

Monetizing *Standalone* Energy Storage

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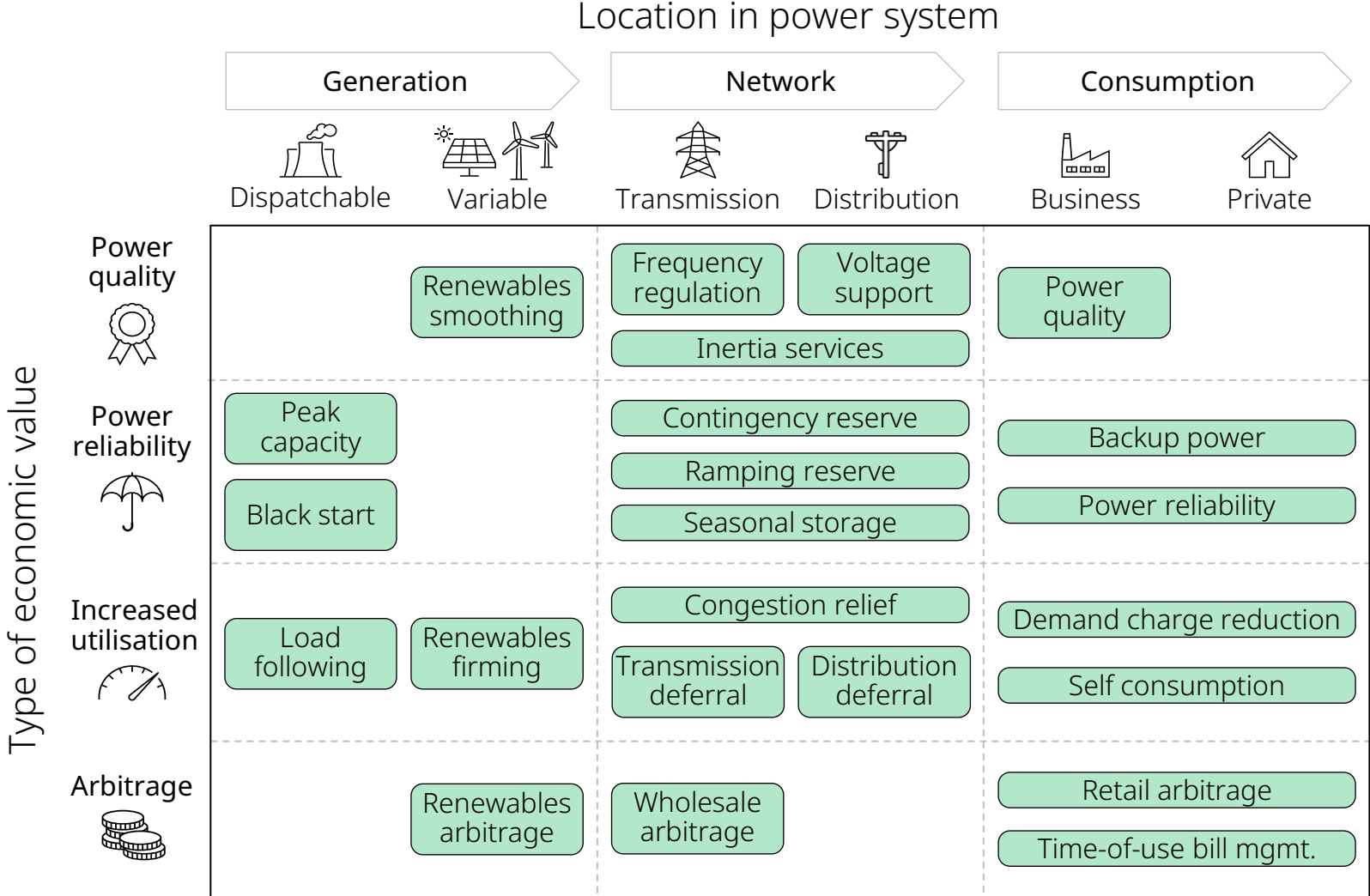
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Solarplaza Summit
Energy Storage

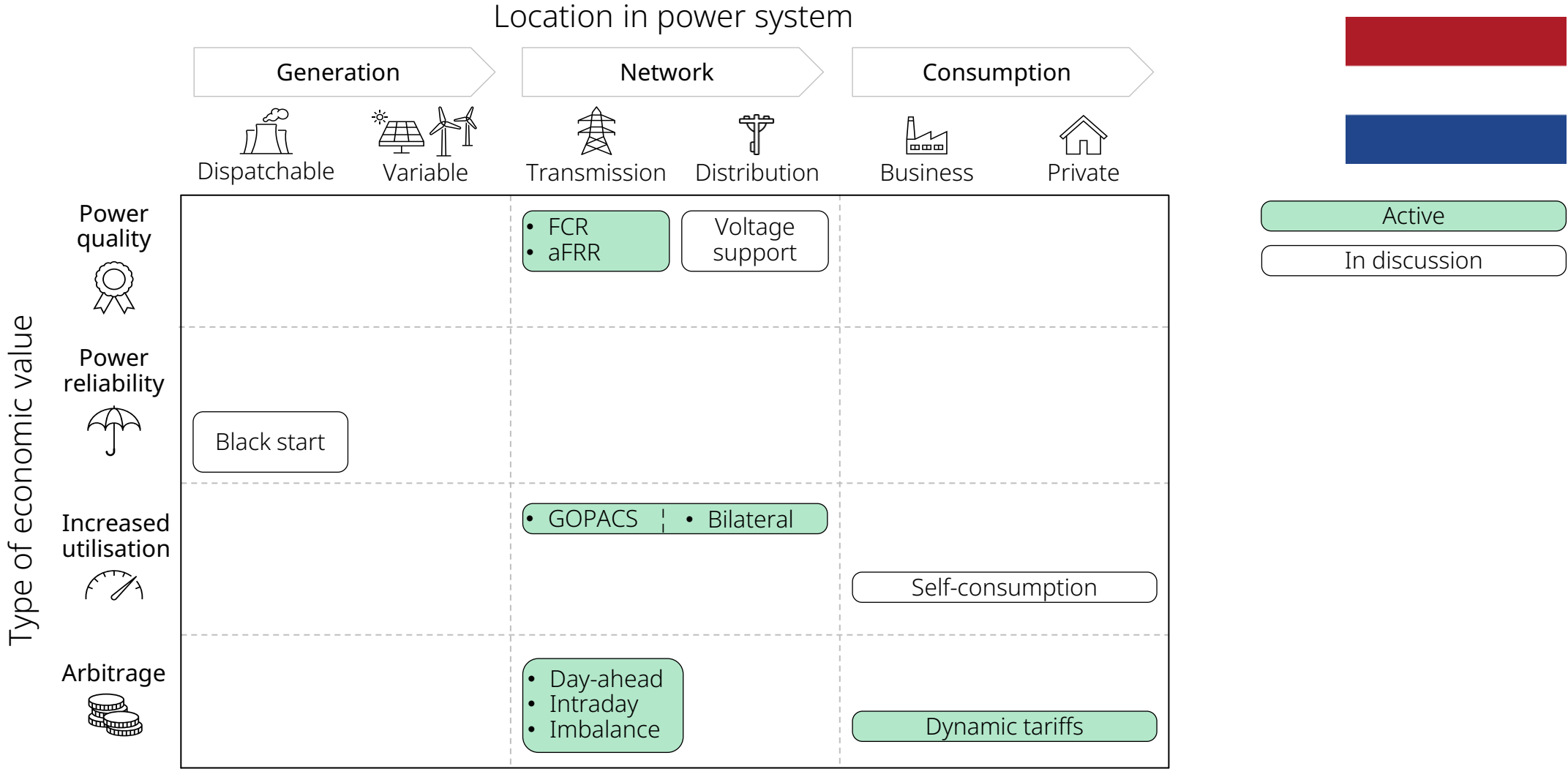
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Storage provides economic value in various applications



