



# UK Battery Storage and Flexibility Conference

31 October 2017, East Wintergarden, Canary Wharf, London



# Themes for the day

## Demand for flexible technologies



Will a surge in renewables unleash more demand for flexibility?



Will scarcity pricing persist into the future?



Are EVs the ultimate source of flexibility?

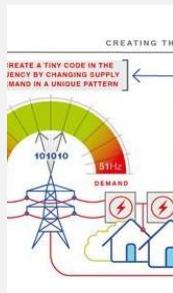
## Making the investment case work



Can arbitrage help avoid a battery storage overbuild scenario?



How to finance increasingly merchant gas peakers?



Will DSR deliver at scale?

## Policy and system design



Is policy moving fast enough to support flexible technologies?



Should storage and solar be grid scale or behind-the-meter?



Will energy markets be revolutionised by zero prices, blockchain etc?

## Keynote presentations



Alex Chisholm  
Permanent Secretary  
BEIS



Tony Cocker  
Chairman, Infinis  
Former CEO, E.ON UK



Ben Irons  
Executive Director  
Aurora Energy Research

# Panel discussions

## Panel 1: Battery storage beyond FFR



## Panel 2: The long term value of flexibility



## Panel 3: The electricity system of the future



### Panelists:

- Richard Howard, Aurora
- Mark Cumbo, Santander
- Chris Miles, Anesco
- Clare King, Osborne Clarke
- Dan Monzani, BEIS
- Erik Nygard, LimeJump

### Panelists:

- John Feddersen, Aurora
- Stephen Davies, E.ON
- Olivier Fricot, Investec Bank
- Frances Warburton, Ofgem
- Dan Wells, Foresight Group
- Sam Wither, UK Power Reserve

### Panelists:

- Cameron Hepburn, Aurora
- Roger Atkins, Electric Vehicles Outlook
- Paul Massara, North Star Solar
- Richard Braakenburg, Green Investment Group
- Claire Spedding, National Grid

## Photos from the day



# The year in review

A look-back on noteworthy energy industry headlines since Q4 2016



2017

A photograph showing a vast array of solar panels in the foreground, angled upwards. Above them, the sky is a clear, vibrant blue dotted with several large, white, puffy cumulus clouds.

# Solar

- 73GW of new solar PV built globally in 2016, up 50% from the year before
- Capital cost declines continue to exceed expectations
  - Oct 2017: Record of \$17.8/MWh set in Saudi Arabia
  - Sub \$30/MWh now possible in many countries, undercutting thermal
- 26 May 2017: UK achieves solar production record of 8.7GW
- Sept 2017: UK's first subsidy-free solar farm opens



# Wind

- Continued rapid technological progress; 15MW turbines anticipated by mid 2020s
- 3 Apr 2017: 'zero bids' in German CfD auction
- 11 Sept 2017: UK auction sees bids as low as £57/MWh
- Subsidy-free investment nearing in UK. Could access balancing and ancillary markets
- Oct: Helm Review proposes "equivalent firm power" bids into CM



# Coal

- 21 April 2017: first ever coal-free day since 1880s
- July: coal generation falls to record monthly low, just 2% of total



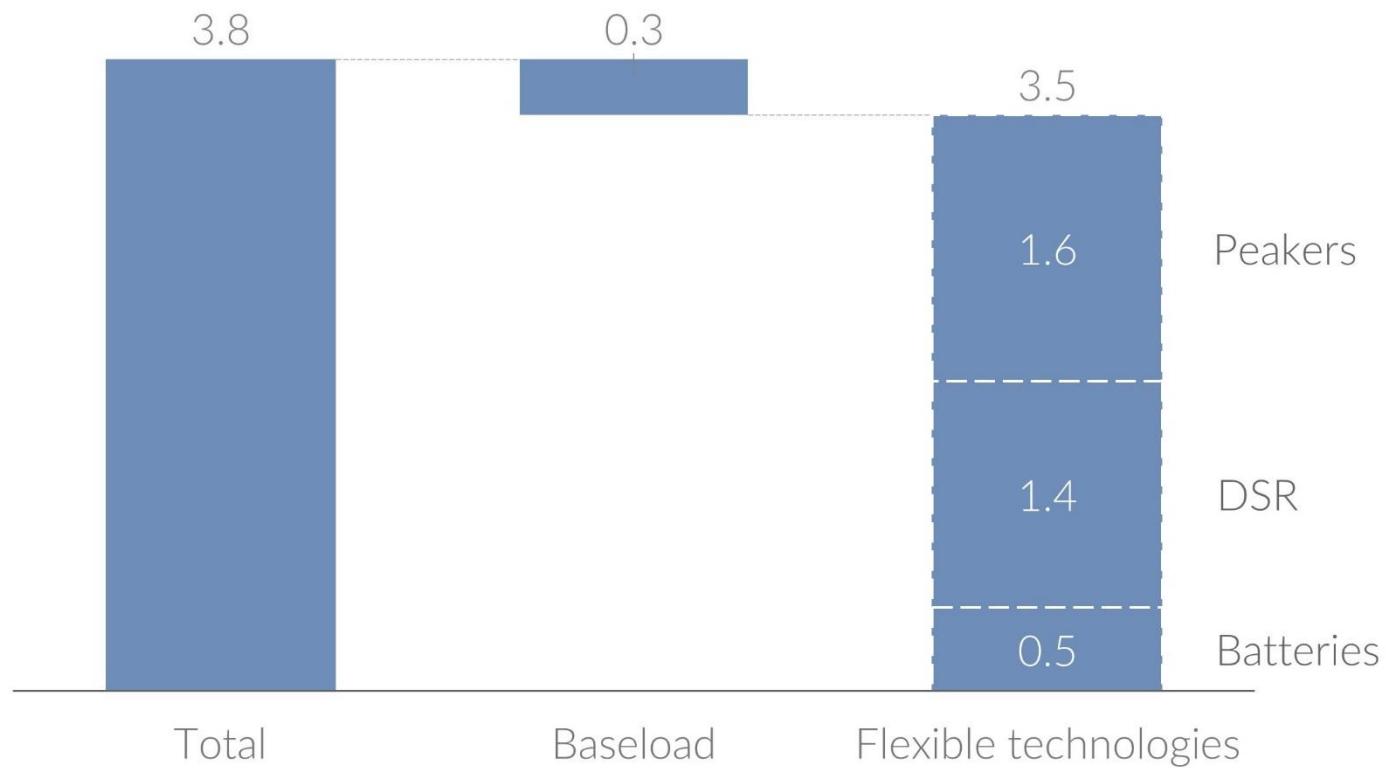
# EVs

- New models unveiled in 2017 include Tesla's Model 3, Proterra's electric bus, Daimler's heavy-duty electric truck
- China sets aggressive sales targets of 7m EVs by 2025
- UK to ban internal combustion engine car sales by 2040
- UK progress on charging infrastructure

# Flexible technologies

New build contracts awarded in 2016 T-4

GW



Source: National Grid

# Peakers

- Autumn 2016: New emissions limits introduced
- 1 Mar 2017: Ofgem proposed cut to Triads to £3.7/kW by 2021
- 17 May 2017: System price exceeds £1,500/MWh





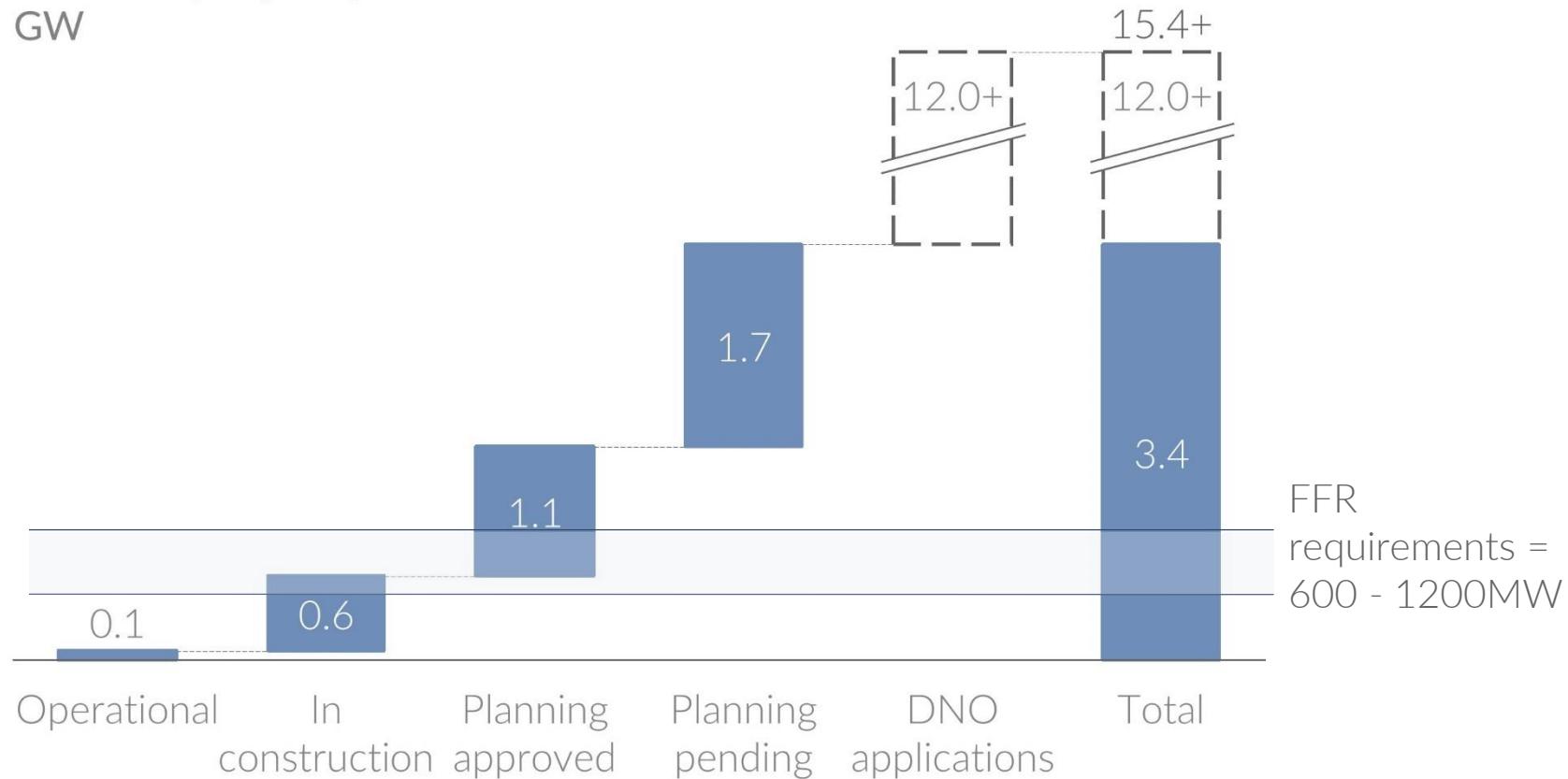
# Batteries

- 13 March 2017: Consultation on removal of double charging and other barriers
  - 13 July 2017: SNAPS consultation announced by National Grid
  - 24 July 2017: Capacity Market consultation to reduce de-rating of storage
  - 13 Sept 2017: Renewables Obligations granted for solar paired with batteries
- 

