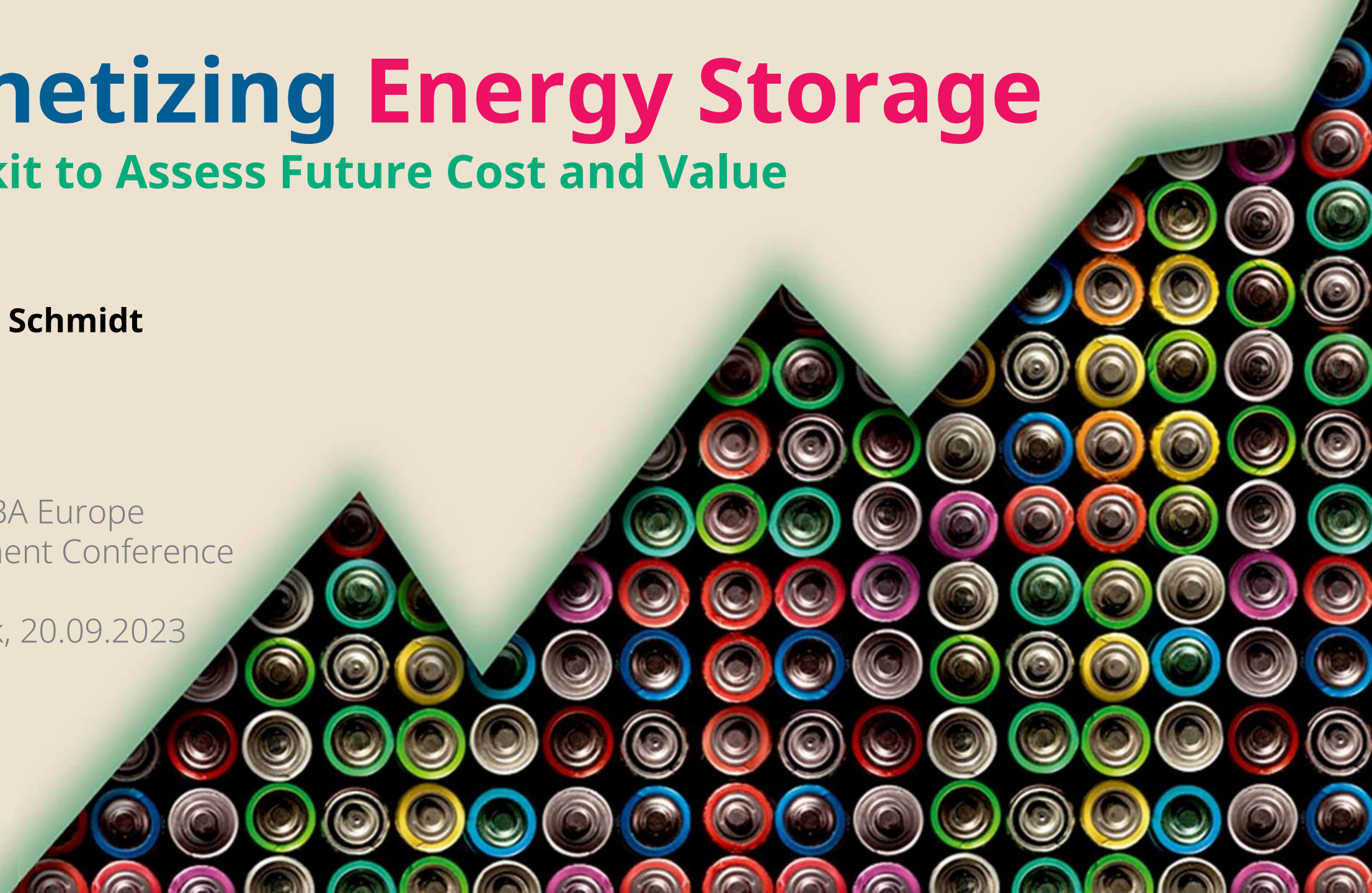
Monetizing Energy Storage

A Toolkit to Assess Future Cost and Value

Dr Oliver Schmidt

Statkraft BA Europe
Development Conference

Noordwijk, 20.09.2023

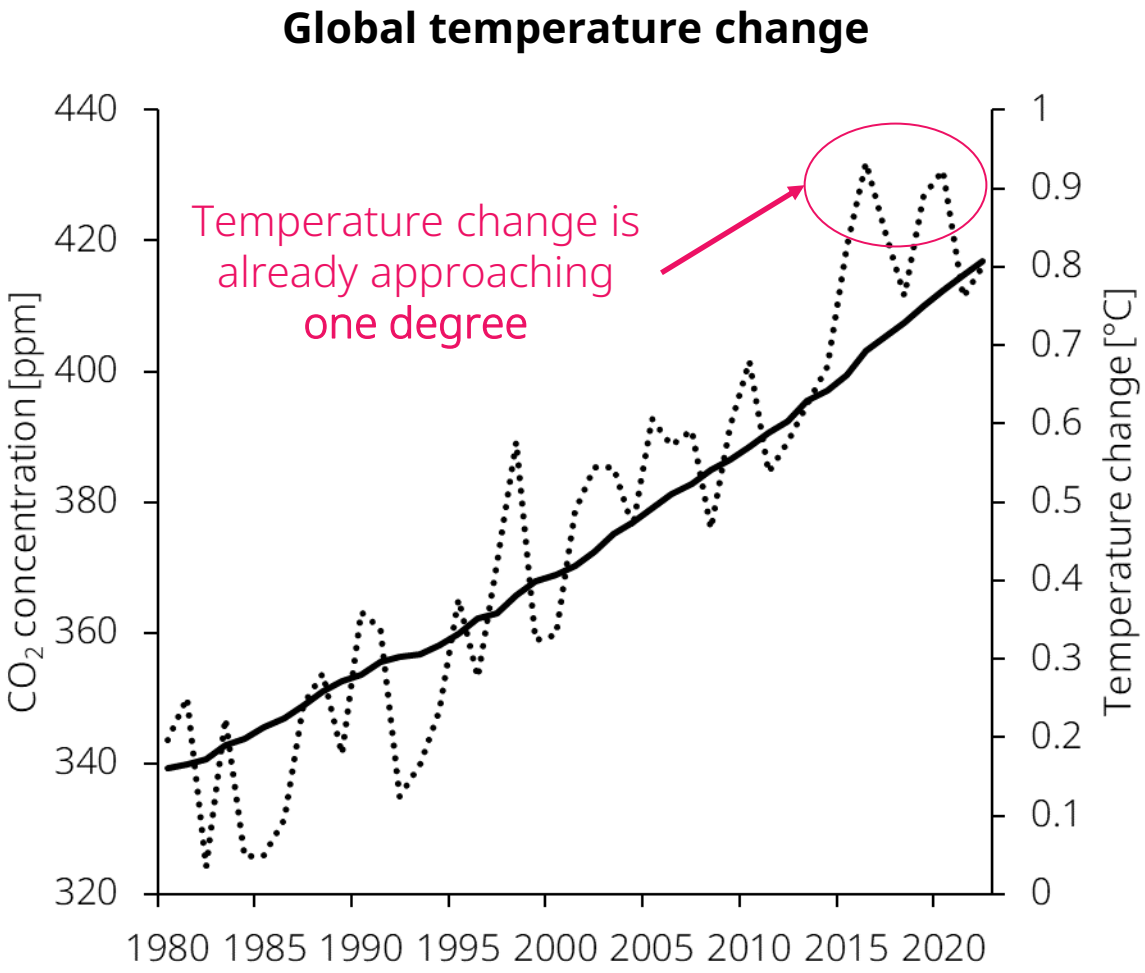


My focus is energy storage and project development

Oliver Schmidt

- Researcher — Imperial College London
- Consultant — Storage Lab
- Developer — dvlp.energy

Our planet is becoming a more dangerous place …



Canada wildfire season is now the worst on record

June 29, 2023

Canada: Four missing after historic rains trigger flooding

July 23, 2023

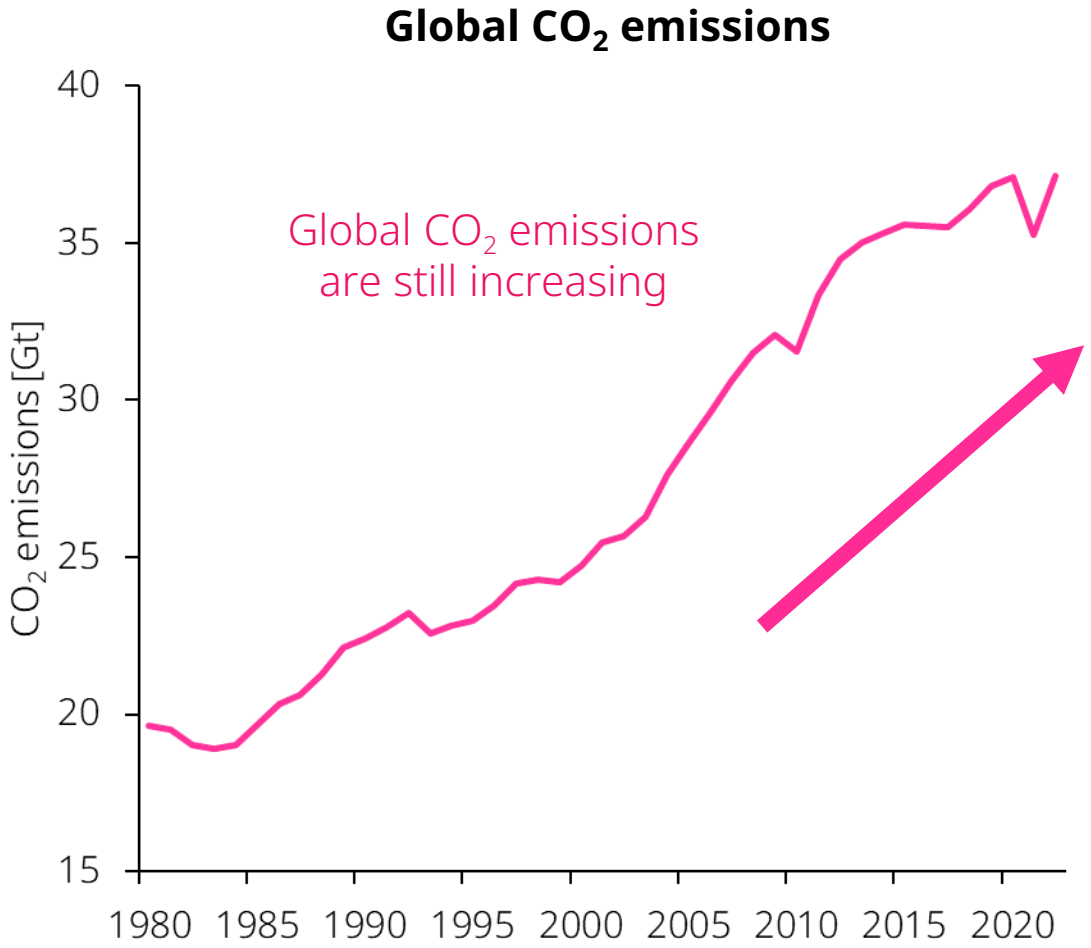
Greece Battles Its Most Widespread Wildfires on Record

August 23, 2023

"Historic flooding event" in Greece dumps more than 2 feet of rain in just a few hours

September 5, 2023

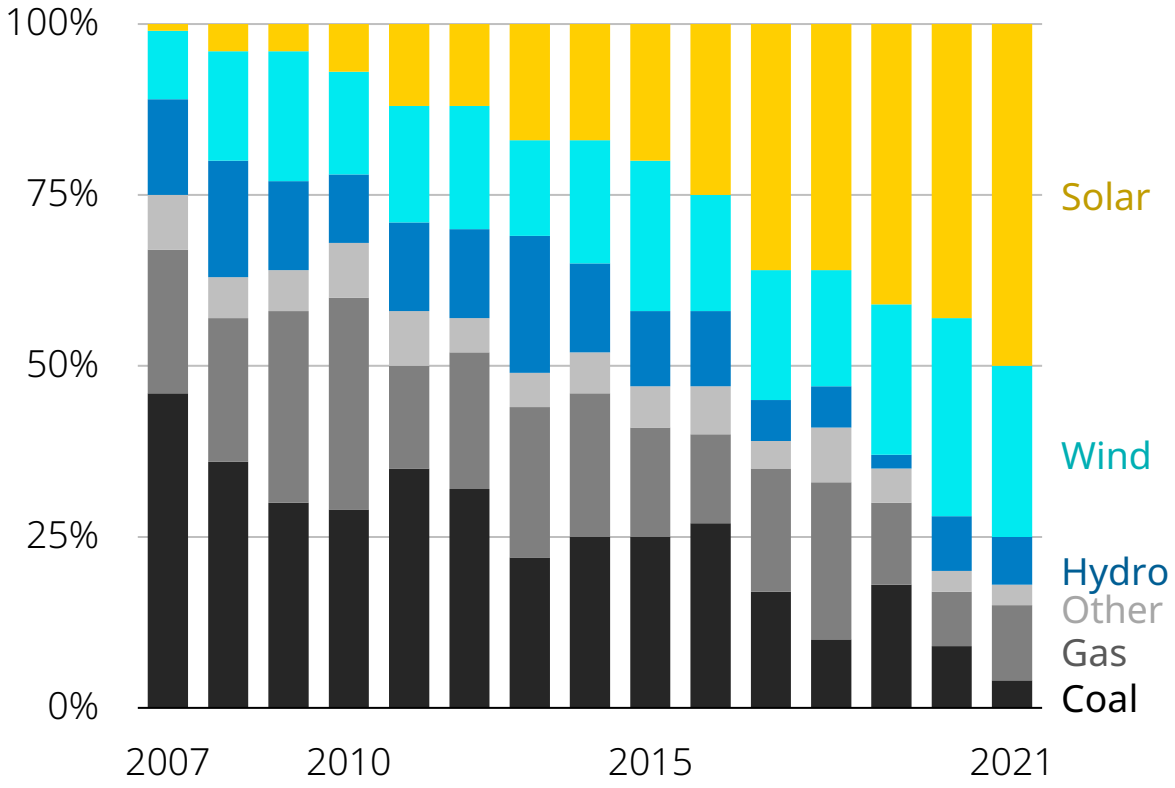
… because global CO_2 emissions are still rising



