BATTERY ENERGY STORAGE SYSTEMS DEVELOPMENT PERSPECTIVE

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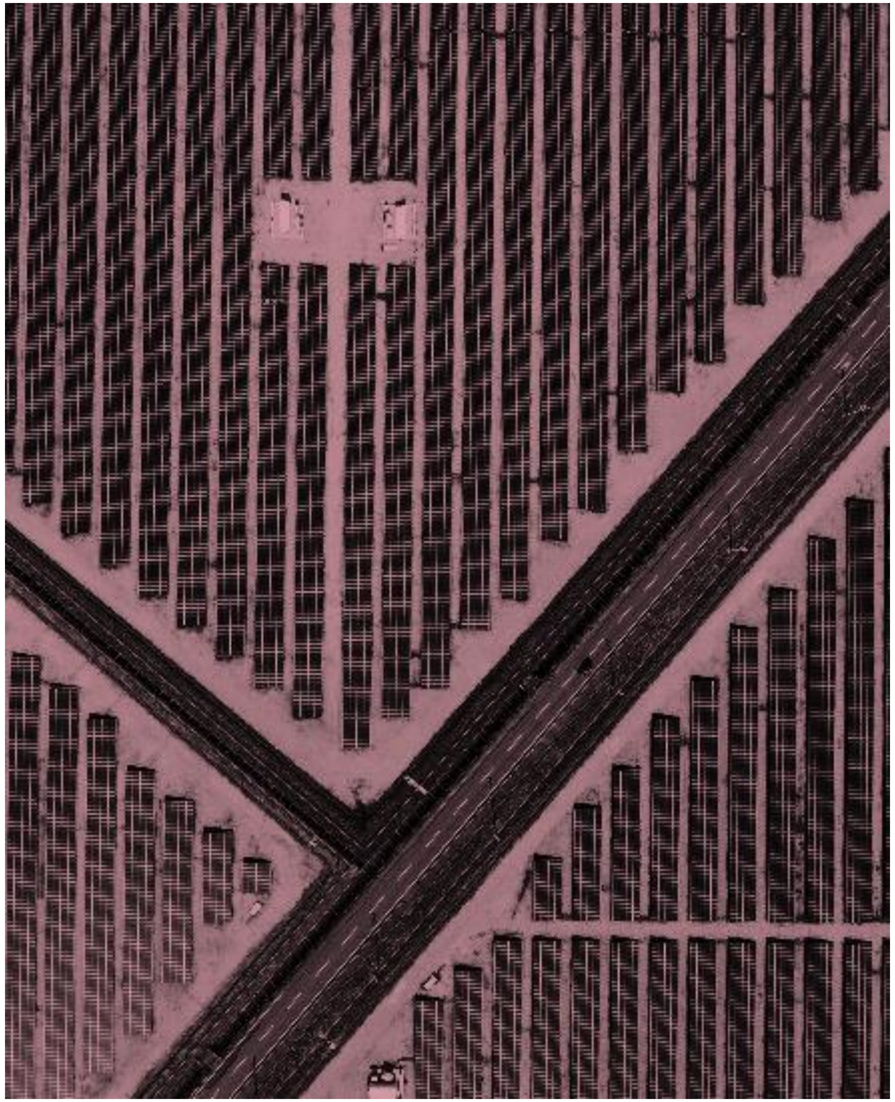