# Batteries

## UK battery capacity

GW

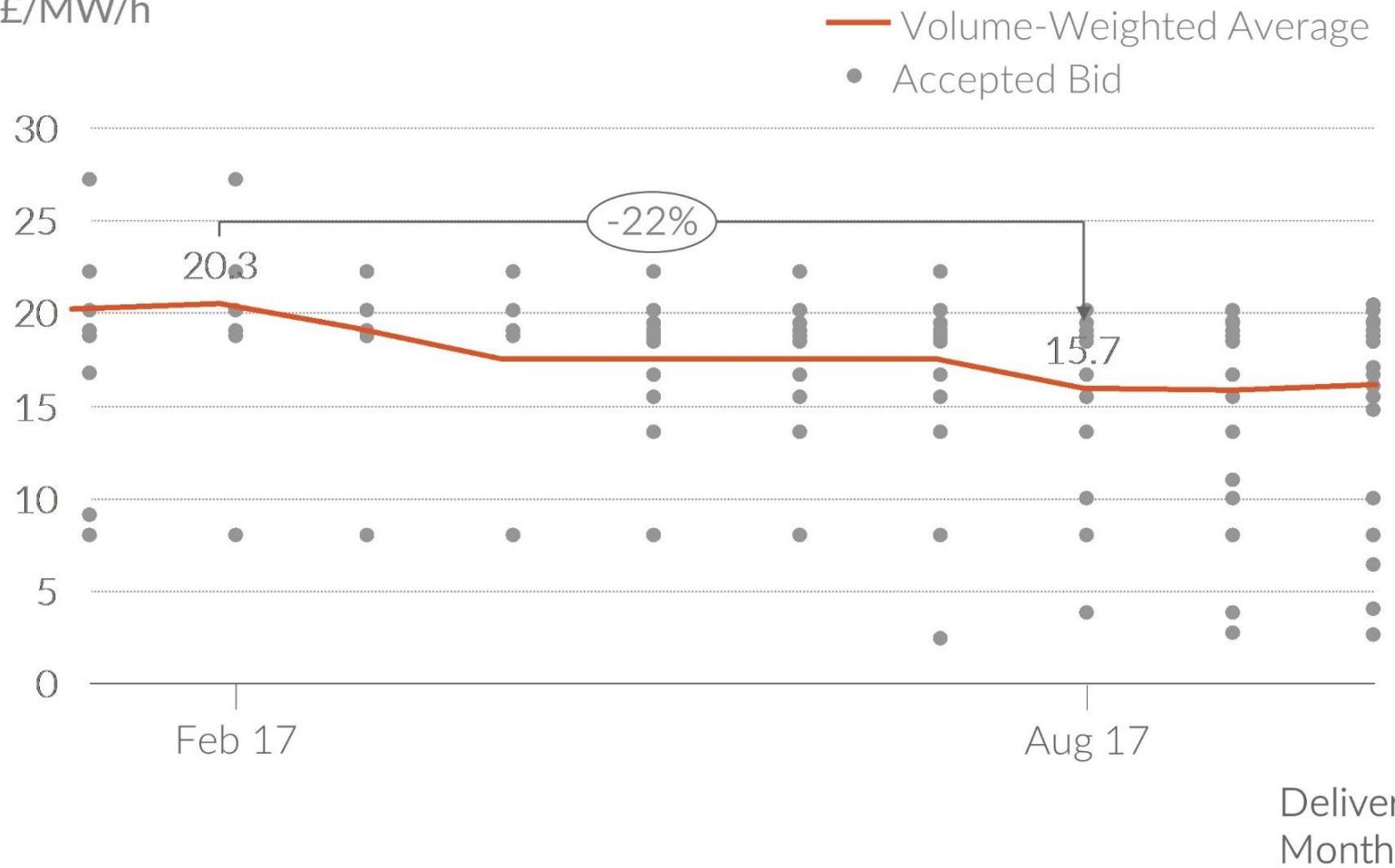


Source: Electricity Market Reform, National Grid, Solar Power Portal

# Batteries

## FFR (dynamic) accepted bids

£/MW/h



Delivery  
Month

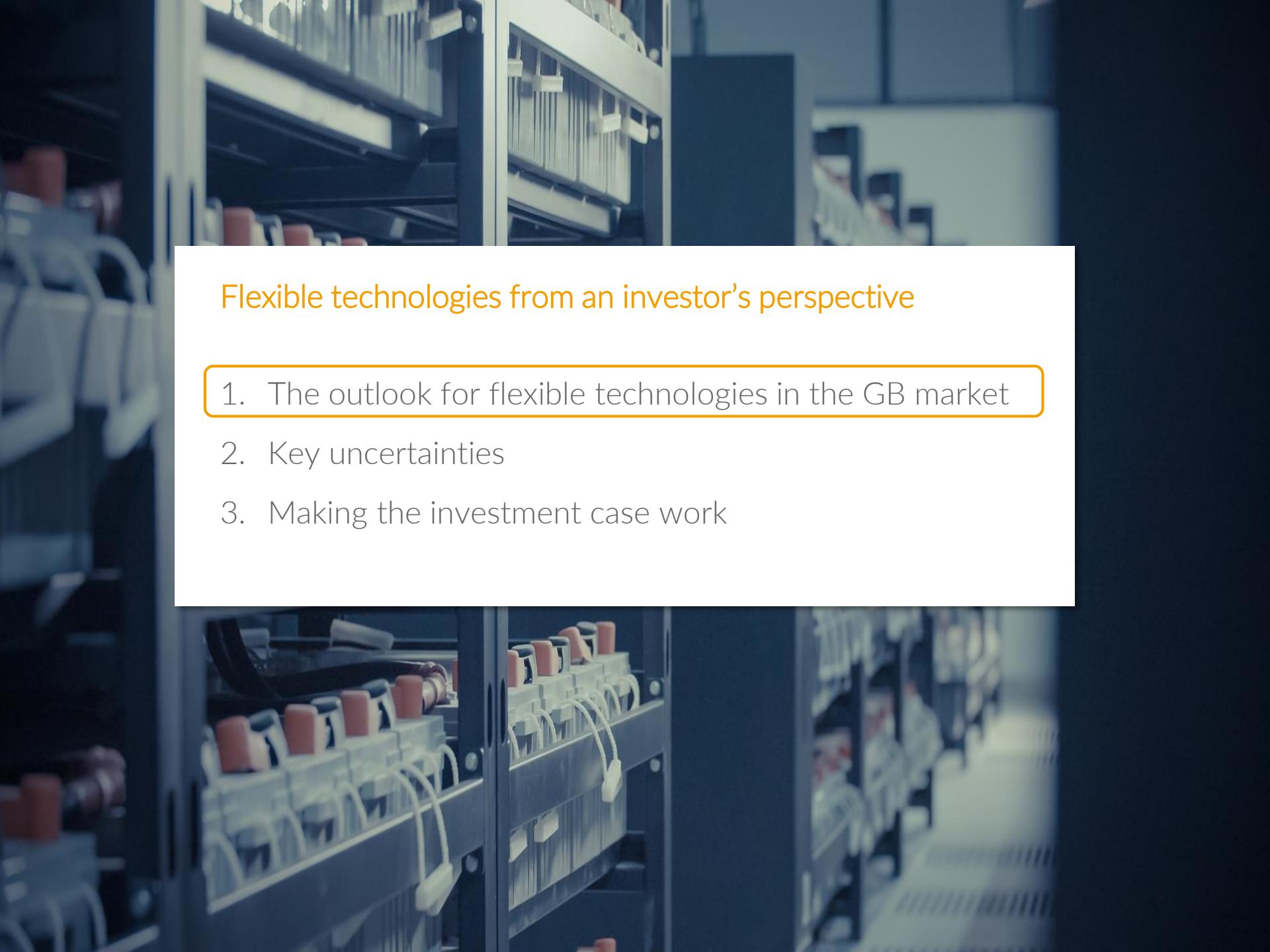
Source: National Grid



## Flexible technologies from an investor's perspective

Dr Ben Irons

Executive Director, Aurora Energy Research



## Flexible technologies from an investor's perspective

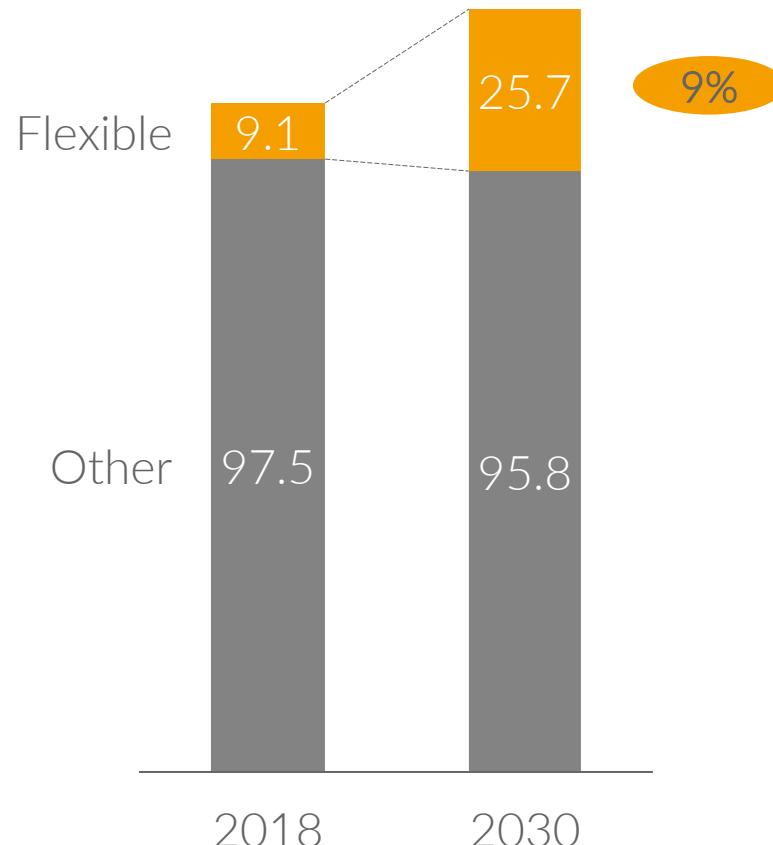
1. The outlook for flexible technologies in the GB market
2. Key uncertainties
3. Making the investment case work