But, the electricity sector is already transforming

What is already happening:

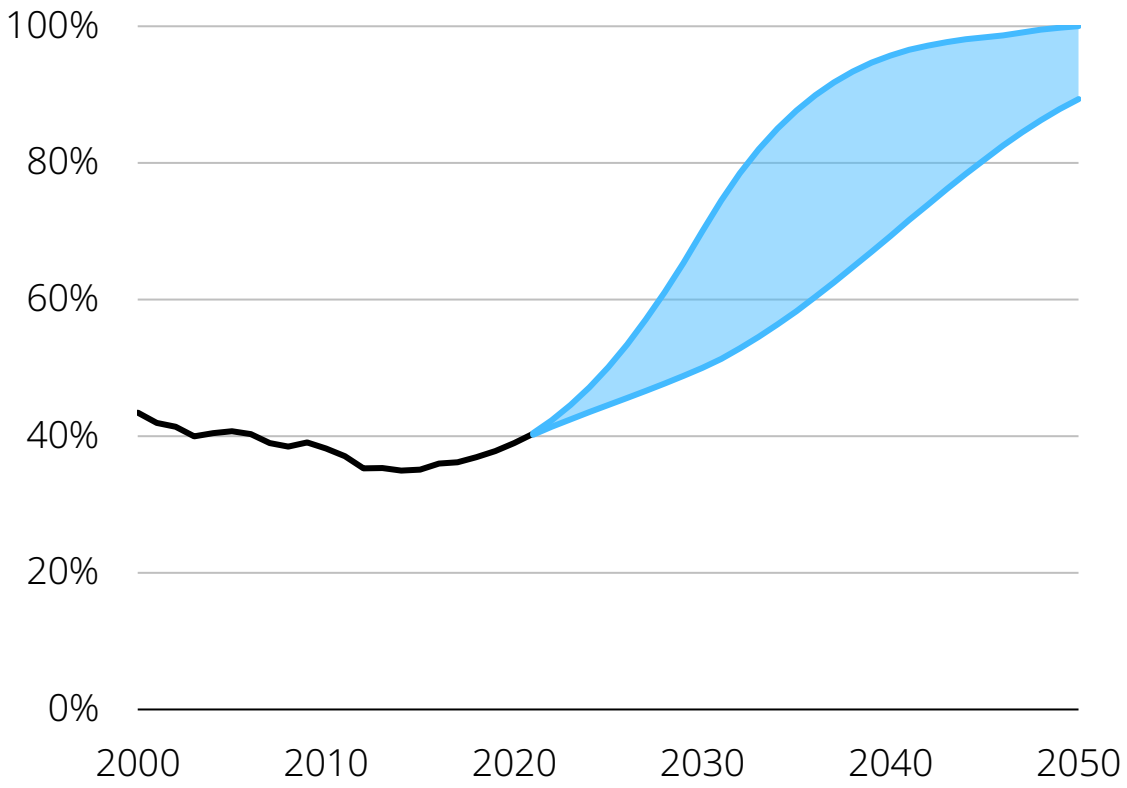
Global capacity additions



Data from BloombergNEF

What will be needed:

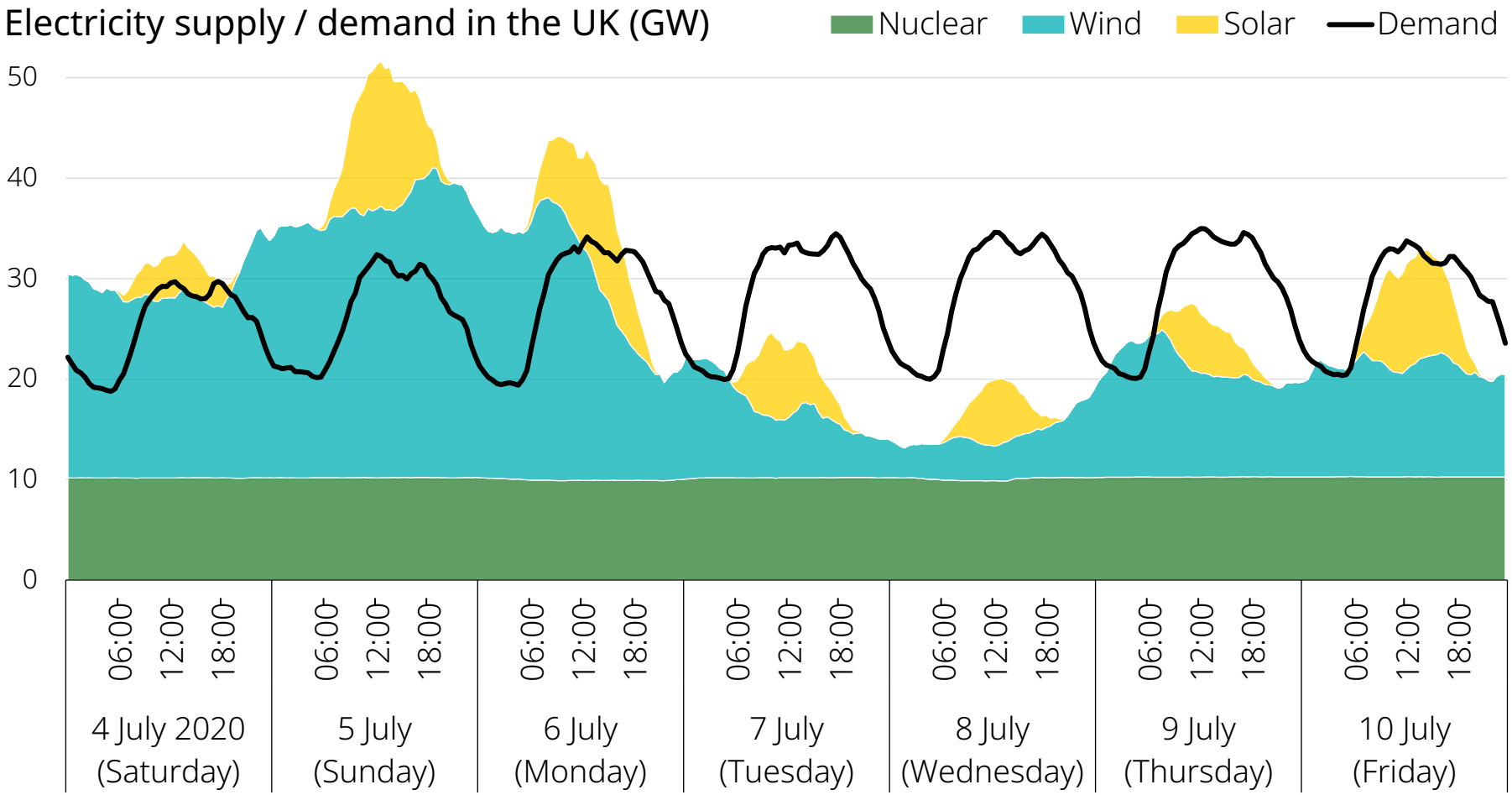
Electricity generation from low-carbon sources