INCREASE OF RENEWABLE ELECTRICITY

EFFECTS ON GRIDS AND THE POWER SECTOR

INCREASE OF RENEWABLE ELECTRICITY

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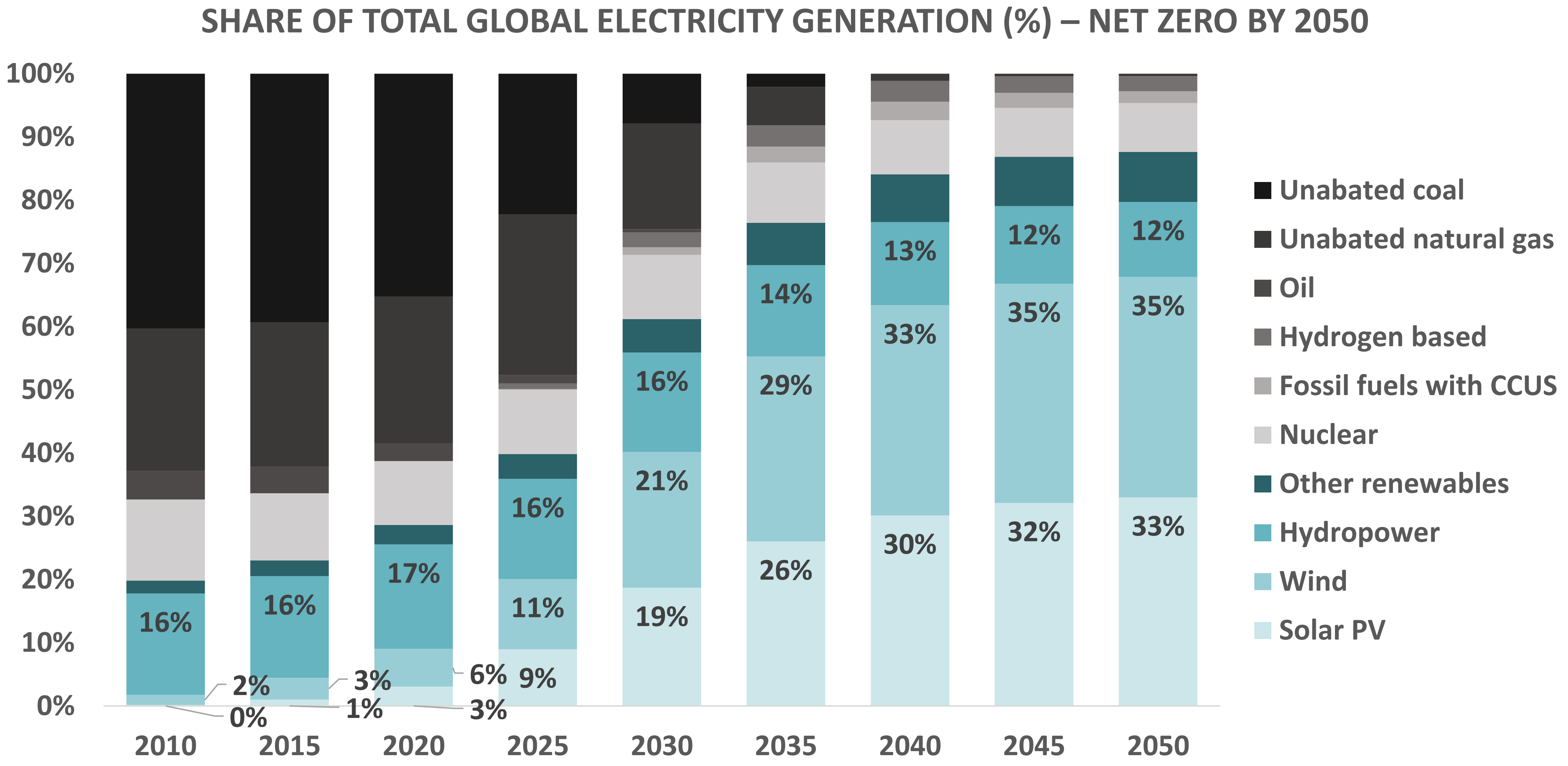
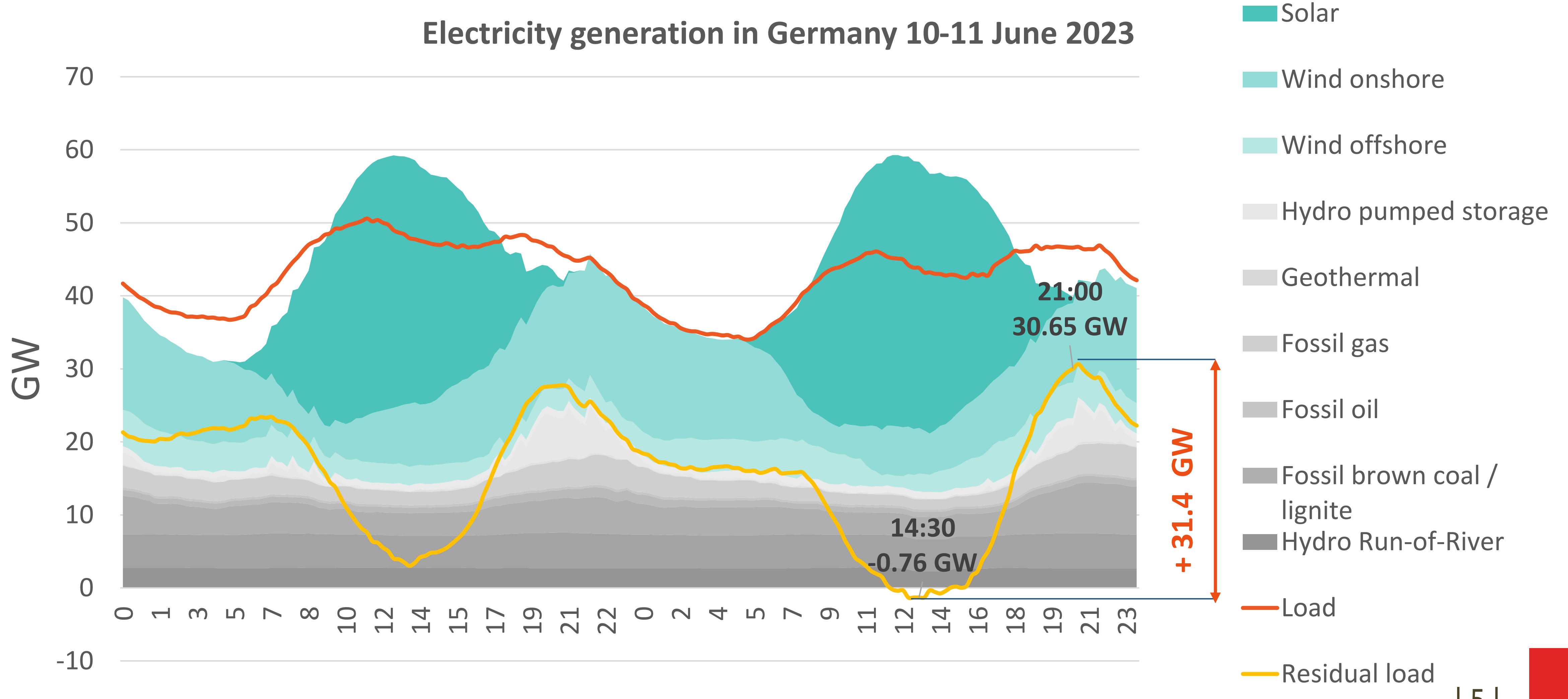


Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

VREs – EFFECTS TO THE GRID AND FLEXIBILITY

	Transmission Level	Distribution Level
Grid Operations	- Increase in required reserve capacity and ramp capabilities - Increase in minimum generation of conventional units on stand-by - Decrease in system inertia - Over generation risks from RES leading to curtailment	- Voltage Flickers/Changes - Frequency Changes - Harmonic Distortions
Grid Planning	- Increase in flexibility costs (balancing) due to higher flexibility demand - Increase in cost of maintaining conventional units at idle state - Challenges in planning of flexibility needs and related procurement (flexibility markets)	Distribution upgrades: - Additional capacity requirements - Uncertainty in generation forecasting - Opportunities for distributed PV + storage

VRES – EFFECTS TO THE GRID AND FLEXIBILITY



DECLINING MARGINAL COSTS AND NEGATIVE ELECTRICITY PRICES

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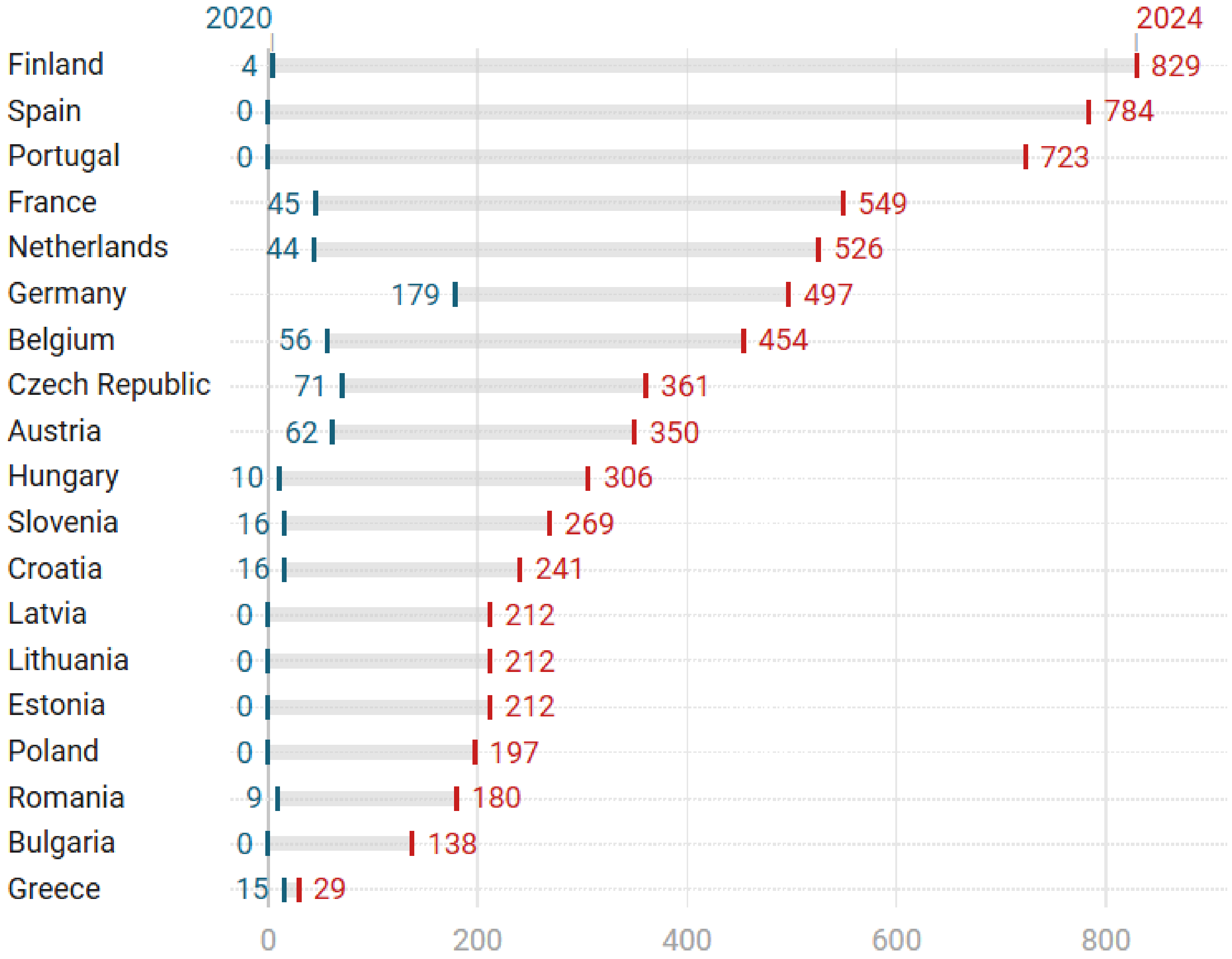


