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Storage in the energy market

Richard Green and Goran Strbac

PES-GM 2015, Denver

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including “The long-run impact of energy storage on prices and capacity”

Richard Green and Iain Staffell

PES-GM 2015, Denver

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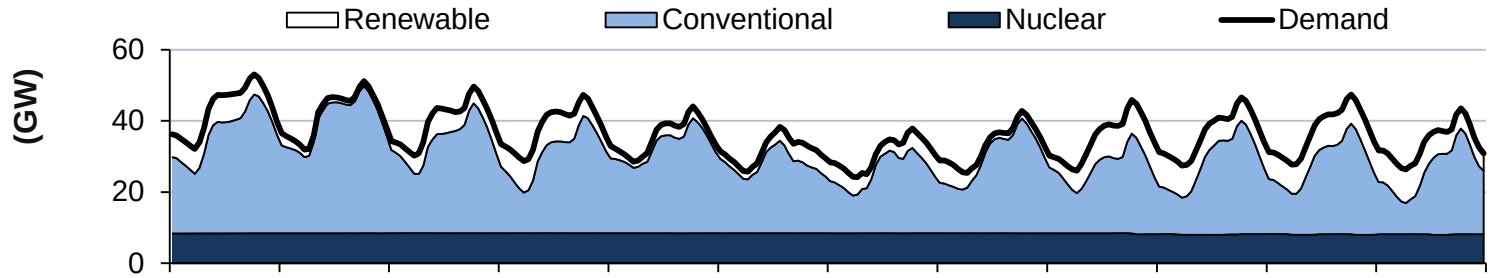
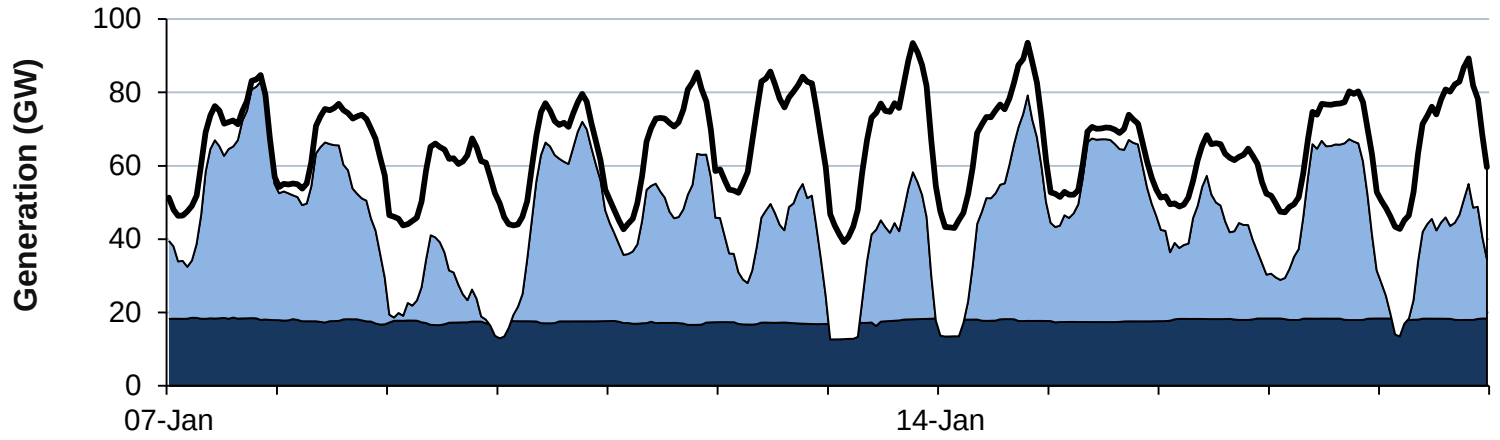
The macro need for storage

UK loads from the DESSTinEE model

2014



2050



Future demand profile changed by electric vehicles and heating; while weather-driven renewables severely constrain other plants

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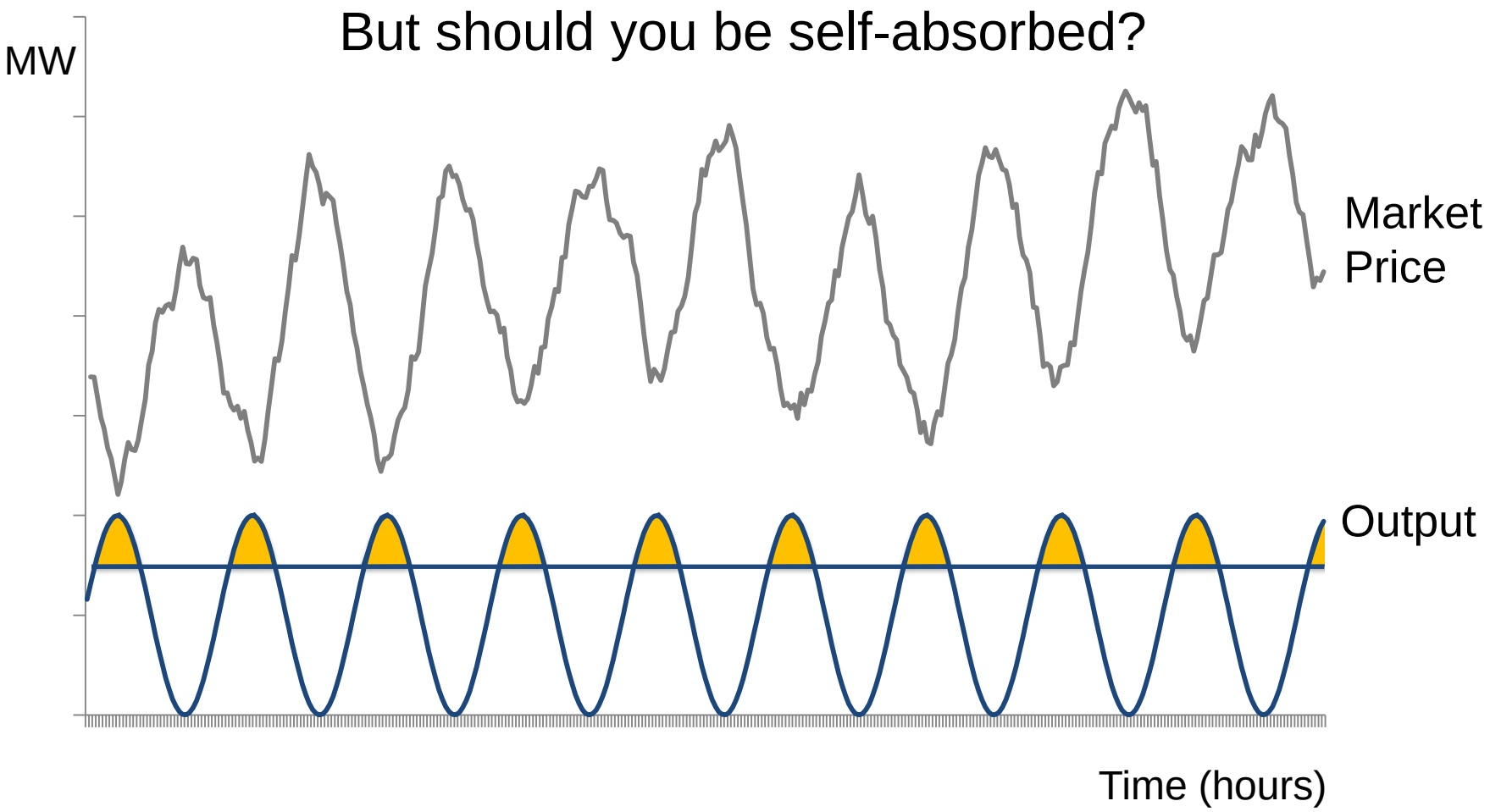
The micro need for storage

Simulated stylised pseudo-data



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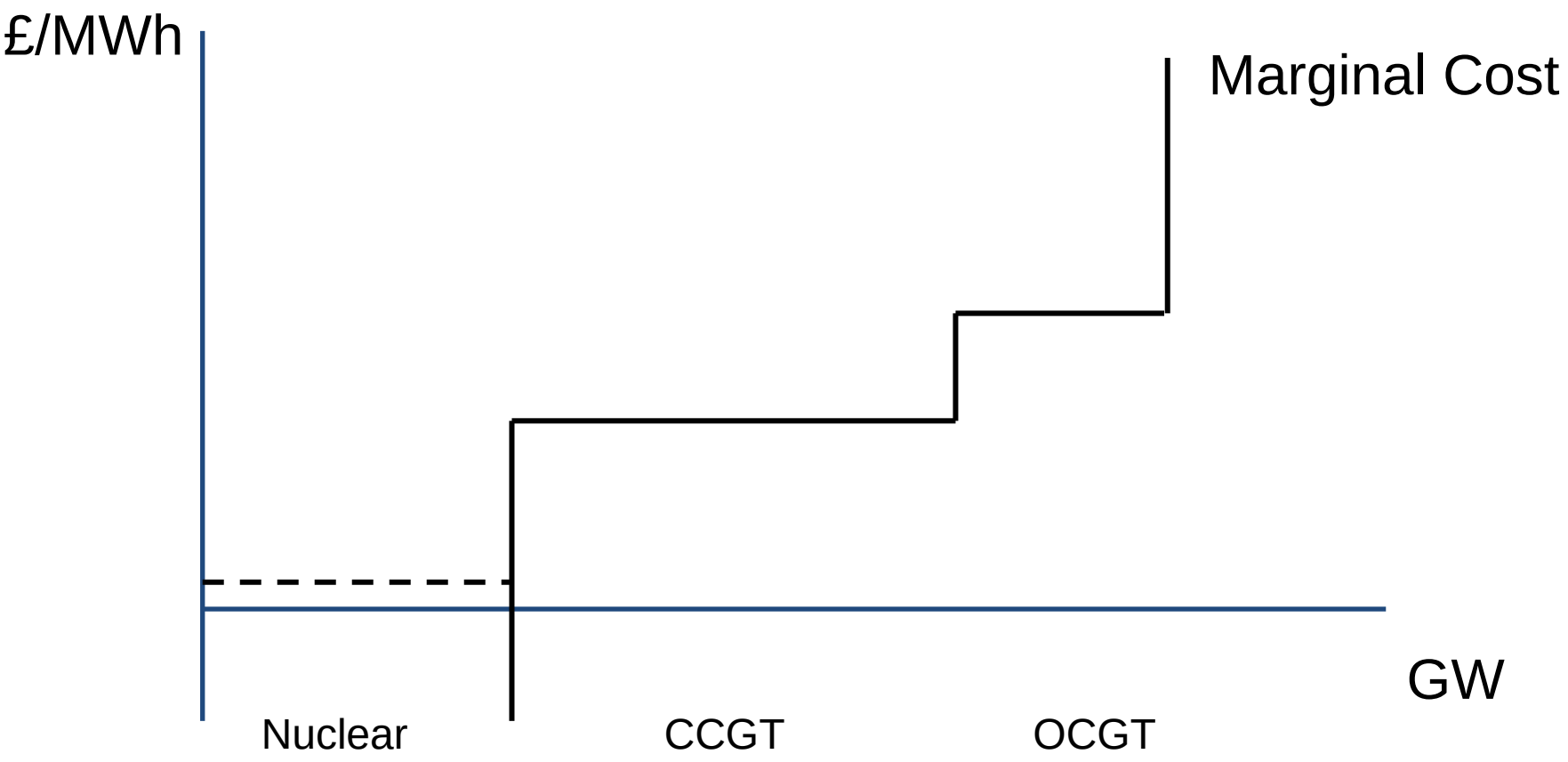
Demand and Supply



