

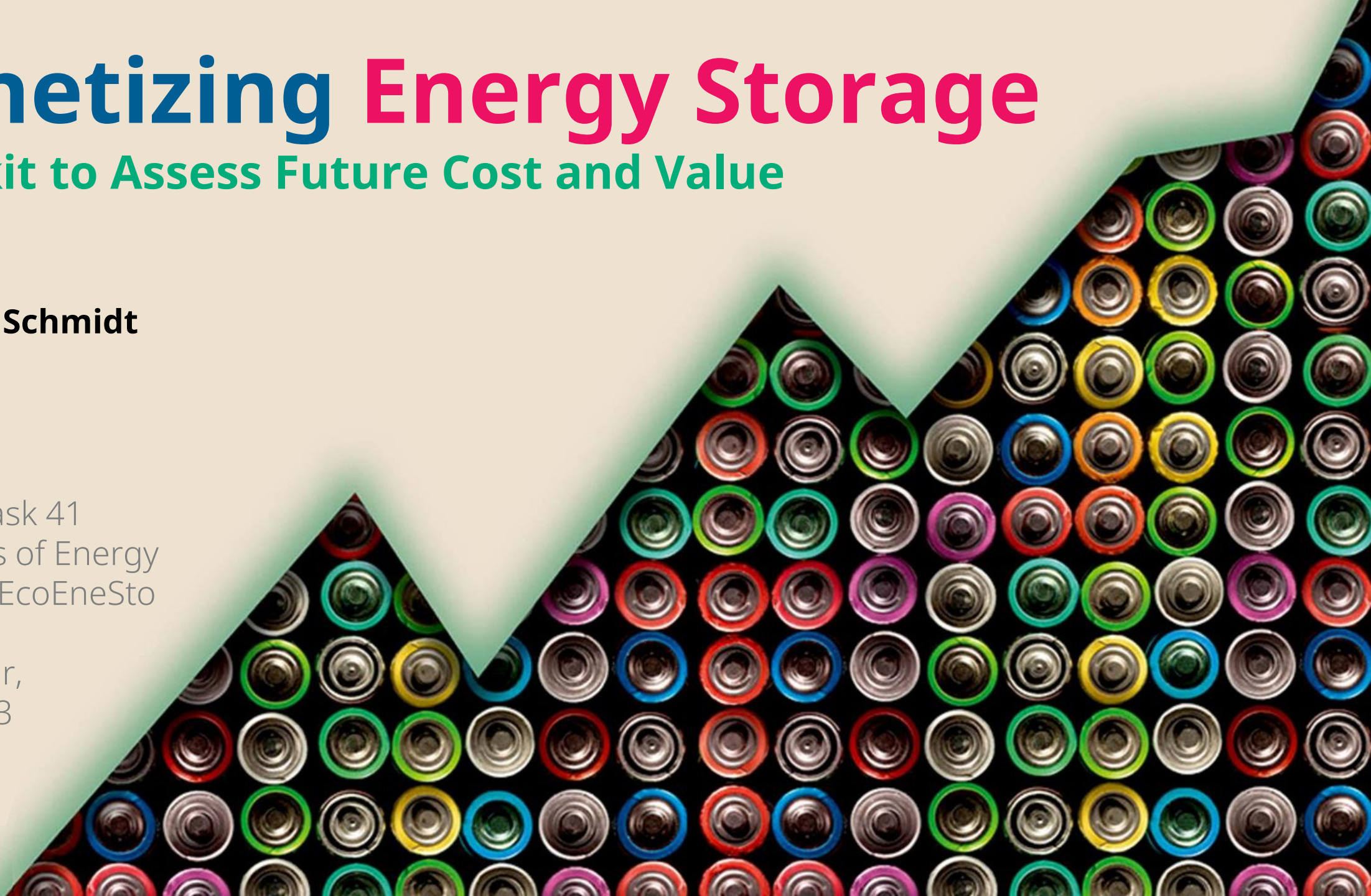
Monetizing Energy Storage

A Toolkit to Assess Future Cost and Value

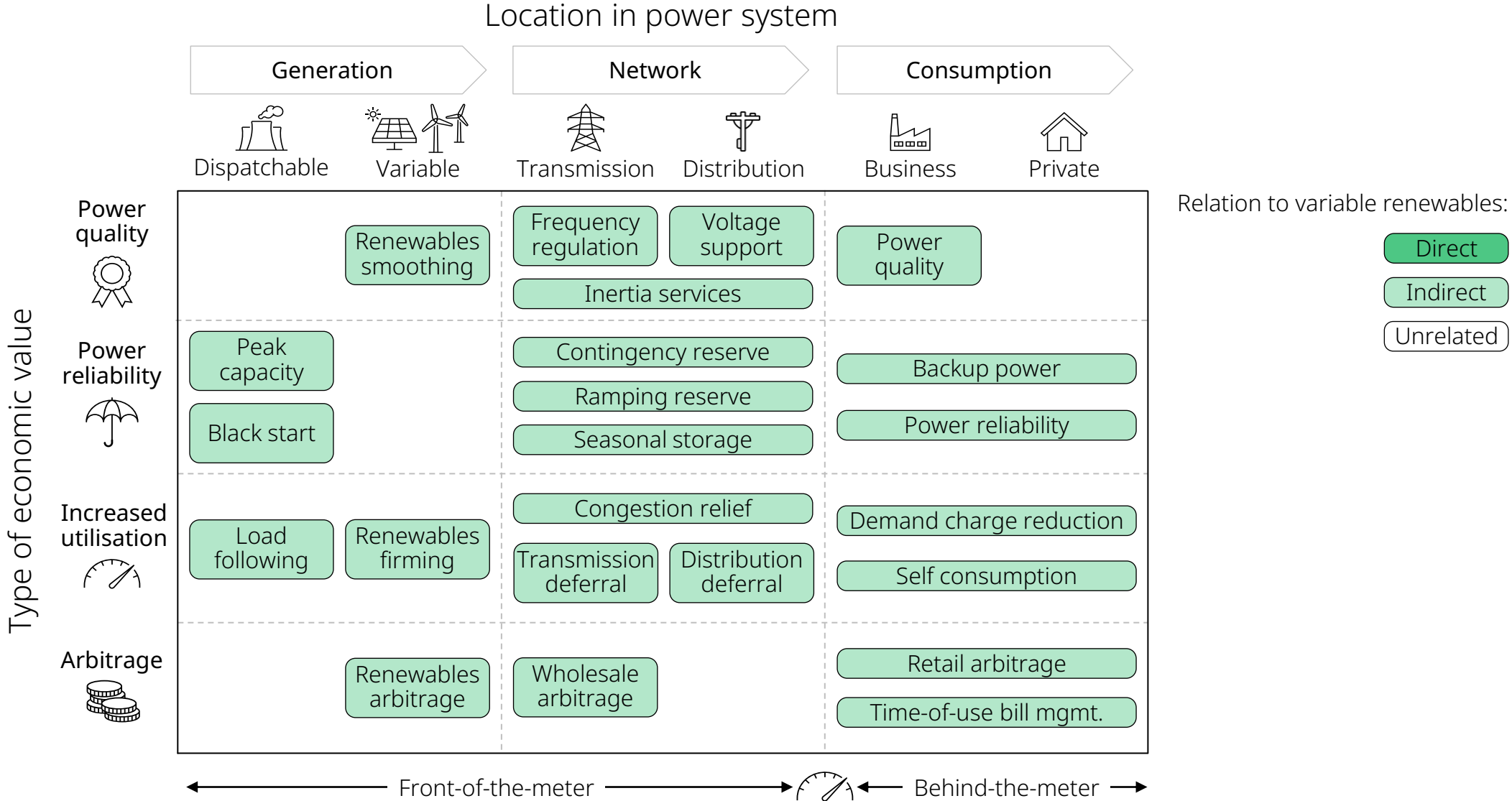
Dr Oliver Schmidt

IEA TCR Task 41
Economics of Energy
Storage – EcoEneSto

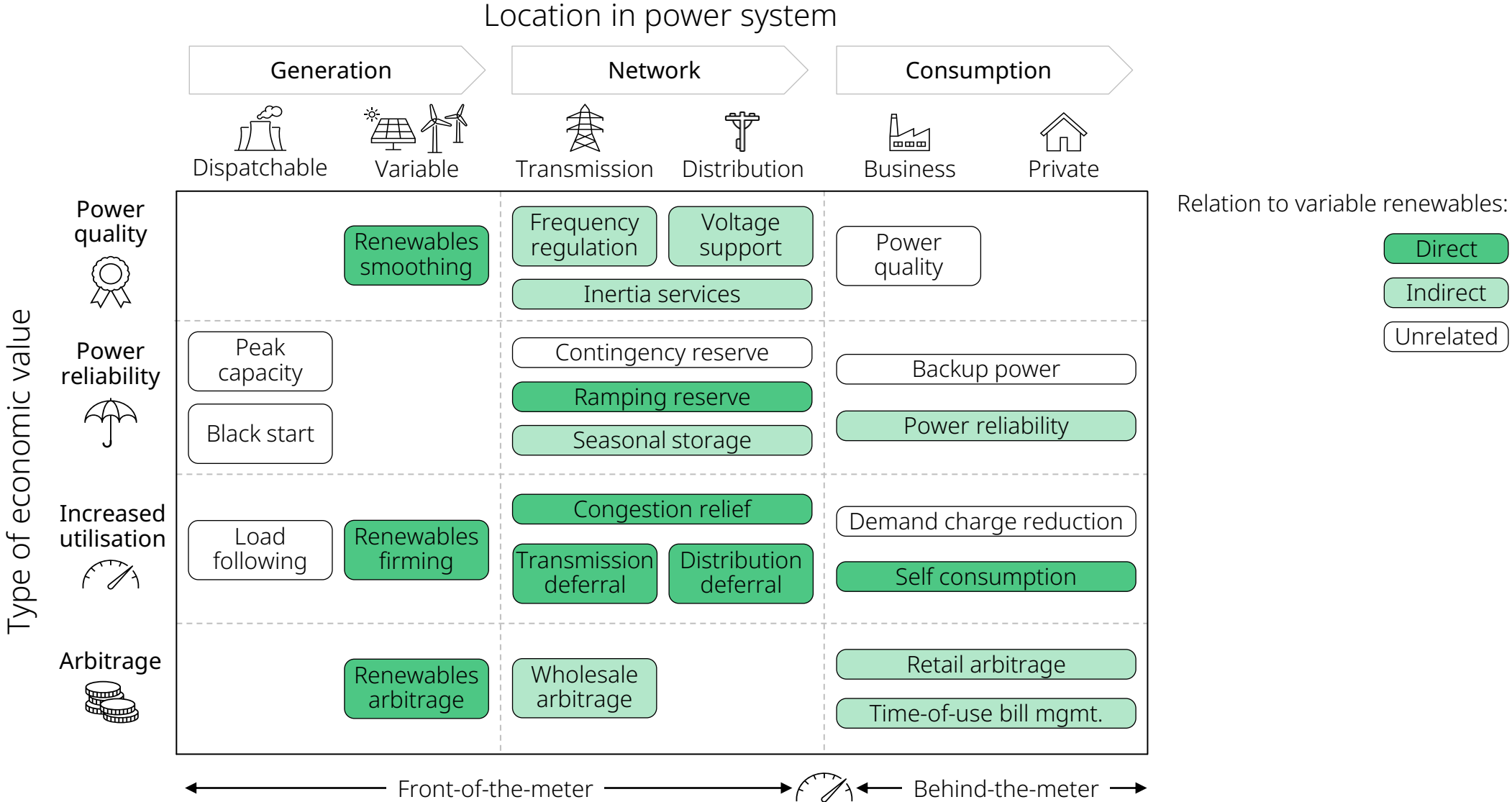