# Aurora expects the capacity market will drive substantial growth in flexible technologies

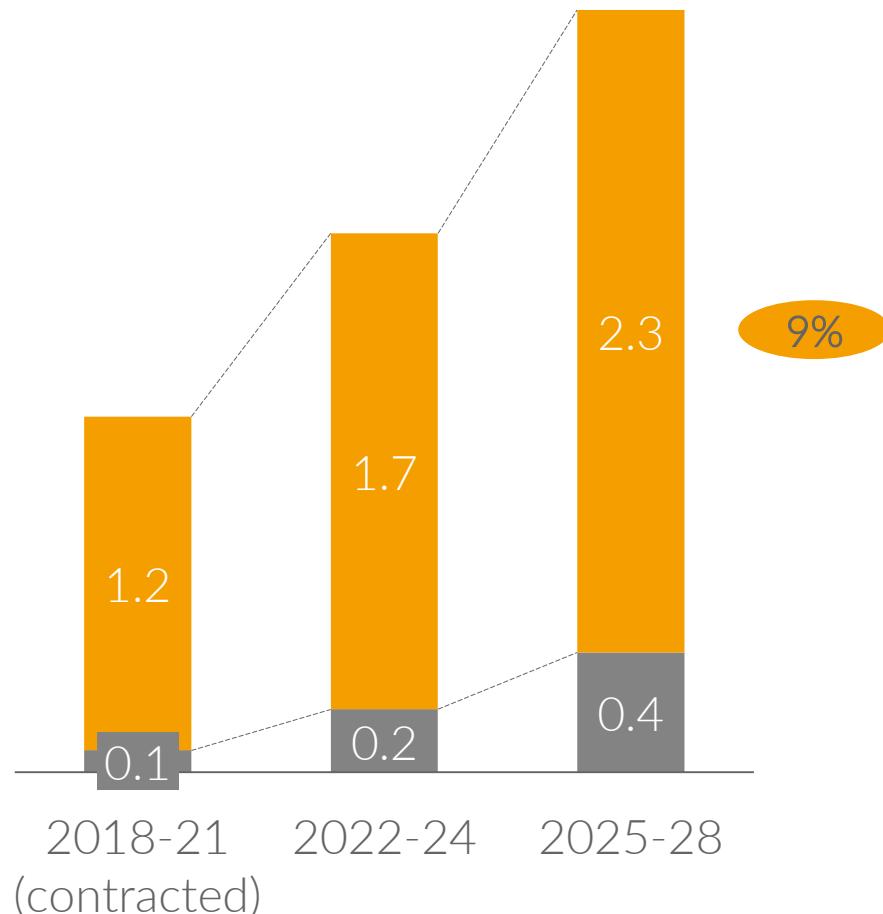
XX%

CAGR

GB capacity mix  
GW



New build capex spend  
£bn per annum

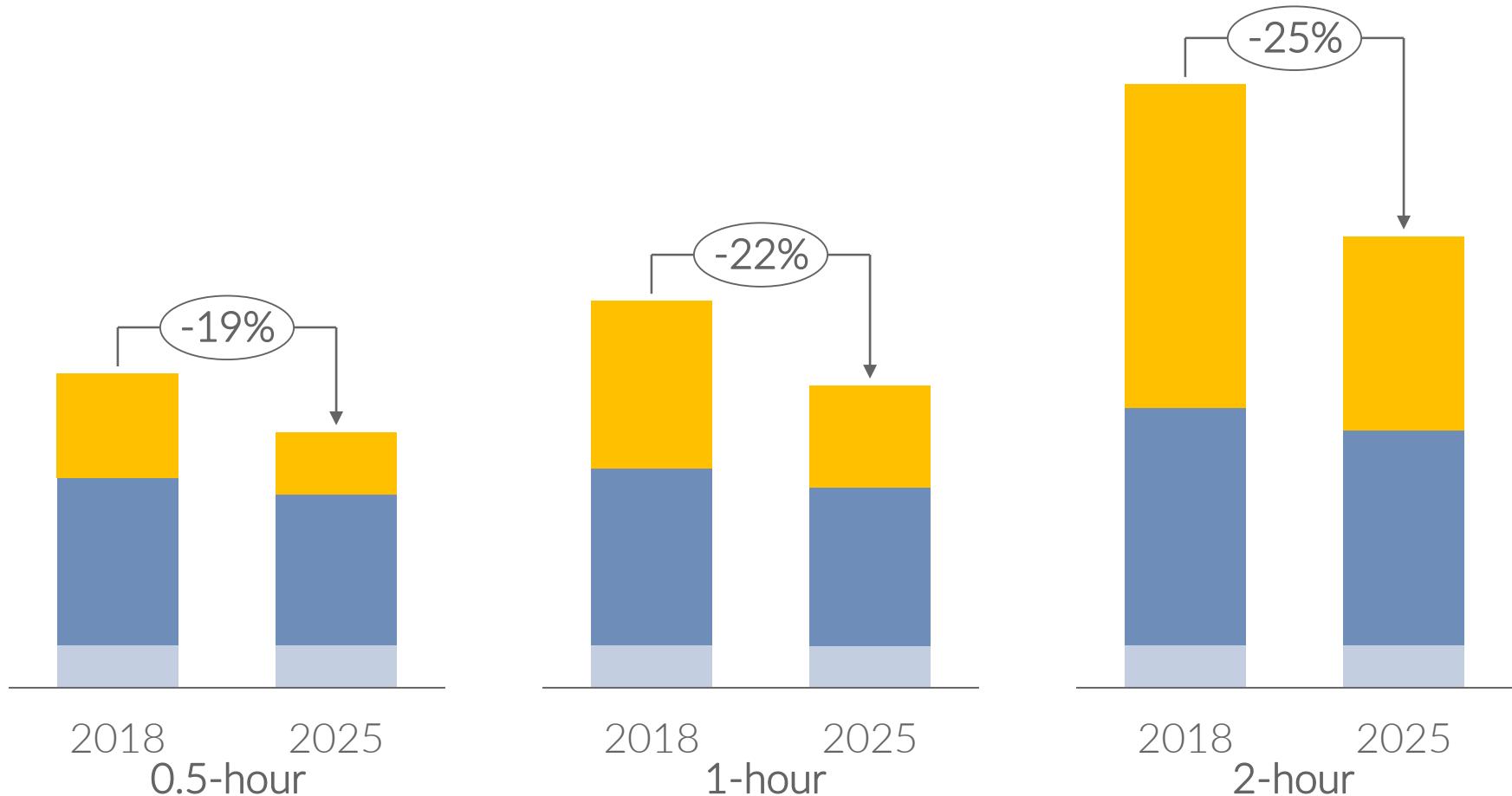


# Our central case has battery cell costs continuing to fall rapidly

## Li-ion costs

Fully installed, £/kW

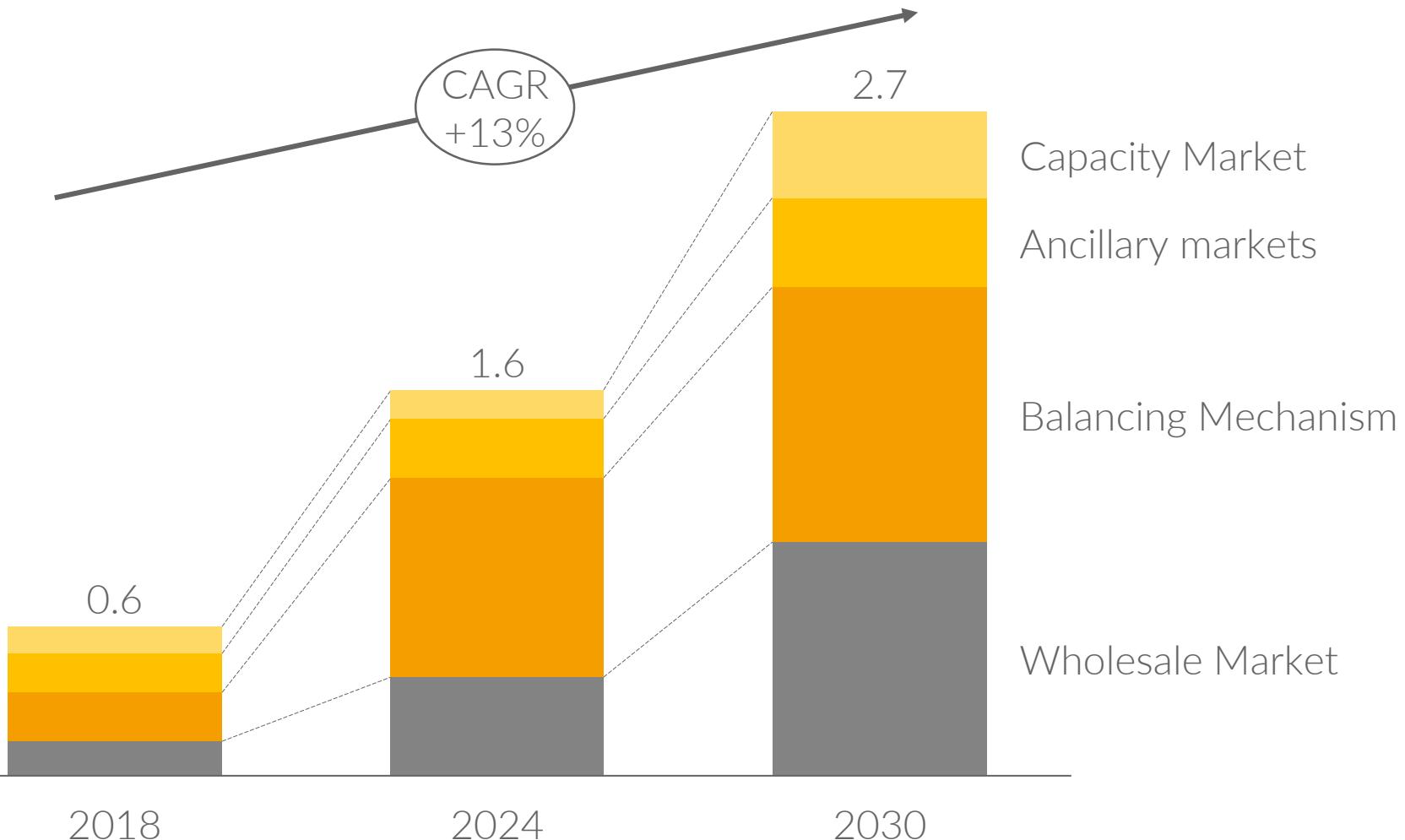
- Cell costs (Central)
- Balance of System
- Connection costs