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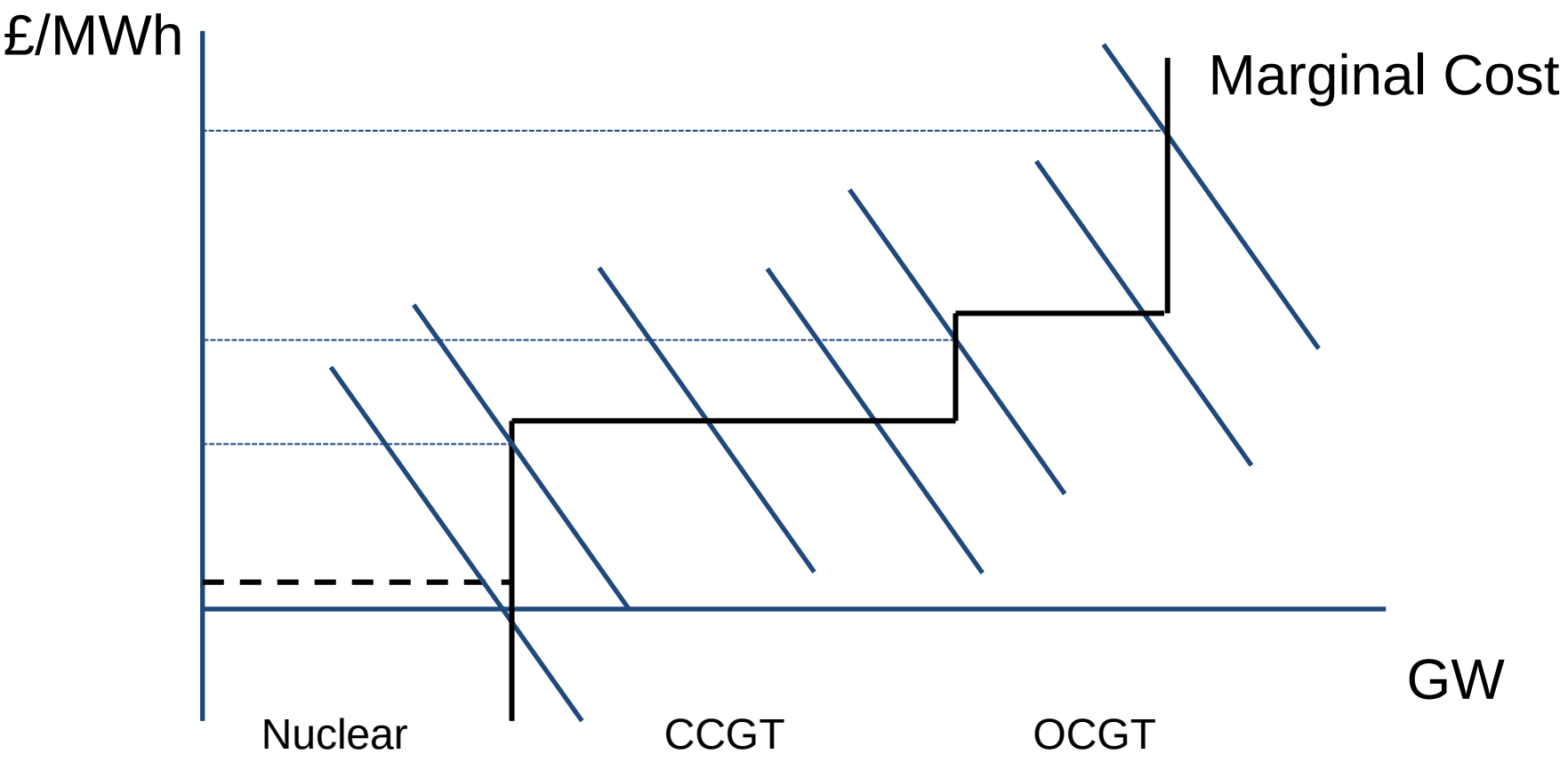
Demand and Supply



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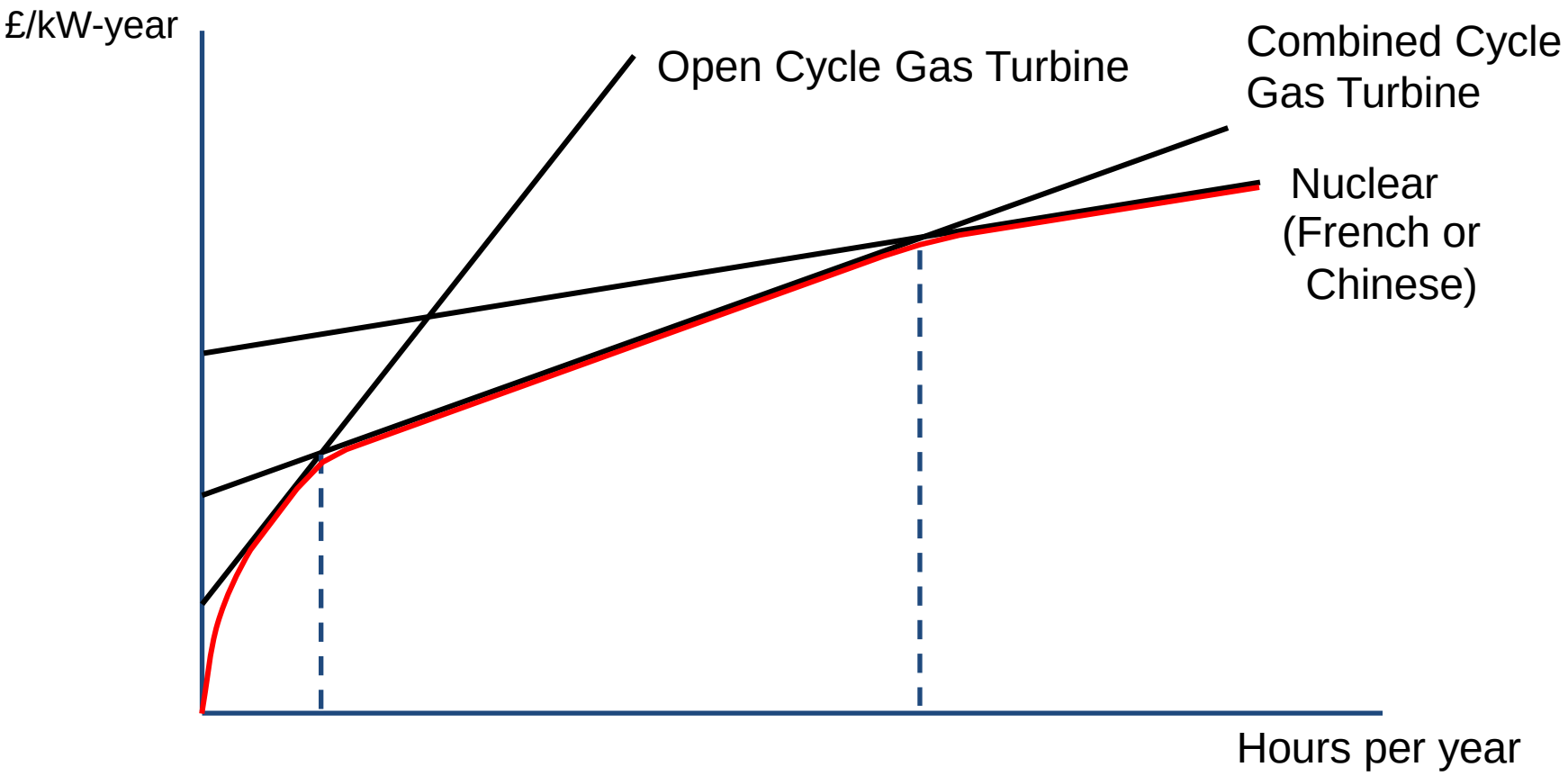
Costs & Revenues



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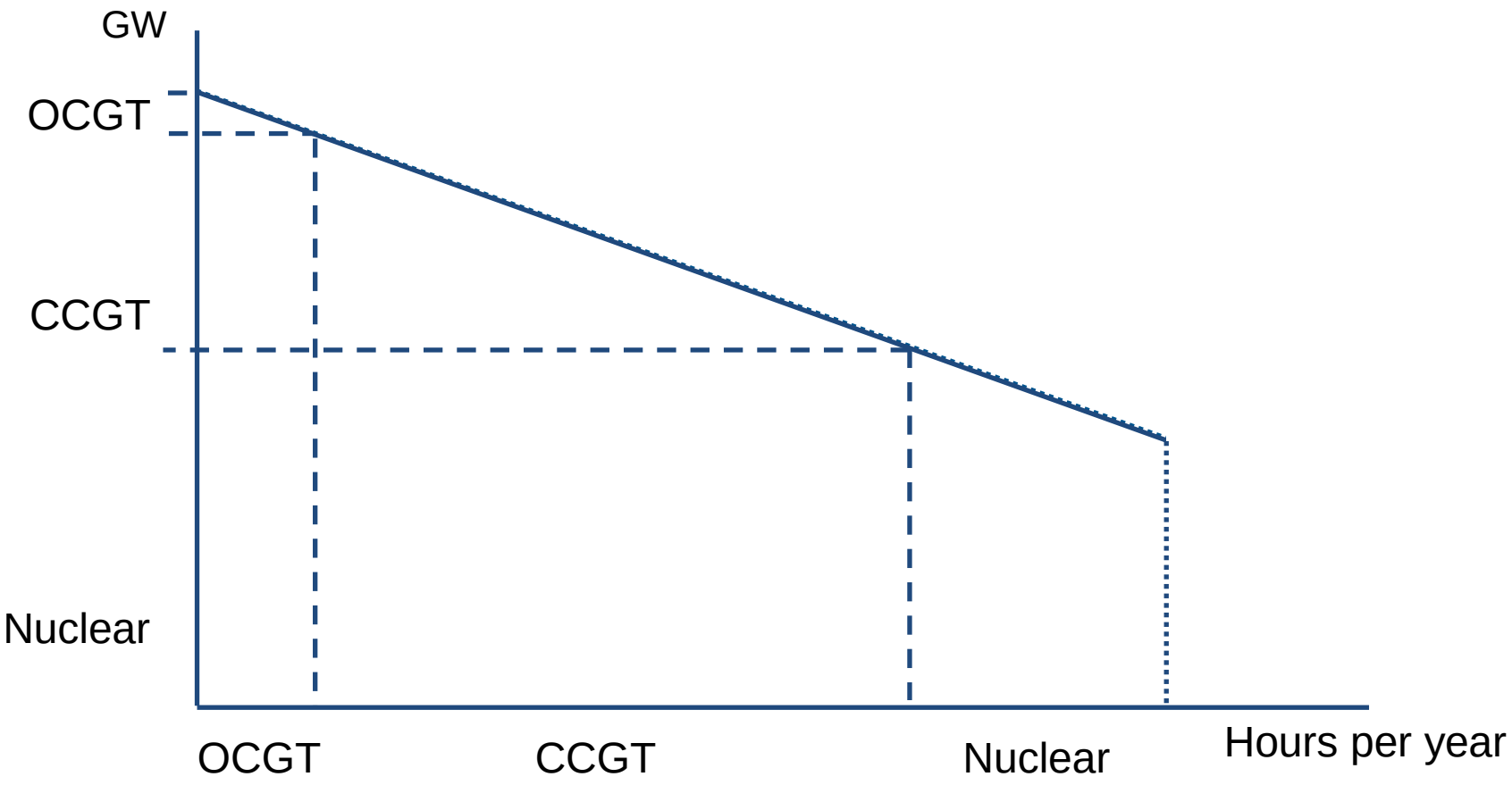
Capacity and Load