In NL, this value can be monetized in 8 specific markets



Lifetime cost quantify the revenue requirement for NPV > 0

Annuitized capacity cost

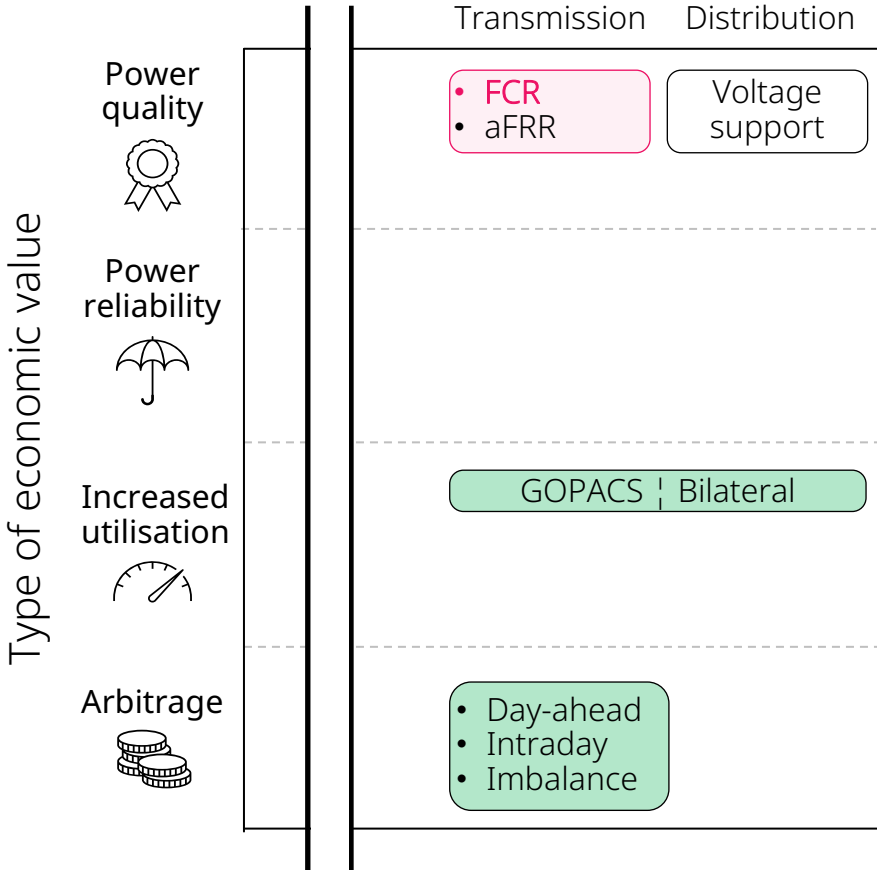
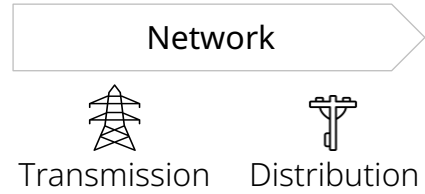
$$\text{ACC} \left[\frac{\text{€}}{\text{kW/yr}} \right] = \frac{\text{Investment} + \text{O\&M} + \text{Charging} + \text{End of life}}{\text{Power capacity} \cdot \text{Lifetime}}$$

Levelized cost of storage

$$\text{LCOS} \left[\frac{\text{€}}{\text{MWh}} \right] = \frac{\text{Investment} + \text{O\&M} + \text{Charging} + \text{End of life}}{\text{Energy capacity} \cdot \text{Cycles per year} \cdot \text{Lifetime}}$$

FCR can be provided at a cost of ~70 €/kW/year

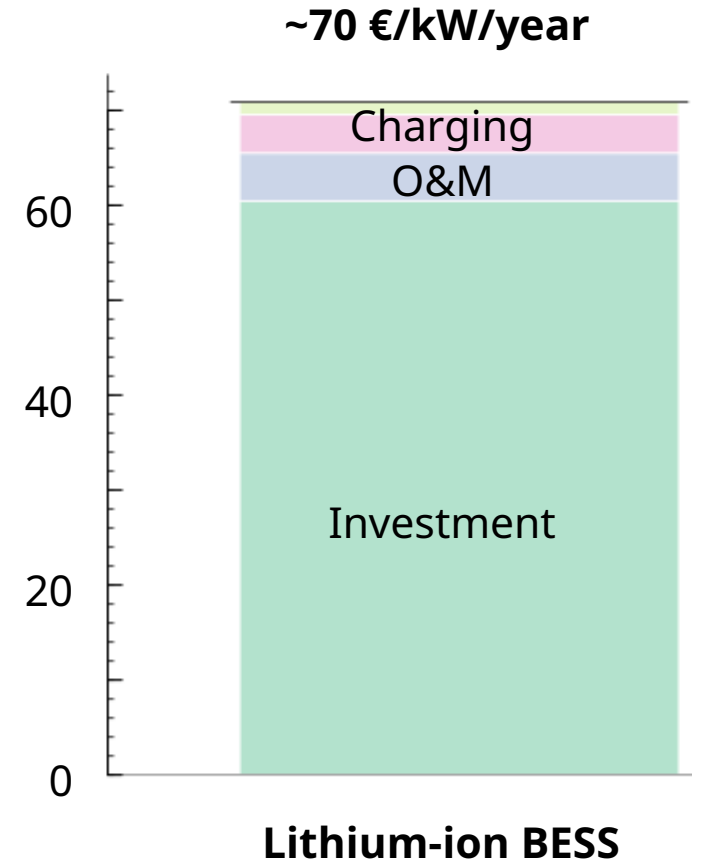
Location in power system



Battery specs

- 10 MW / 5 MWh
- € 4 Mio. capex
- 85% efficiency
- 10 years lifetime
- 8% discount rate

Lifetime cost [€/kW/year]