Data from the IPCC 6th Assessment Report

Flexibility is needed to match low-carbon supply and demand

Hourly / Daily scale

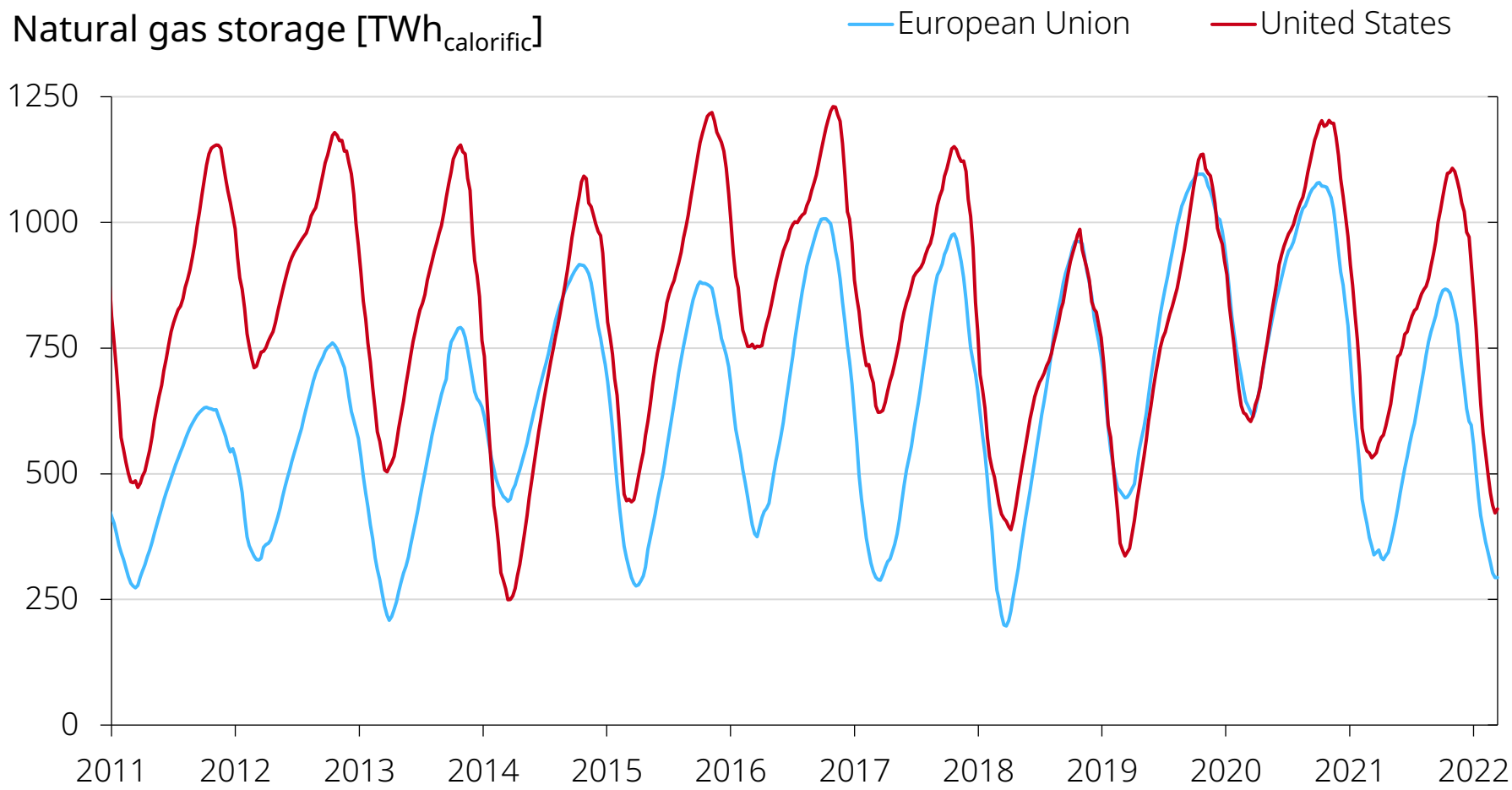


UK storage capacity 2022

- Pumped hydro: 30 GWh
- Battery storage: 3 GWh

Flexibility is needed to match low-carbon supply and demand

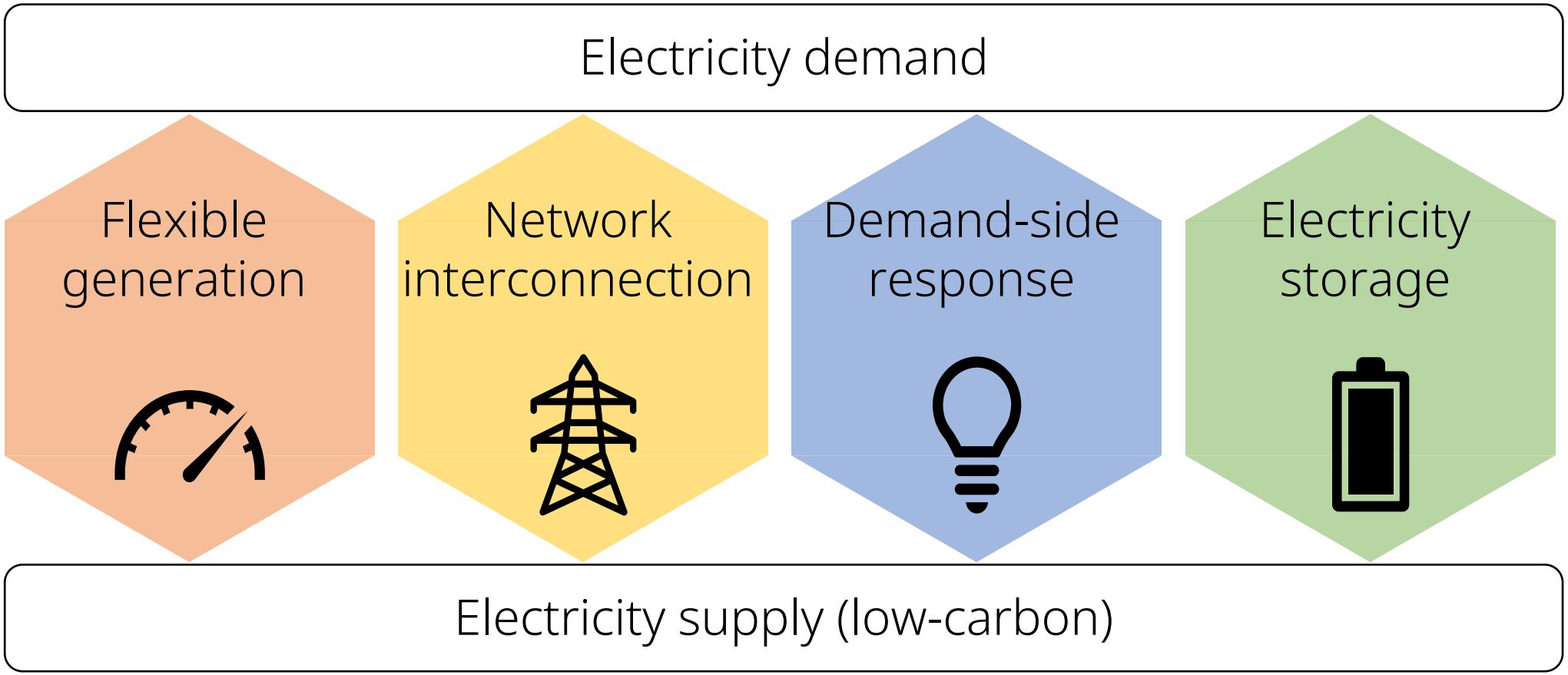
Monthly / Yearly scale



UK storage capacity 2022

- Fossil fuels: 100 TWh
- Electricity: 0.03 TWh

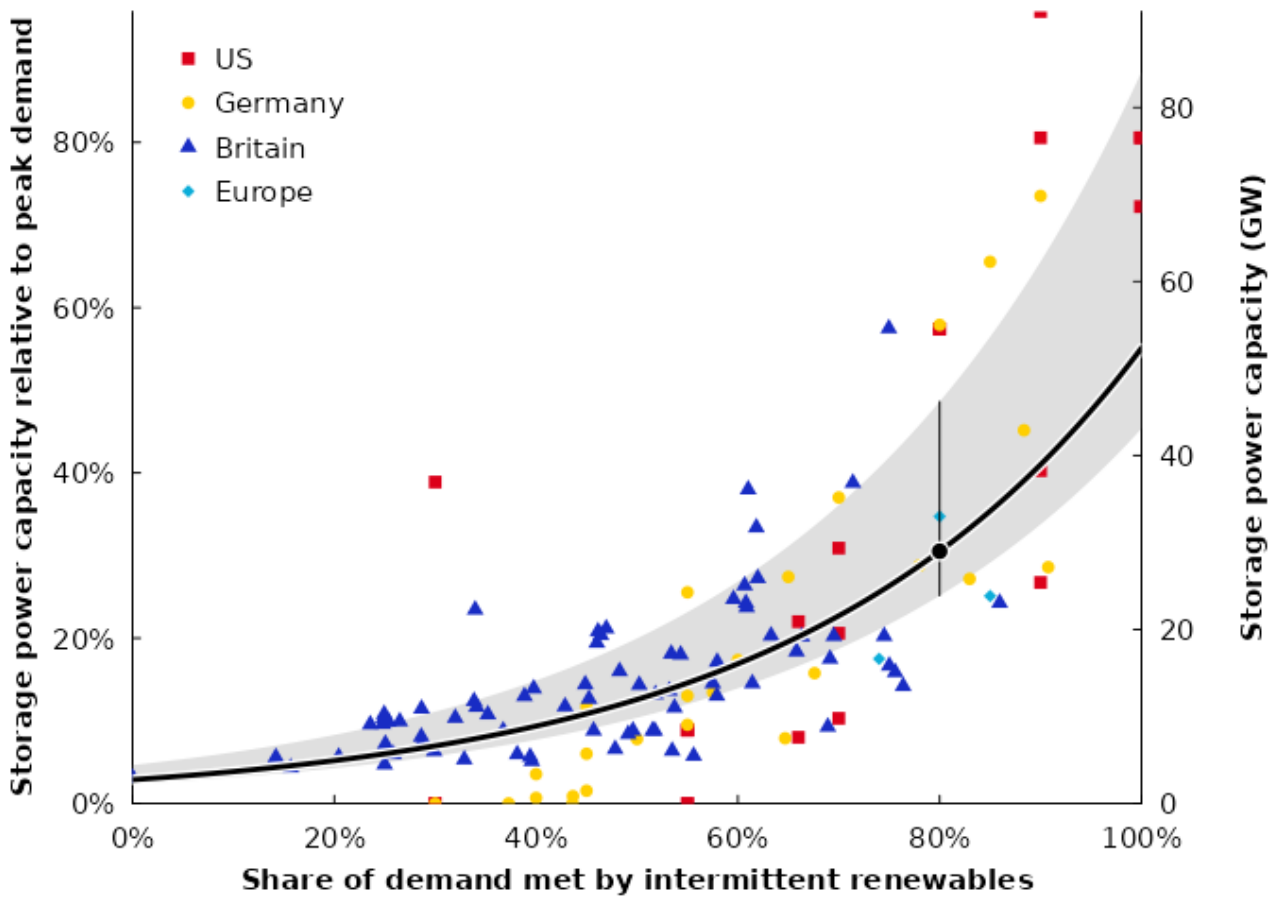
Electricity storage is one of four options to provide flexibility



By 2040, the UK may need 24 – 46 GW electricity storage…

‘Leading the way’ scenario for GB power system by National Grid

- Year: 2040
- Electricity demand: 450 TWh
- Peak demand: 95 GW
- Share of wind and solar: ~80%



You will need 29 GW of storage [24 - 46 best estimate]

Data from National Grid, Future Energy Scenarios, 2023

Graph from www.EnergyStorage.ninja

… and 170 – 570 GWh energy storage capacity

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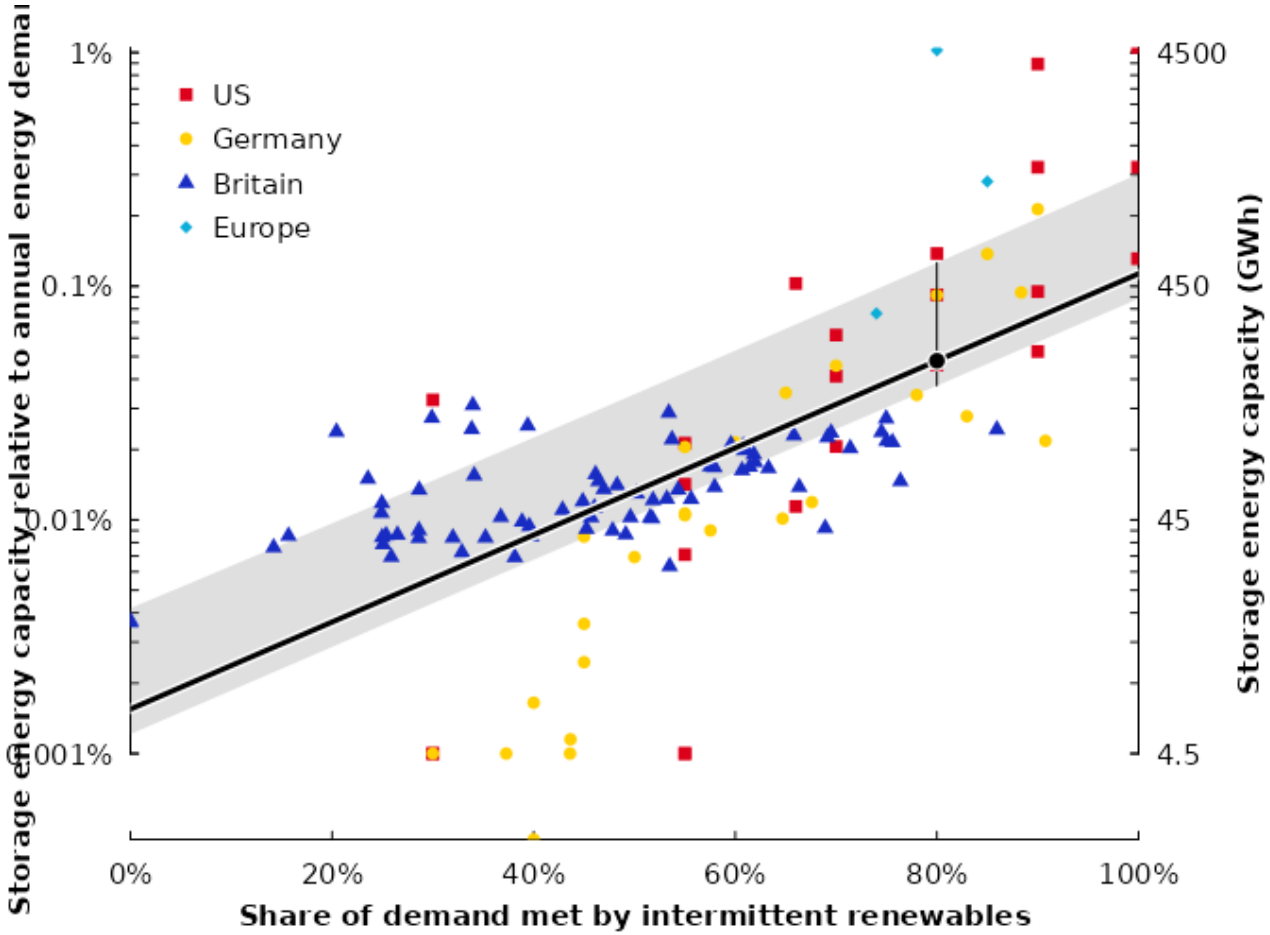


You will need 220 GWh of storage [170 – 570 best estimate]

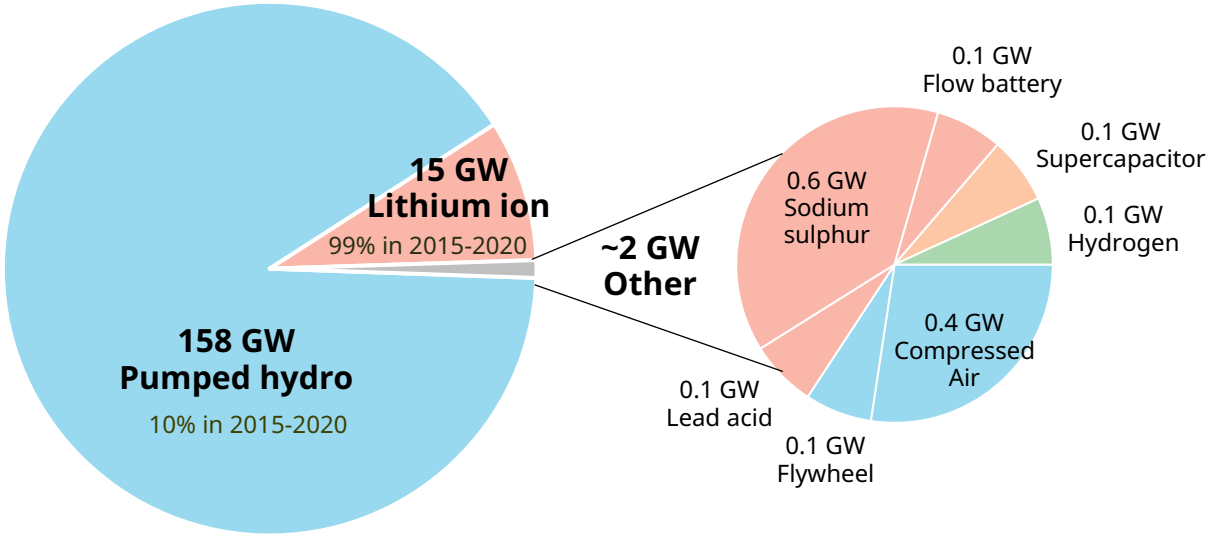
Data from National Grid, Future Energy Scenarios, 2023

Graph from www.EnergyStorage.ninja

Which technology will we use?