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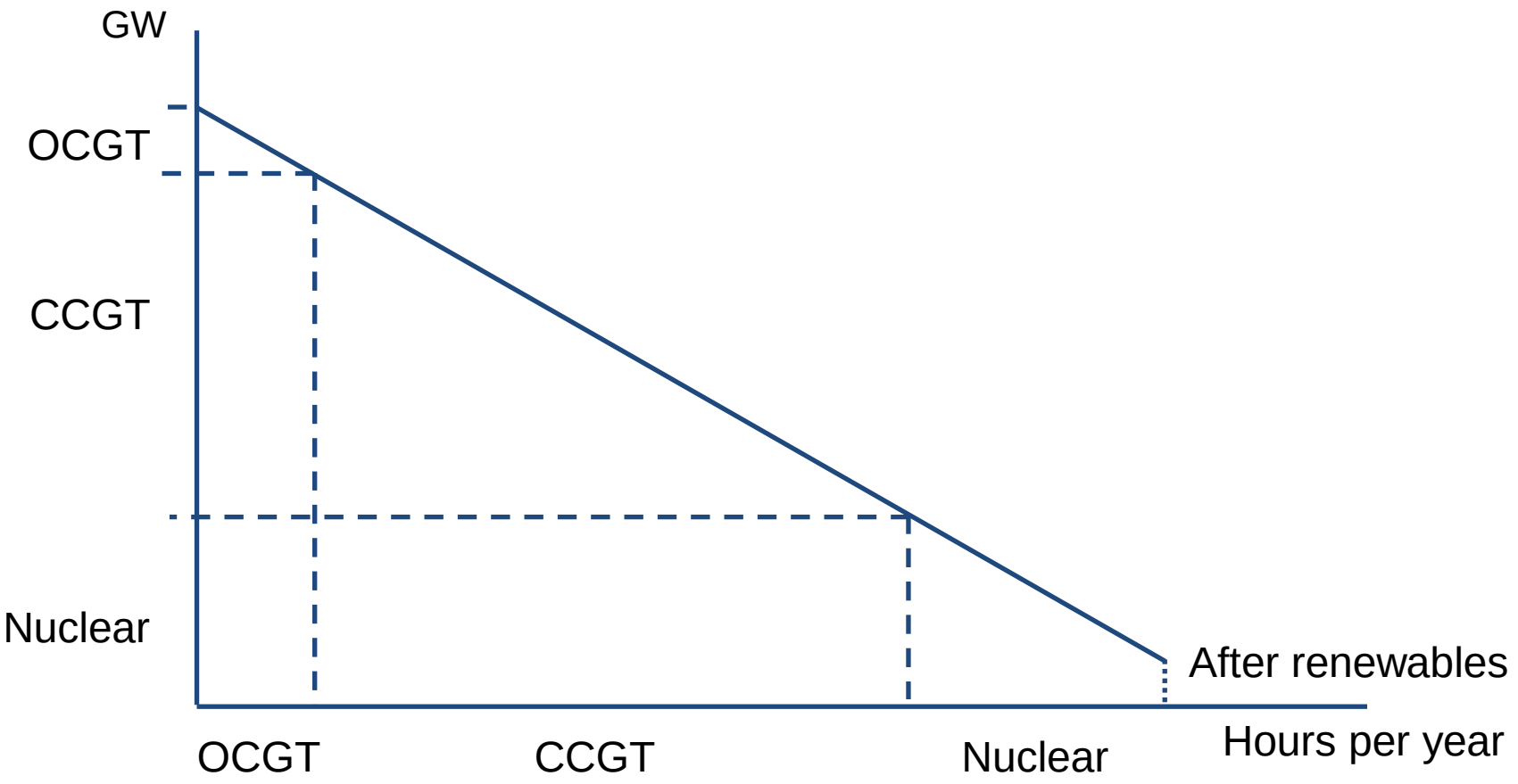
Storage, Capacity and Load



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The Magic optimiser

Linear program written in GAMS

- Optimise dispatch for a year, with starts, no-load and ramping constraints included
- Assume wholesale prices are equal to marginal cost
- Generators added or removed until all types break even
  - Making normal profits including a return on capital
- Storage included at various power capacity levels
  - 4 hours of energy capacity
    - 24-hour storage to be added

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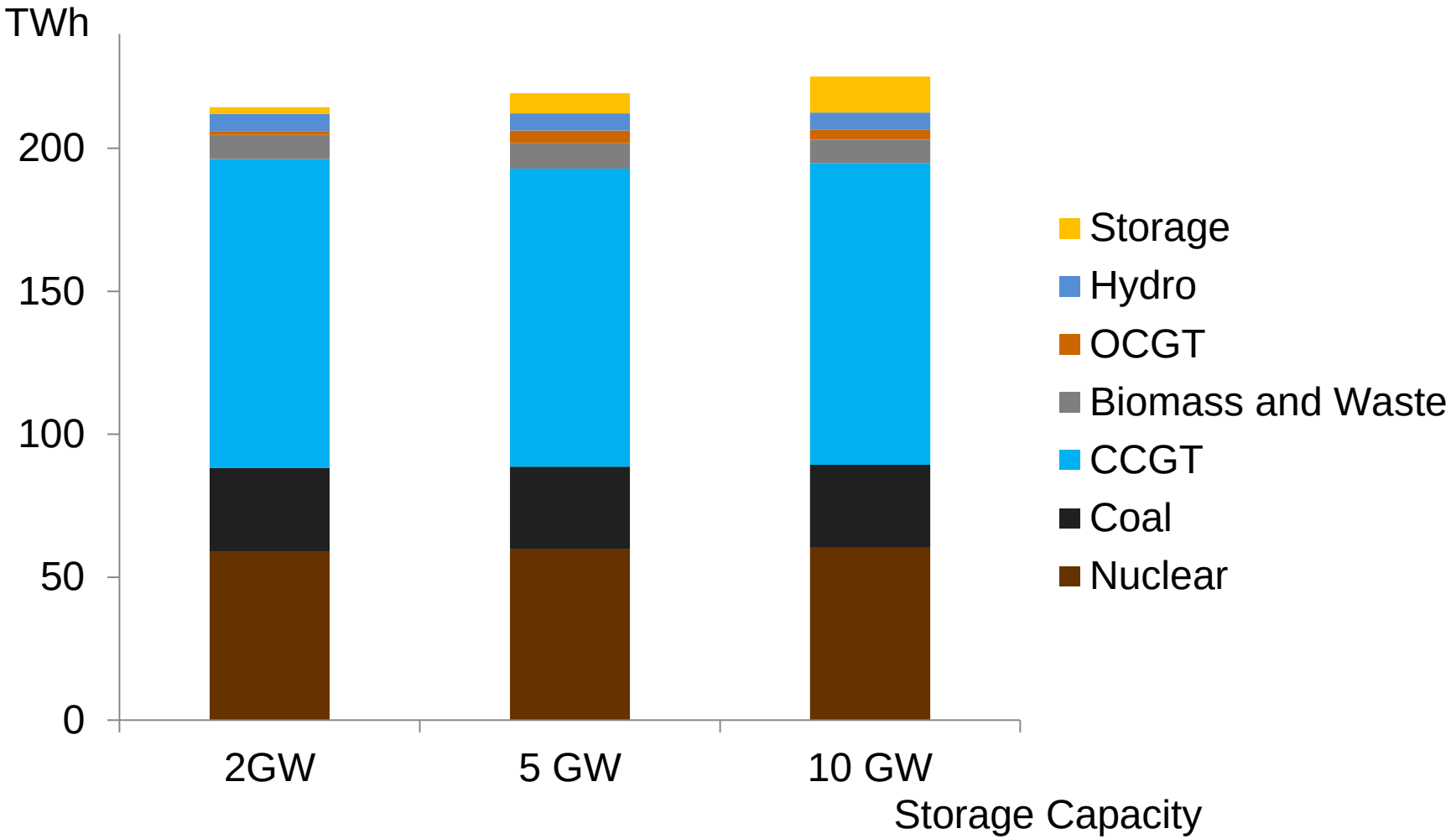
Output Mix

GB 2030, endogenous as storage varies



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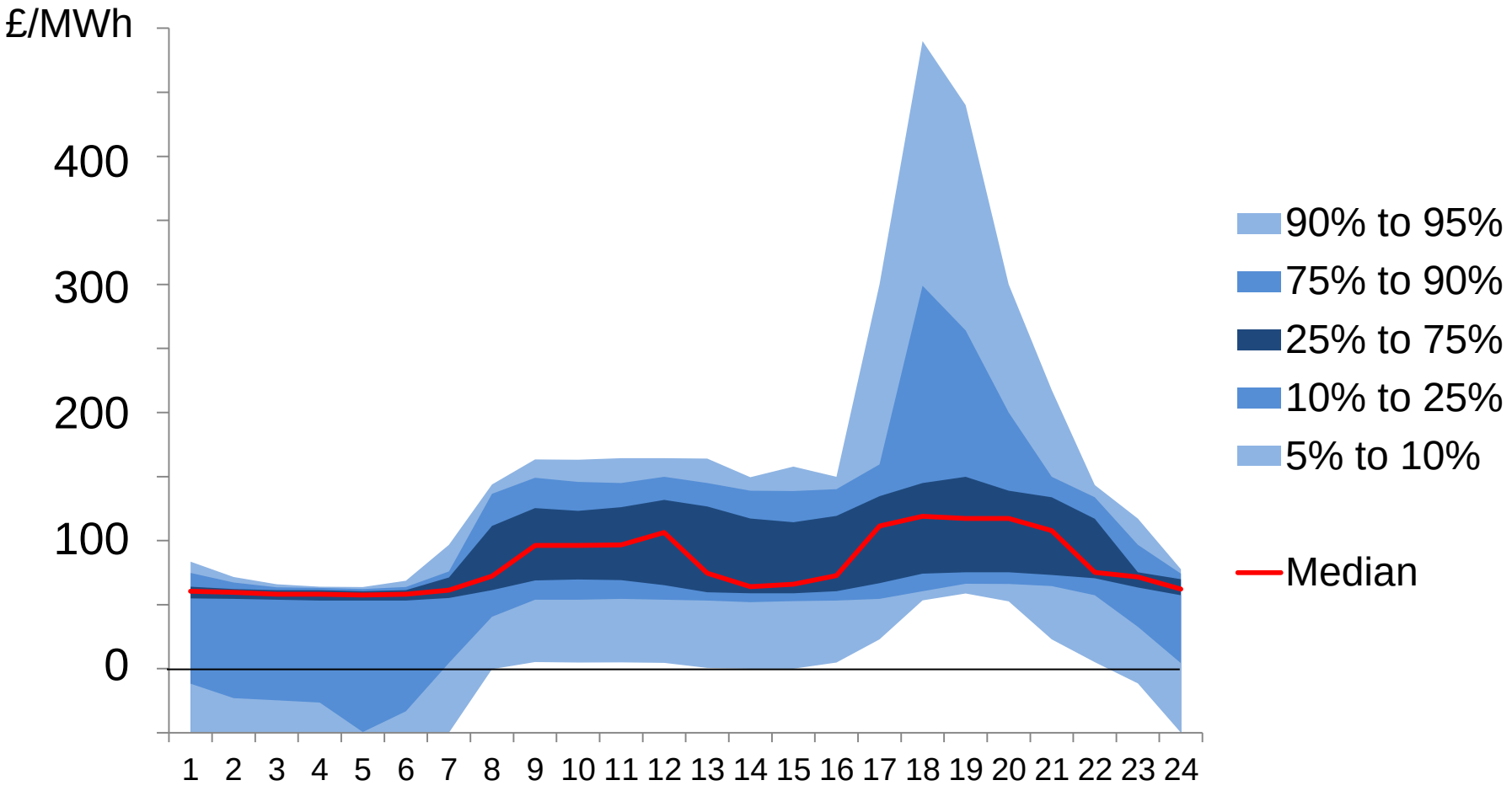
Price variation over the day