The crossborder settlement price used to be higher than that

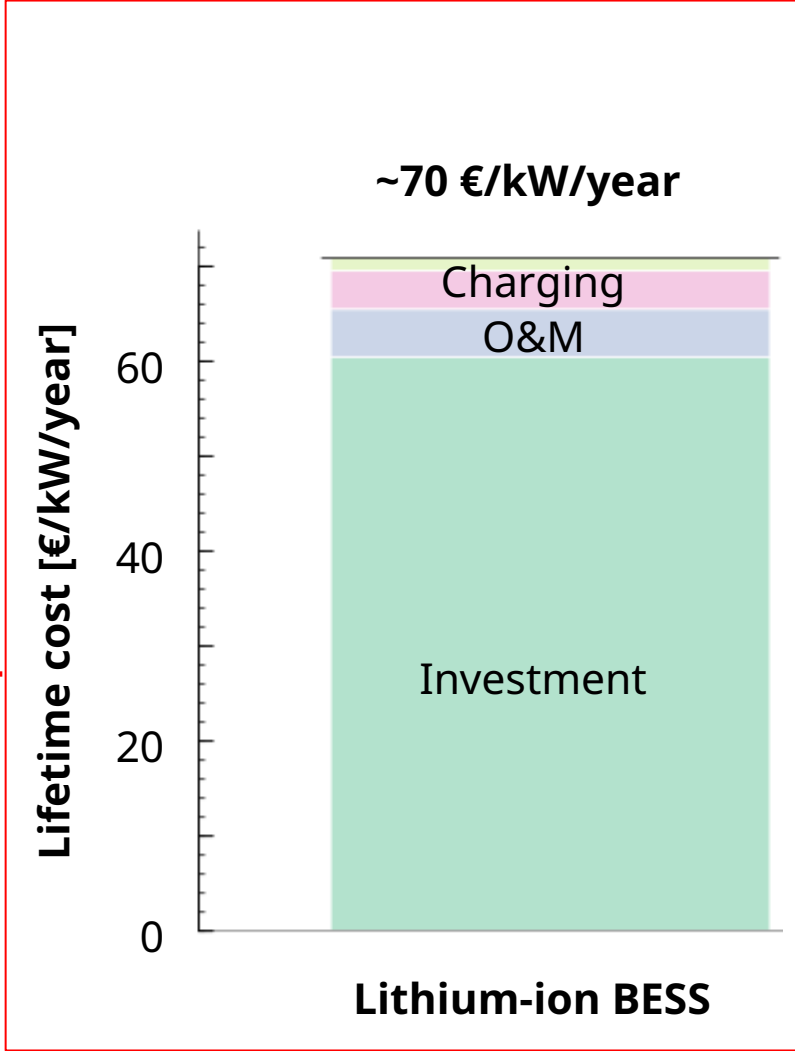
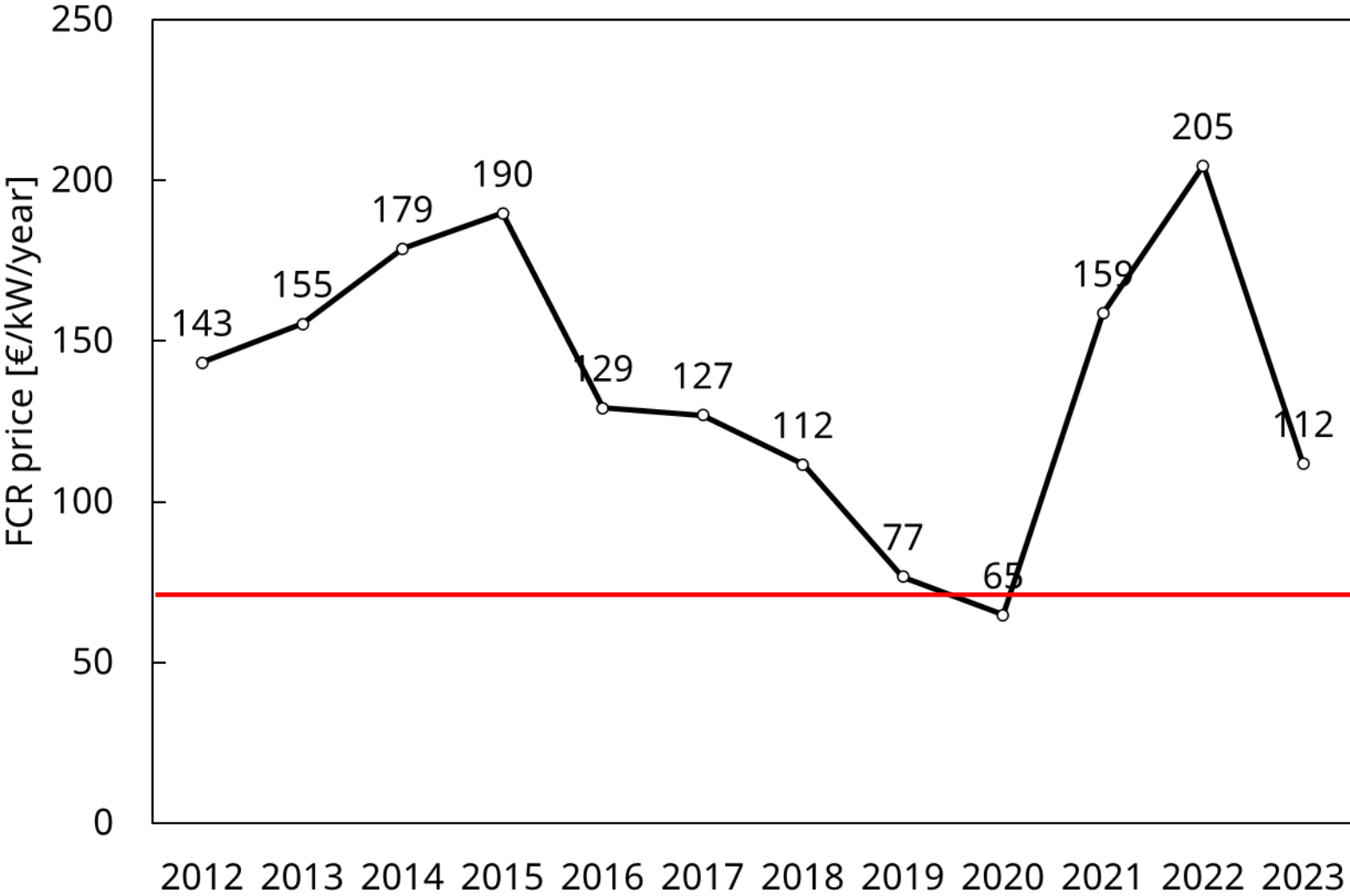
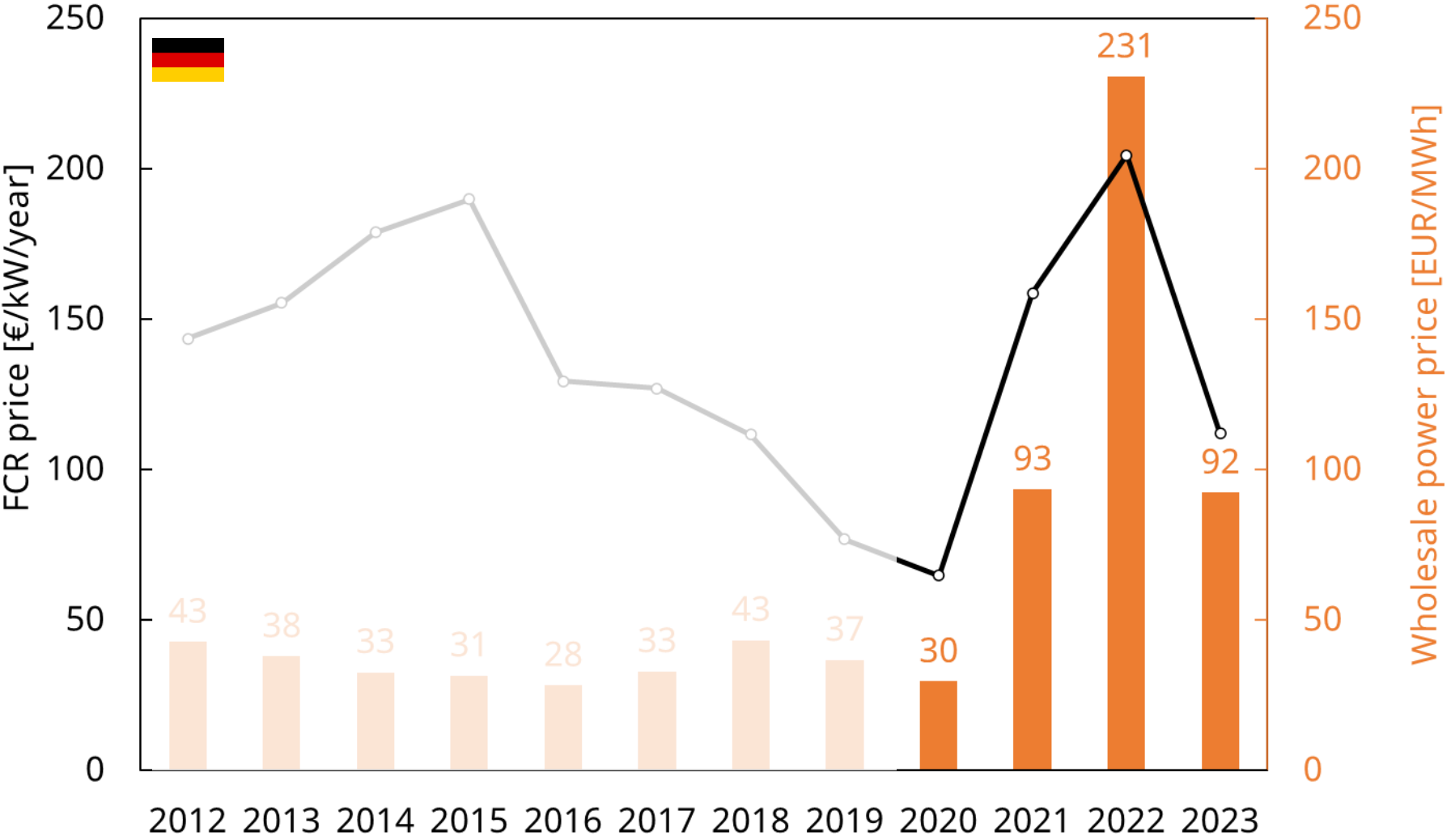