2020 stationary storage:

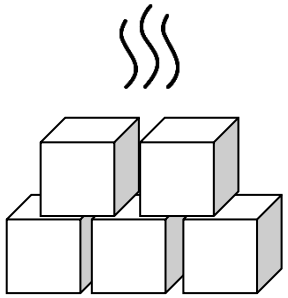
175 GW



2030 stationary storage:

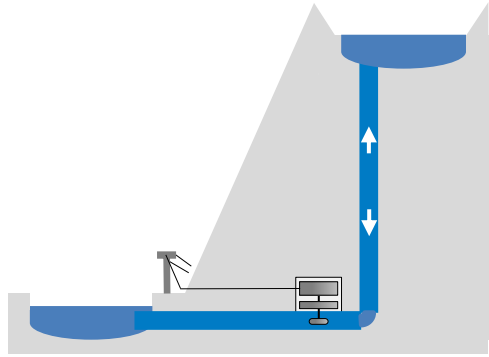
620 GW

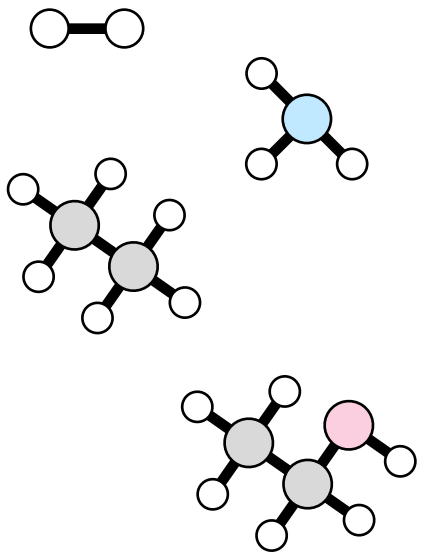
There is a wide range of electricity storage technologies…



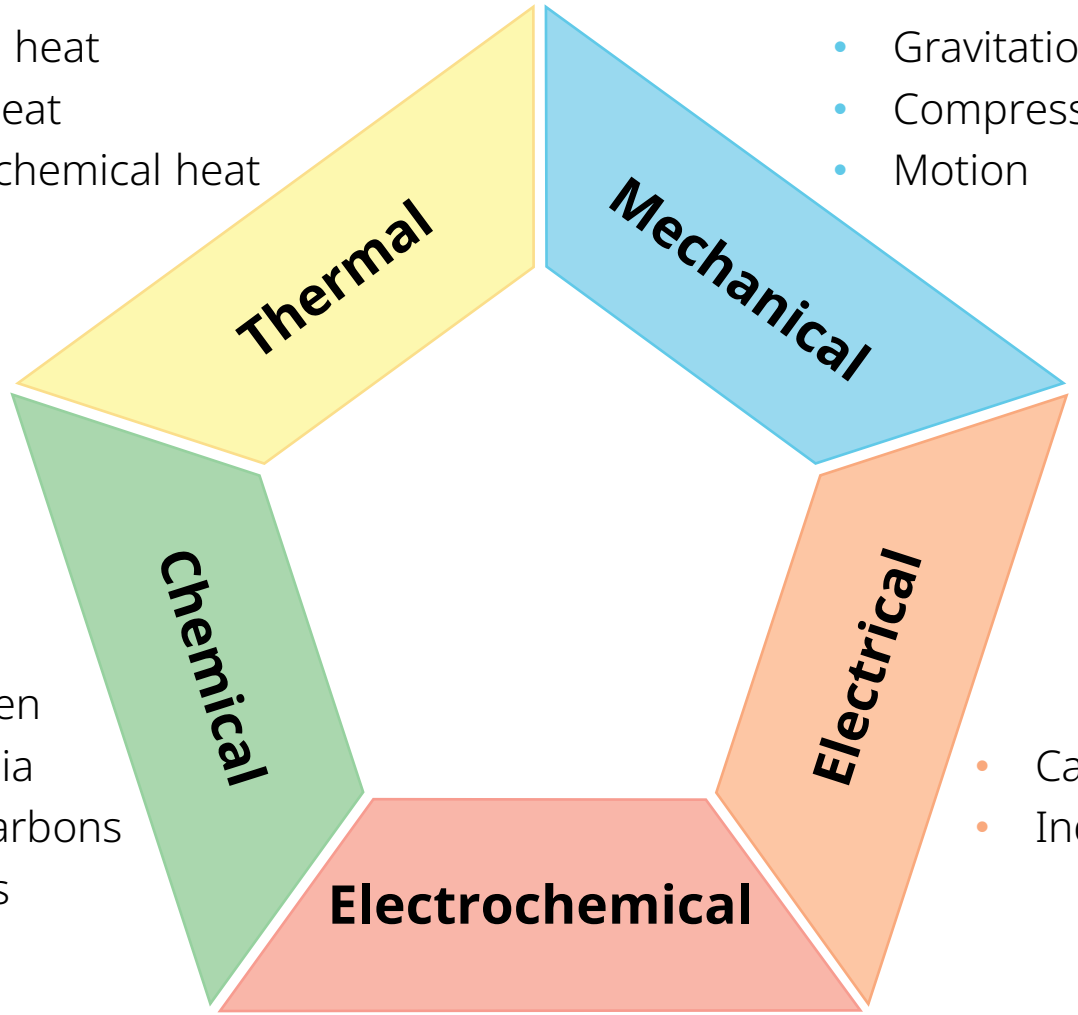
- Sensible heat
- Latent heat
- Thermochemical heat