Storage capacity: 2 GW, 8 GWh



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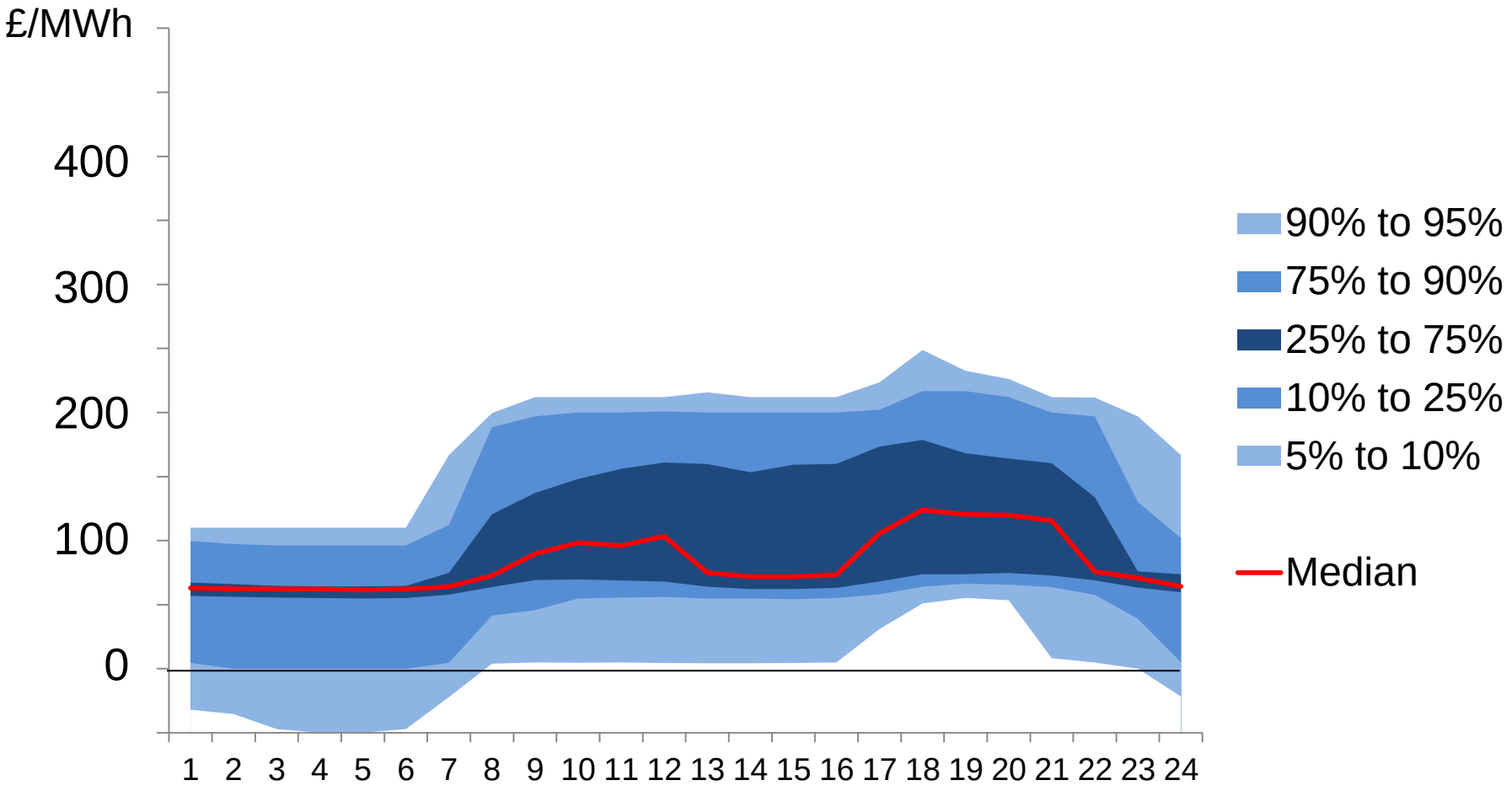
Price variation over the day

Storage capacity: 5 GW, 20 GWh



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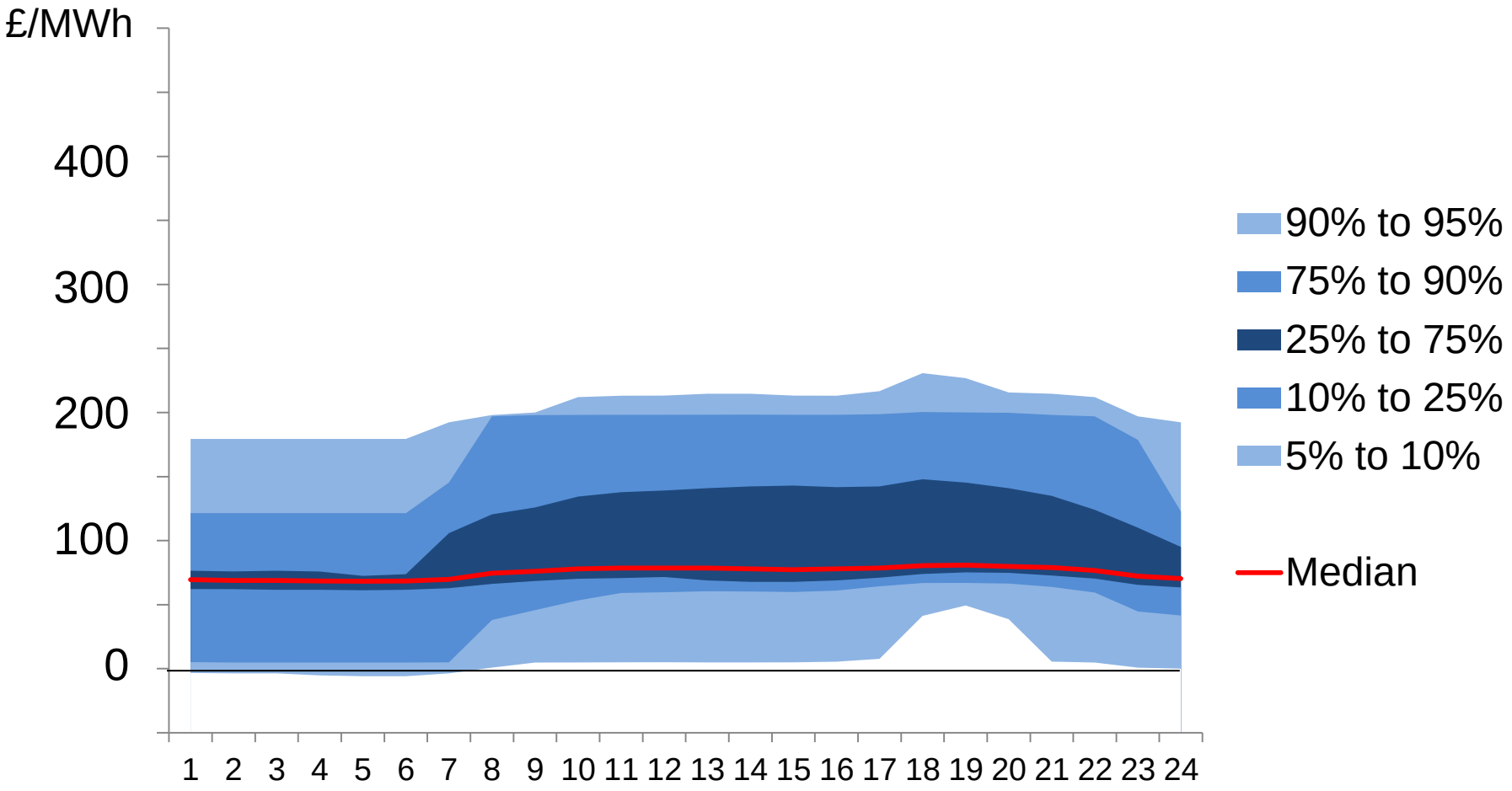
Price variation over the day

Storage capacity: 10 GW, 40 GWh



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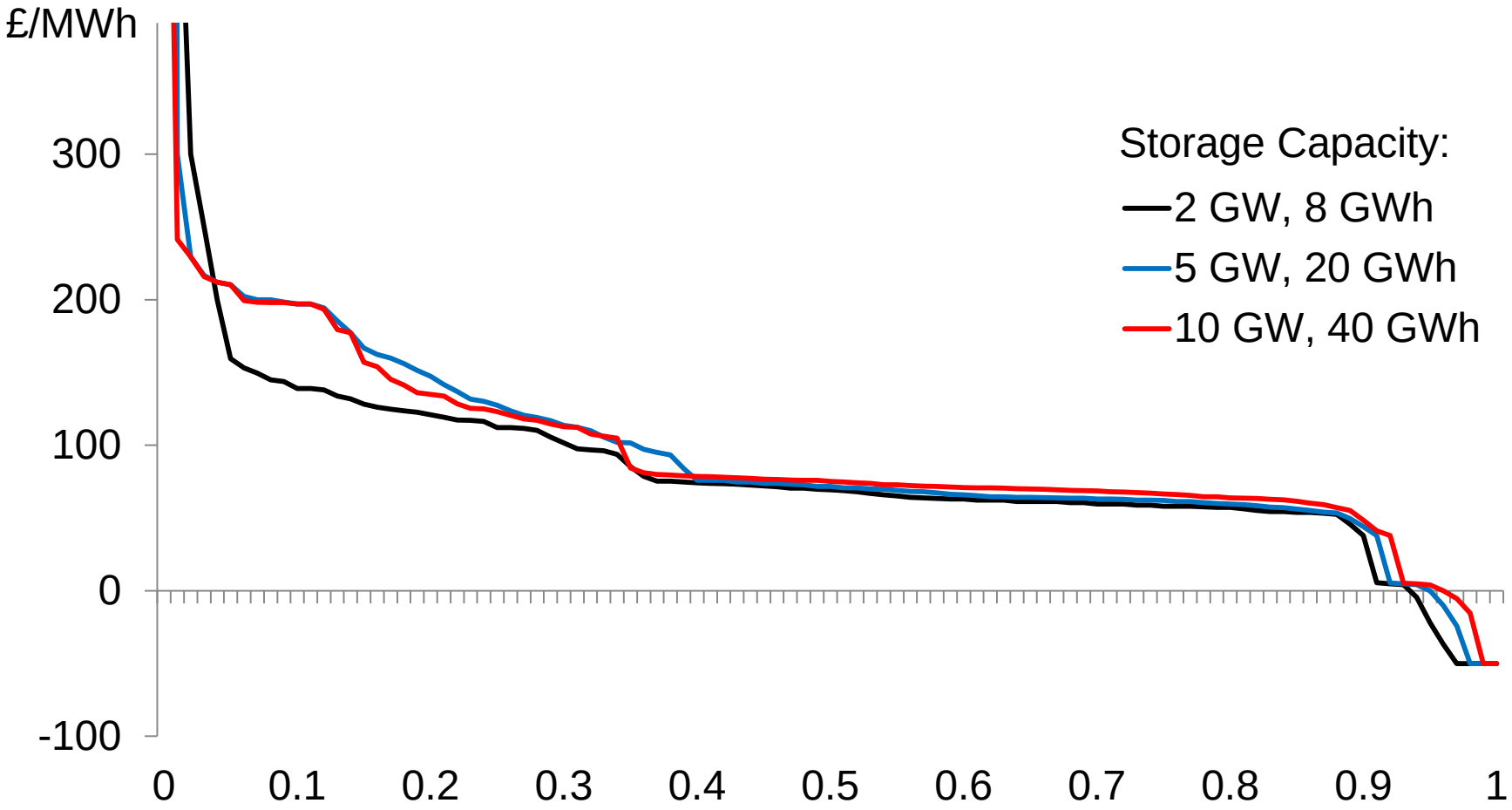
Price-duration curves