# Aurora estimate revenue of flexible technologies will be driven primarily by wholesale and balancing

Revenue for flexible technologies

£bn

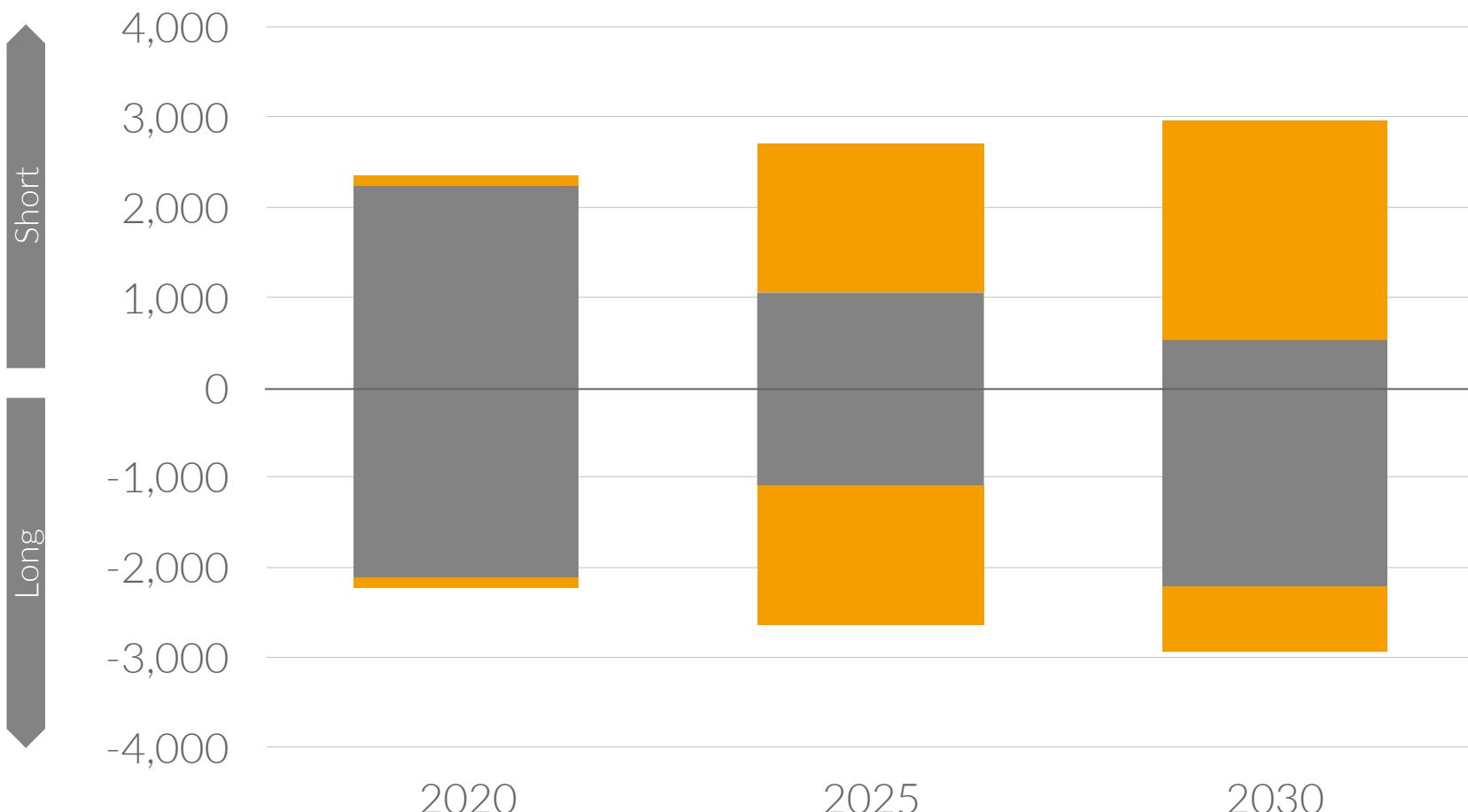


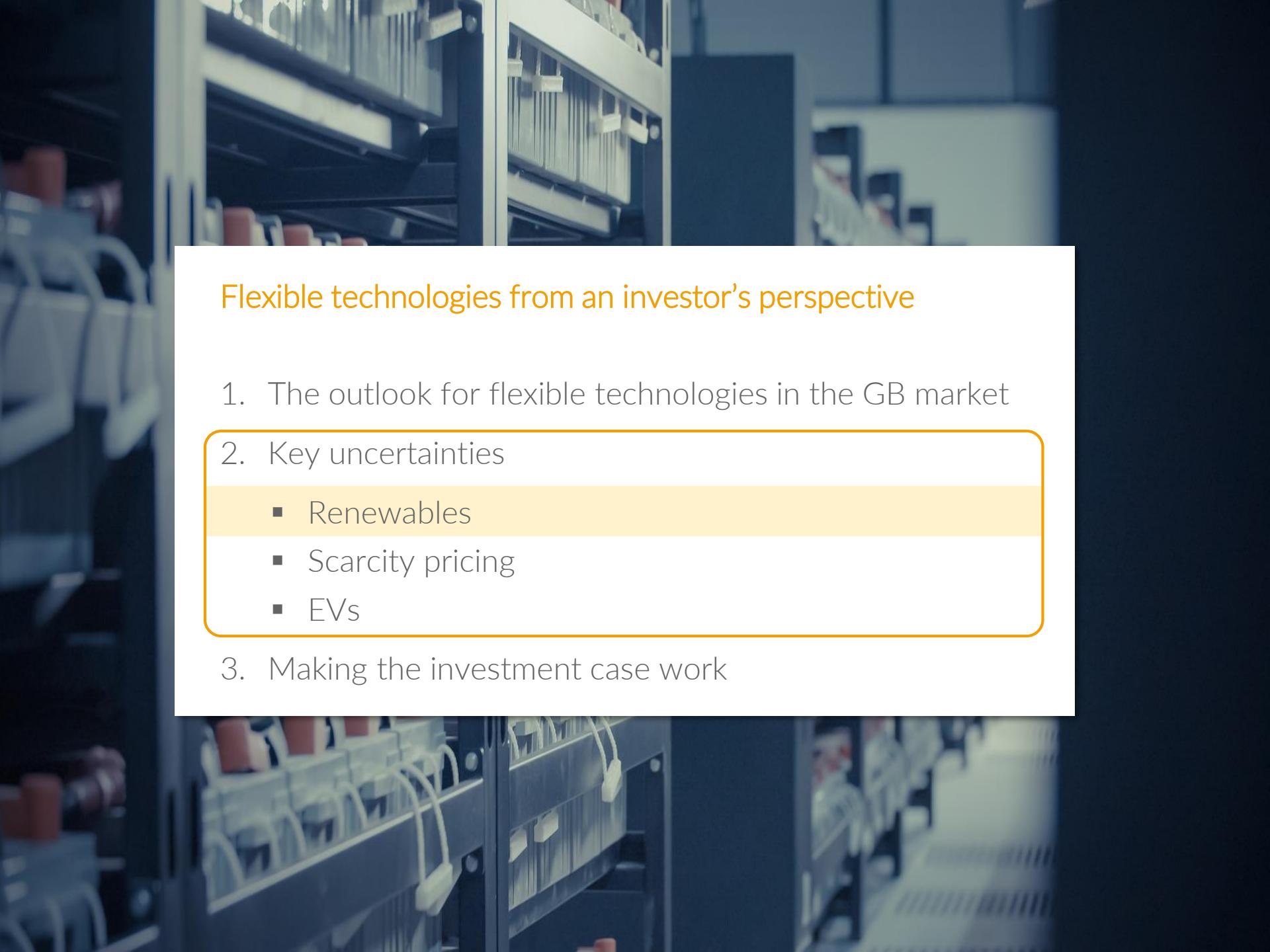
# Batteries dominate the Balancing Mechanism from the mid-2020s, especially on the short side