Chart from www.EnergyStorage.ninja

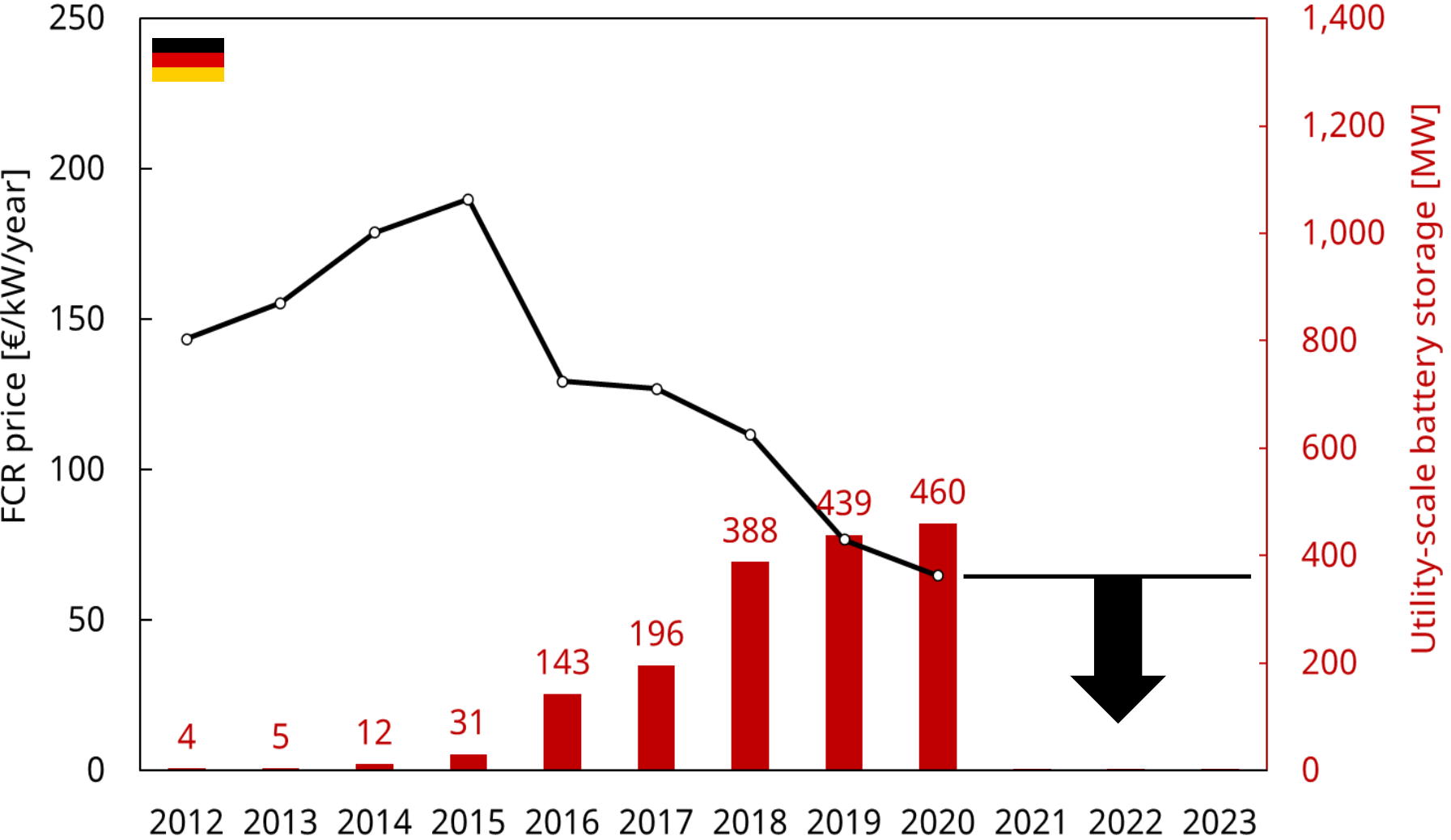
Partly because of high power prices in 2021-23



... average day-ahead wholesale power prices were significantly higher in 2021-2023 than in the 10 years before...

... with a significant impact on FCR prices.

But, up to 2020 prices fell due to more battery capacity



... significant additional deployment suggests that prices will fall further once power prices have stabilized...

....making FCR much less attractive for **full-time** operation.