OnSeminar,
23.11.2023



Storage provides economic value with various applications



Storage provides economic value with various applications



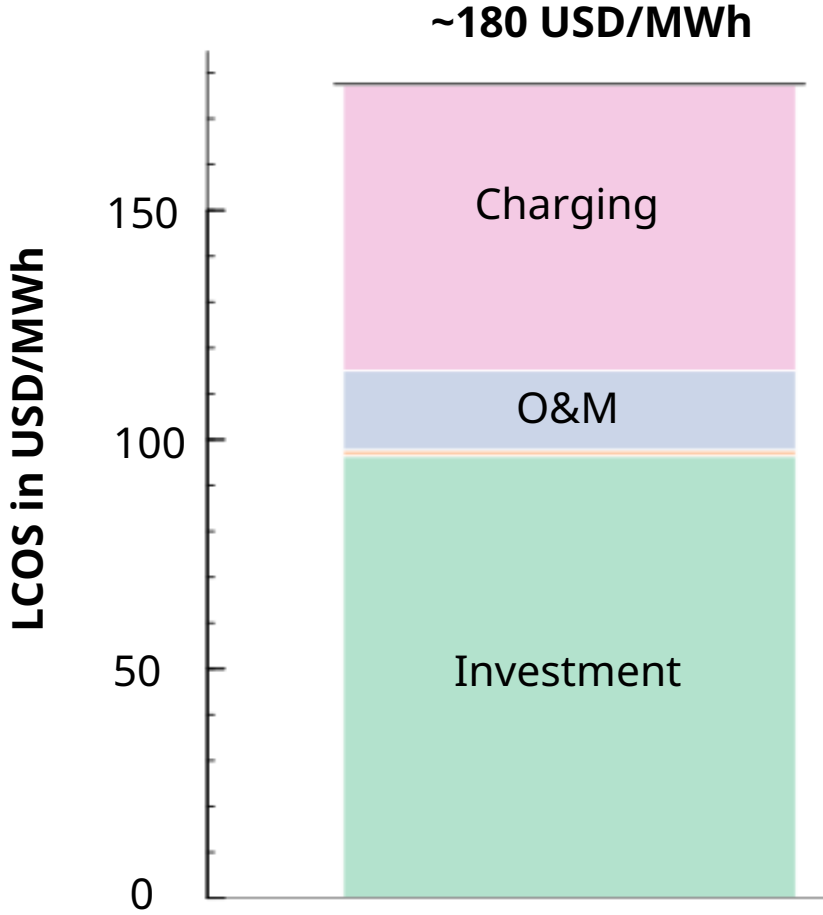
Lifetime cost quantify the cost to provide these values