Bid-offer acceptances

GWh

Battery Other



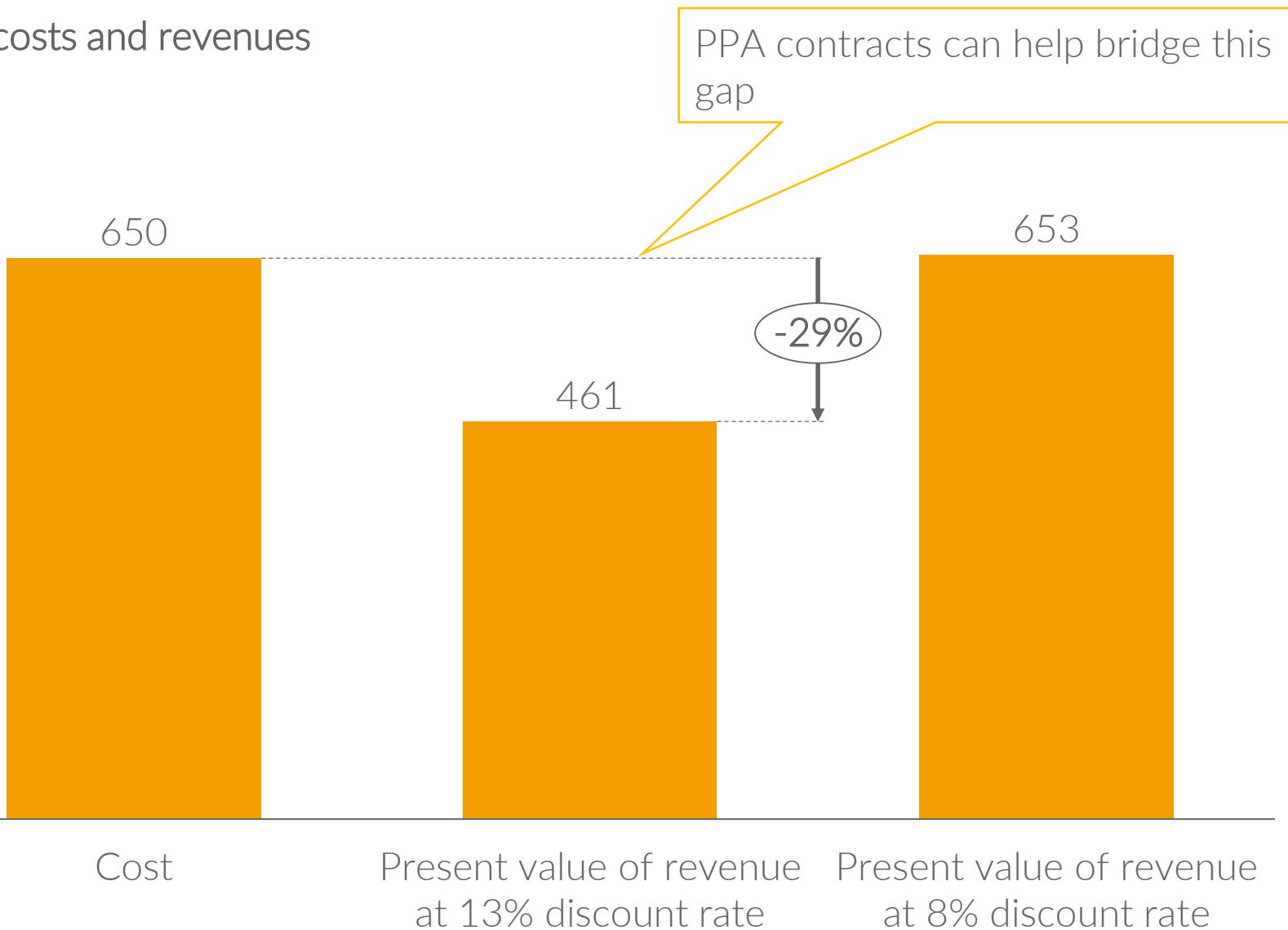


## Flexible technologies from an investor's perspective

1. The outlook for flexible technologies in the GB market
2. Key uncertainties
  - Renewables
  - Scarcity pricing
  - EVs
3. Making the investment case work

# Subsidy-free renewables are nearly investable in GB, but further de-risking is needed

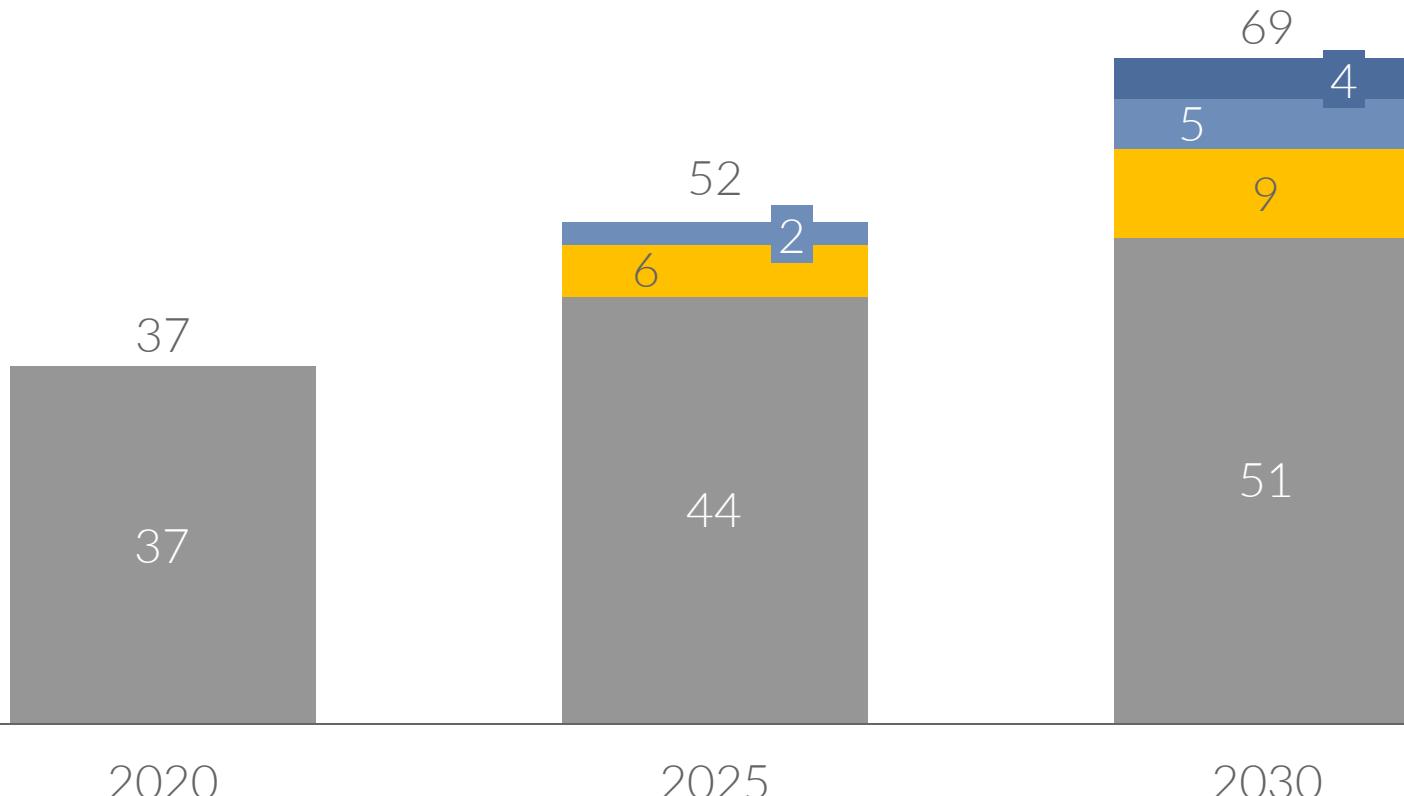
Solar costs and revenues  
£/kW



# Aurora estimate GB could see as much as 20GW of subsidy-free renewables on the system by 2030

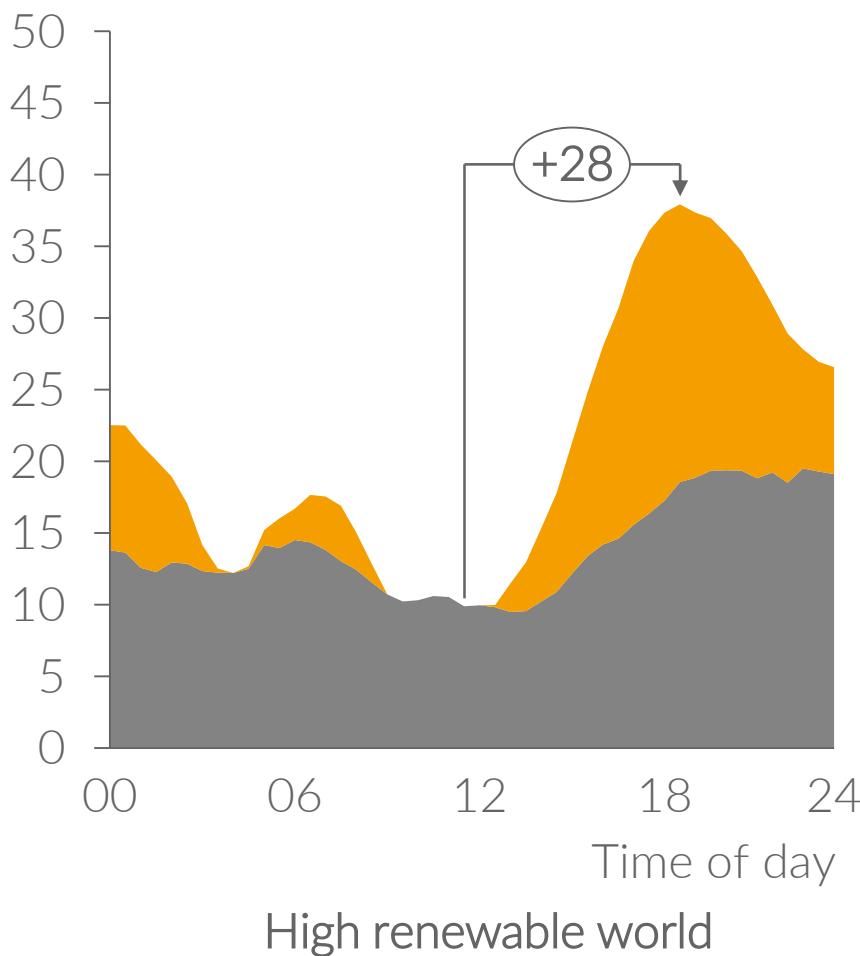
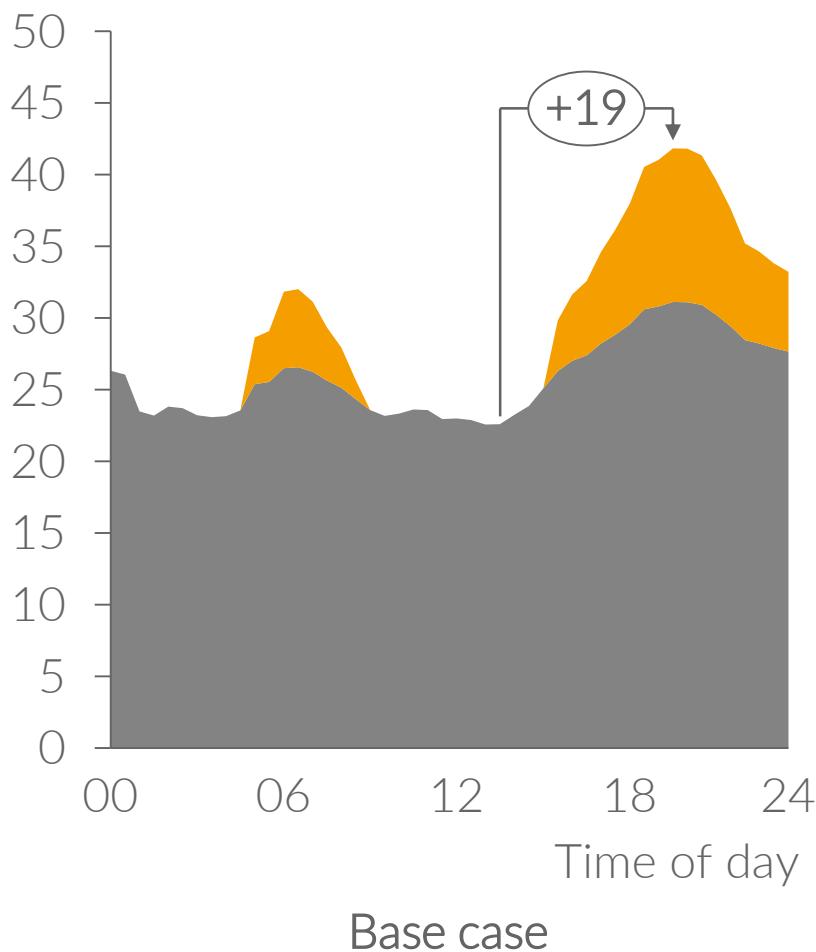
Installed renewable capacity,  
GW