Based on data from ENTSO-E

The number of hours with negative electricity prices in the day ahead market increased significantly from 2020 to 2024.

The data for 2024 only includes hours up to November 2024.

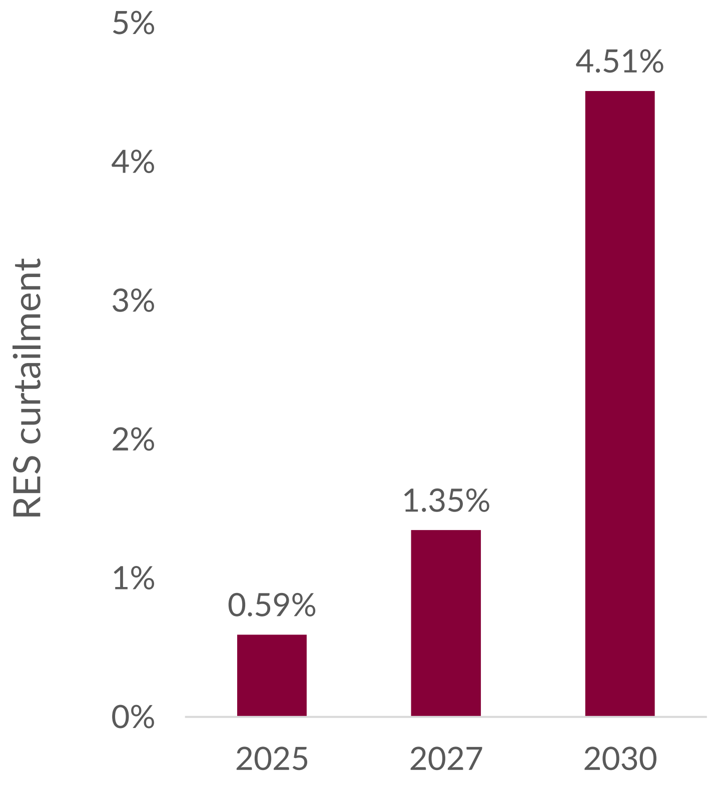
RES CURTAILMENT

0% 36%

Bidding Zone	2025	2027	2030
DE00	0	1	6
DEKF	2	10	36
DKE1	0	0	10
DKKF	1	4	34
DKW1	6	10	16
ES00	1	2	4
IE00	1	1	10
ITCA	8	7	4
ITSI	6	10	4
LT00	0	0	12
NL00	1	4	8
NOM1	1	4	15
NON1	4	2	5
NOS0	1	2	6
PT00	1	4	6
UK00	1	2	7
UKNI	6	8	34