Lifetime cost analysis:

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

Pumped hydro provides peak capacity at ~180 USD/MWh

Peak capacity: 300 cycles per year x 4 hours per cycle

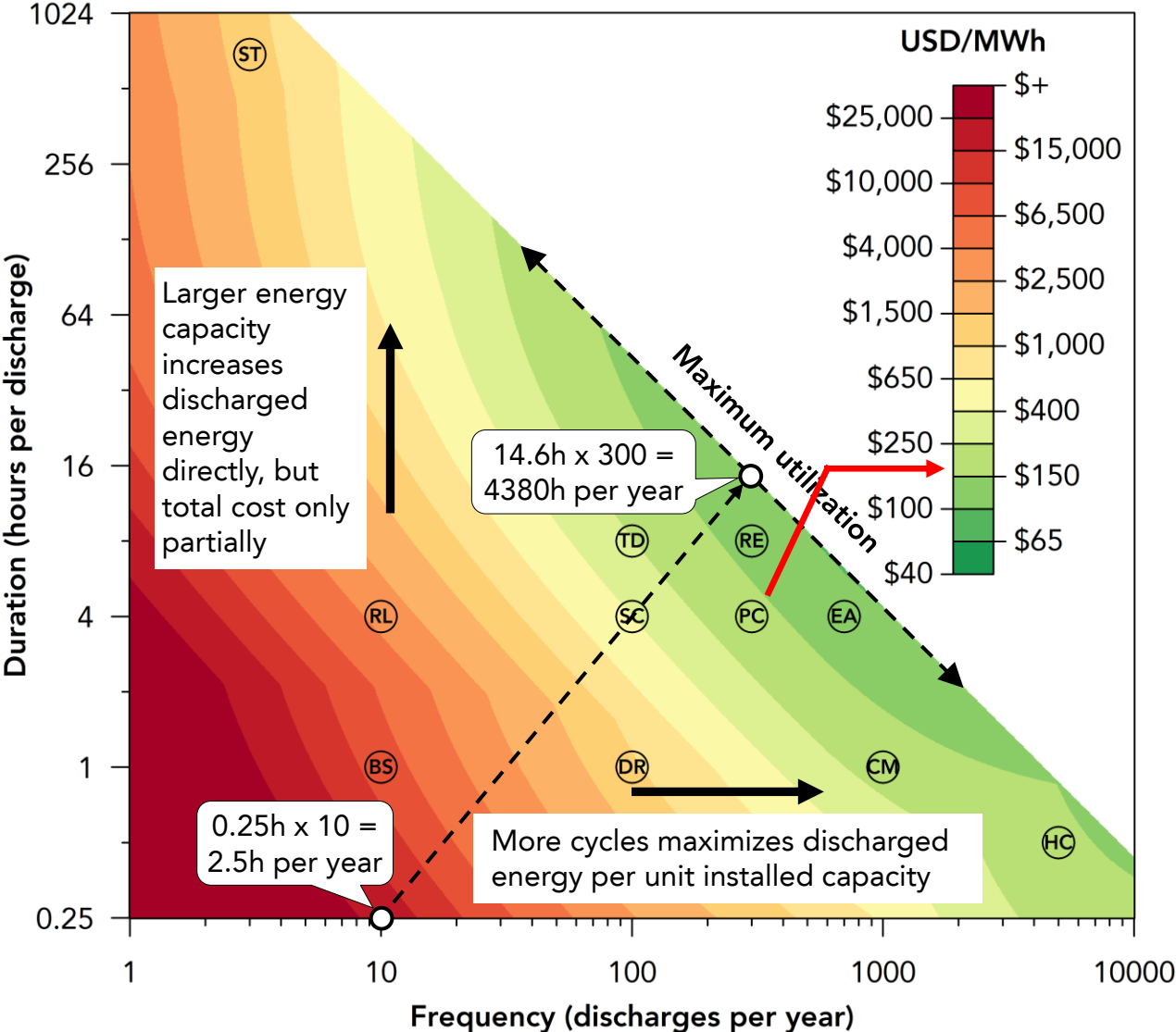


Specifications

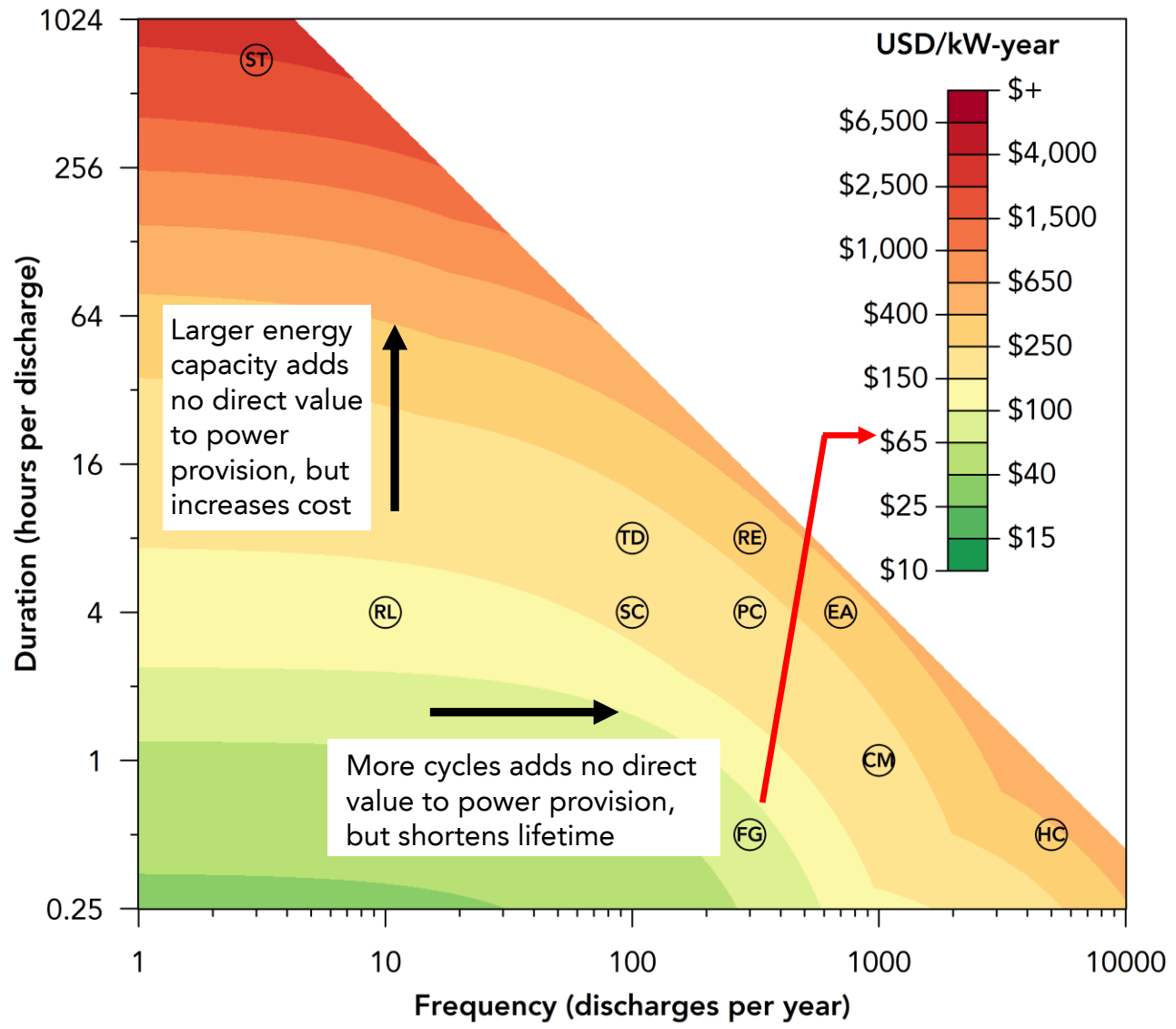
- 100 MW / 400 MWh
- 300 USD/kWh_{cap}
- 80% efficiency
- 50 years lifetime
- 8% discount rate