Subsidy-free offshore      Subsidy-free solar  
Subsidy-free onshore      Subsidised renewables



# This further squeezes out baseload generation and increases demand for flexibility

Demand net of renewables,  
GW, 2030 average

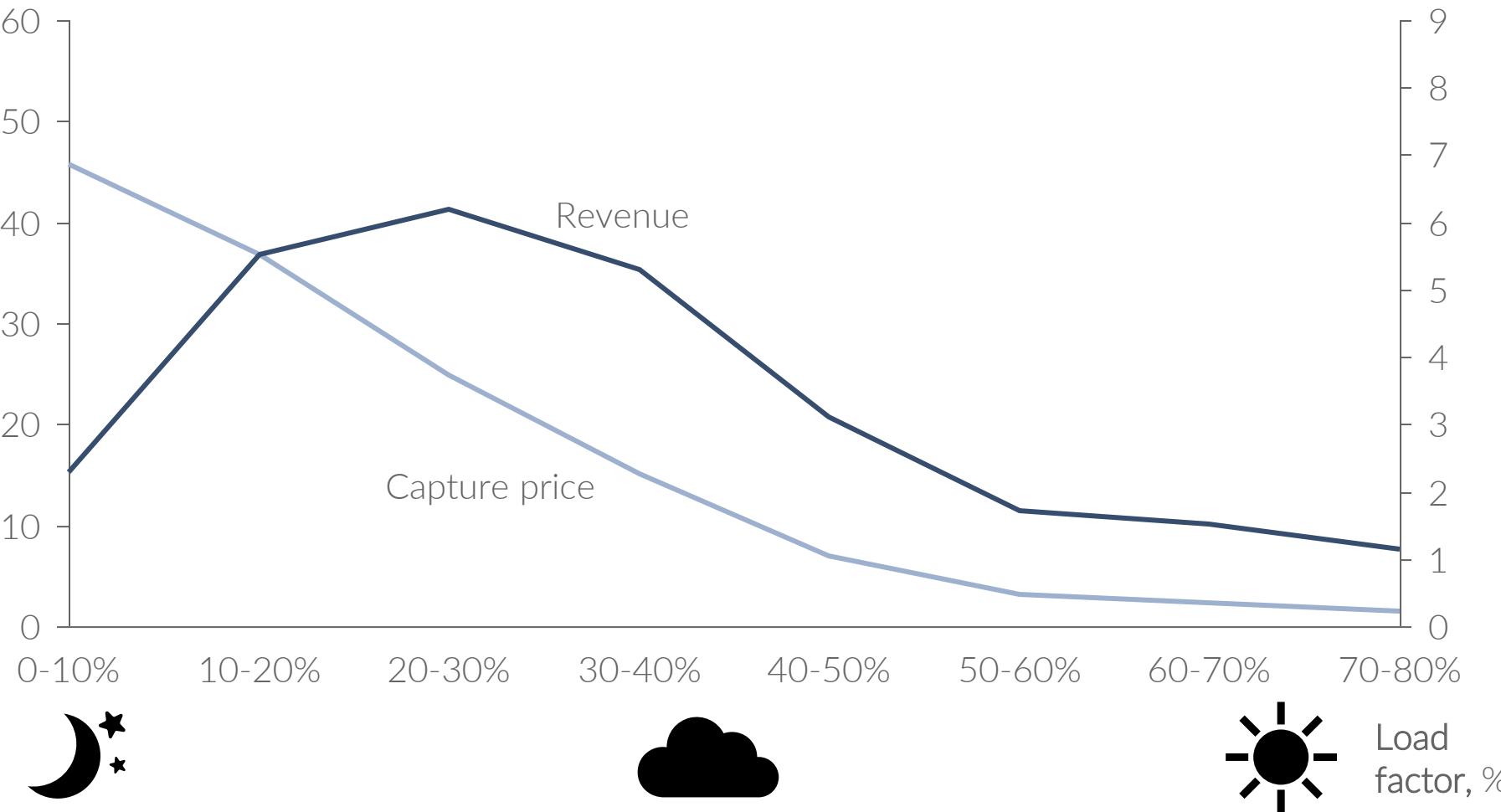


# In a high solar world, capture prices are low on sunny days; cloudy days are most profitable

GERMANY HIGH RENEWABLES SCENARIO, 2030

Solar capture price,  
EUR/MWh

Revenues,  
EUR/MW/h

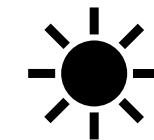
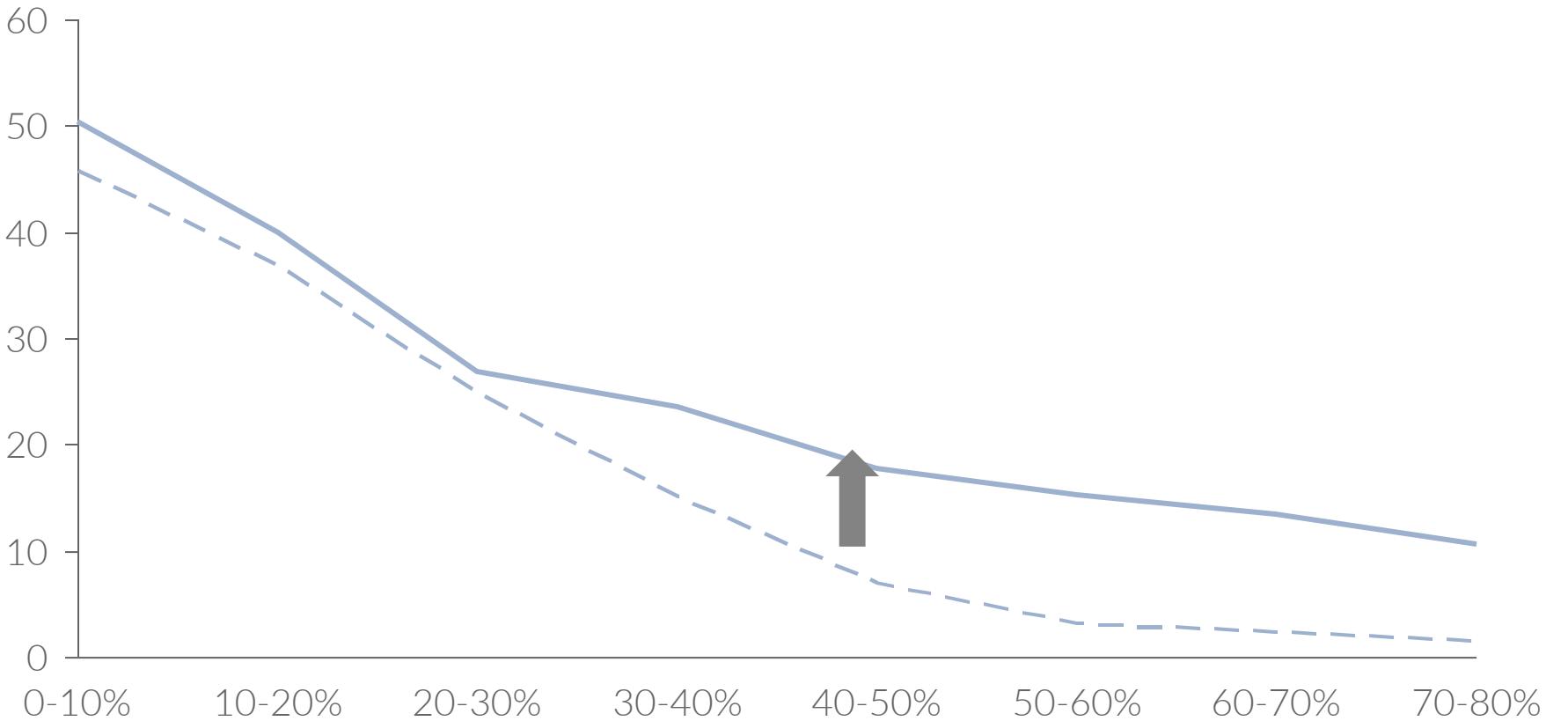


# More batteries support the solar capture price when load factors are high

GERMANY HIGH RENEWABLES SCENARIO, 2030

Solar capture price,  
EUR/MWh

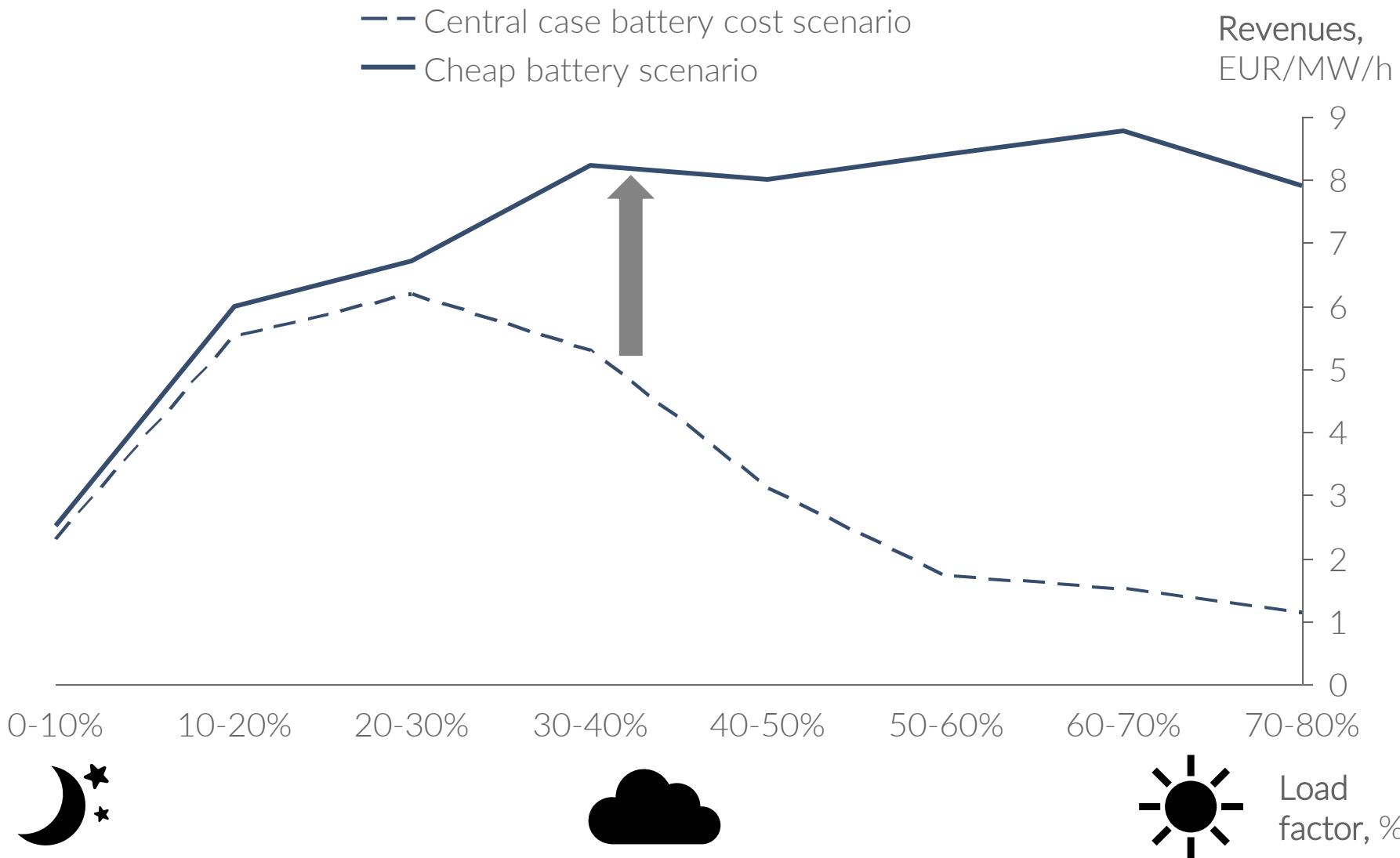
— Central case battery cost scenario  
— Cheap battery scenario