GB, 2030 with endogenous capacity



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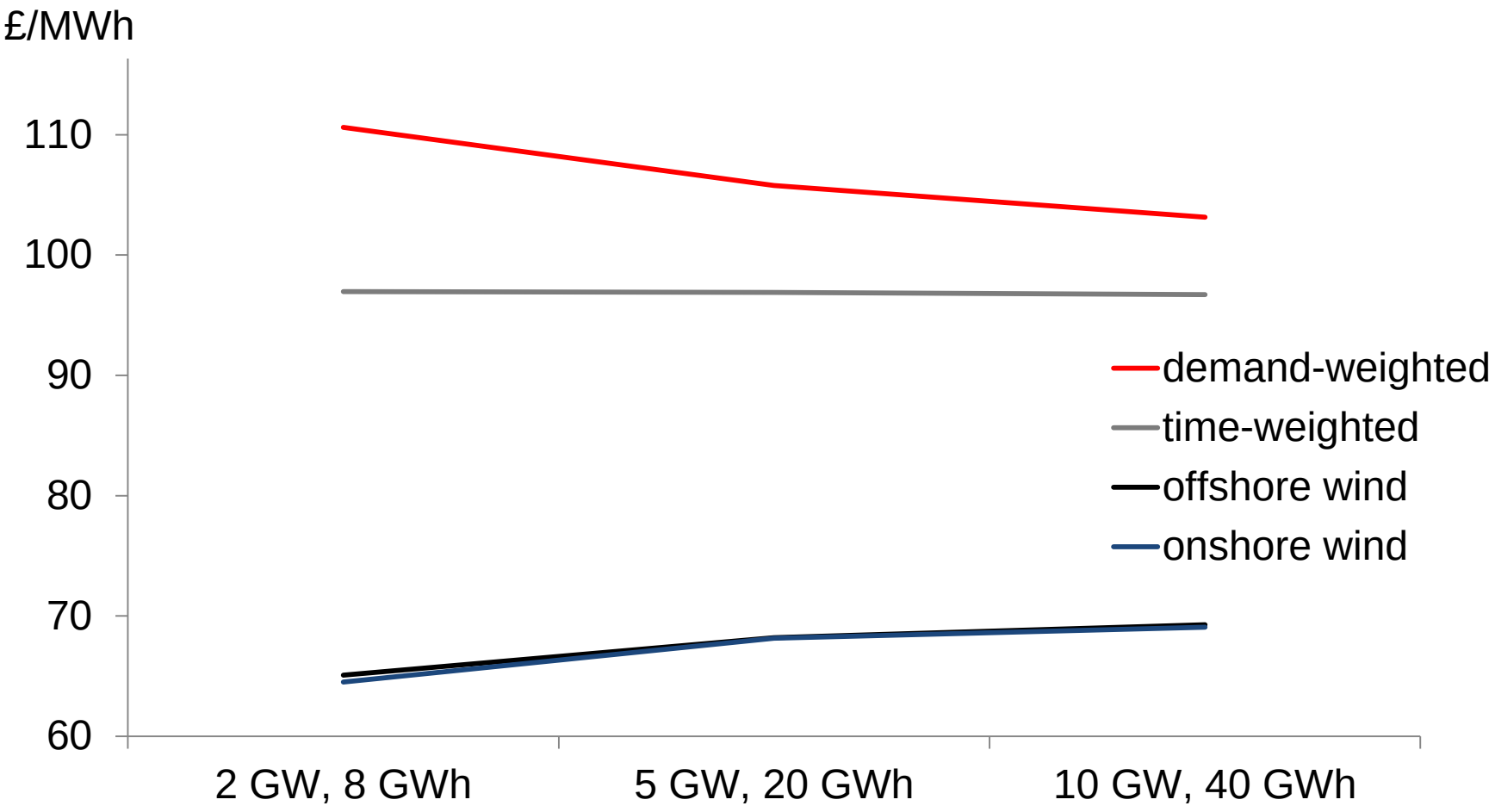
The impact of storage on prices

Endogenous generating capacities



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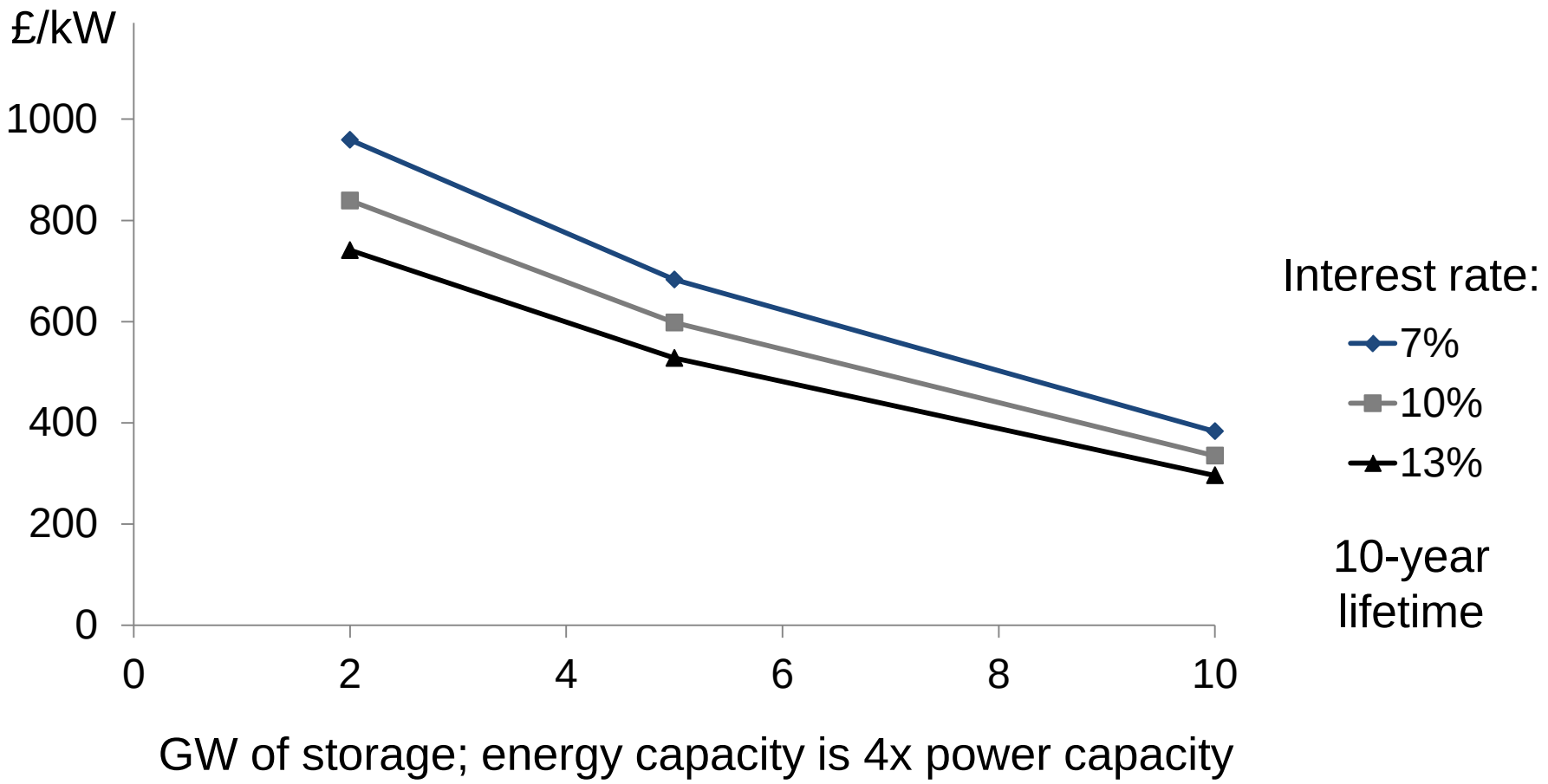
"Market" demand for storage

(energy arbitrage only)



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"Market" demand for storage

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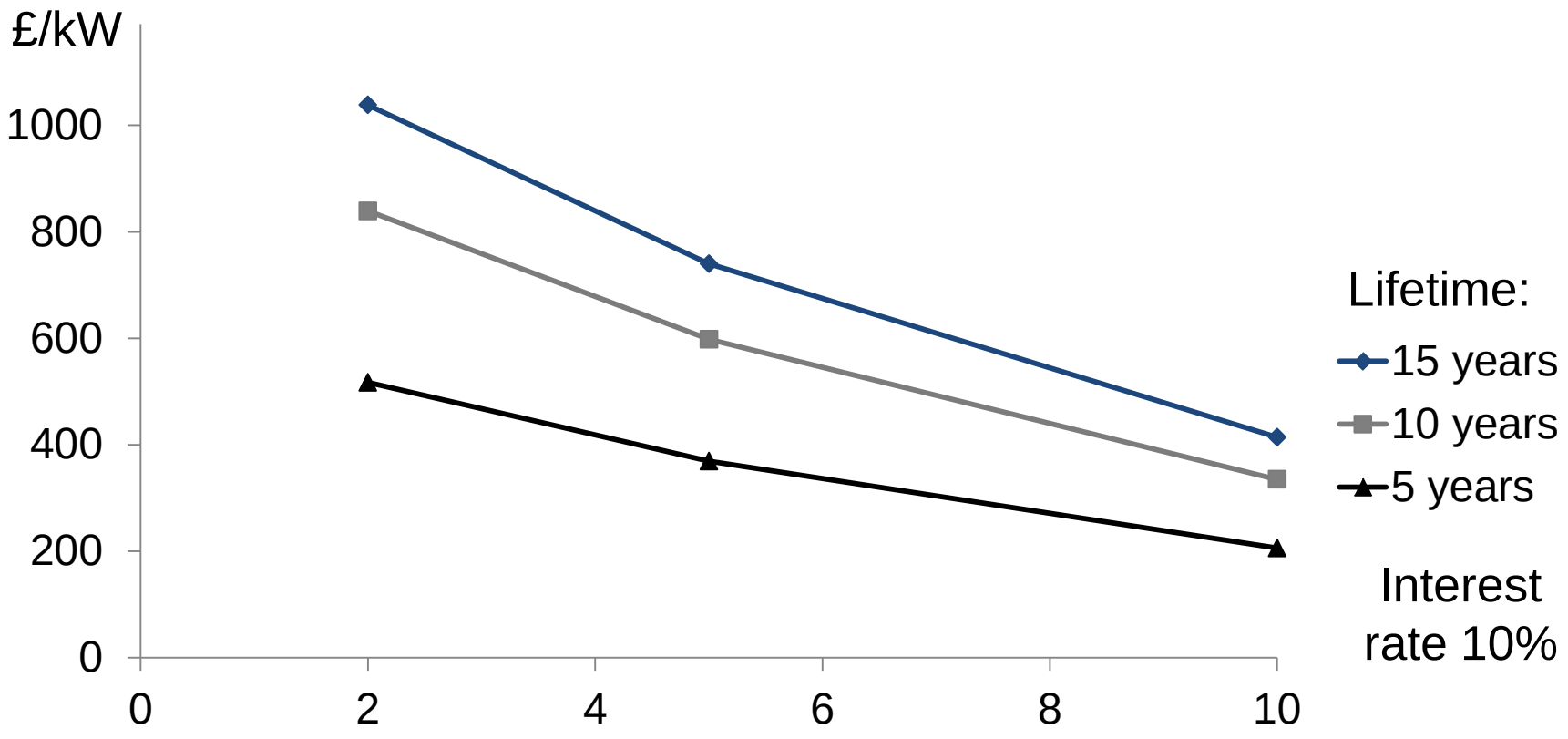