Arbitrage can be provided at a cost of ~160 €/MWh

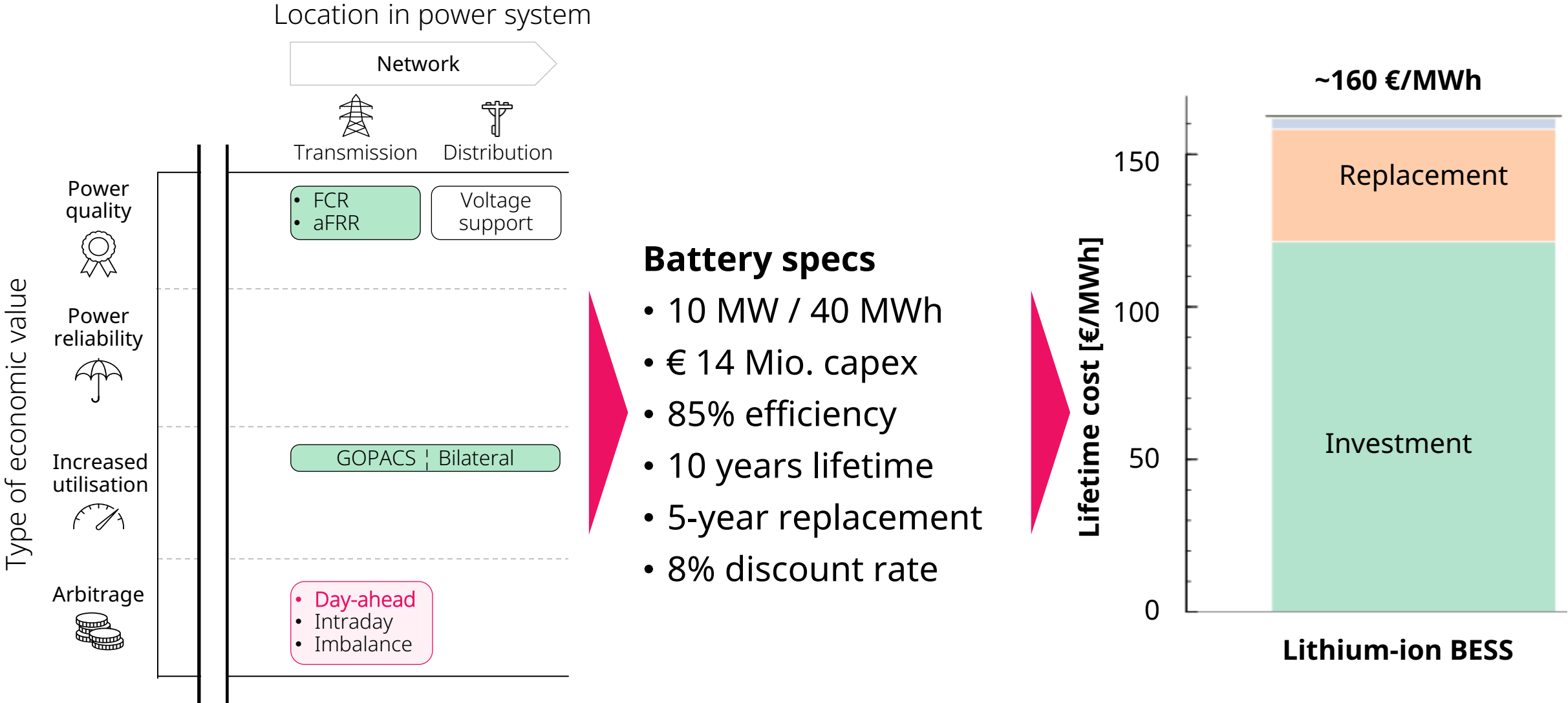


Chart from www.EnergyStorage.ninja

However, average 2023 arbitrage revenues were 57 €/MWh

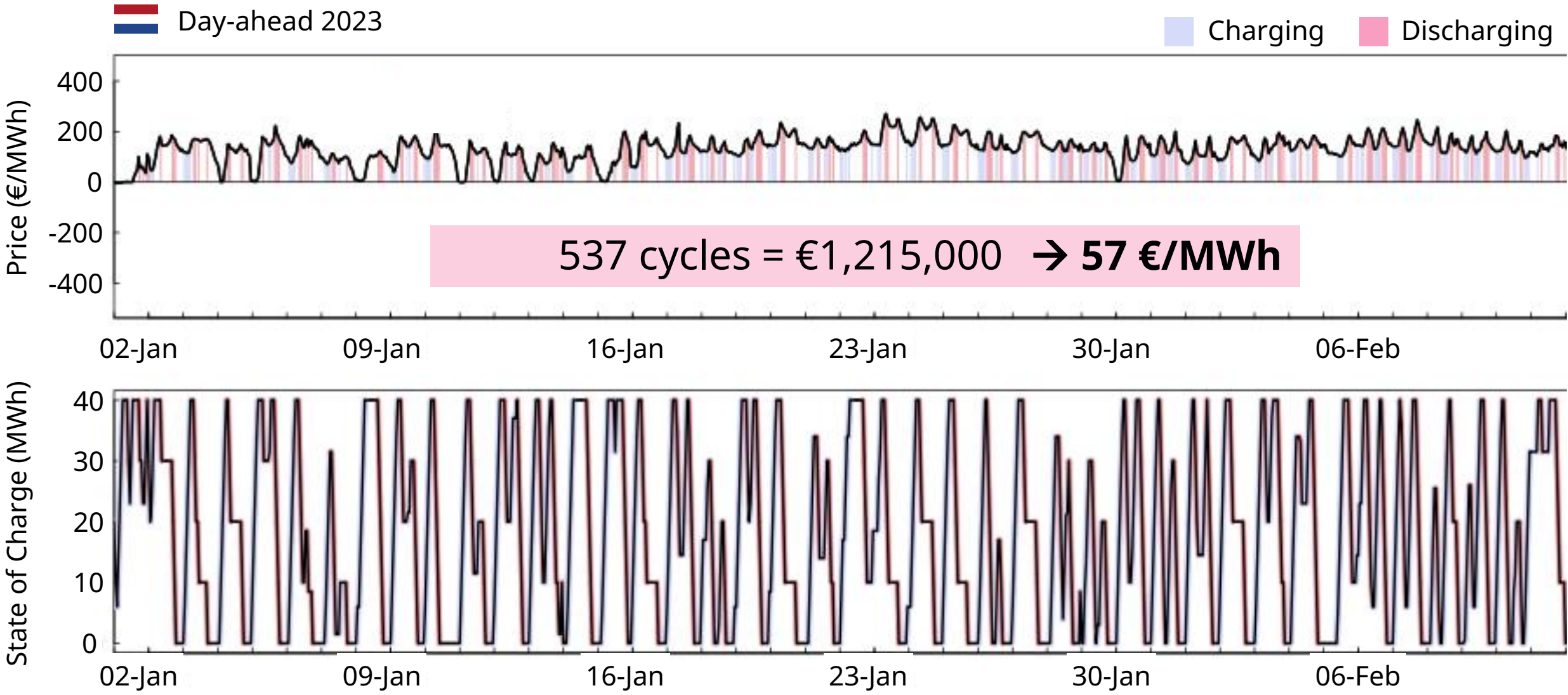


Chart from www.EnergyStorage.ninja

But, fewer cycles allow to extract most of the value still

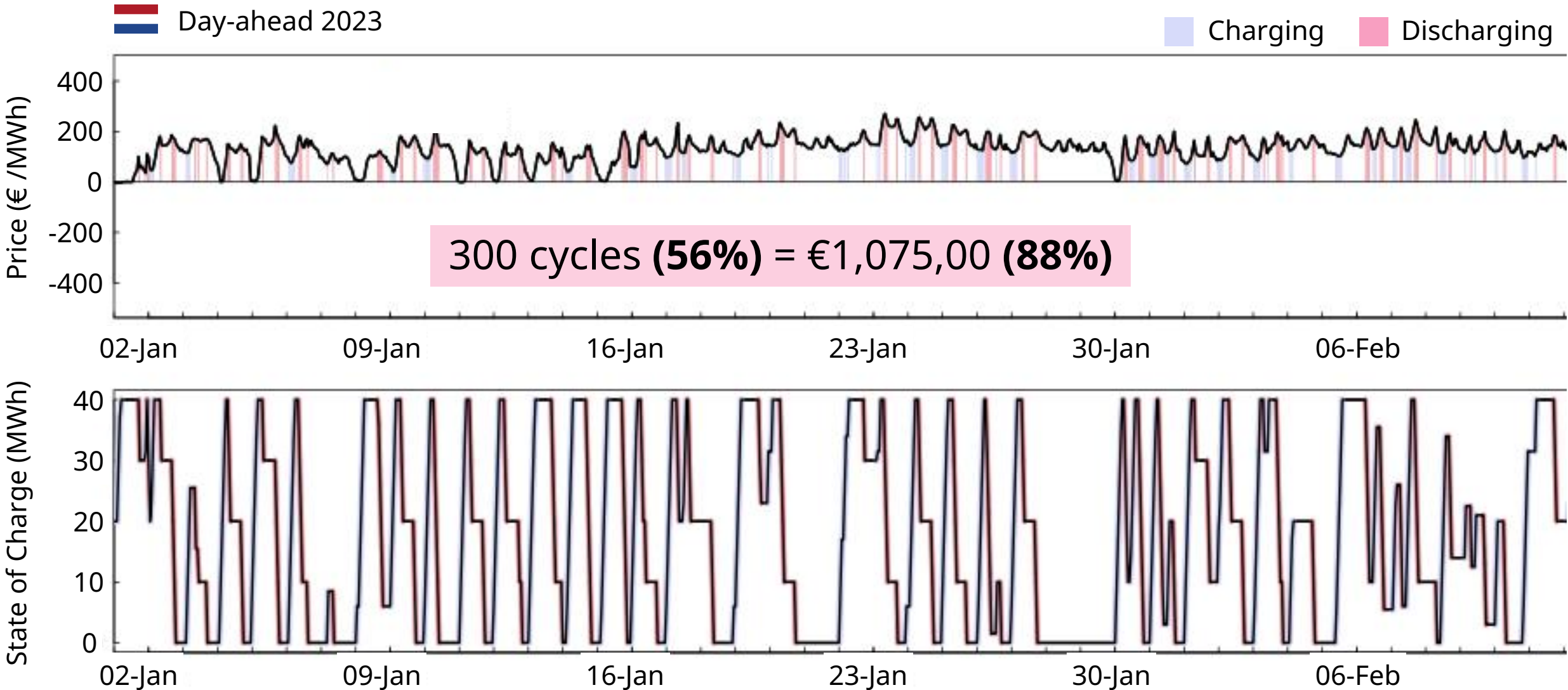


Chart from www.EnergyStorage.ninja

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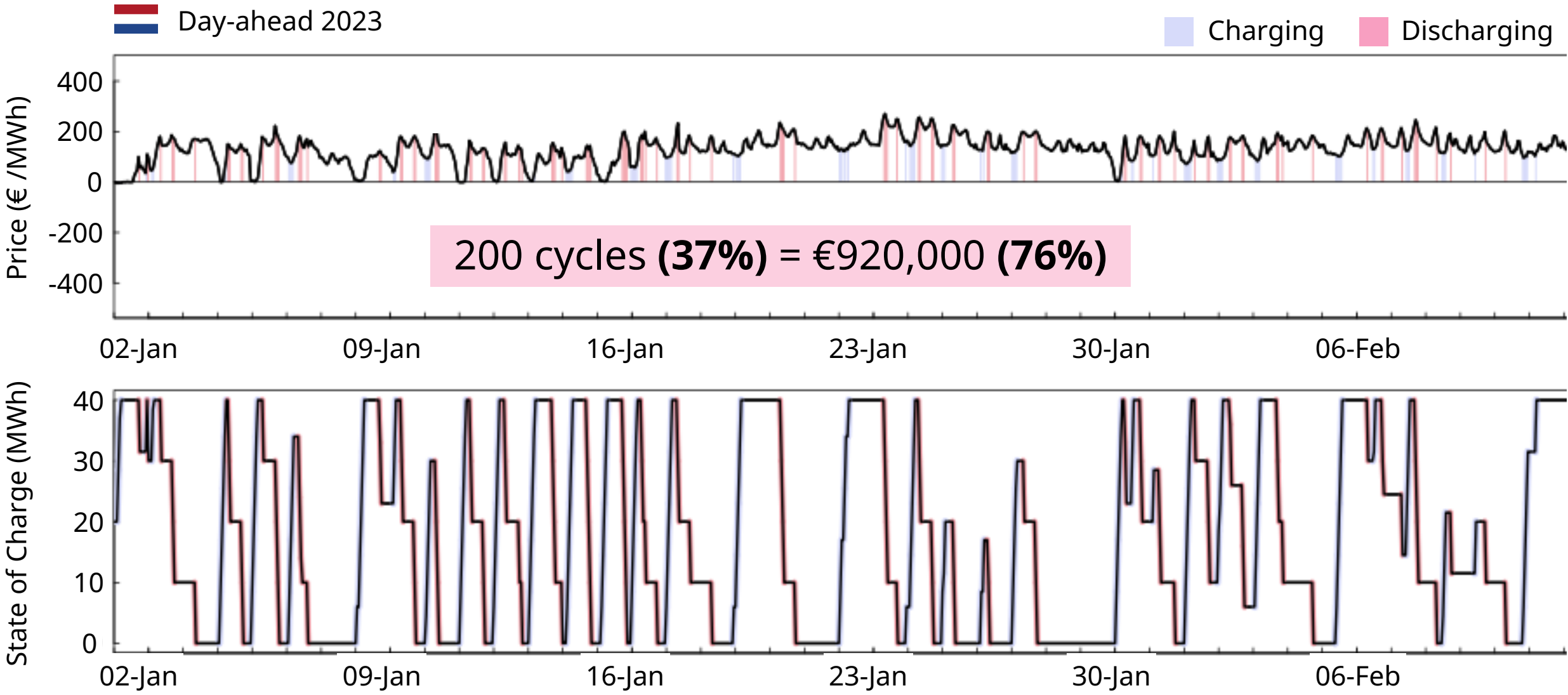