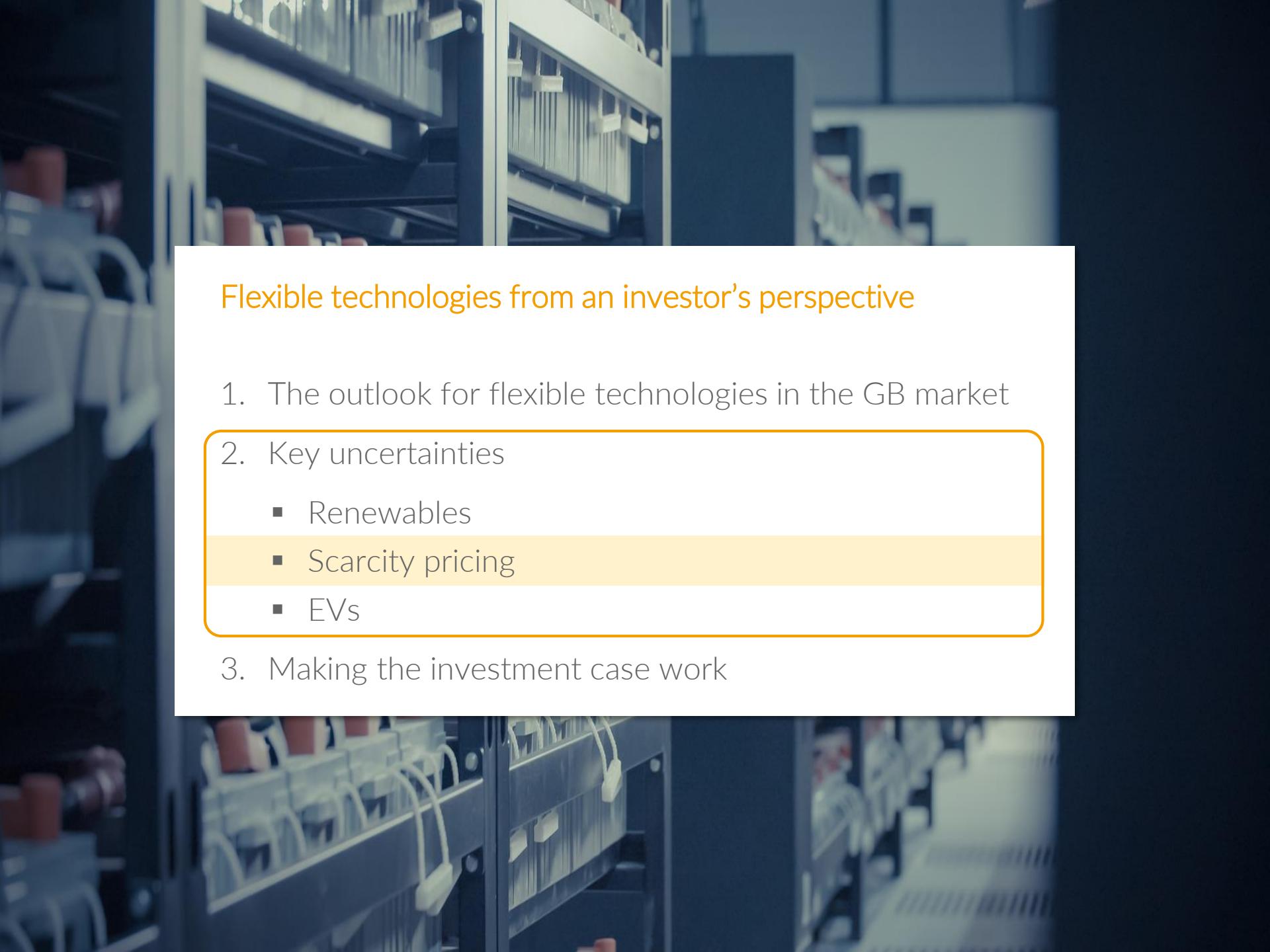


Load  
factor, %

# This materially improves revenue, even at high load factors

## GERMANY HIGH RENEWABLES SCENARIO, 2030





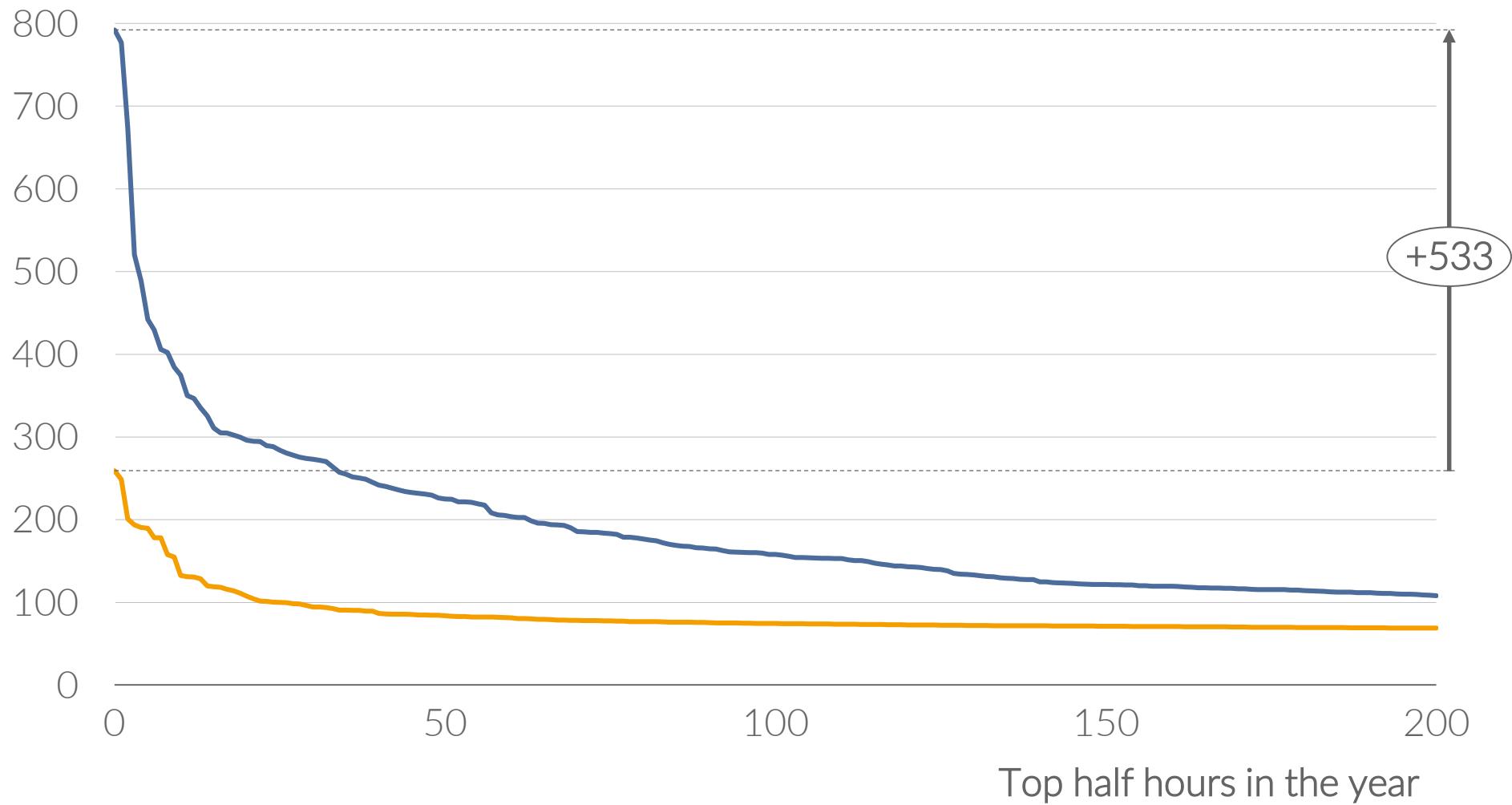
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# Top prices vary significantly from year to year, depending on the amount of scarcity