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Conclusions

- Storage will change the loads on thermal/hydro plants
- Storage will reduce price fluctuations
- Storage will change capacity mix
  - More base load capacity, less peaking capacity
- We need to consider these effects together

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But storage is versatile…

- Power Capacity
- Energy Arbitrage
- Energy Balancing
- Transmission Constraints
- Distribution Constraints…

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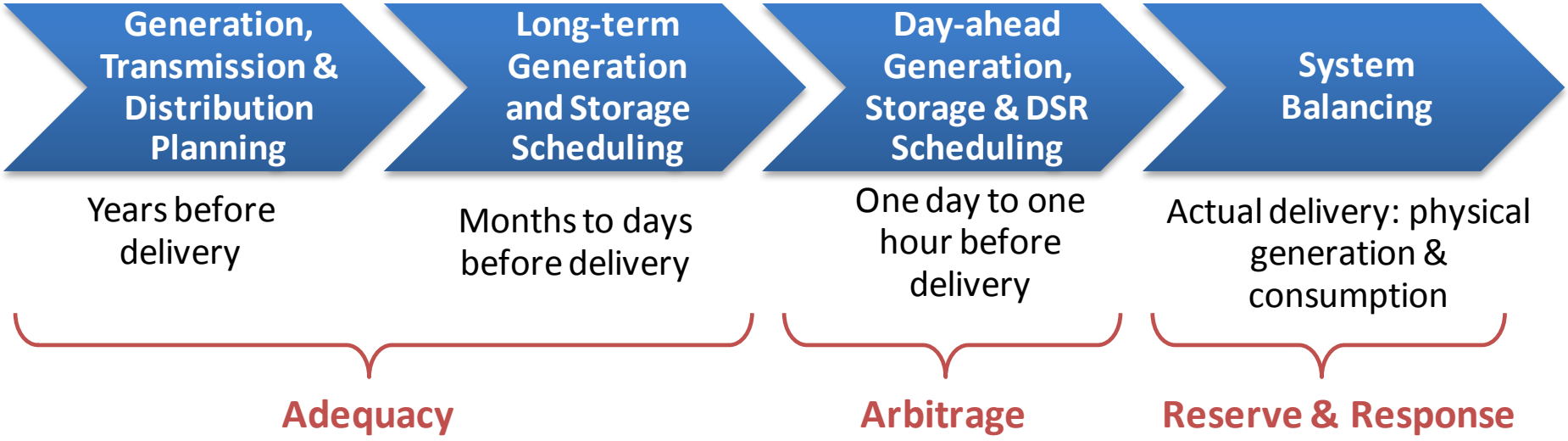
Valuing storage: Time and location matters!



Whole-systems modelling is critical for capturing Time and Location interactions

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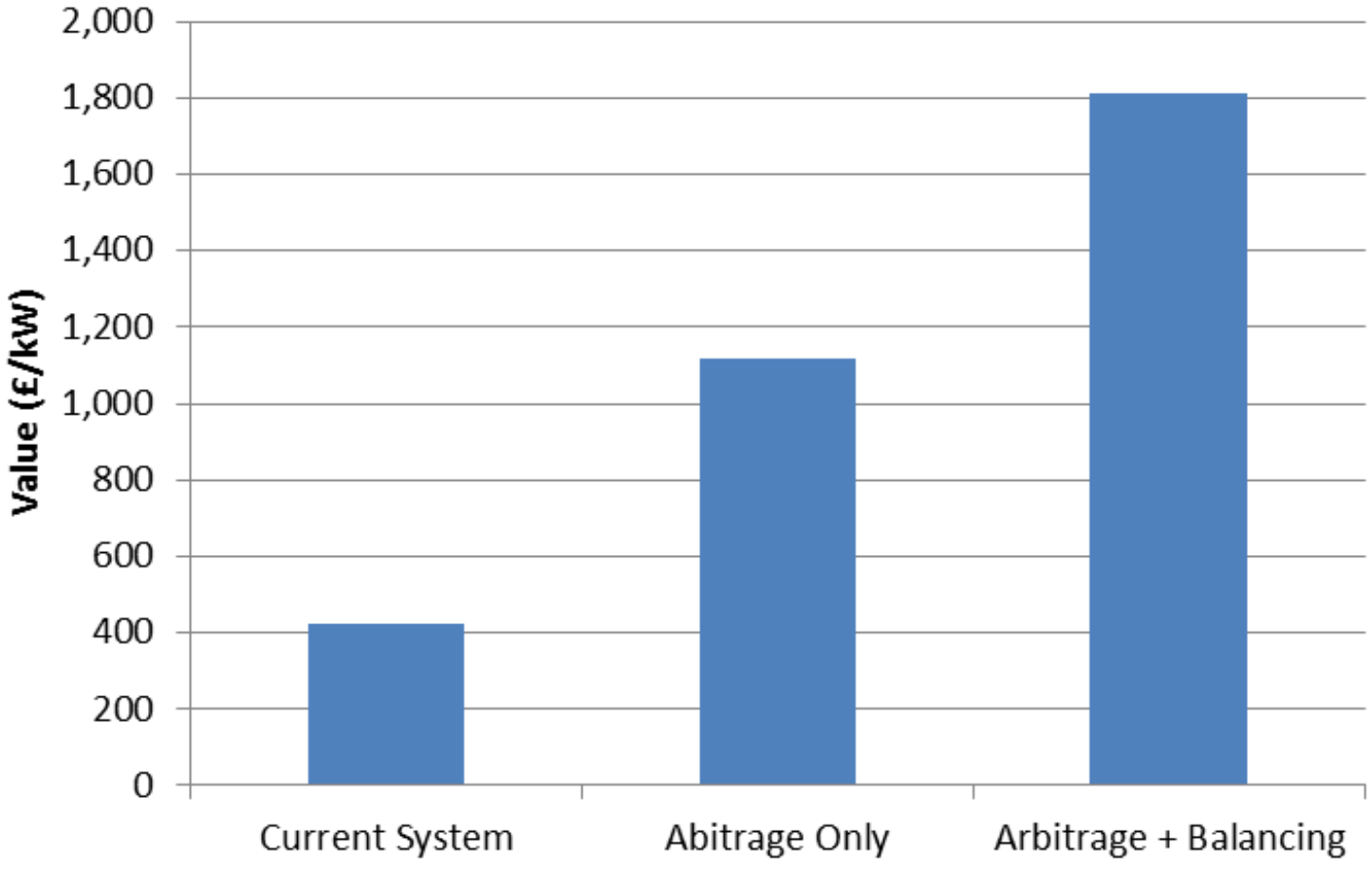
The stochastic value of storage: dealing with uncertainty



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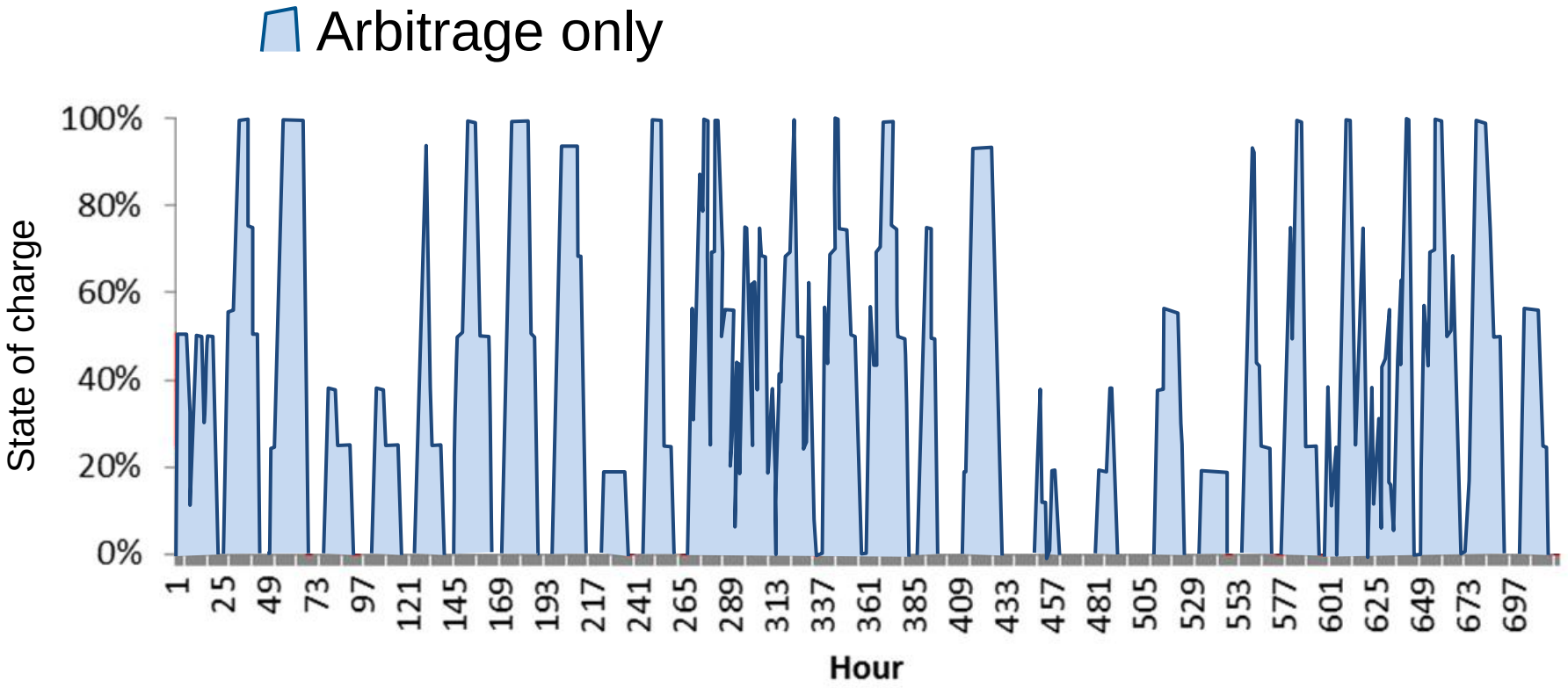
It’s profitable to be charged more