ENTSO-E, European Resource Adequacy Assessment

Aggregated for all explicitly modelled bidding zones

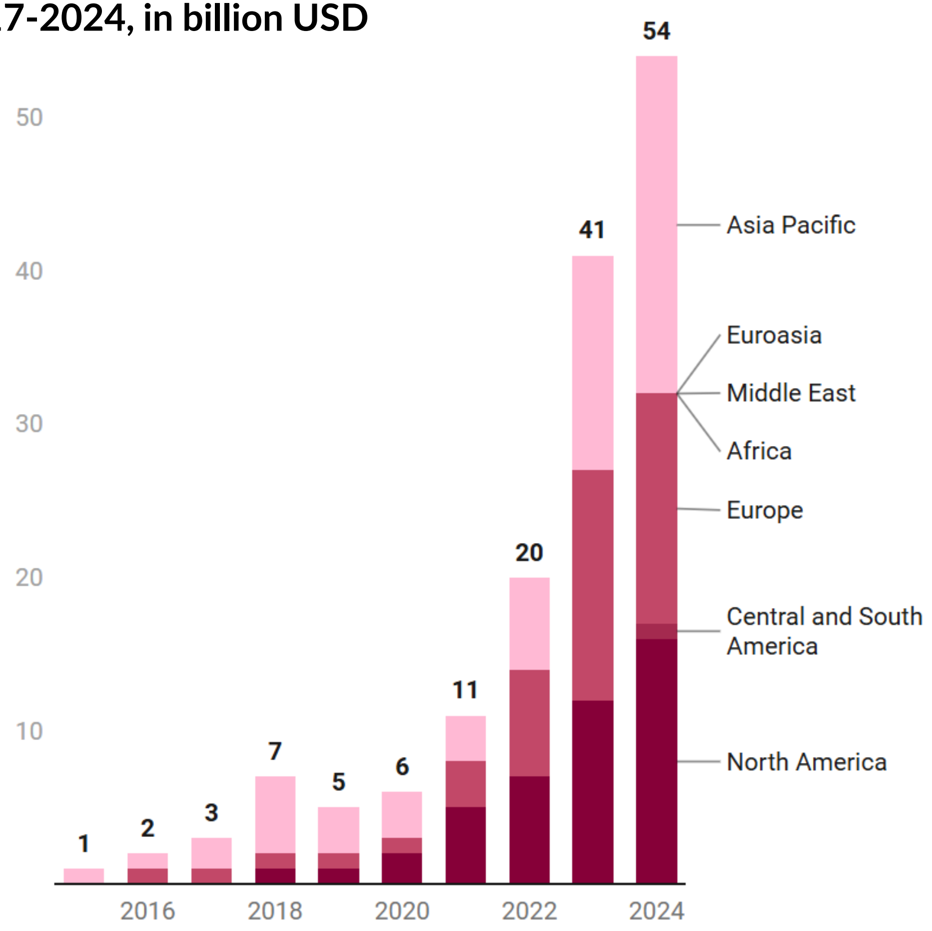


- RES Curtailment defined as (Energy Curtailed from RES/Available Energy from RES).
- Only Bidding Zones with RES curtailment larger than 1% on average are shown.

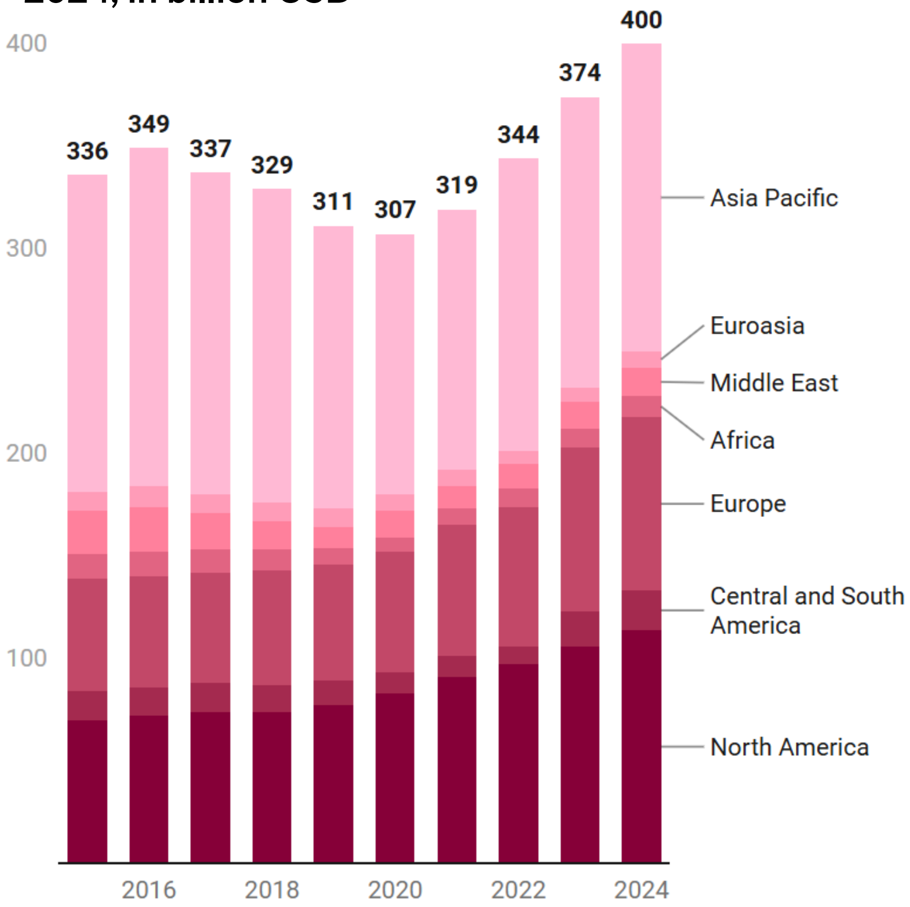
THE GROWTH OF BATTERY STORAGE

The integration of renewables and upgrades to existing infrastructure have sparked a recovery in spending on grids and storage.