Chart from www.EnergyStorage.ninja

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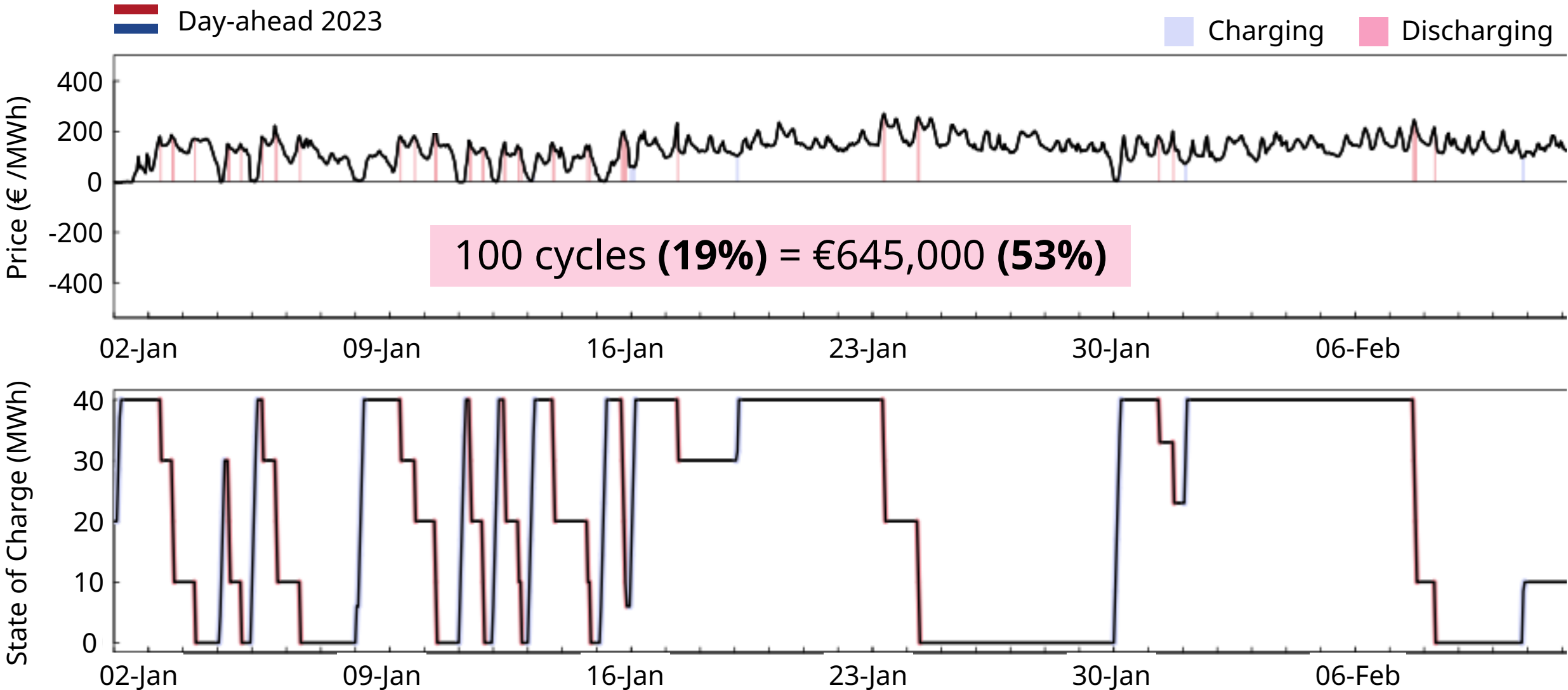
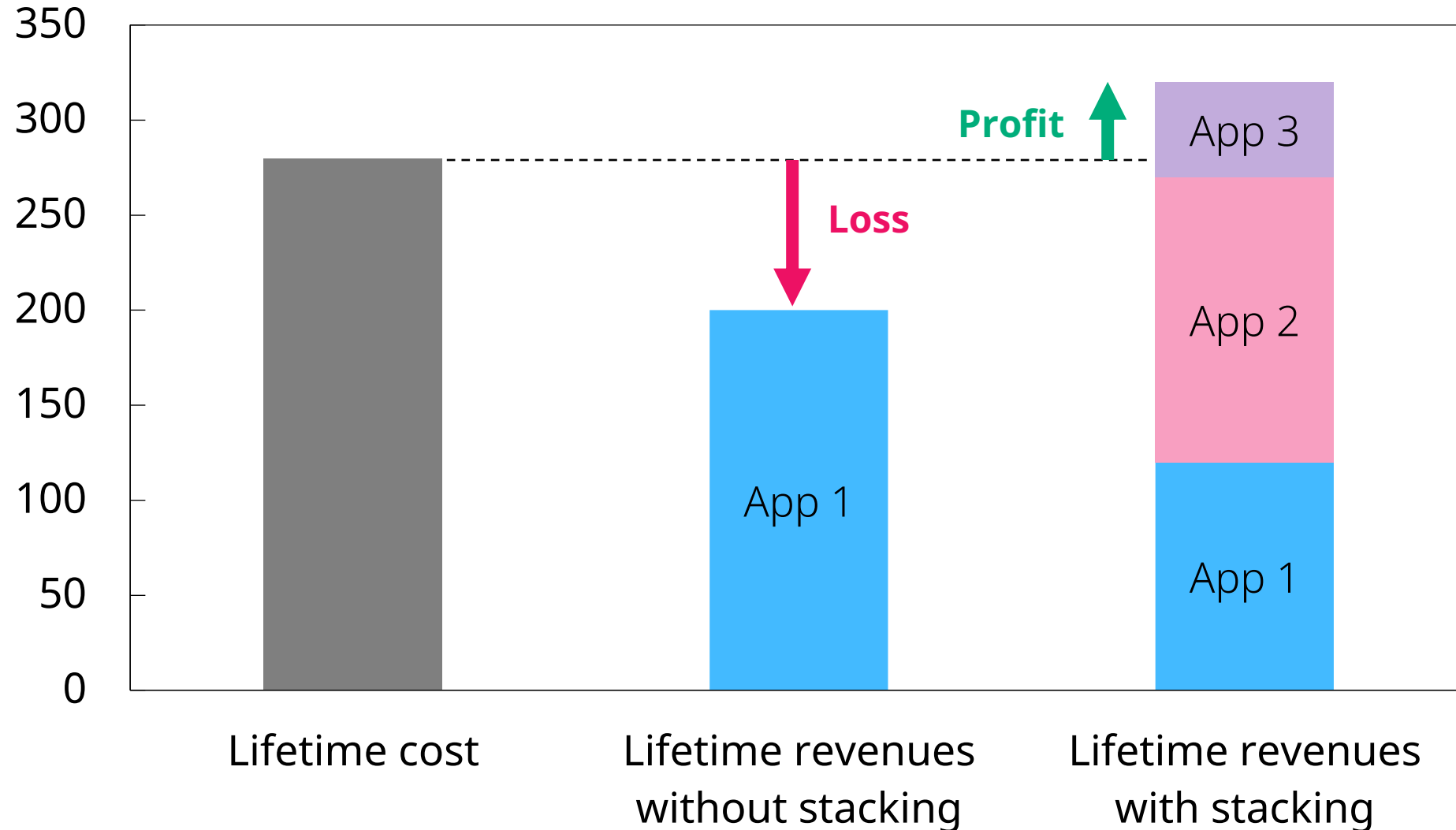
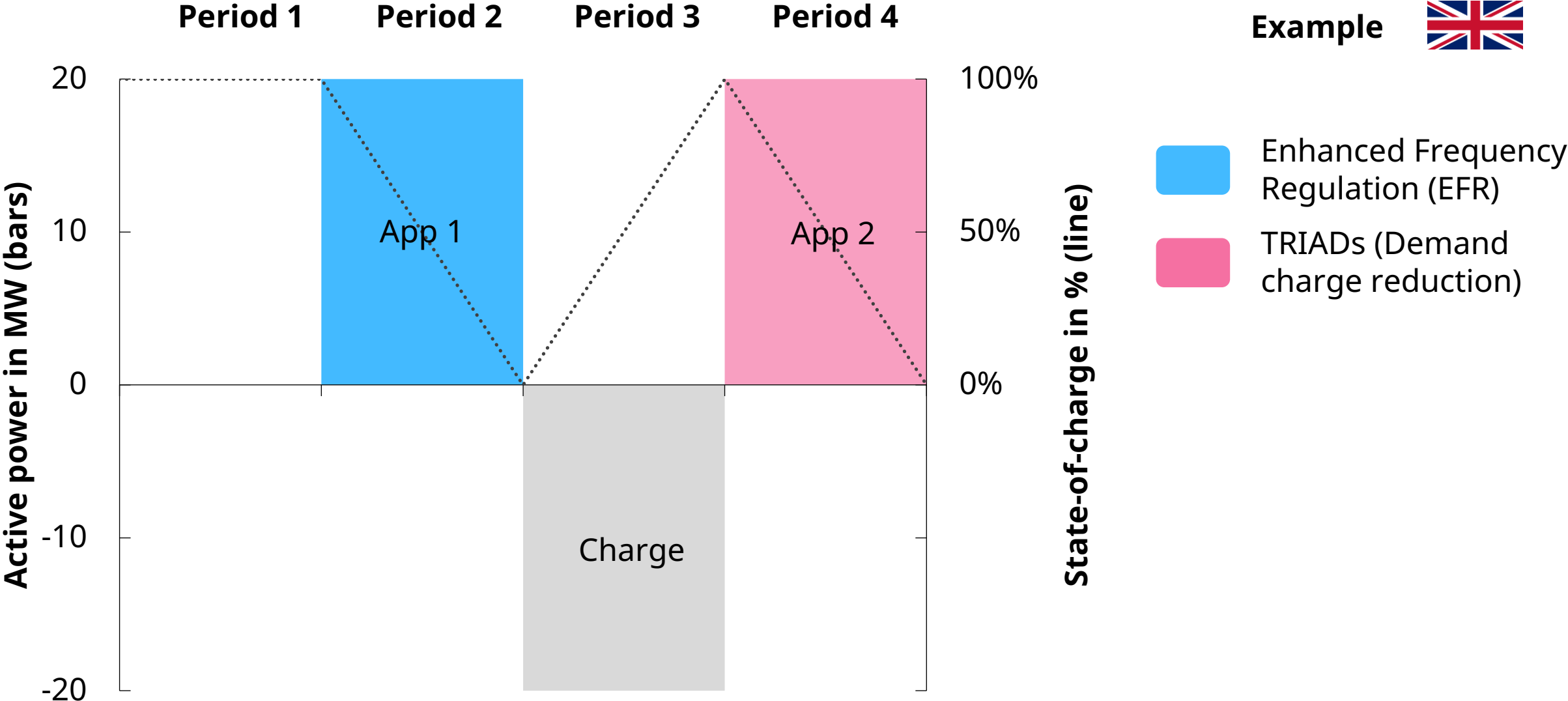