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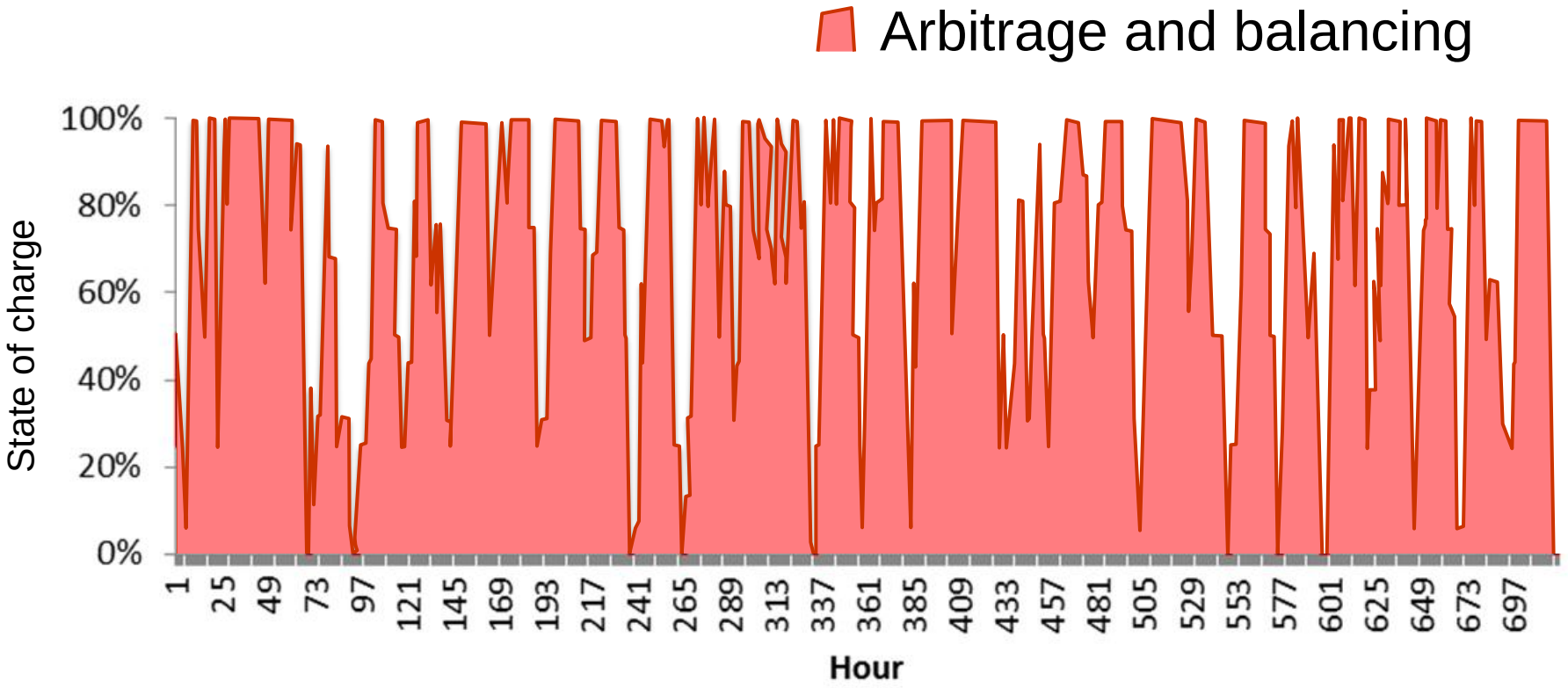

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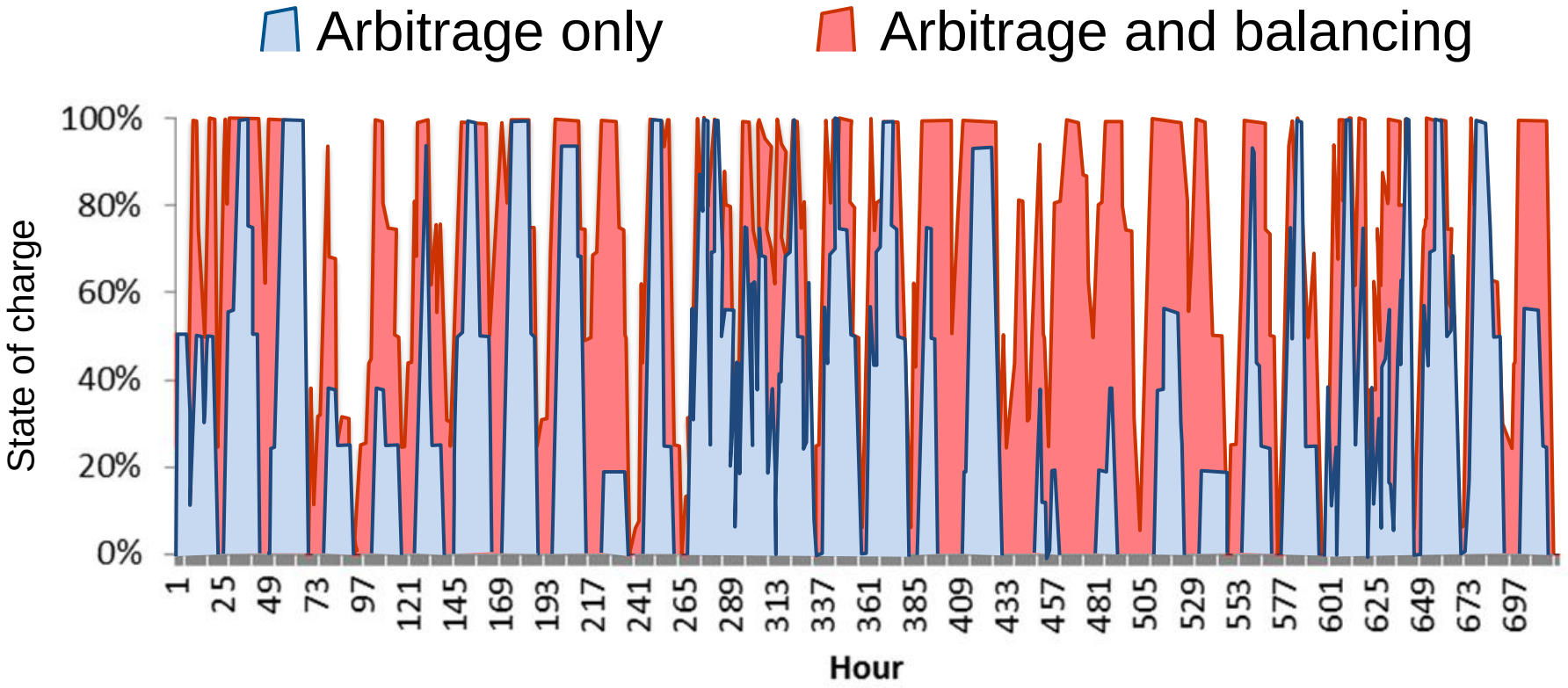

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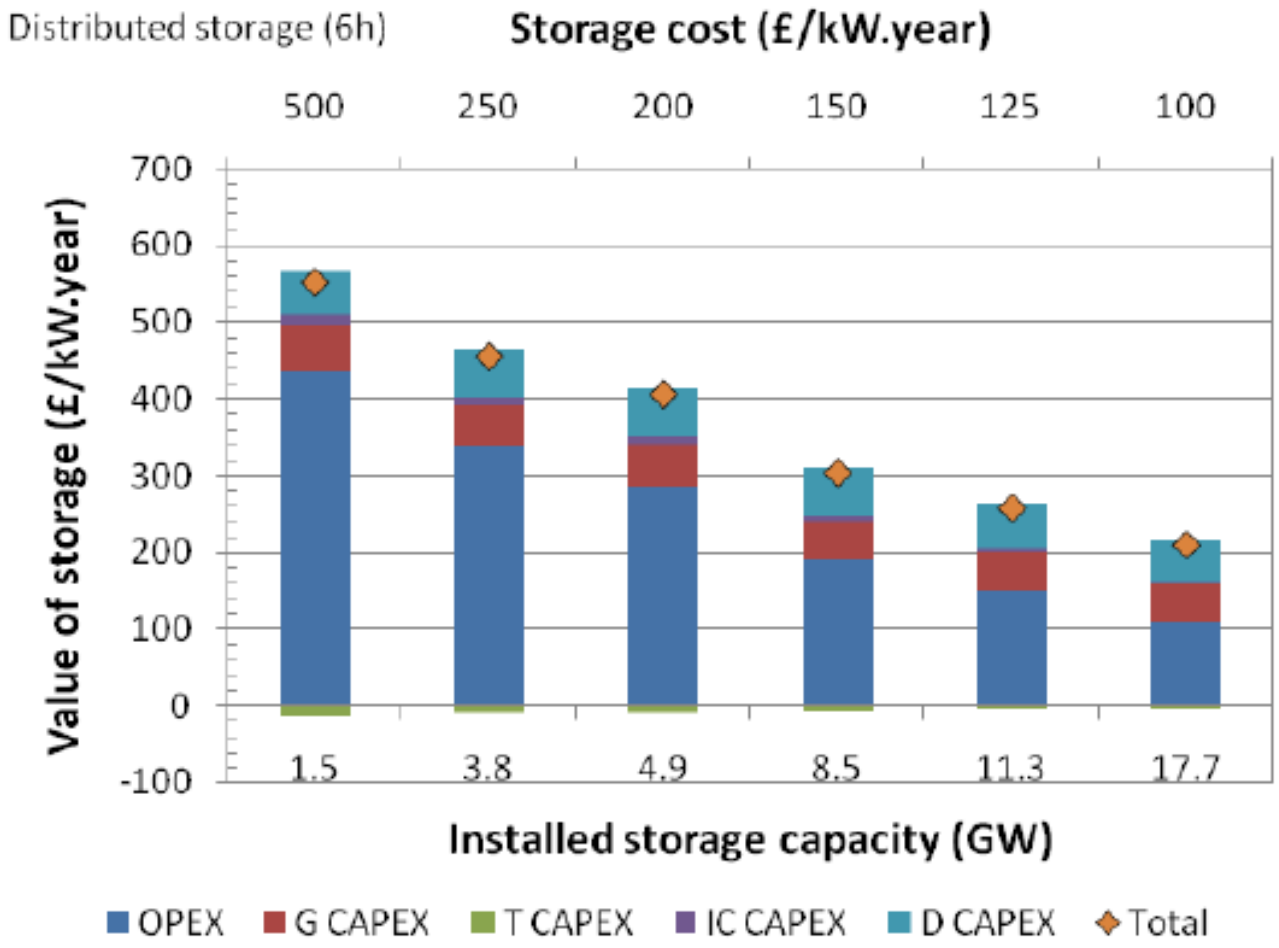
Average value of storage

Distributed to near customers



Opex: save fuel costs from “buy cheap, sell dear”

Capex: save cost of investment in generation, transmission, interconnectors or distribution system as power can be stored when the system is not constrained and released later when it is.

Source: Strbac et al (2012) Report to Carbon Trust, Fig. 12 (part)

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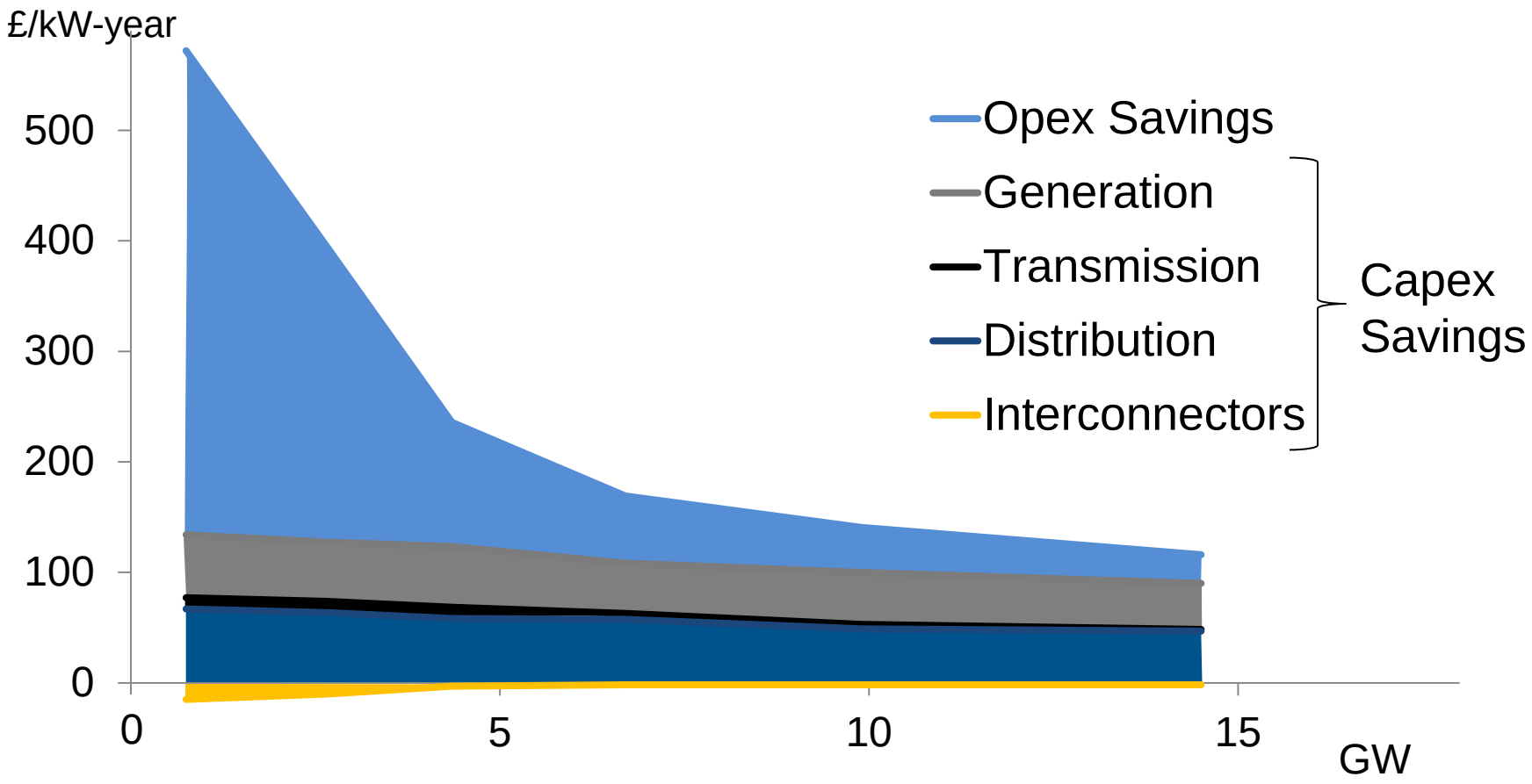
Marginal Value of Storage

