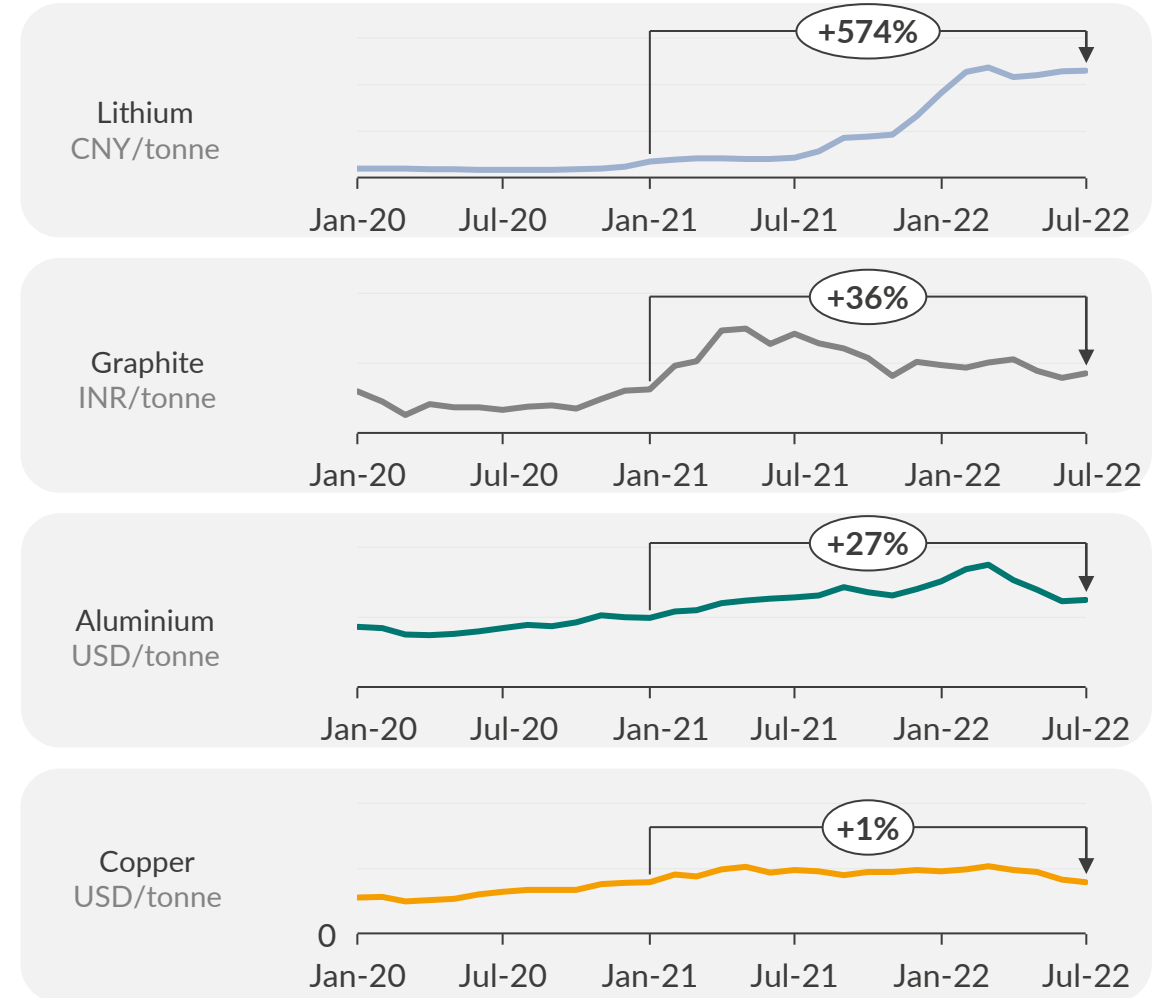
1) Europe is defined here as EU27 countries minus Malta and Cyprus, plus UK and Norway. 2) Flexible includes batteries, thermal peakers, hydrogen peakers, DSR, CHP and pumped storage. 3) Gas CCGT includes abated thermal H2 CCGT and Gas CCS. 4) Other thermal includes CHP and peat. 5) Other renewables includes biomass, BECCS, hydro and marine. 6) Based on the hourly variations of non-dispatchable renewables.