- Gravitation
- Compression
- Motion

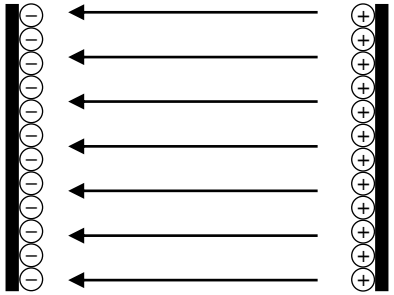


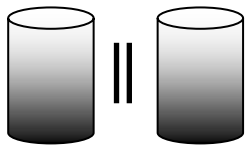


- Hydrogen
- Ammonia
- Hydrocarbons
- Alcohols

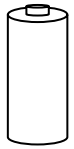


- Capacitance
- Inductance

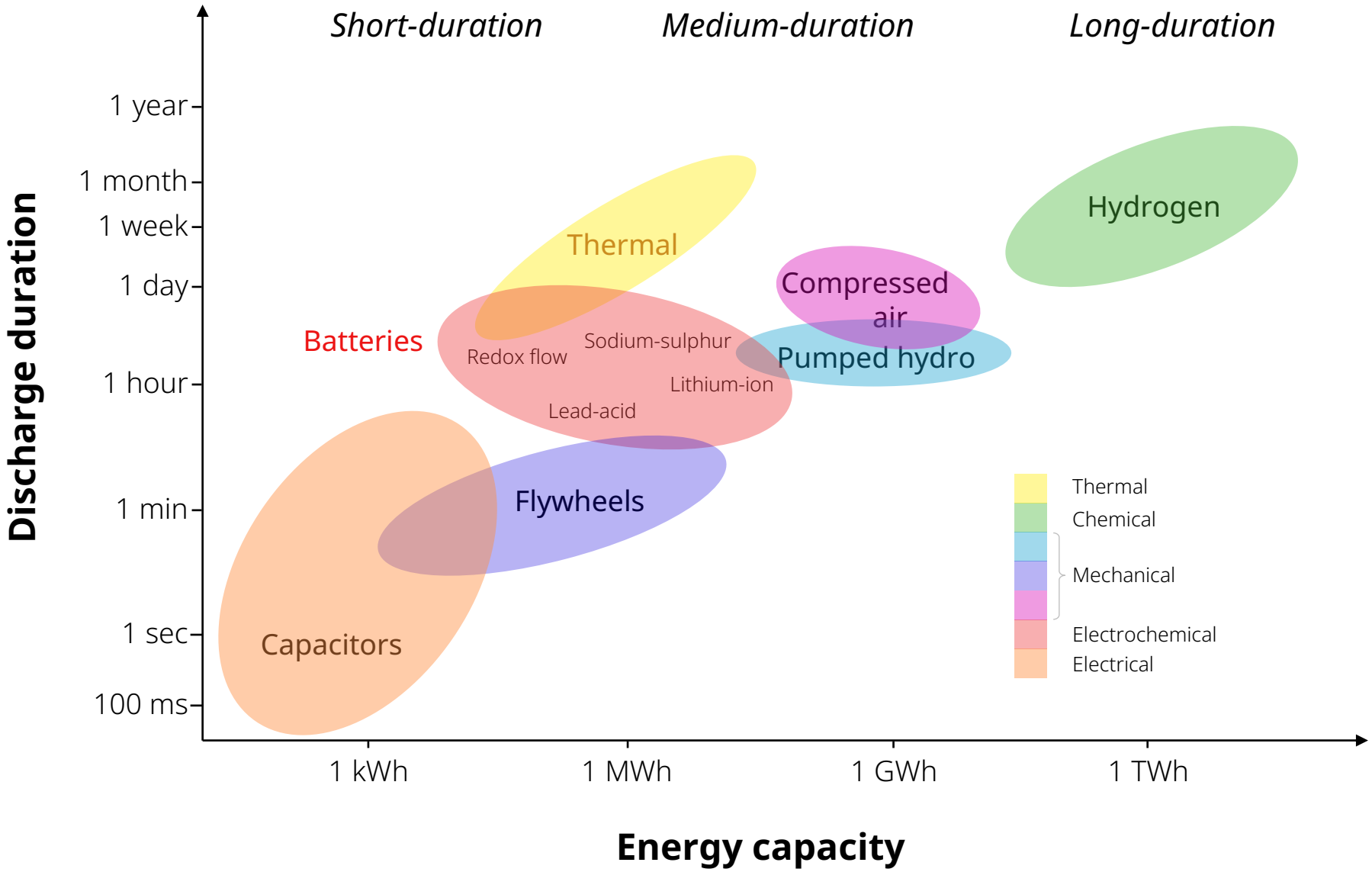




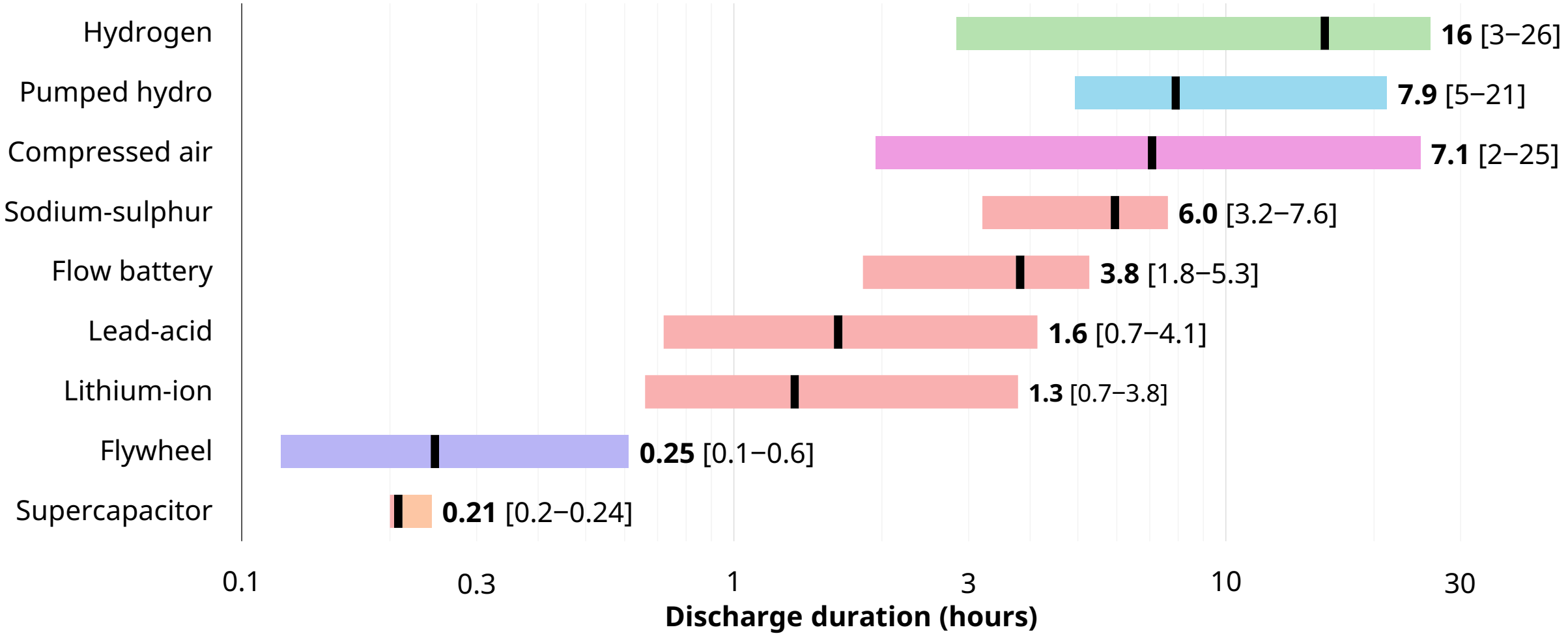
- Sealed batteries
- Flow batteries



… that all fit for different purposes



This is confirmed when looking at projects installed globally



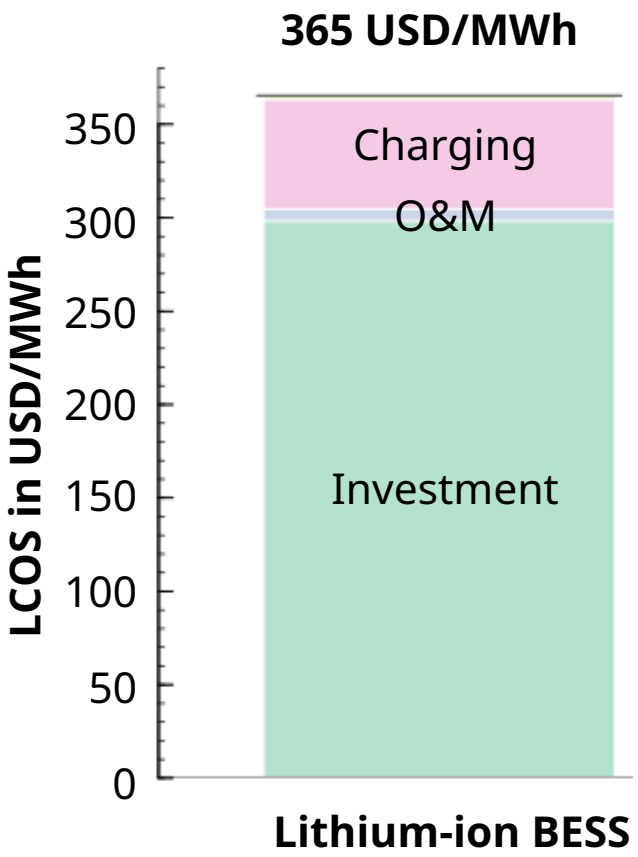
Lifetime cost is the metric to decide which technology to use

Levelised Cost Of Storage:

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

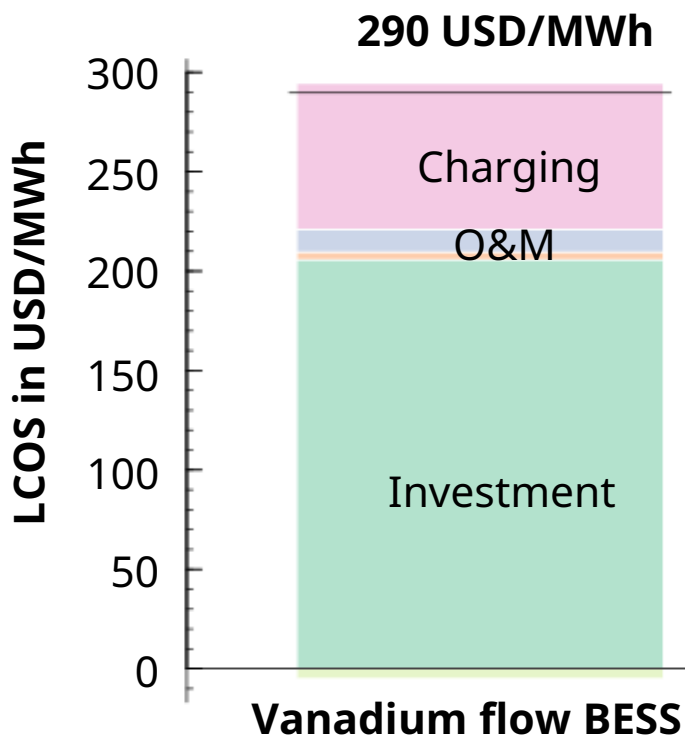
In peak capacity, flow batteries beat lithium-ion BESS

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



Specifications

- 362 USD/kWh$_{cap}$
- 86% efficiency
- 3,500 cycles



Specifications

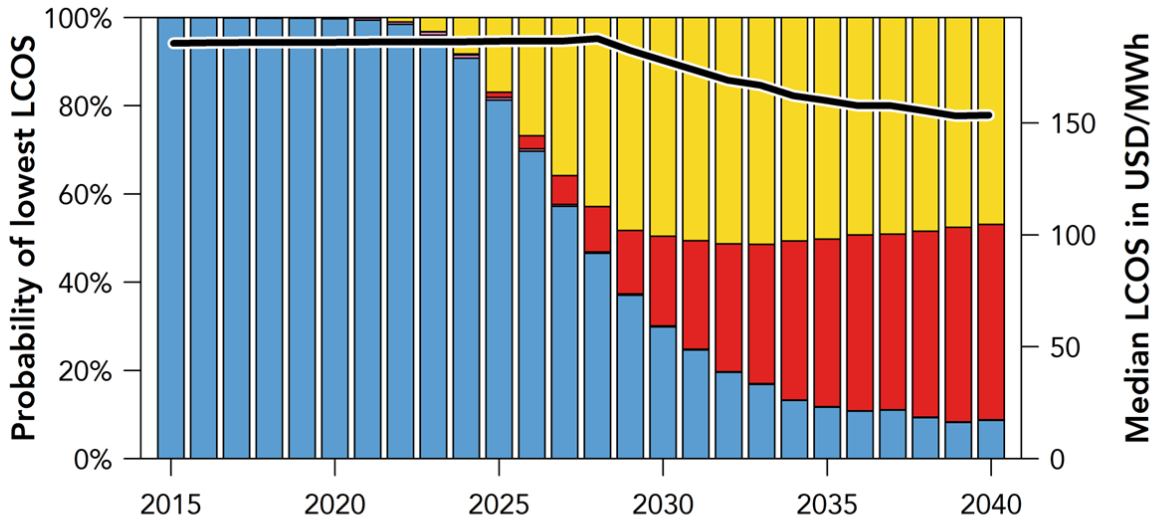
- 625 USD/kWh$_{cap}$
- 68% efficiency
- 20,000 cycles

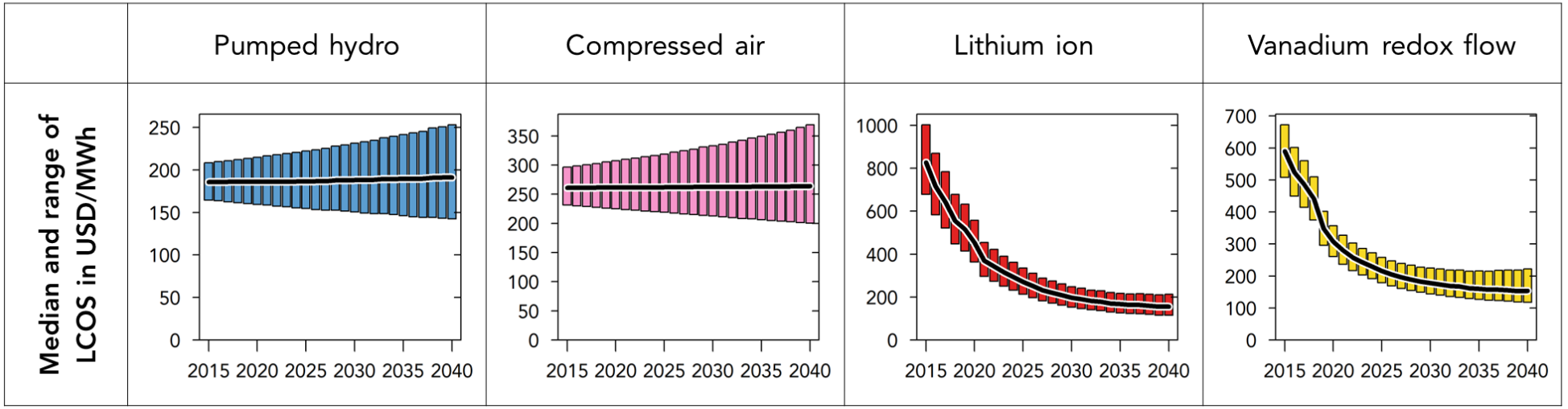
Graph from www.EnergyStorage.ninja

But, technology competitiveness changes over time

PC Peak capacity

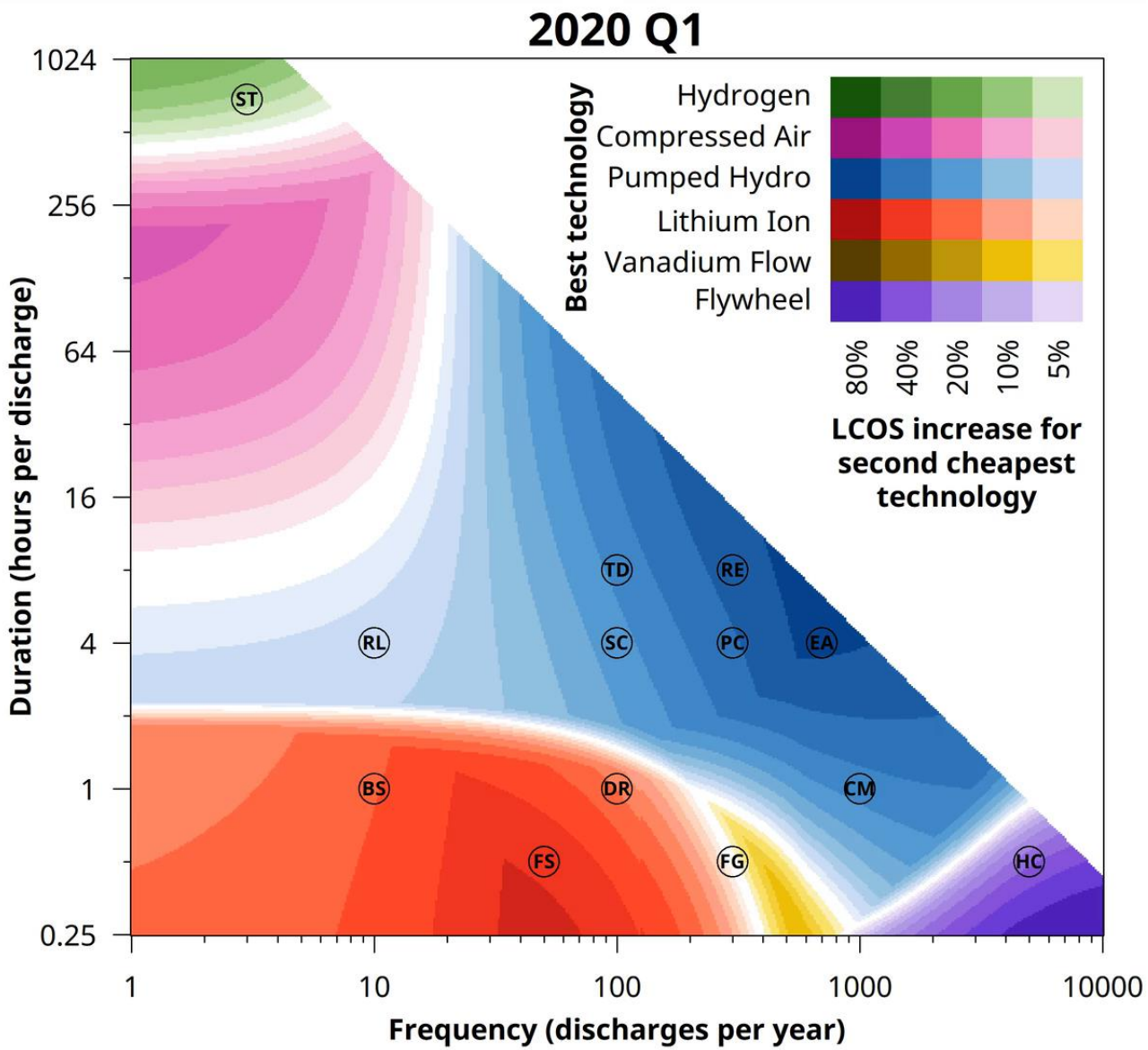
Power capacity	10 MW
Discharge duration	4 hours
Annual cycles	300
Response time	>10 seconds
Electricity price	50 USD/MWh