Investment in energy storage by region 2017-2024, in billion USD



Investment in power grids by region 2017-2024, in billion USD



IEA (2024), World Energy Investment 2024, IEA, Paris https://www.iea.org/reports/world-energy-investment-2024, Licence: CC BY 4.0

GROWTH OF ENERGY STORAGE

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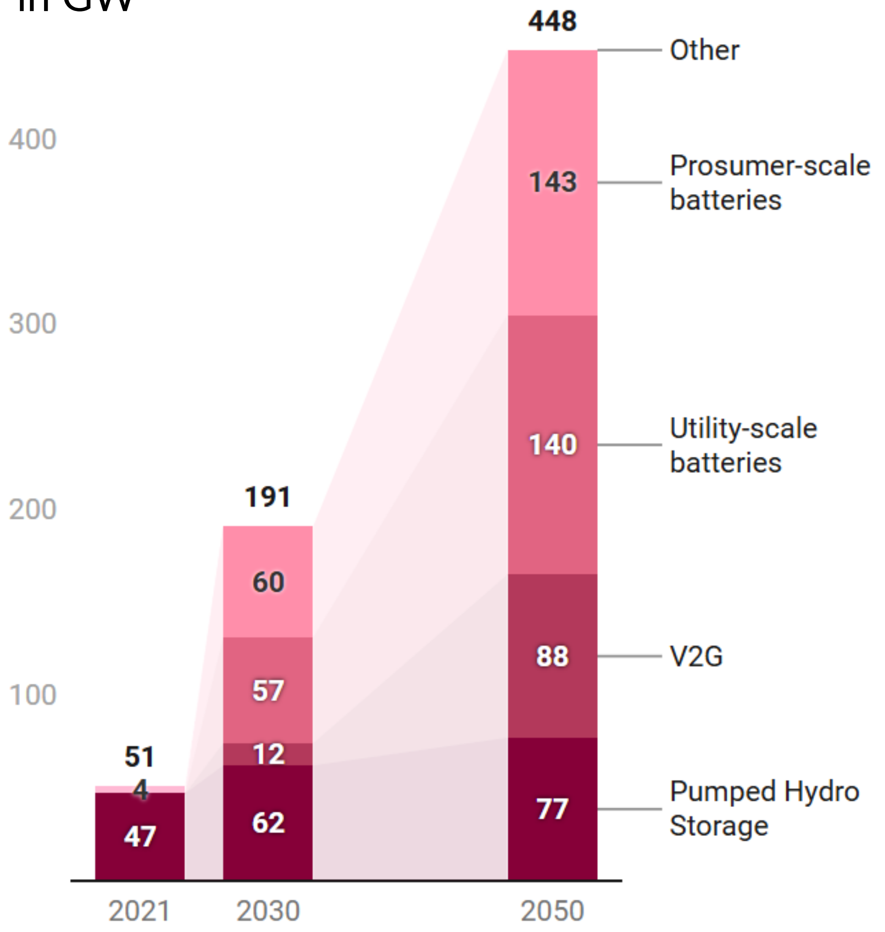
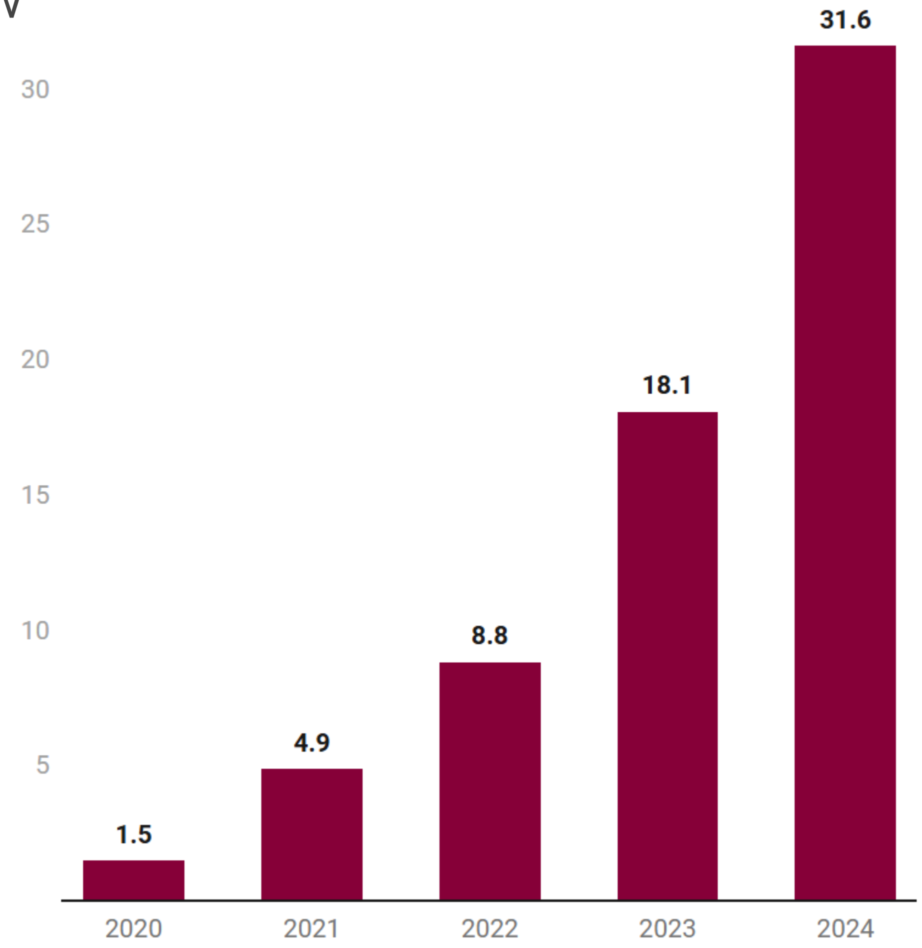
Energy storage capacity in EU + UK, in GW