Graph from www.EnergyStorage.ninja

The cost to provide energy reduces with duration and cycles

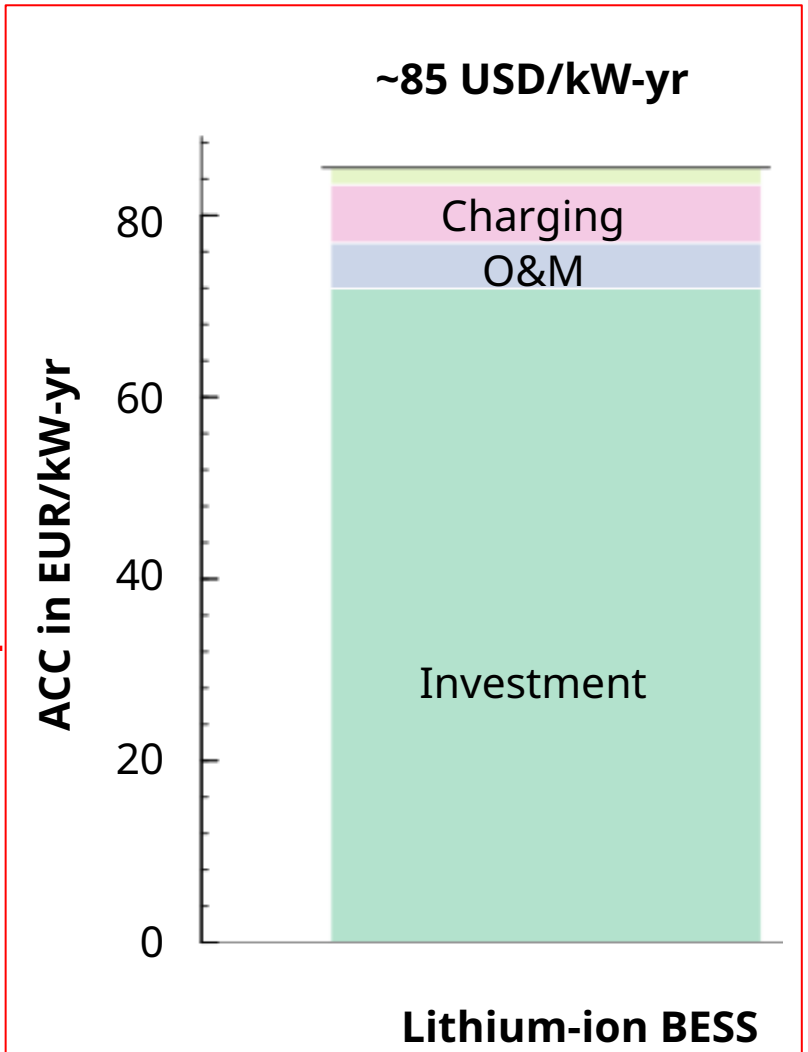
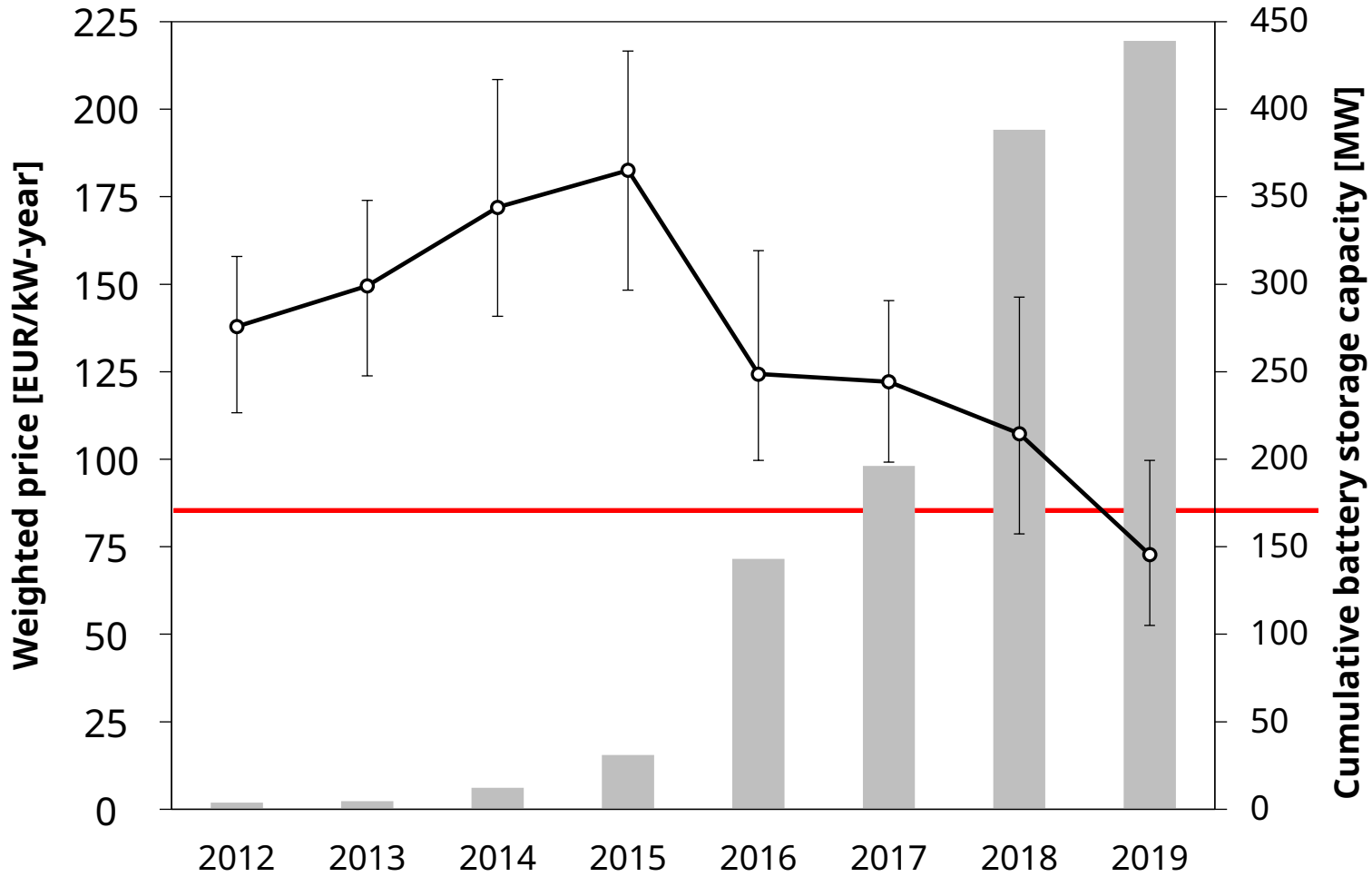