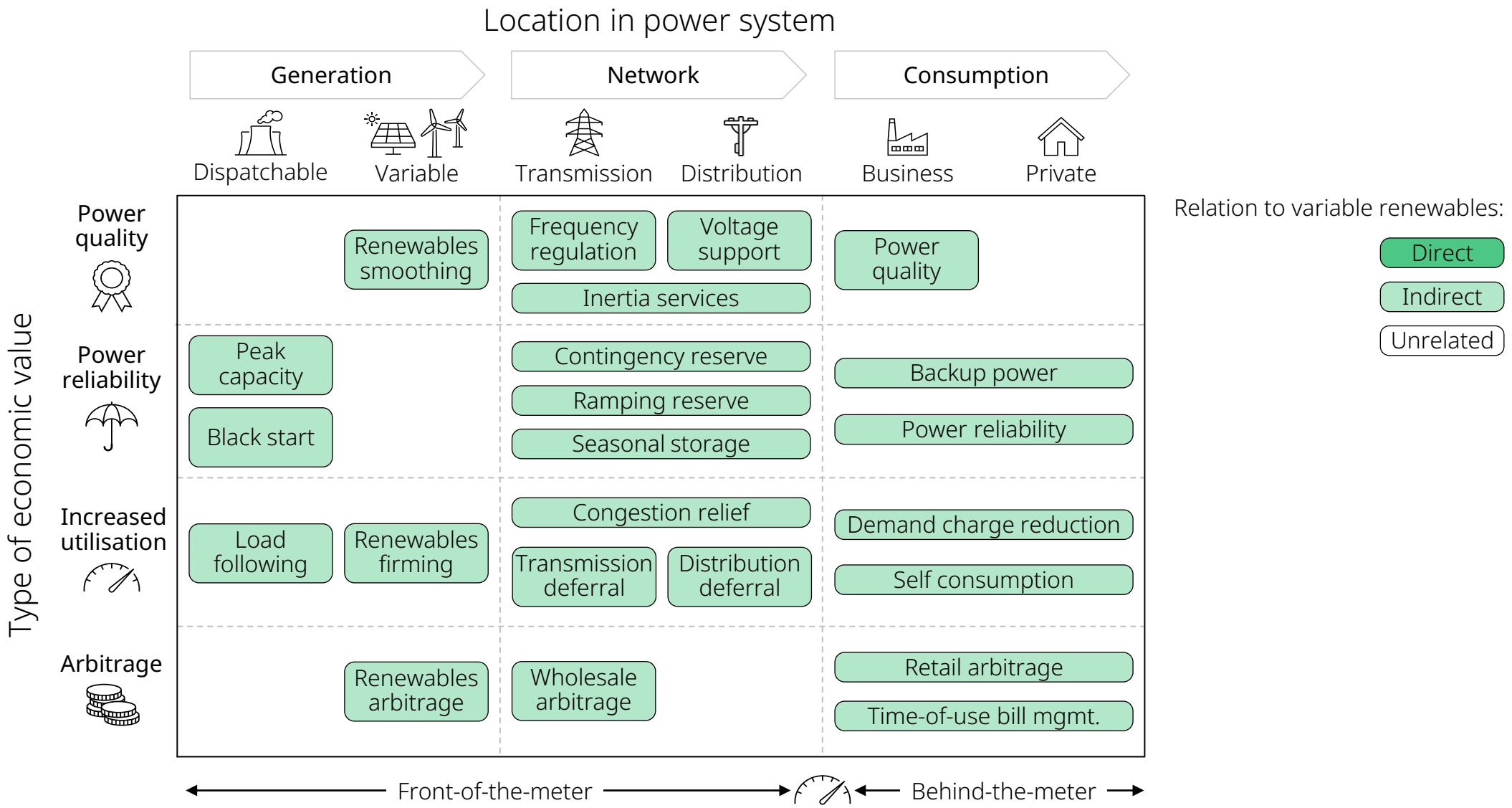
Graph from www.EnergyStorage.ninja

There are dominant technologies for different requirements



Graph from www.EnergyStorage.ninja

At the same time, there is a wide range of applications…



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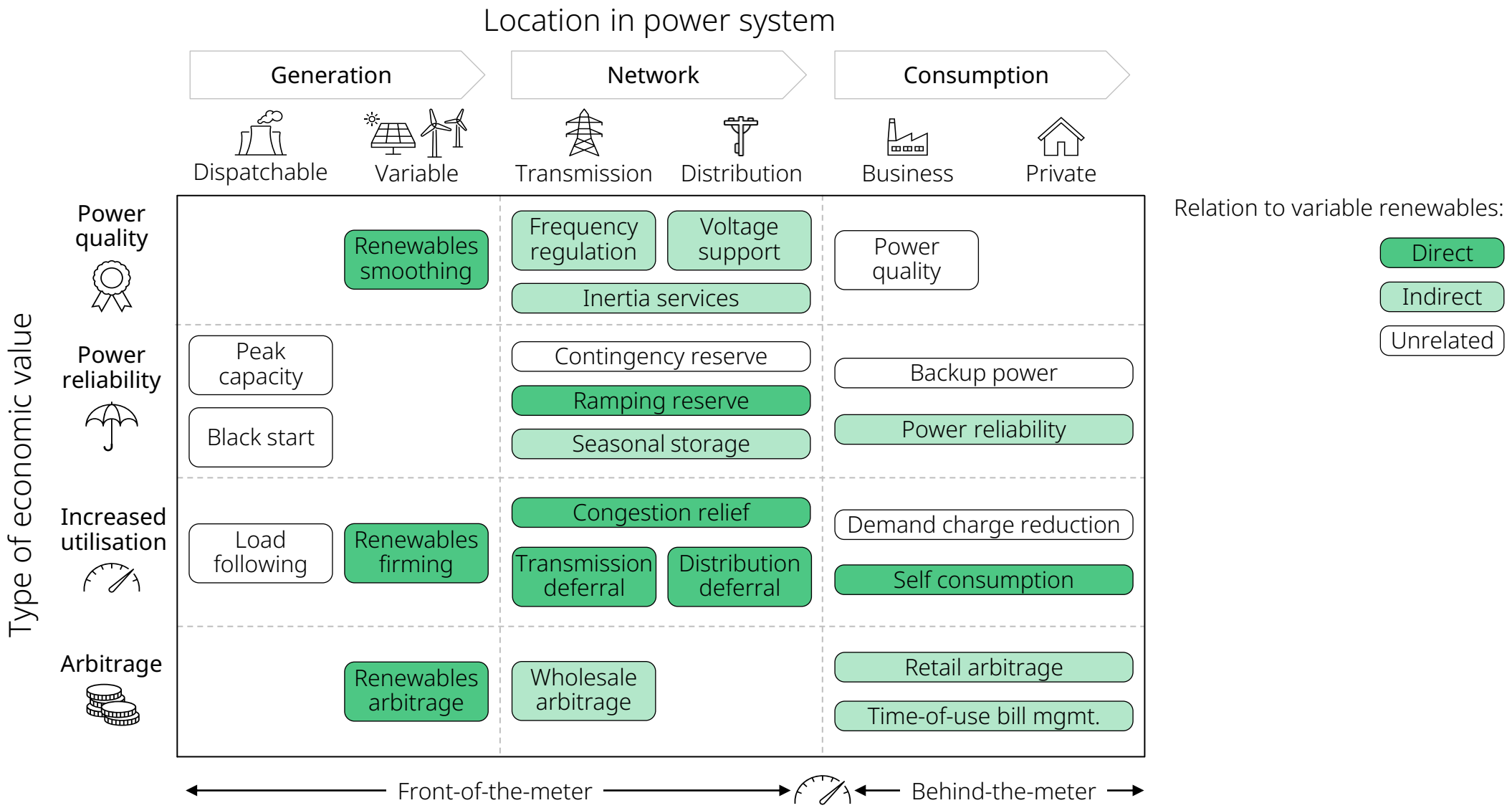


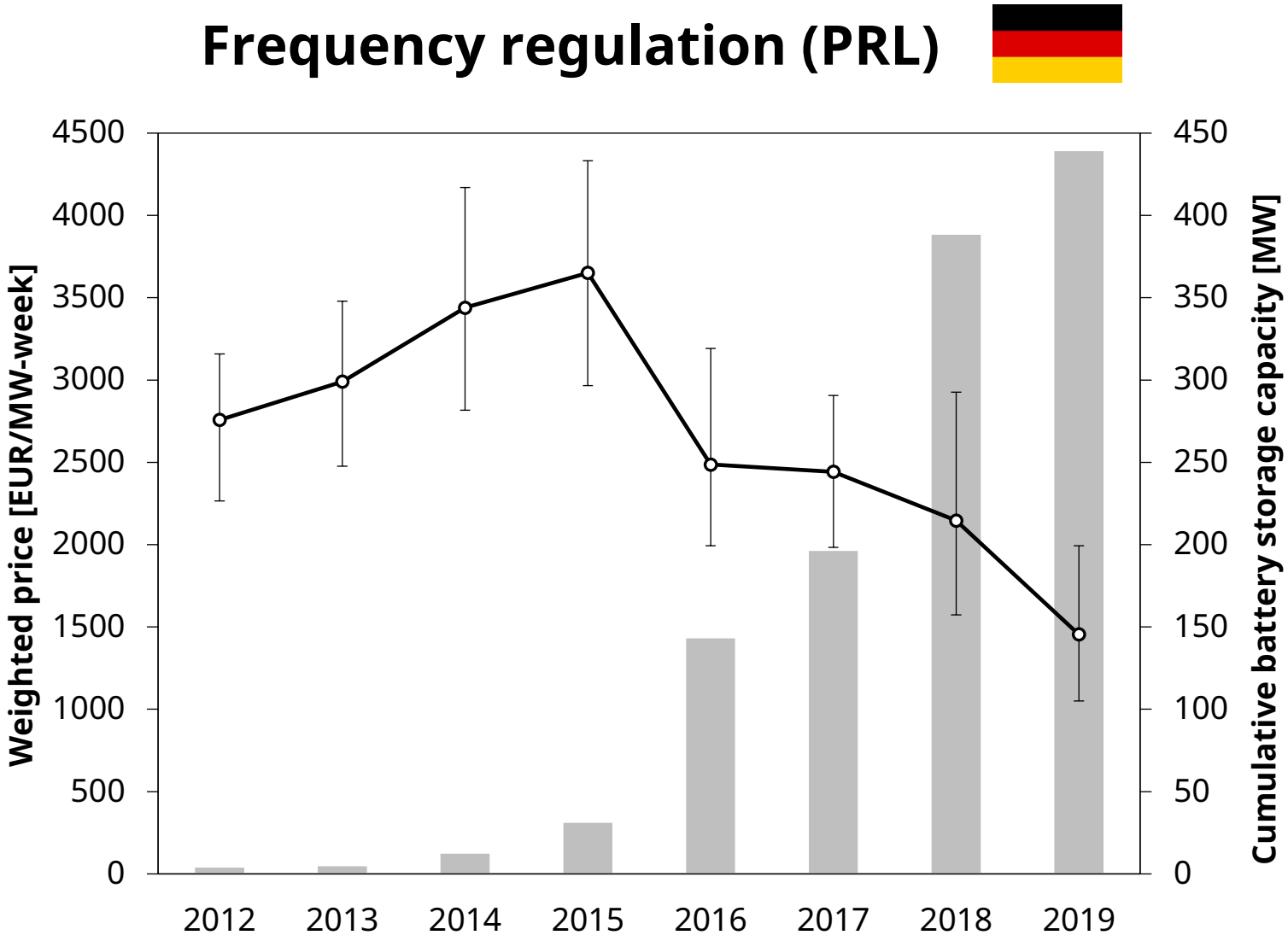
… that may roughly follow 4 phases of deployment

Phase	Description	Archetype application	Deployment potential	Discharge duration	Response time
Pre-2010	Low-cost nuclear power	Various	–	Mostly 8-12 hours	Minutes