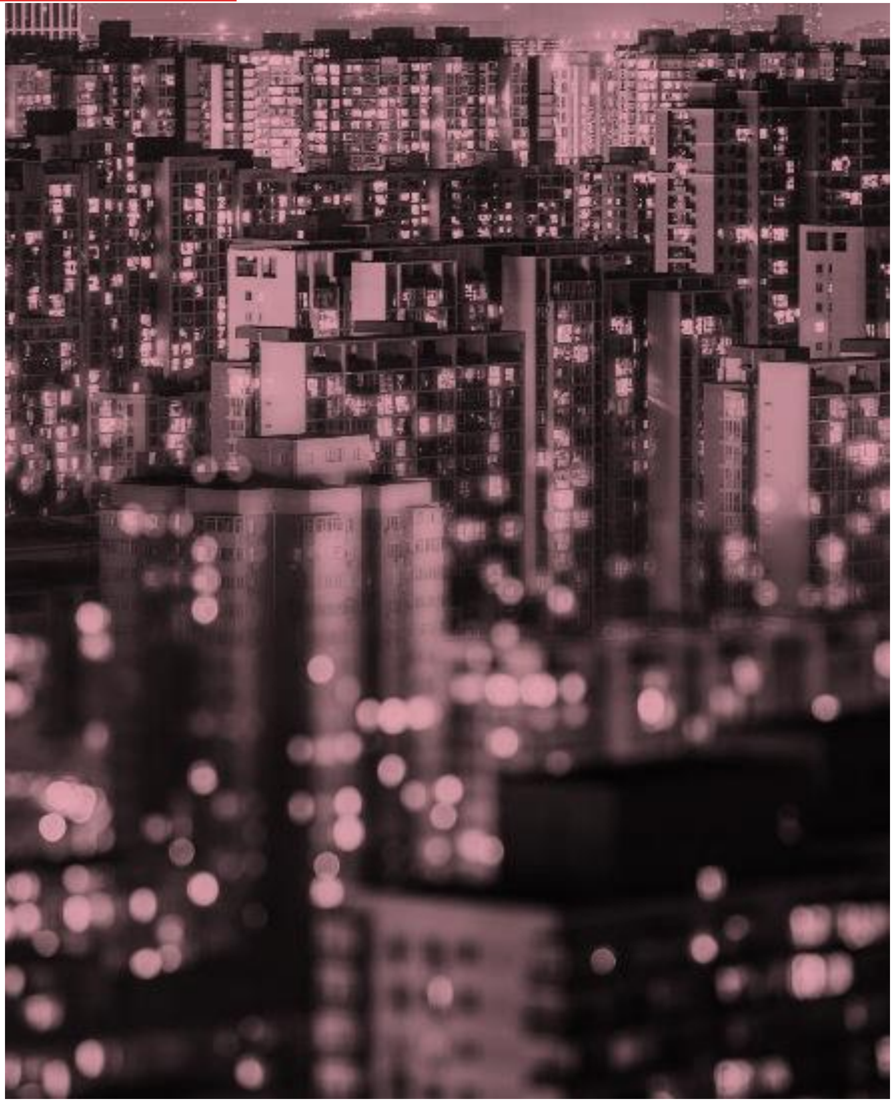


Source: [Euroelectric Power Barometer 2023.]()

Large-scale battery storage capacity in the USA, in GW



Source: U.S. Energy Information Administration, *2022 From EIA-860 Early Release, Annual Electric Generator Report*