The cost to provide power increases with duration and cycles



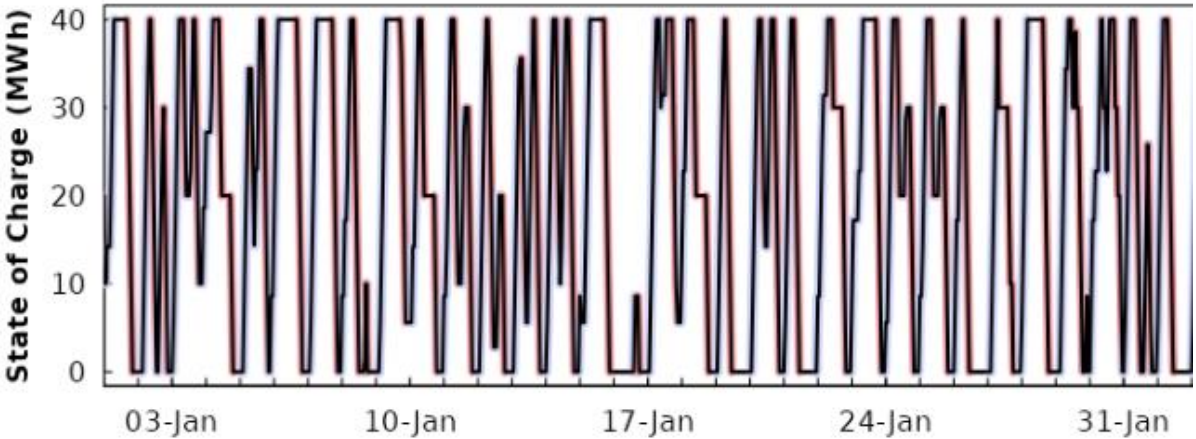
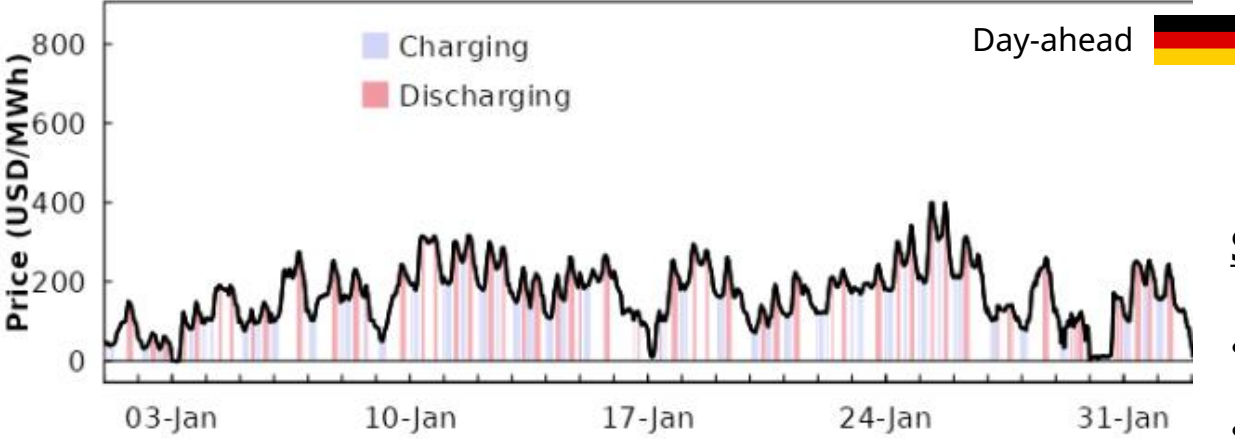
Power quality services are relatively shallow

Frequency regulation (PRL)



Arbitrage services are not yet profitable

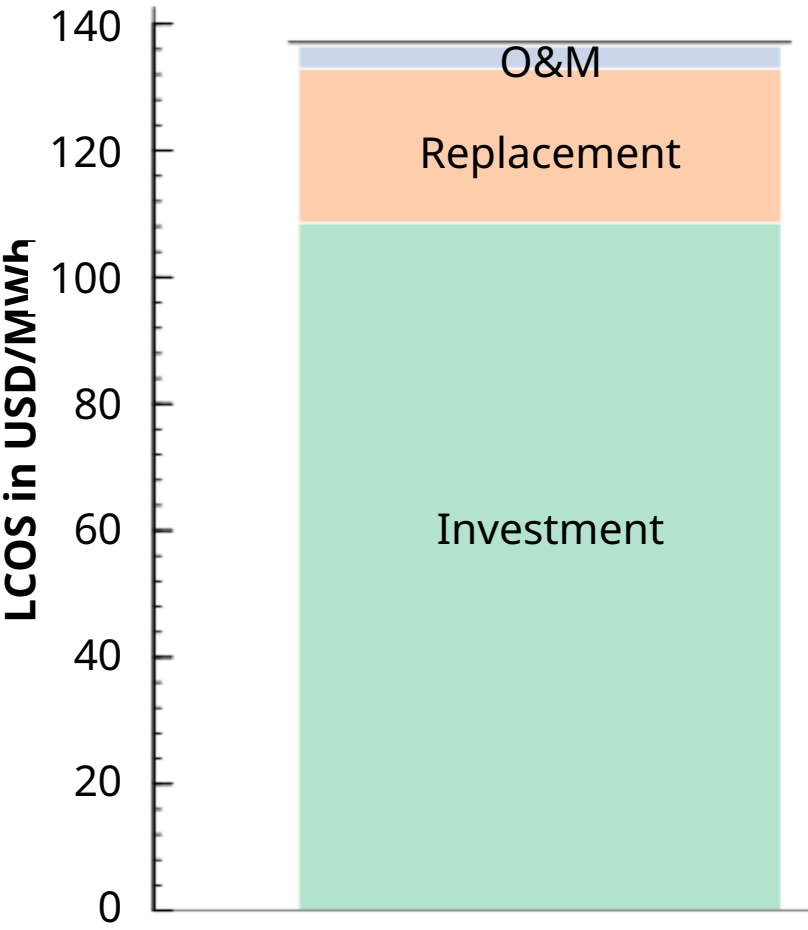
Revenue: 100 USD/MWh



Specifications

- 10 MW/40 MWh
- 350 USD/kWh_{cap}
- 15 years
- 550 cycles p.a.
- 86% efficiency
- 8% discount rate