Chart from www.EnergyStorage.ninja

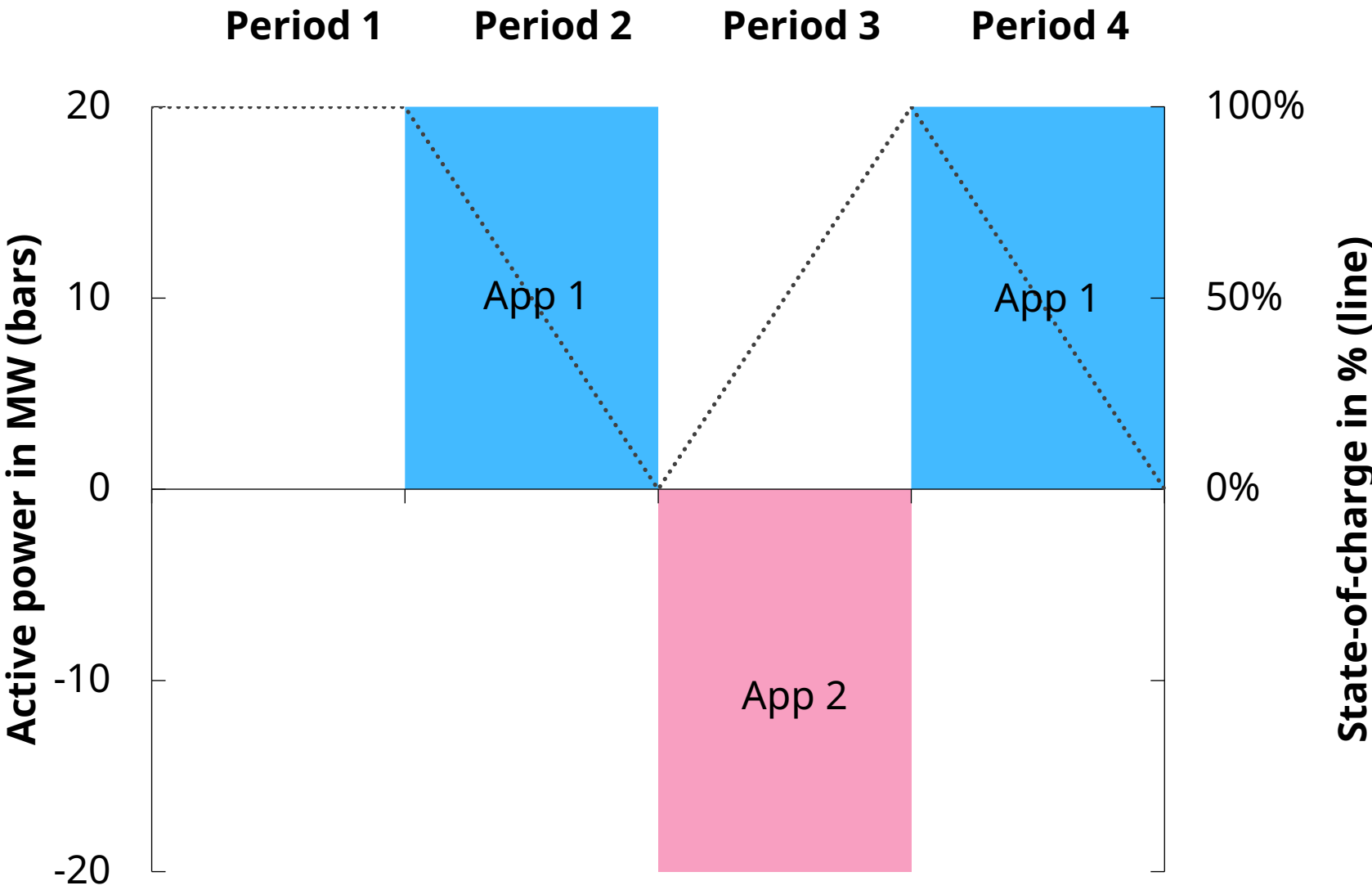
Therefore, multiple revenue streams must be combined