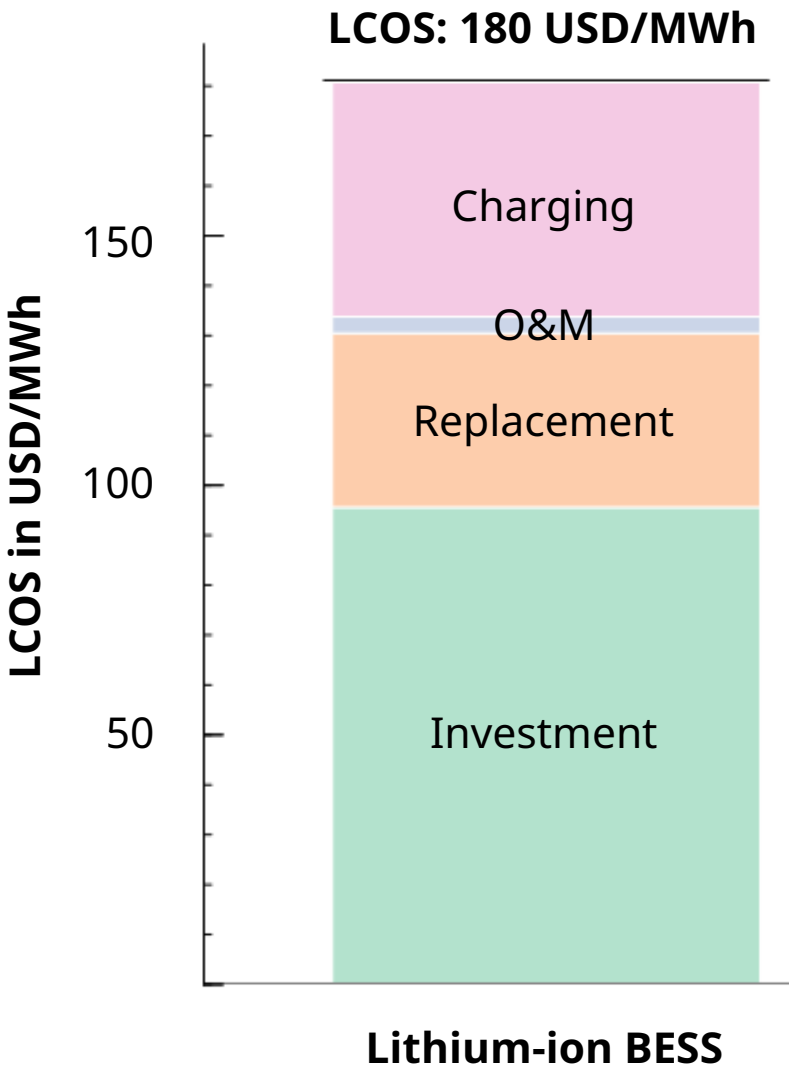
low mid high ? uncertain

Concept from NREL

System stability markets (Phase 1) are relatively shallow…

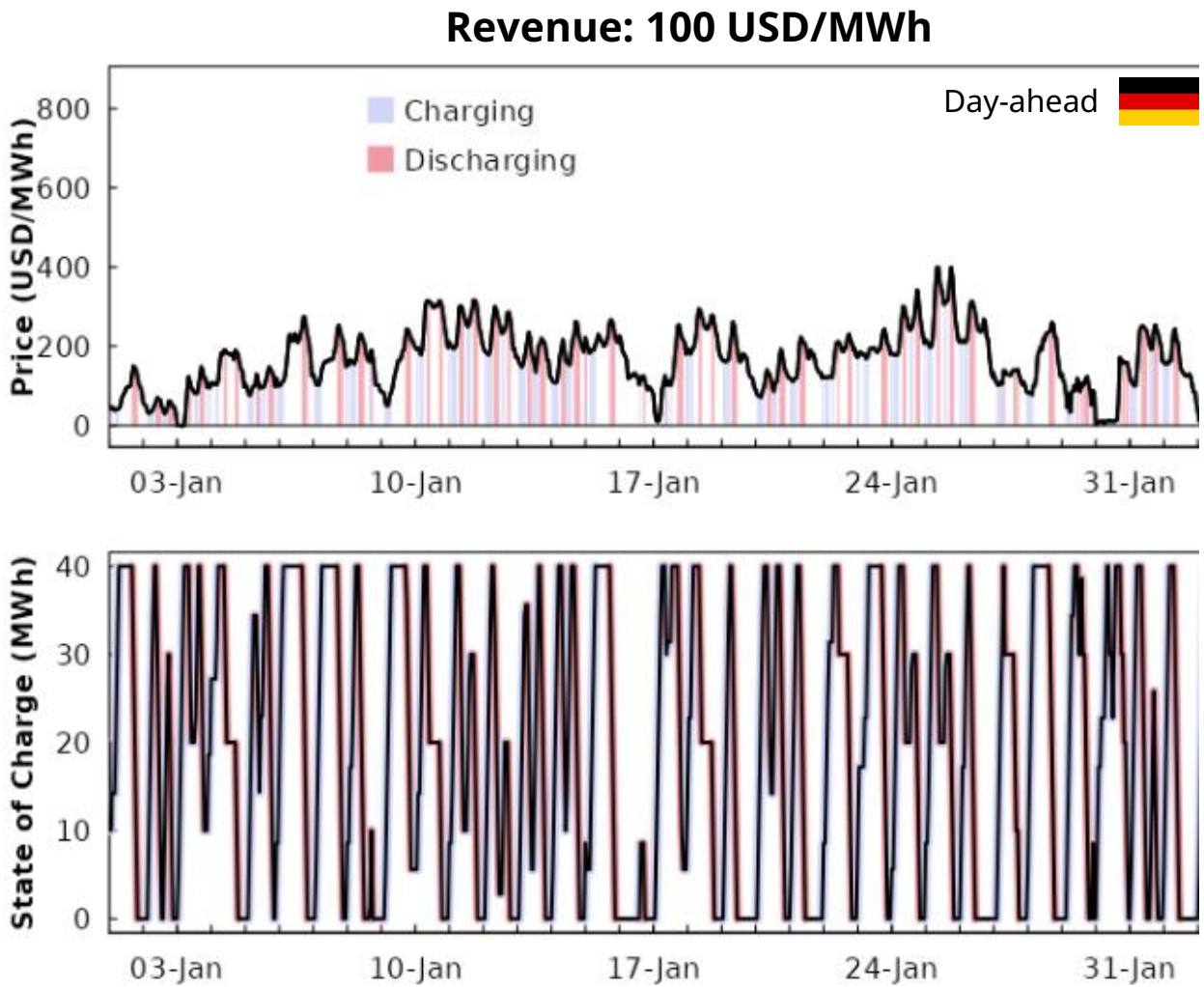


… and operation in spot market arbitrage is not yet profitable



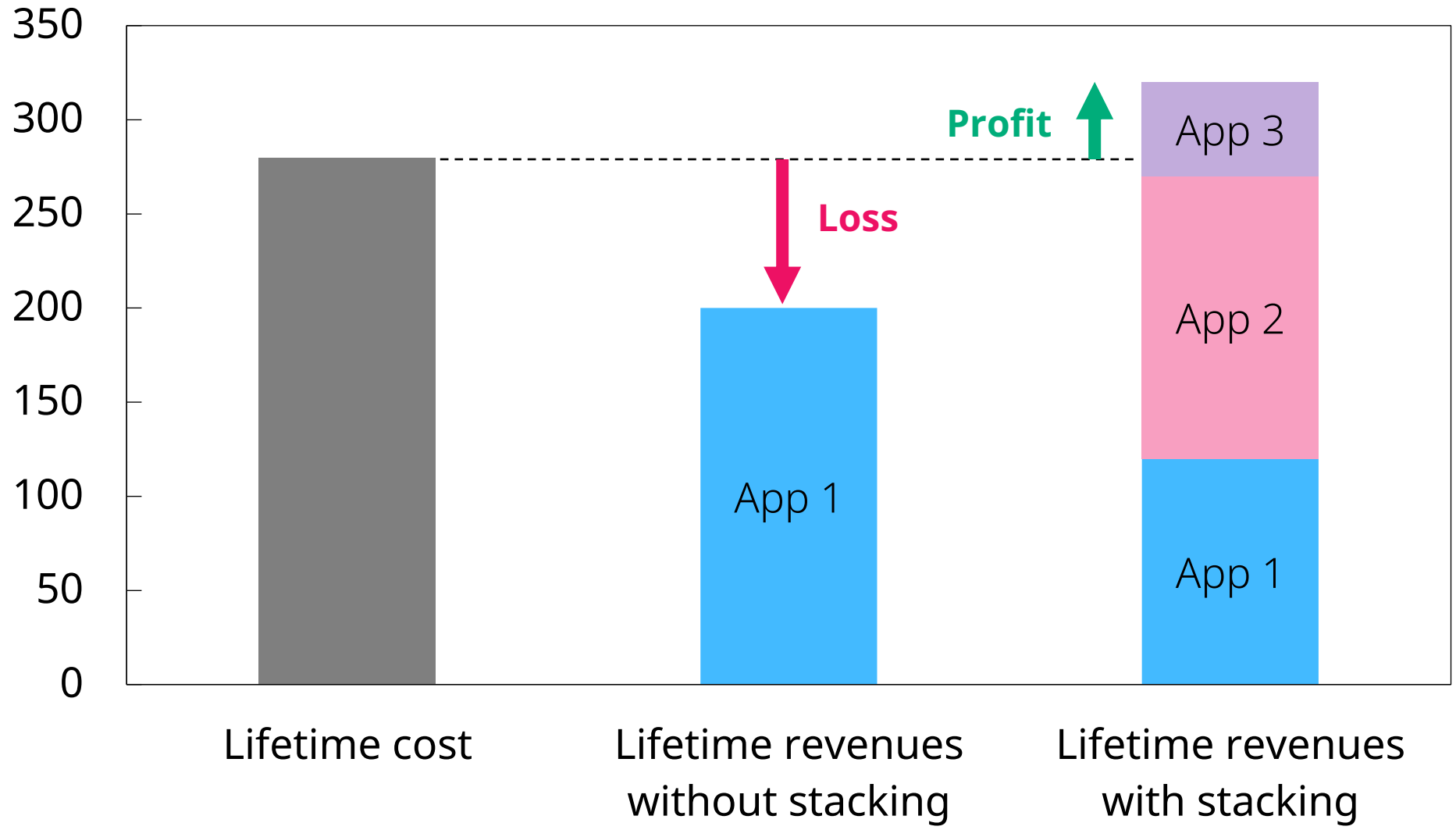
Specifications

- 10 MW / 40 MWh
- 15 years
- 550 cycles p.a.
- 86% efficiency
- 8% discount rate