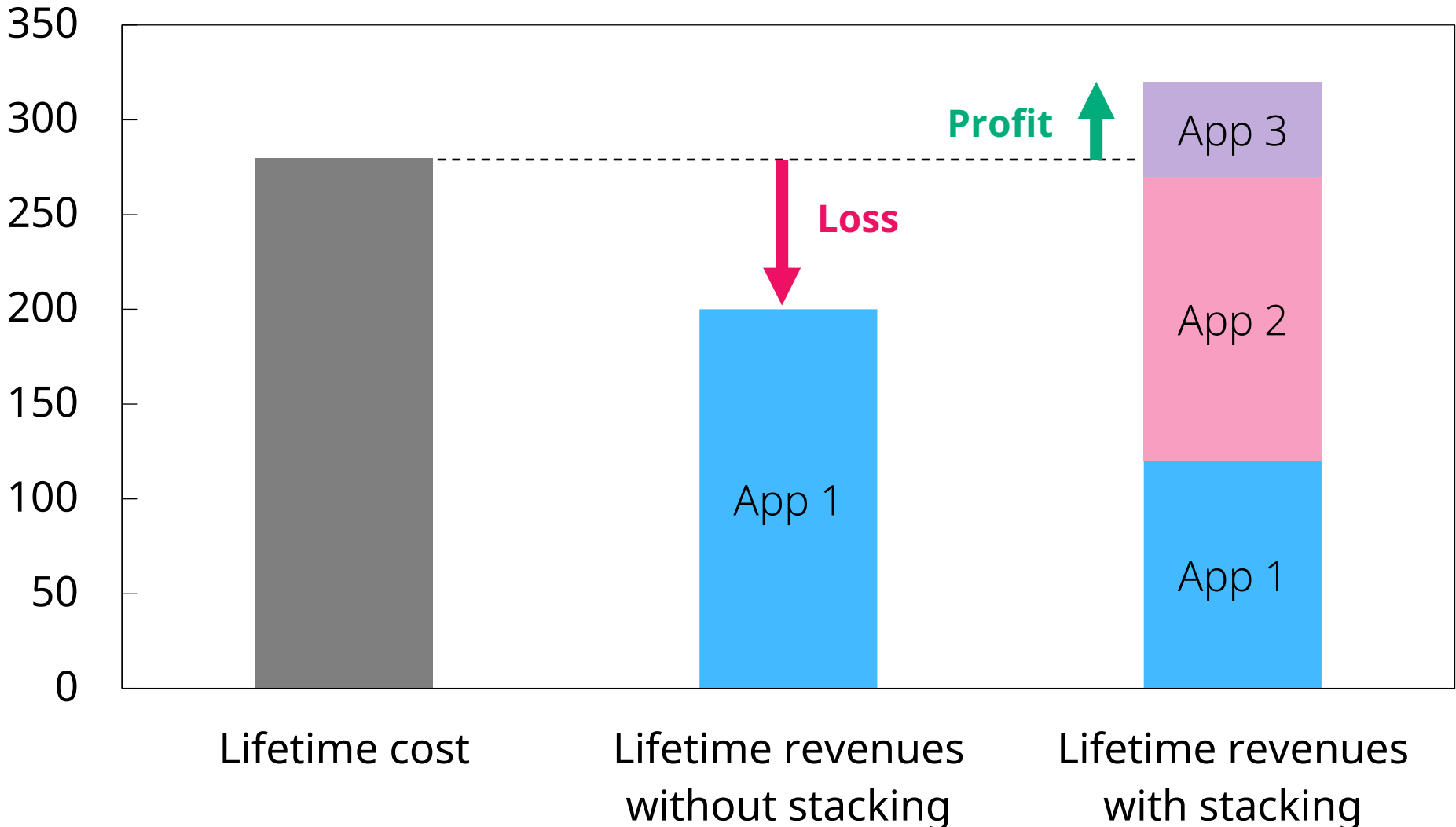
LCOS: 140 USD/MWh



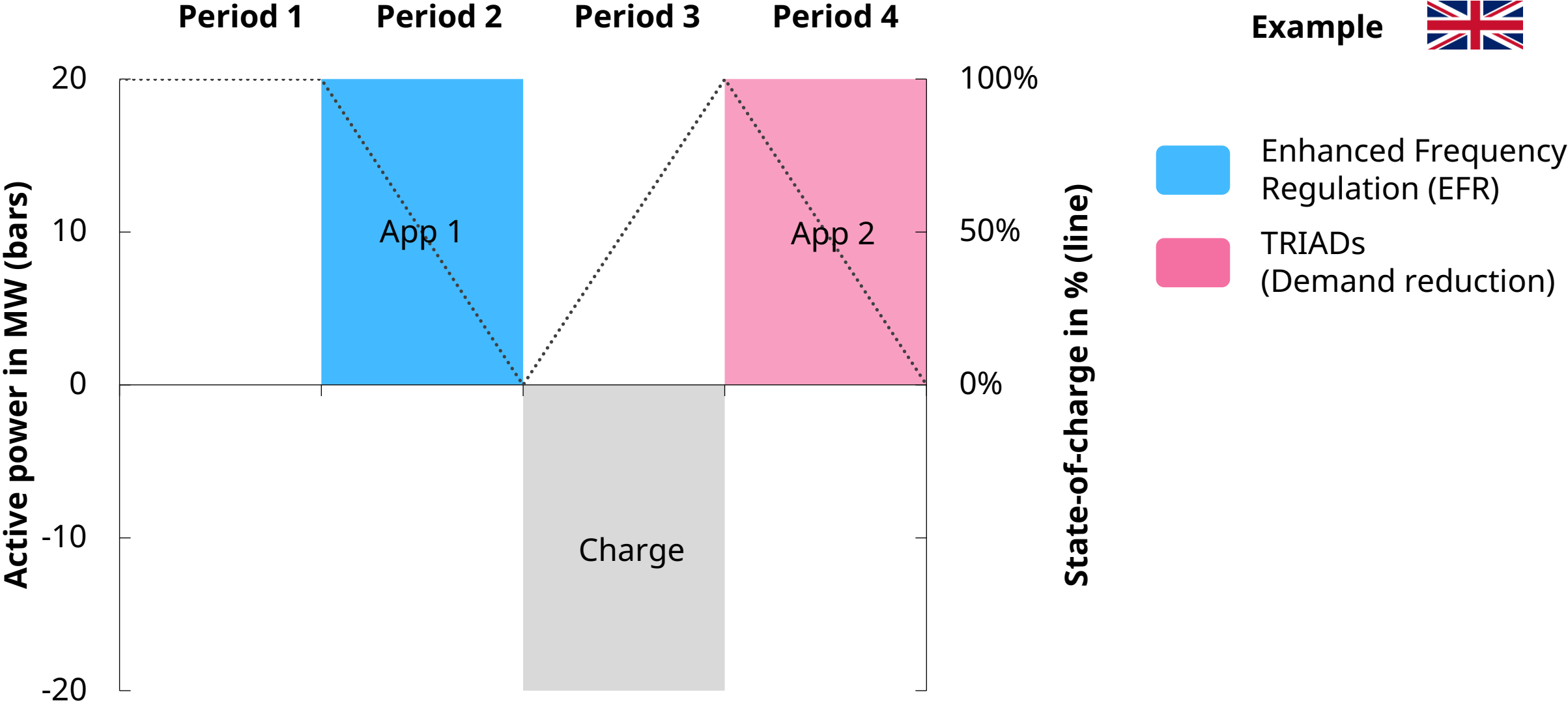
Graph from www.EnergyStorage.ninja