Even though costs for battery main inputs have risen by up to 574% in the past year, we expect costs to decrease by ca. 57% in the long run

Li-ion battery total system costs - 2h asset¹
EUR/kW real 2021



Commodity Price Futures



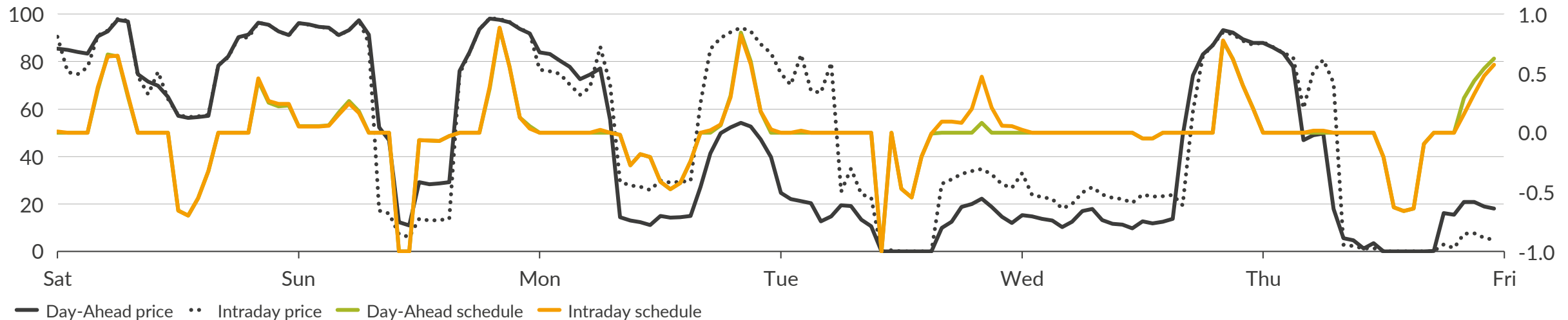
1) Research is based on benchmarking across our market base.

Balancing, wholesale and capacity markets are the key sources of revenues for batteries that optimise their dispatch based on prices