(Strbac *et al.*, 2012)



(Marginal values derived from and averaged over the capacity intervals in the previous slide)

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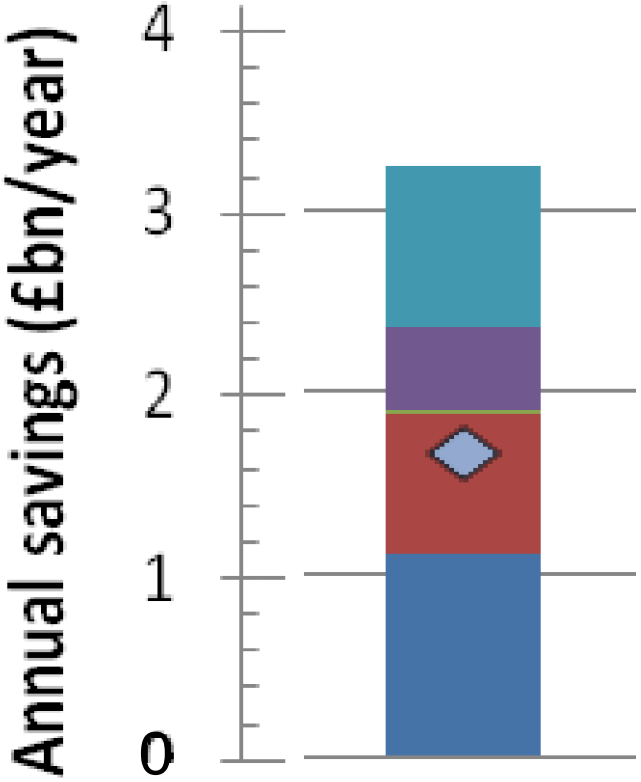
Complexity of managing storage with split benefits



Balancing services

Network services

OPEX G CAPEX T CAPEX IC CAPEX D CAPEX S CAPEX Total

Can the market facilitate this?

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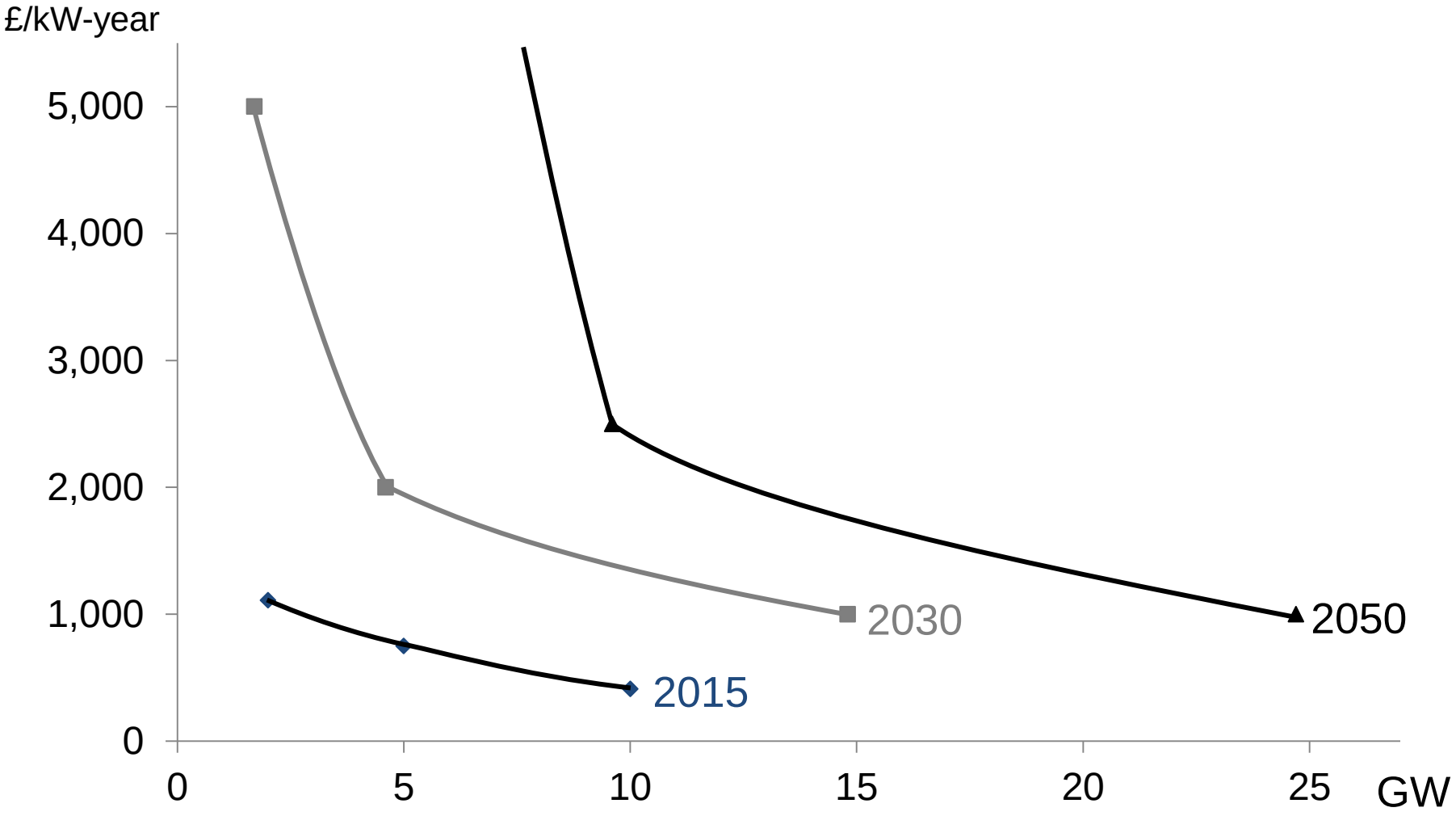
The value of storage over time



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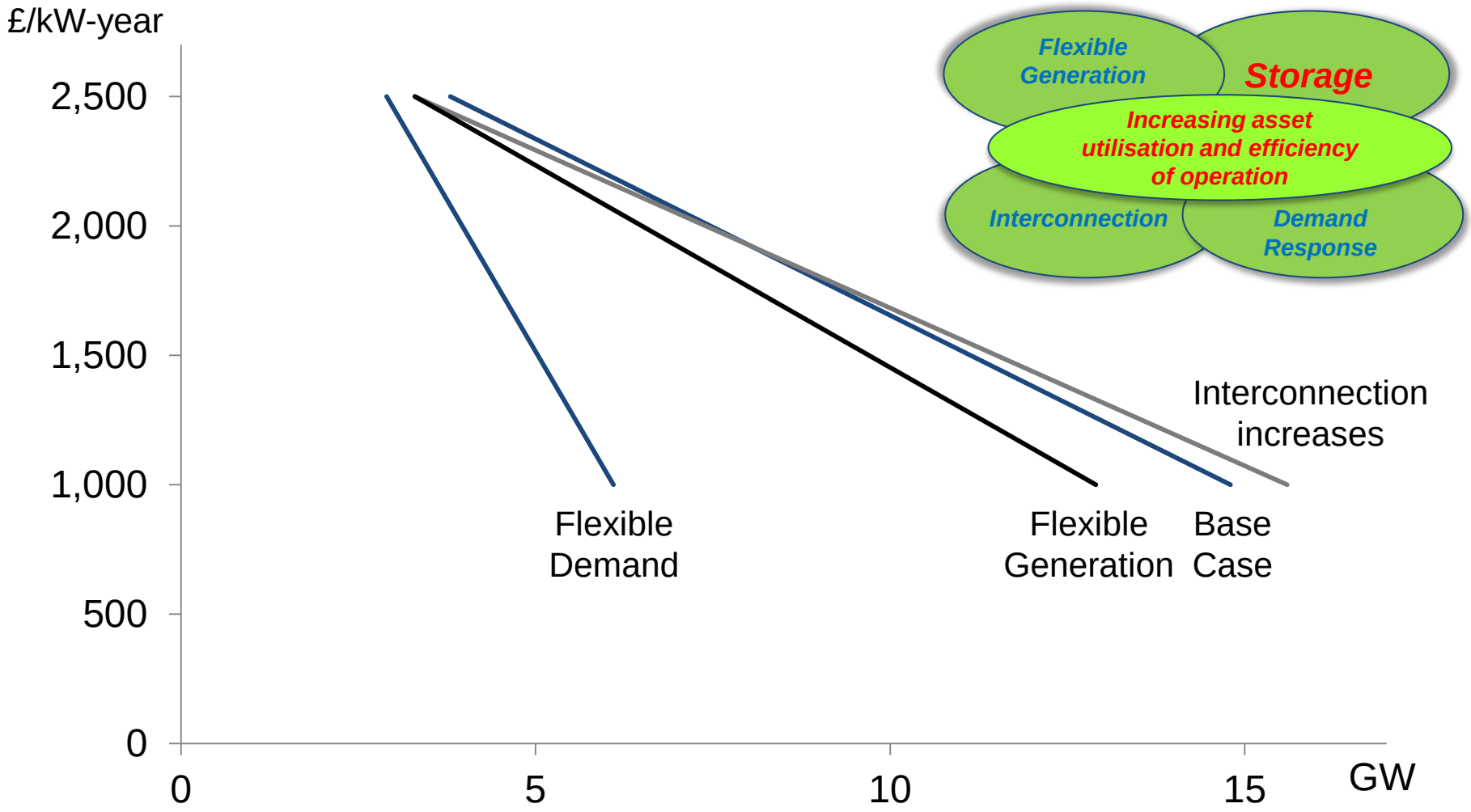
What about the competitors?



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Making it happen

- Policy makers
  - Recognise increased risk and complexity associated with innovation and the deployment of energy storage technologies
- Market, regulatory and commercial regime design
  - Facilitate multi-service provision and market for flexibility
  - Facilitate investment under uncertainty
- Storage scientists and technologists
  - Halve the price and double the lifetime (please)

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