Lithium-ion BESS

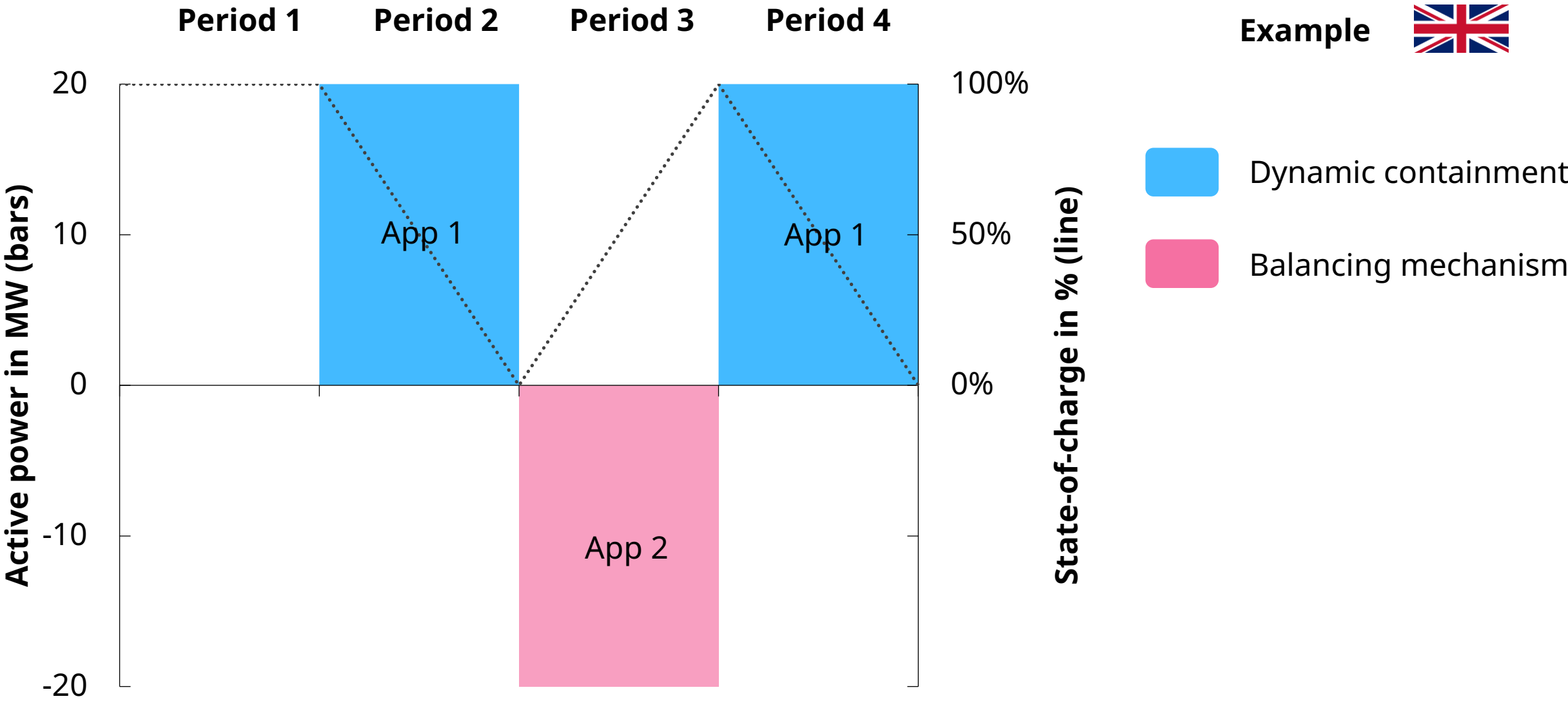
Therefore, multiple revenue streams must be combined