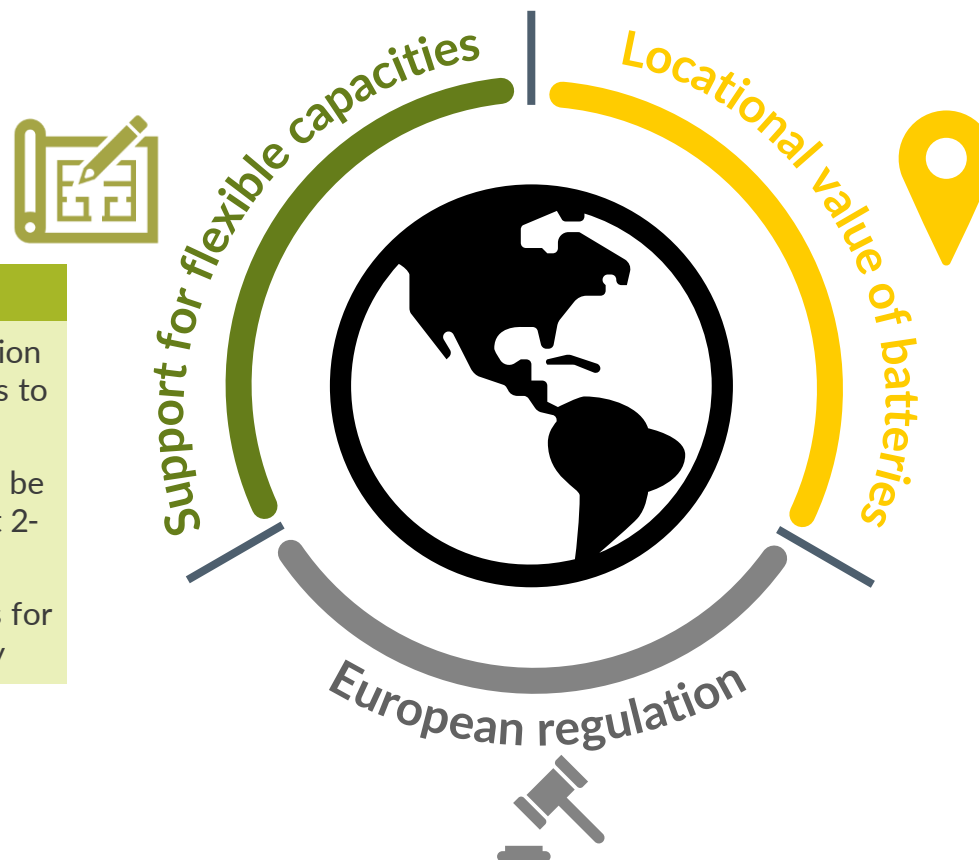
Market	Wholesale (Day-Ahead/Intraday)	Primary Reserve	Secondary Reserve	Capacity Markets
Description	<ul style="list-style-type: none"> Platform to buy and sell power to meet demand Every hour and is contracted one day before delivery (Day-Ahead) and continuously (Intraday) 	<ul style="list-style-type: none"> Measure to secure grid stability Flexibility providers get revenue through capacity payments 	<ul style="list-style-type: none"> Exists to ensure grid stability, gets activated after the FCR Energy will be procured via the European platform PICASSO, TSOs are in charge of procuring capacity 	<ul style="list-style-type: none"> Capacity markets reward capacity to ensure security of supply Batteries are allowed to participate with a derating factor
Revenue stream	<ul style="list-style-type: none"> Arbitrage 	<ul style="list-style-type: none"> Capacity payment 	<ul style="list-style-type: none"> Capacity and energy payment 	<ul style="list-style-type: none"> Capacity payment

Wholesale price
EUR/MWh, real 2021

Battery electricity generation
MWh



Regulatory and political developments could entail market design changes that boost the development of batteries further



Support for flexible capacities

- A higher share of volatile renewable generation and the plan to reduce gas dependency leads to a need for dispatchable capacity
- Potential market design developments could be additional capacity markets in EU in the next 2-5 years
- Policy makers could launch support schemes for longer-duration storage to increase flexibility