Option 1: Sequential stacking





Option 2: Sequential stacking in opposite directions



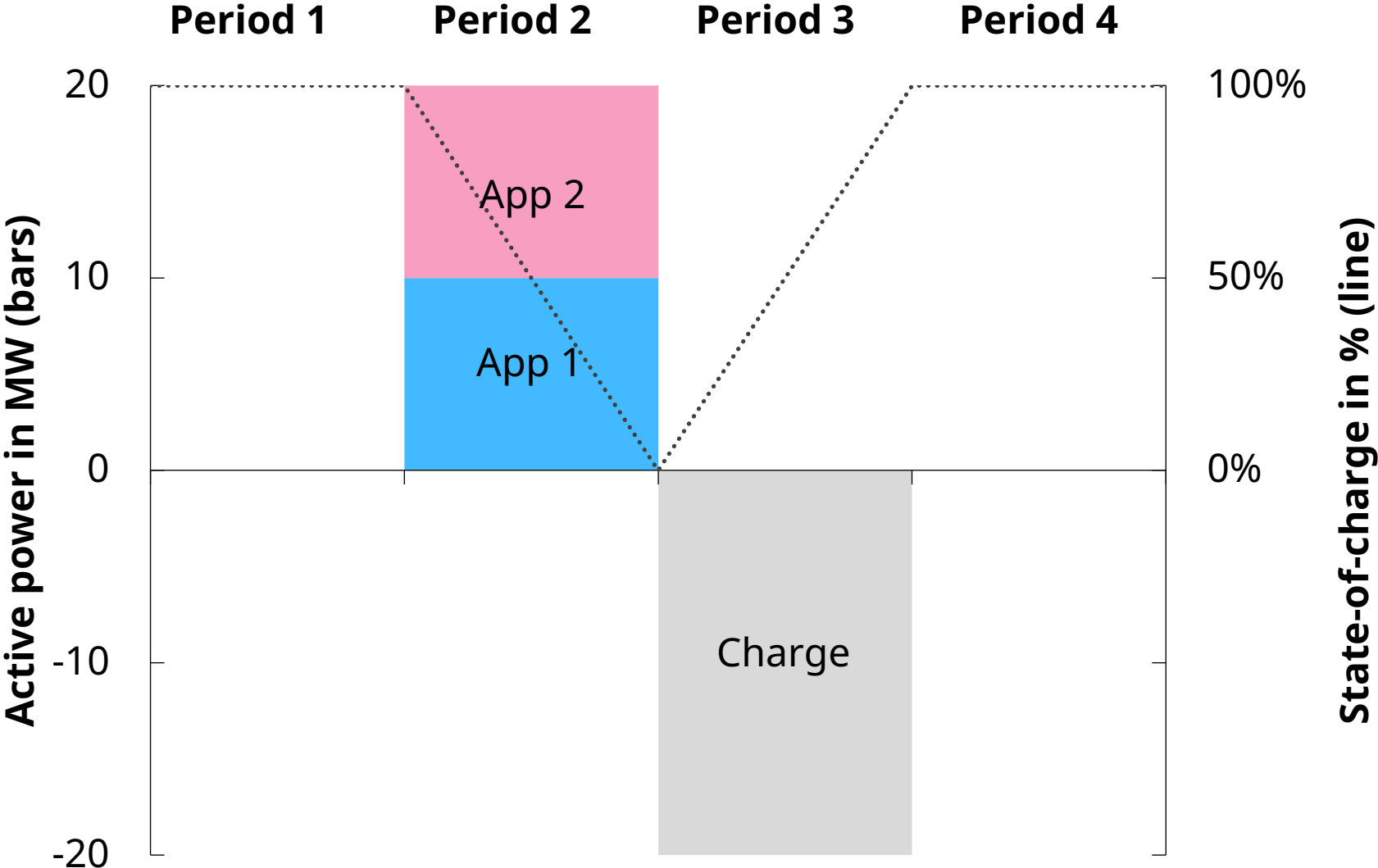
Example 

-  Dynamic Containment Low
-  Balancing mechanism



OR

-  Wholesale market
-  Dynamic Containment High

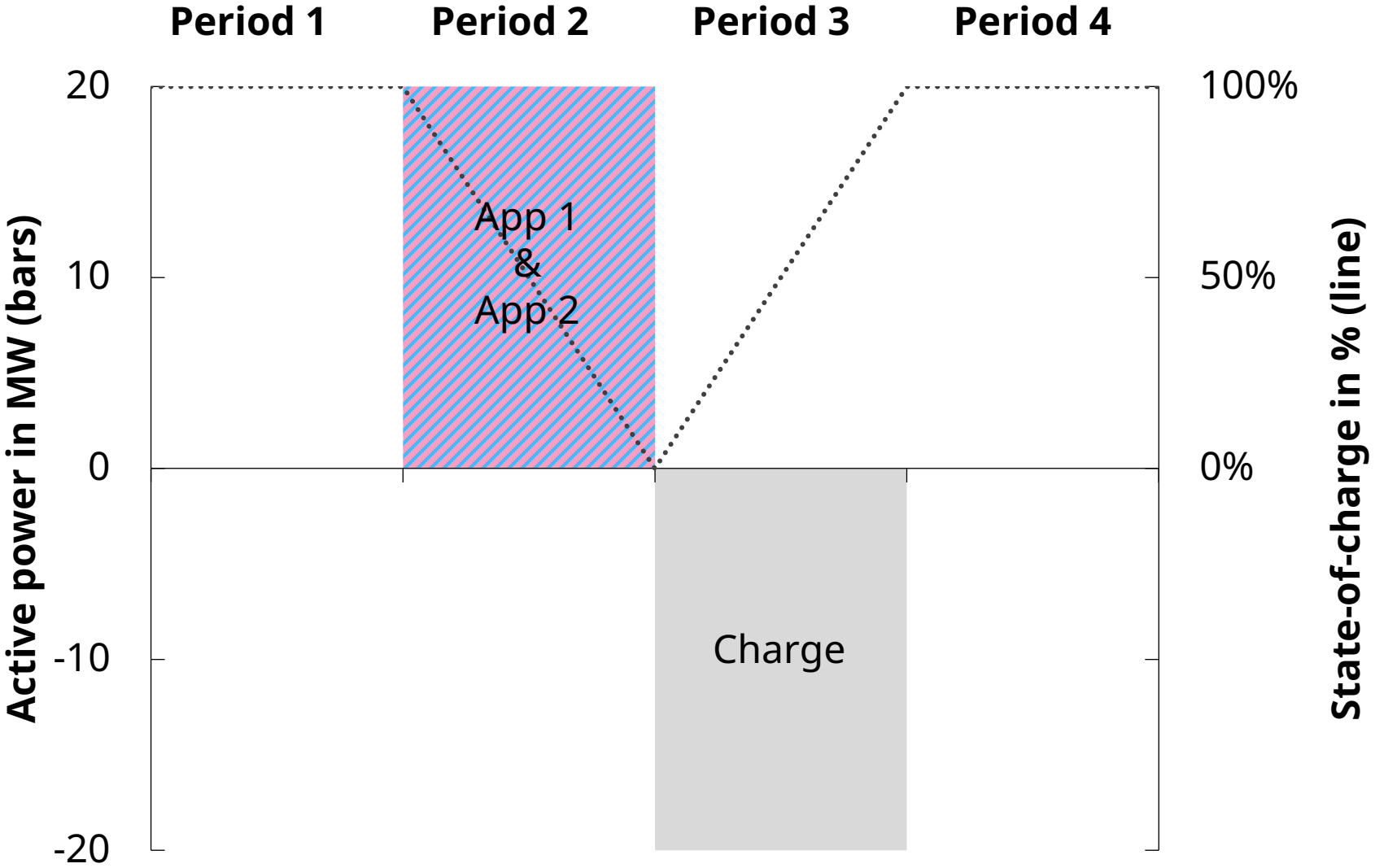
Option 3: Parallel stacking





Example 

-  Dynamic regulation
-  Wholesale market

Option 4: Overlapped stacking



Example 

-  Capacity market
-  Firm frequency response (FFR)

The insights and tools shown here are freely available for your analyses

"Essential for me as an investor to navigate this complex, fast-paced energy storage industry."

Gerard Reid, Alexa Capital

"The go-to resource... exemplary in terms of academic rigour set in a real world context."

Jim Skea, Chair of the IPCC

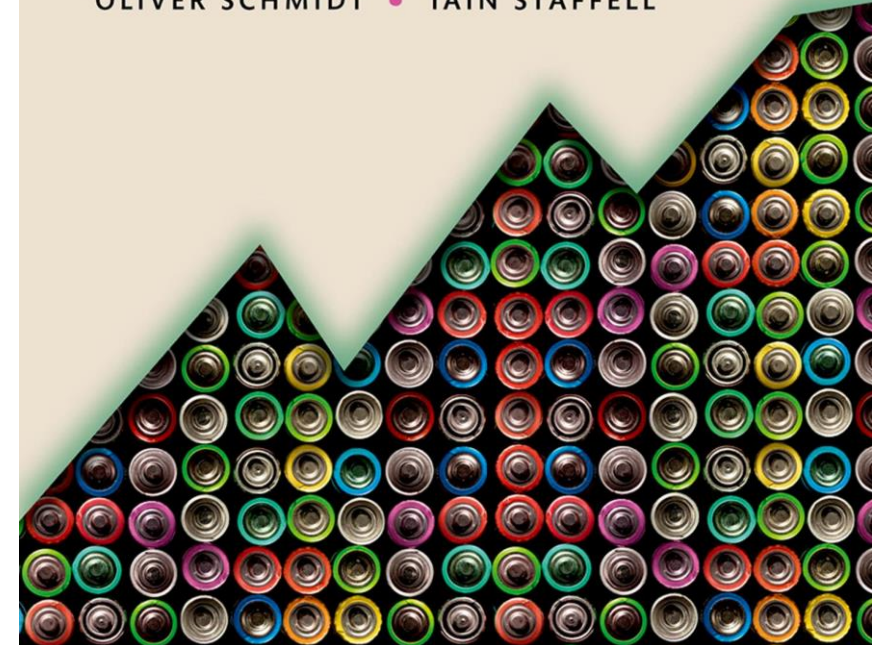
User-friendly tools for custom analyses: www.EnergyStorage.ninja

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Value Analysis Models

- Project Economics**: Cumulative cashflow, Discounted cumulative cashflow, Periodic cashflow.
- Arbitrage**: Price (USD/MWh) vs. Time (04-Jan to 25-Jan). Legend: Charging (blue), Discharging (red).
- System Need**: Storage power capacity relative to peak demand vs. Share of demand met by interconnector renewables. Legend: US (red), Germany (blue), Europe (green).
- System Value**: Value of the battery capacity vs. Storage power capacity (MW). Legend: The initial investment, Stage 1: Ebe = 0.7, 100% = 0.5%, Stage 2: Ebe = 0.1, 70% = 0.5%, 100% = 0.5%, No storage.

Cost Analysis Models

- Lifetime Cost**: LCOE in USD/MWh vs. USD \$65.91 / MWh. Legend: End of life \$0.12, Charging \$56.73, O&M \$6.18, Replacement, Investment \$268.87.
- Tech Competitiveness**: Probability of lowest LCOE vs. Peak capacity. Legend: Compressed air, Flow battery, Vanadium flow battery, Zinc bromine, Lead acid, Li-ion.
- Competitive Landscape**: Technologies with the lowest levelized cost of storage vs. LCOE increase for second cheapest technology. Legend: Hydrogen, Compressed air, Flow battery, Li-ion, Lead acid, Vanadium flow battery, Zinc bromine.
- Investment Cost**: Investment cost vs. Time (2020 to 2030). Legend: Round trip efficiency, Round trip energy, Round trip power, Round trip capacity, Round trip volume.