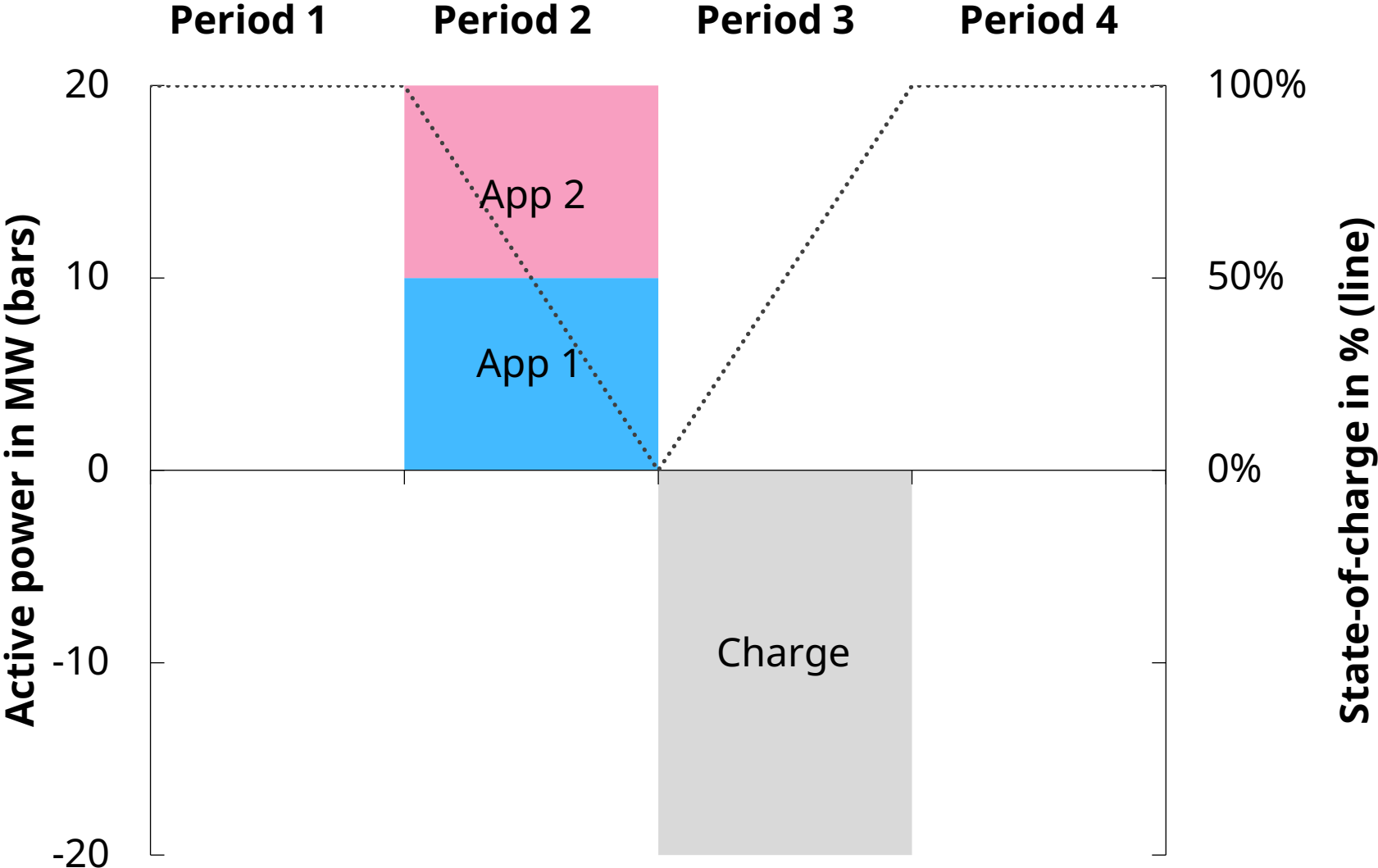
Option 1: Sequential stacking





Option 2: Sequential stacking in opposite directions



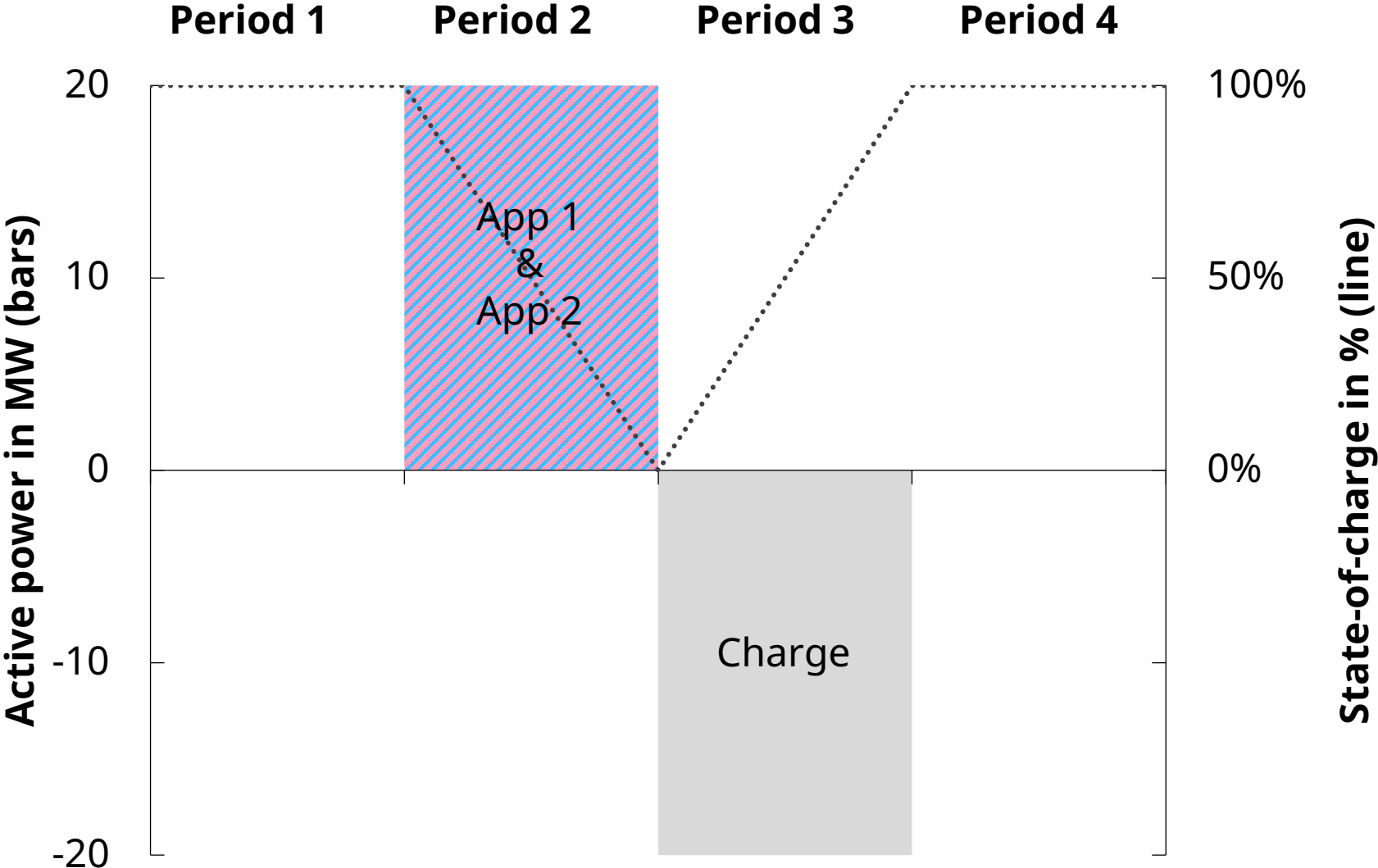
Option 3: Parallel stacking





Example 

-  Dynamic regulation
-  Wholesale market

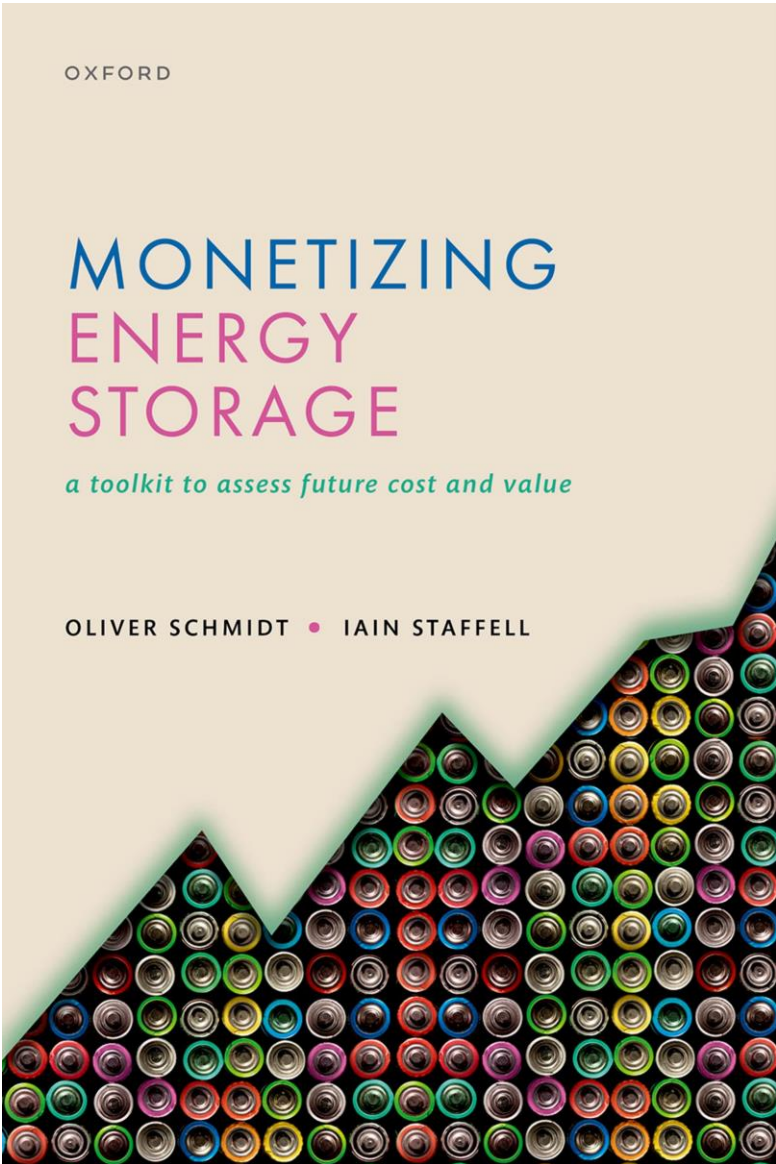
Option 4: Overlapped stacking



Example 

-  Capacity market
-  Firm frequency response (FFR)

All insights and tools available in my book and website



More insights (and data and methodology)

User-friendly tools for custom analyses