USE OF BATTERY ENERGY STORAGE

USE OF BATTERY STORAGE SYSTEMS

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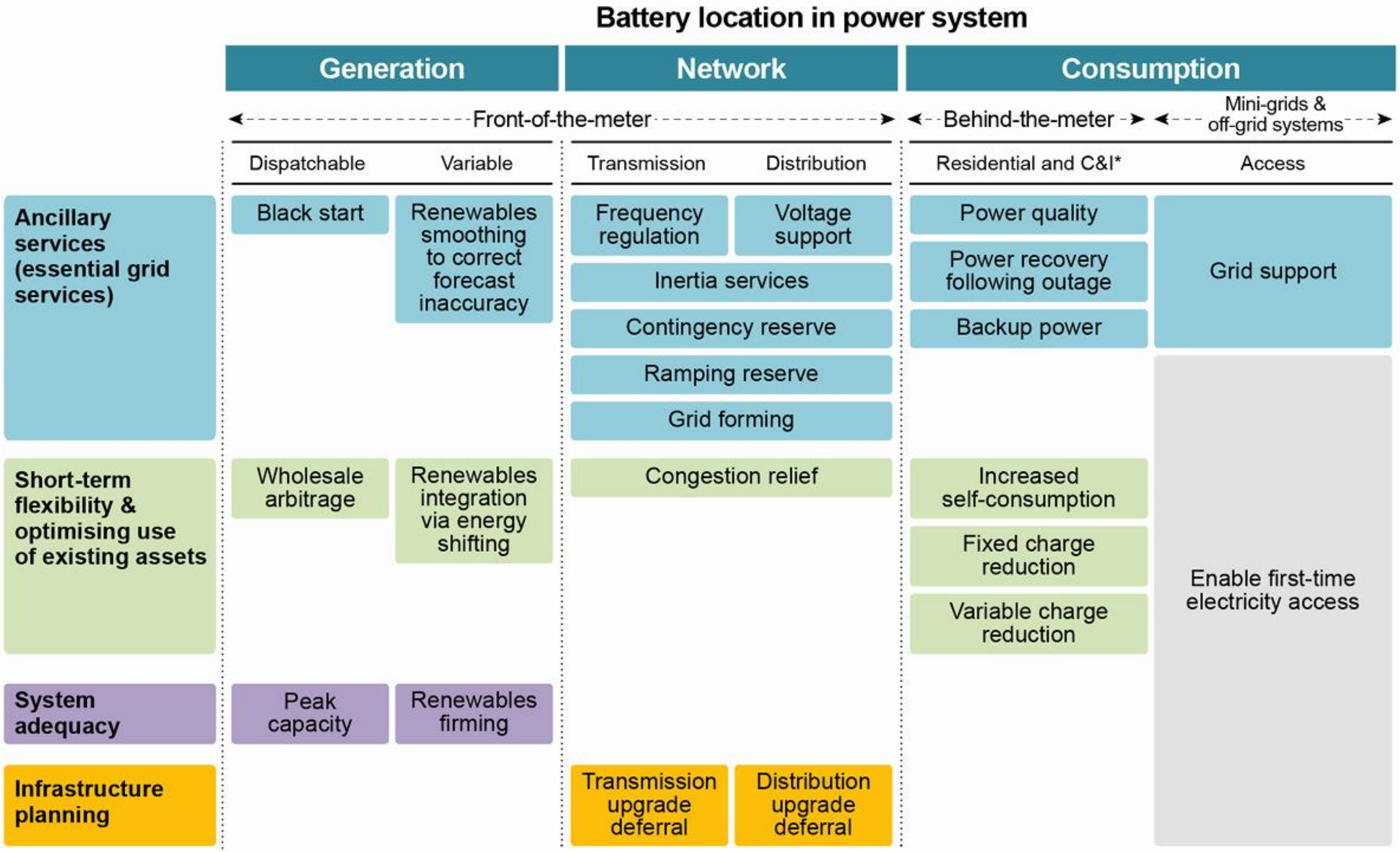
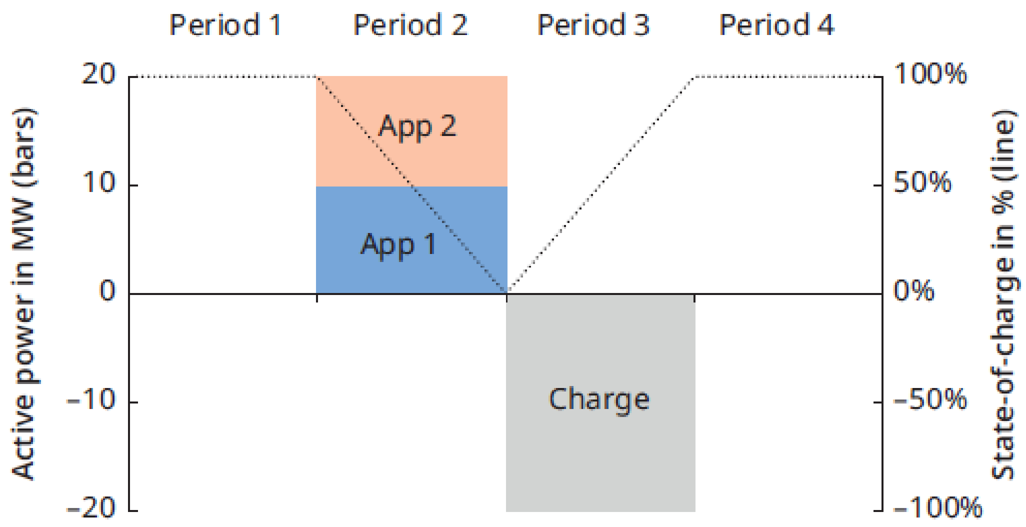


REVENUE STACKING



- Electricity storage operators in Great Britain can provide part of their available power capacity for frequency response services like Dynamic Regulation and bid their remaining capacity into the Balancing Mechanism.
- Operators should not exceed the power committed to the individual applications in order not to compromise any other application contracted for simultaneously.
- Parallel stacking is among the most common types of revenue stacking. There are numerous examples for various applications in various geographies.

THANK YOU FOR YOUR ATTENTION

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