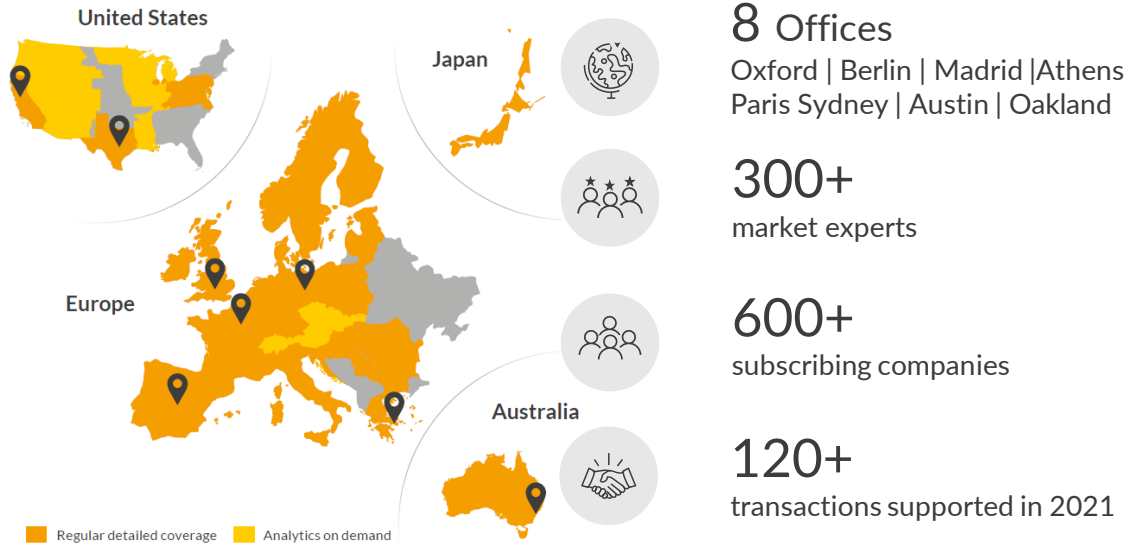
Locational value of batteries

- With increasing share of renewables, grid management becomes a more challenging task for system operators
- Congestions within the country will increase, i.e. between northern and southern Germany
- Batteries can provide flexibility, alleviate congestions and provide virtual power lines

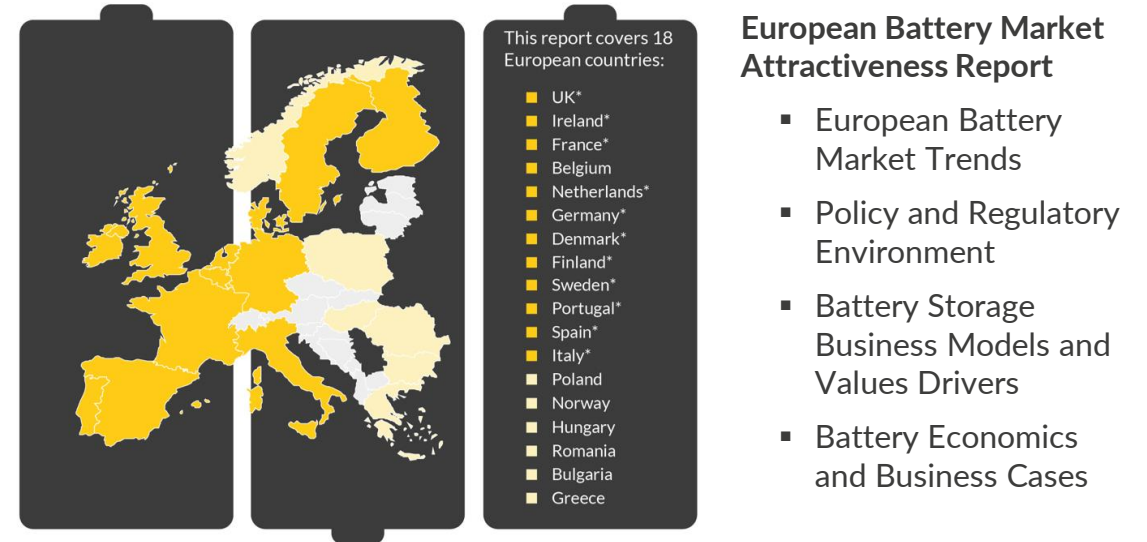
- After the Clean Energy Package in 2018, storage is also addressed in the reform of Renewable Directive (RED III) and its role to provide needed flexibility is acknowledged. REDIII states that market design should not discriminate against storage and allow it to provide flexibility and balancing services to the system
- With the ongoing energy cost crisis, storage has an important role to play to bring flexibility to the system

Aurora provides data-driven intelligence for the global energy transformation and offers various flexibility services

1 Aurora offers energy market modelling across multiple countries



2 We provide insights into the most attractive markets for batteries



3 In addition, we offer bespoke battery business case calculations

Based on flex market price forecasts and input parameters:



- CAPEX/OPEX
- Duration and efficiency
- Lifetime and cycles
- Entry year

Find out more:

Henrike Sommer, Associate
henrike.sommer@auroraer.com

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