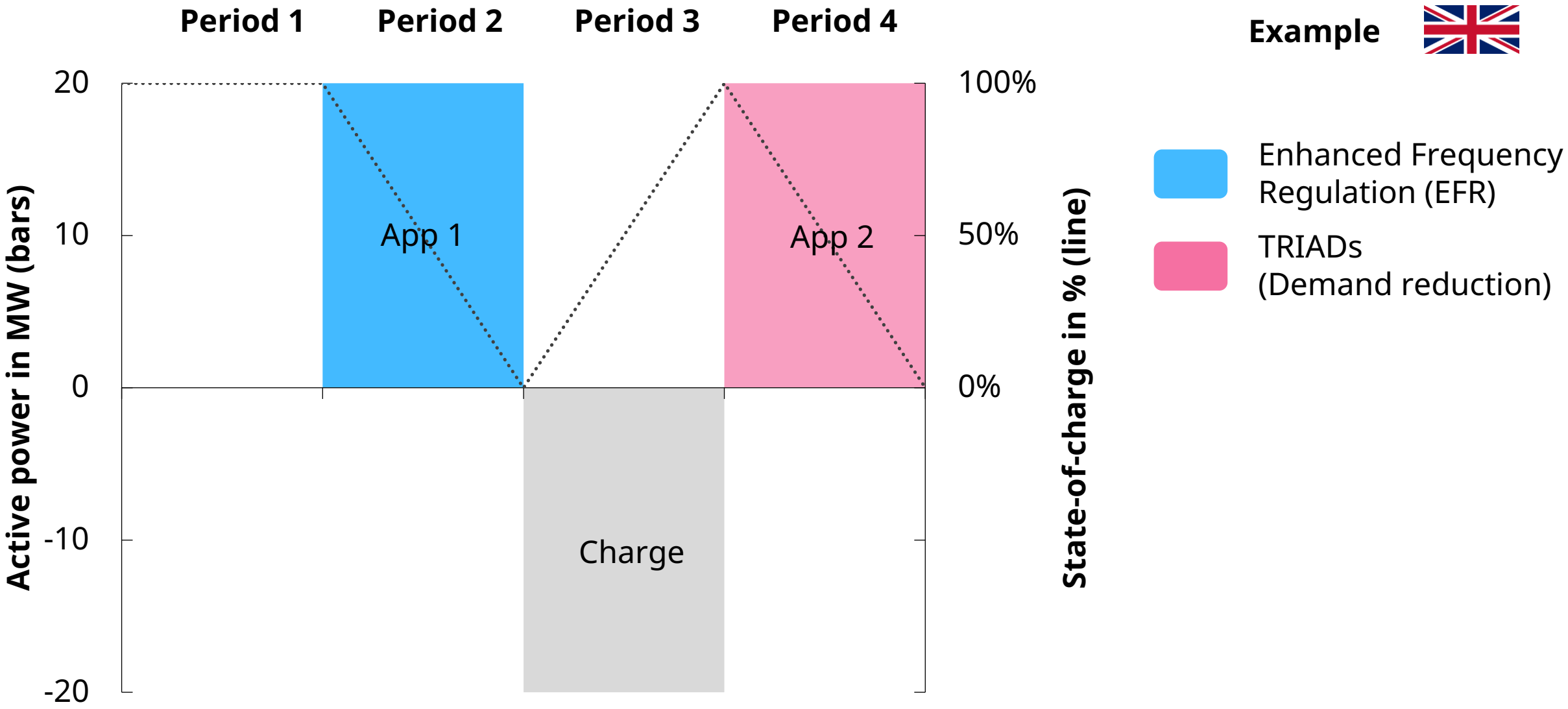


Graph from www.EnergyStorage.ninja

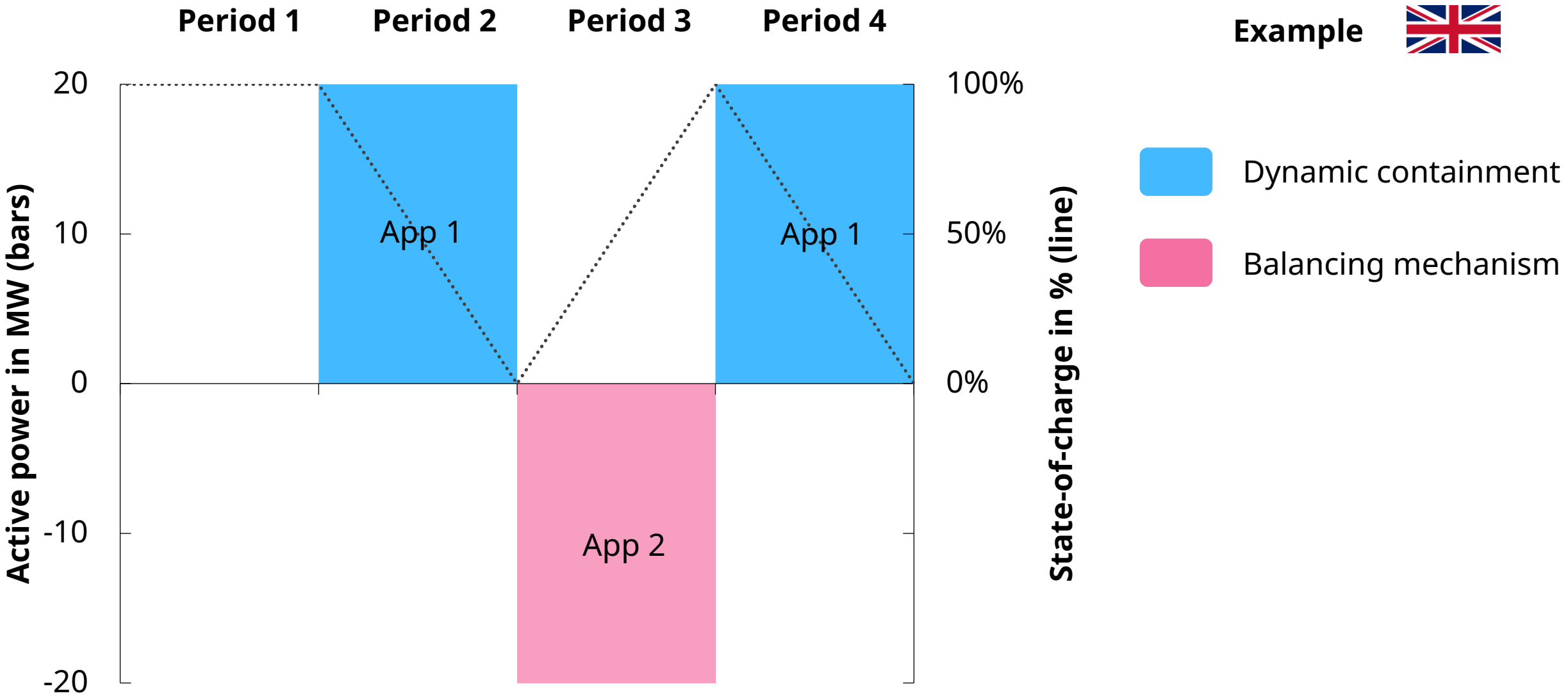
Therefore, multiple revenue streams must be combined



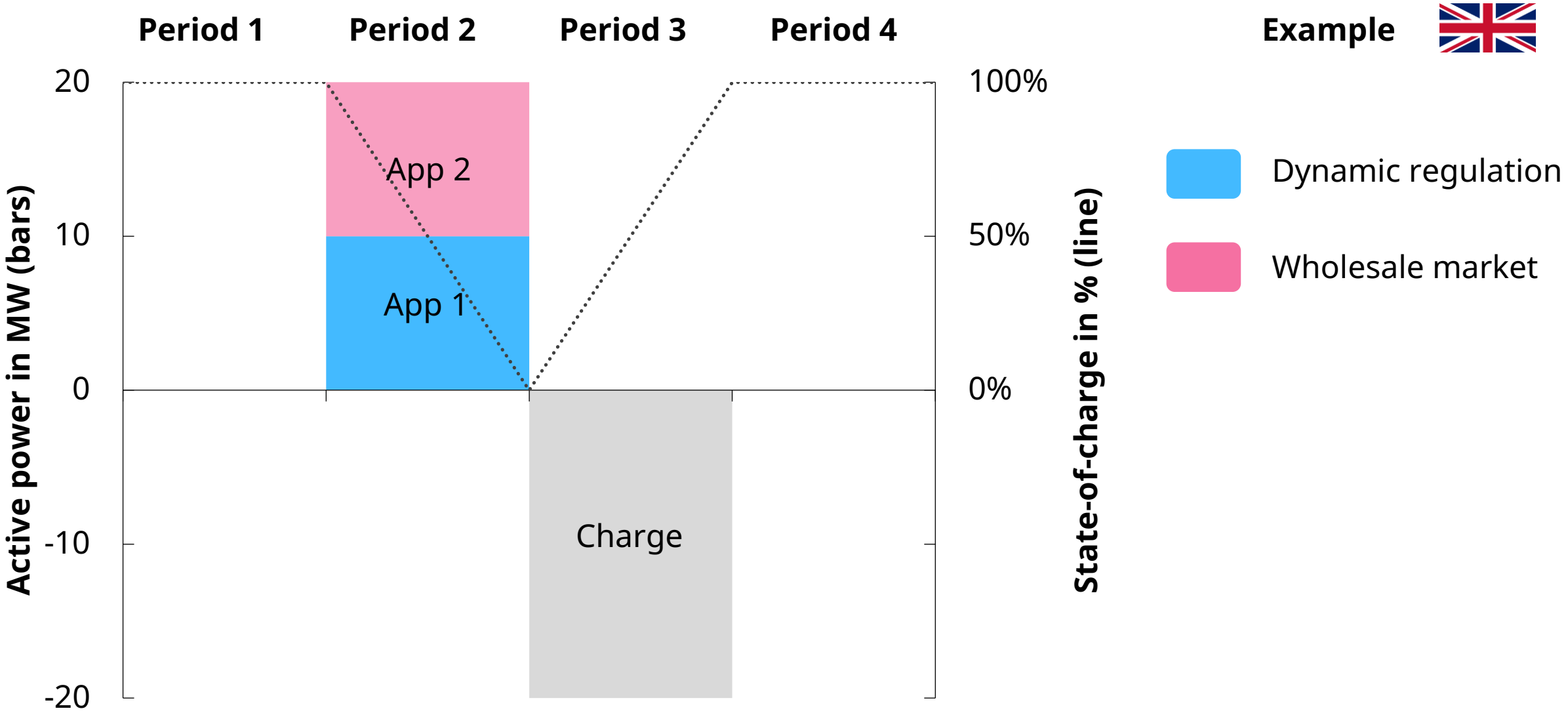
Option 1: Sequential stacking



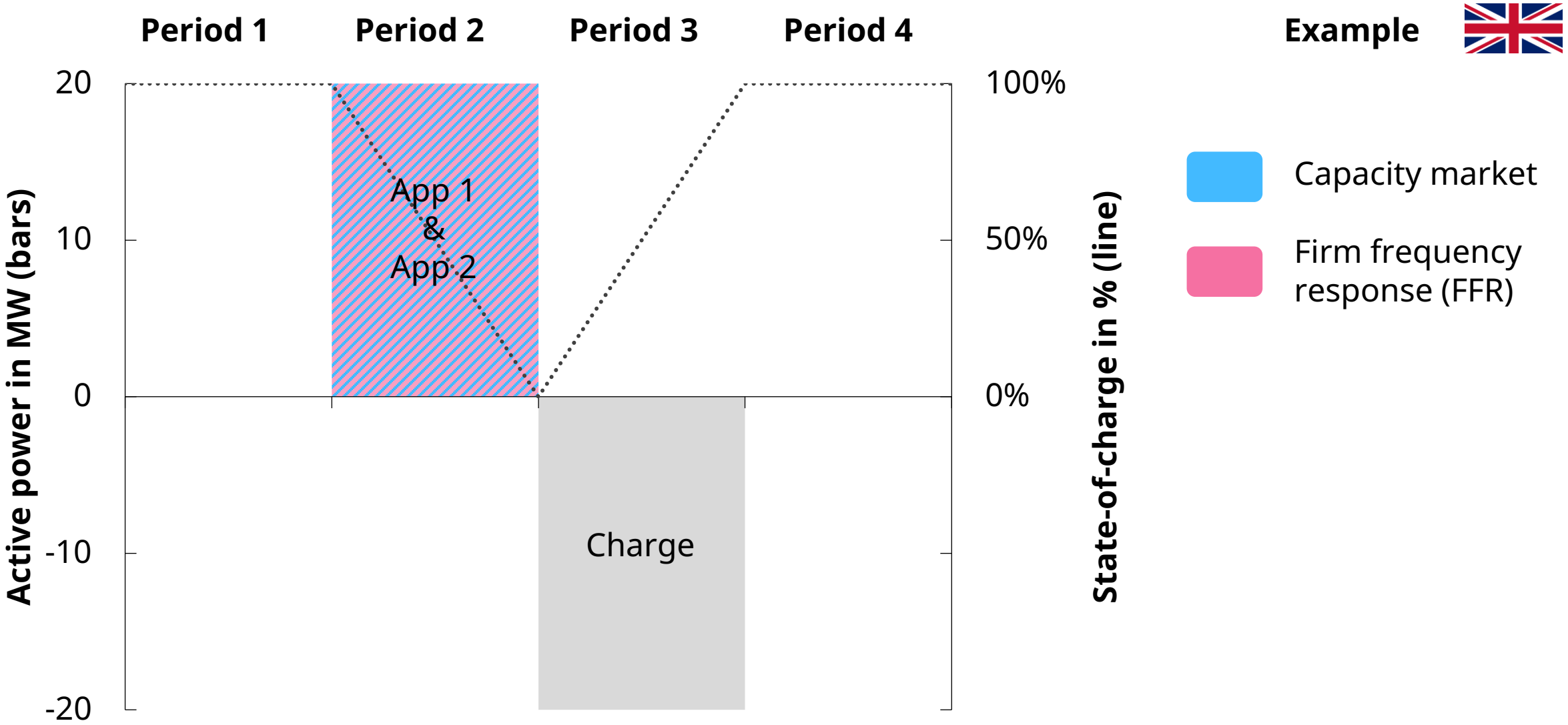
Option 2: Sequential stacking in opposite directions



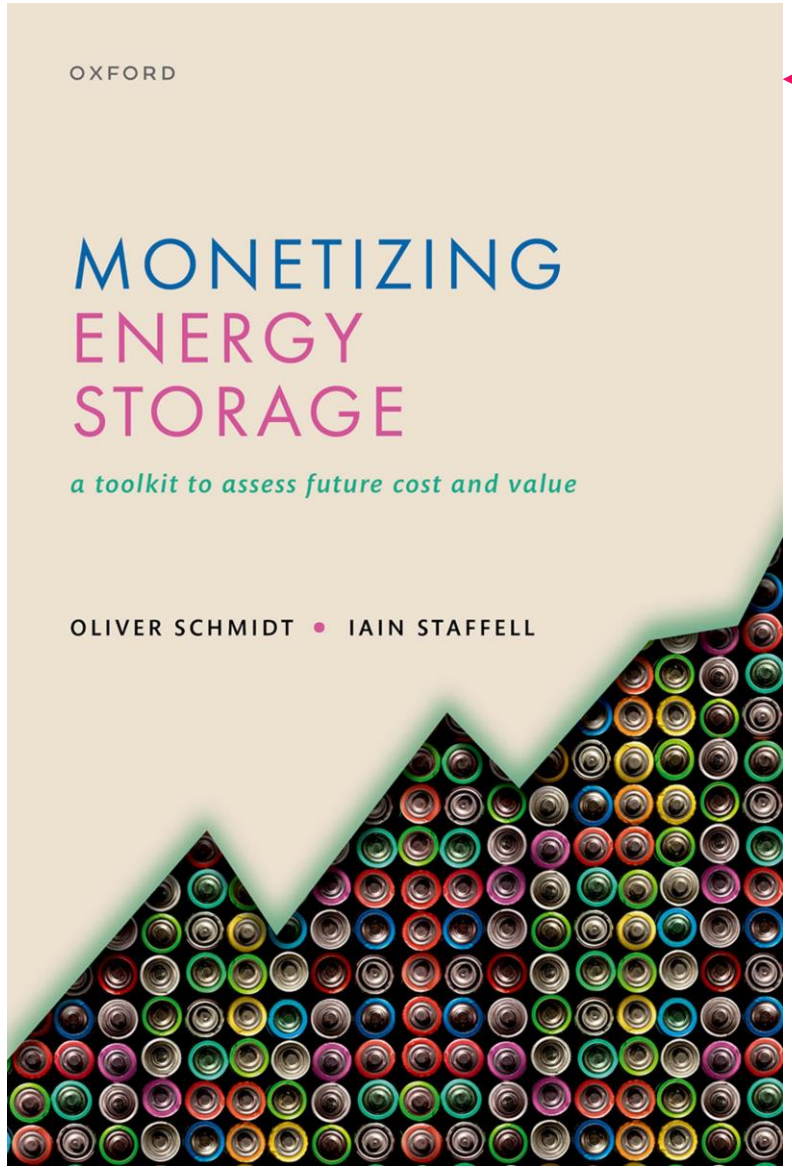
Option 3: Parallel stacking



Option 4: Overlapped stacking



All insights and tools available in my book and website



More insights (and data and methodology)

User-friendly tools for custom analyses