Wholesale energy price  
£/MWh

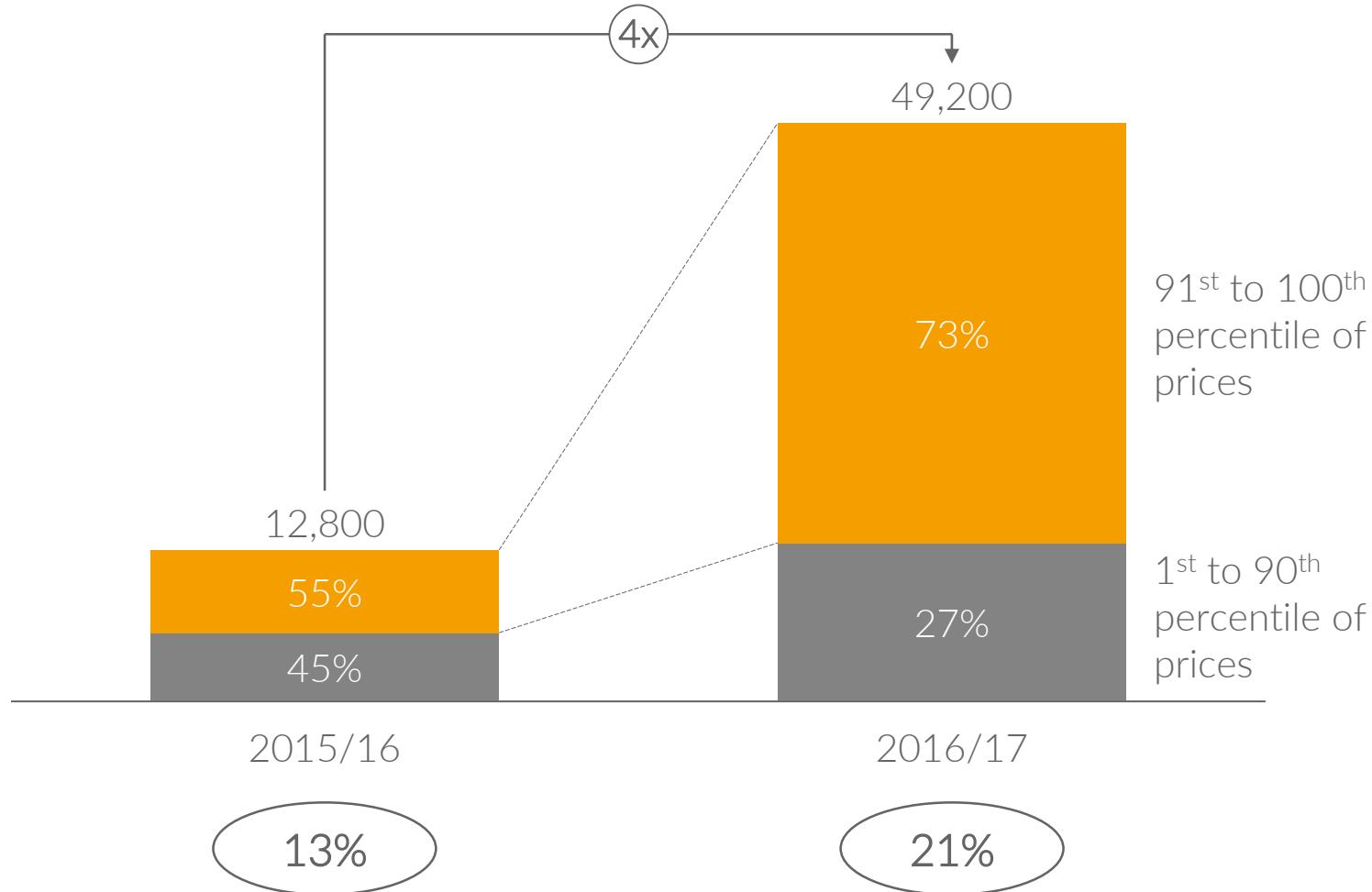
2015  
2016



# These top prices critically determine the profitability of flexible assets

Gross profits from energy sales for a typical gas peaker  
£/MW/year

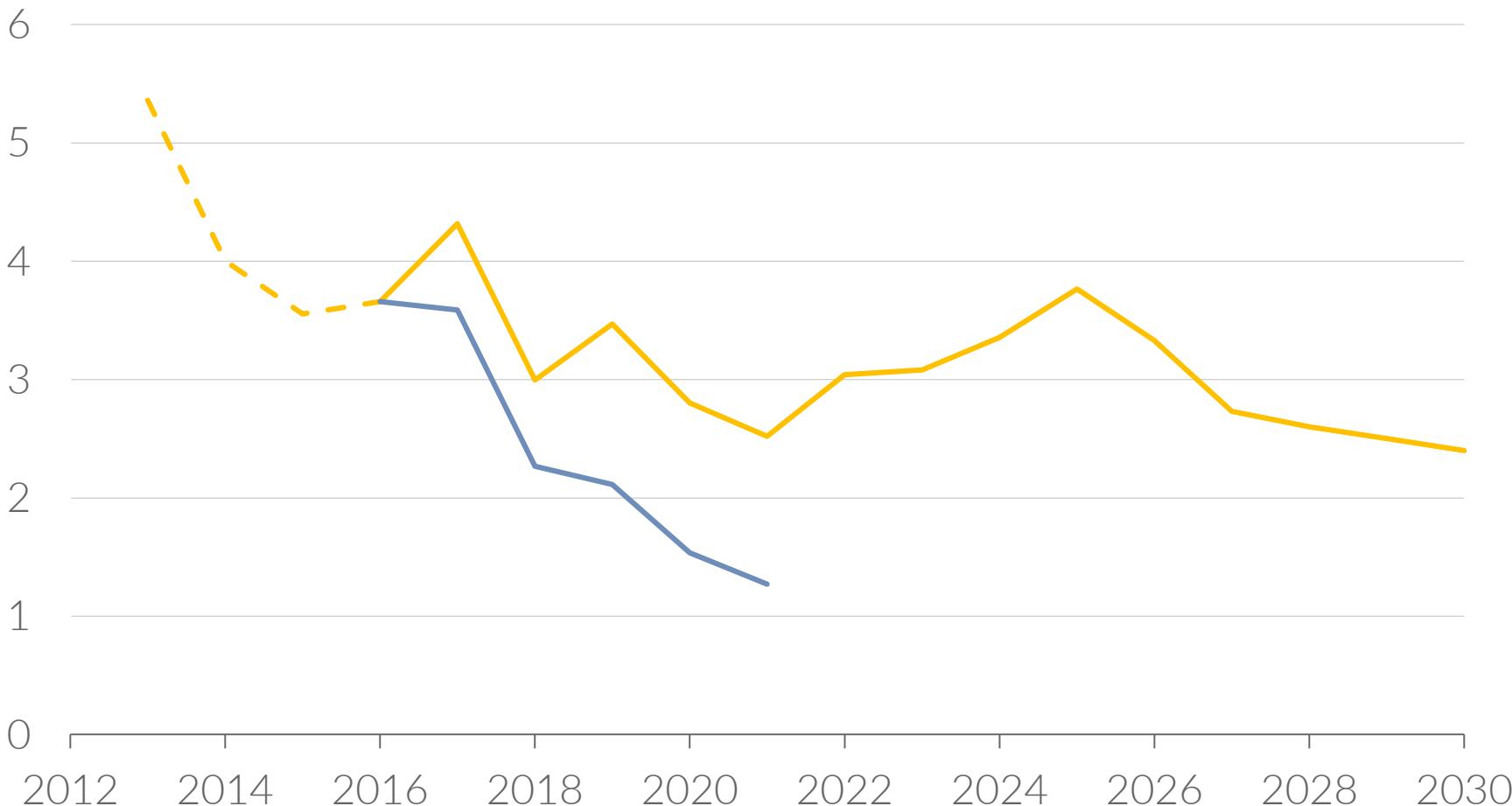
XX% ROI



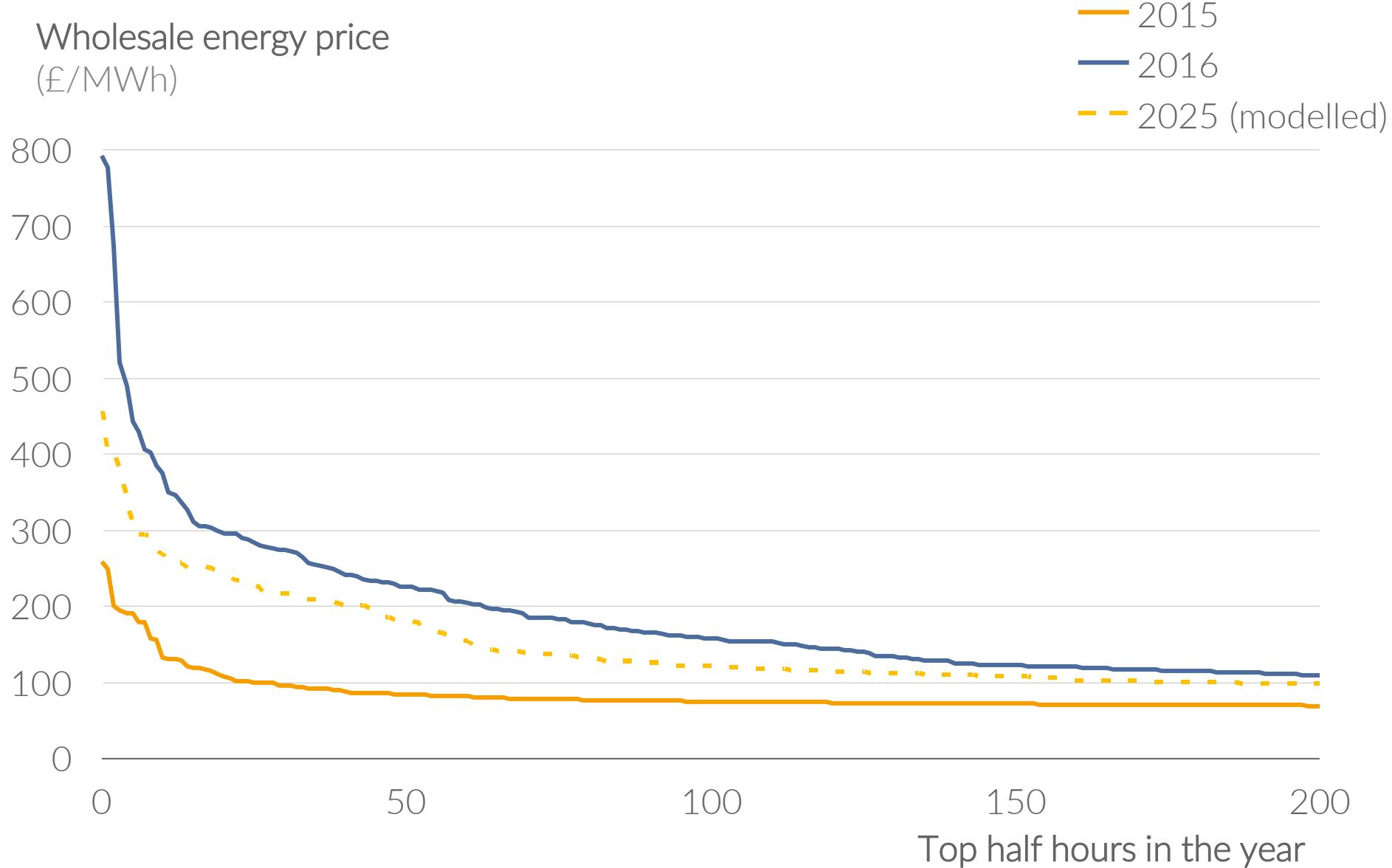
# Under current capacity market design, de-rated capacity margins are likely to remain low

Minimum de-rated capacity margin  
GW

Targeted margin  
With potential non-delivery

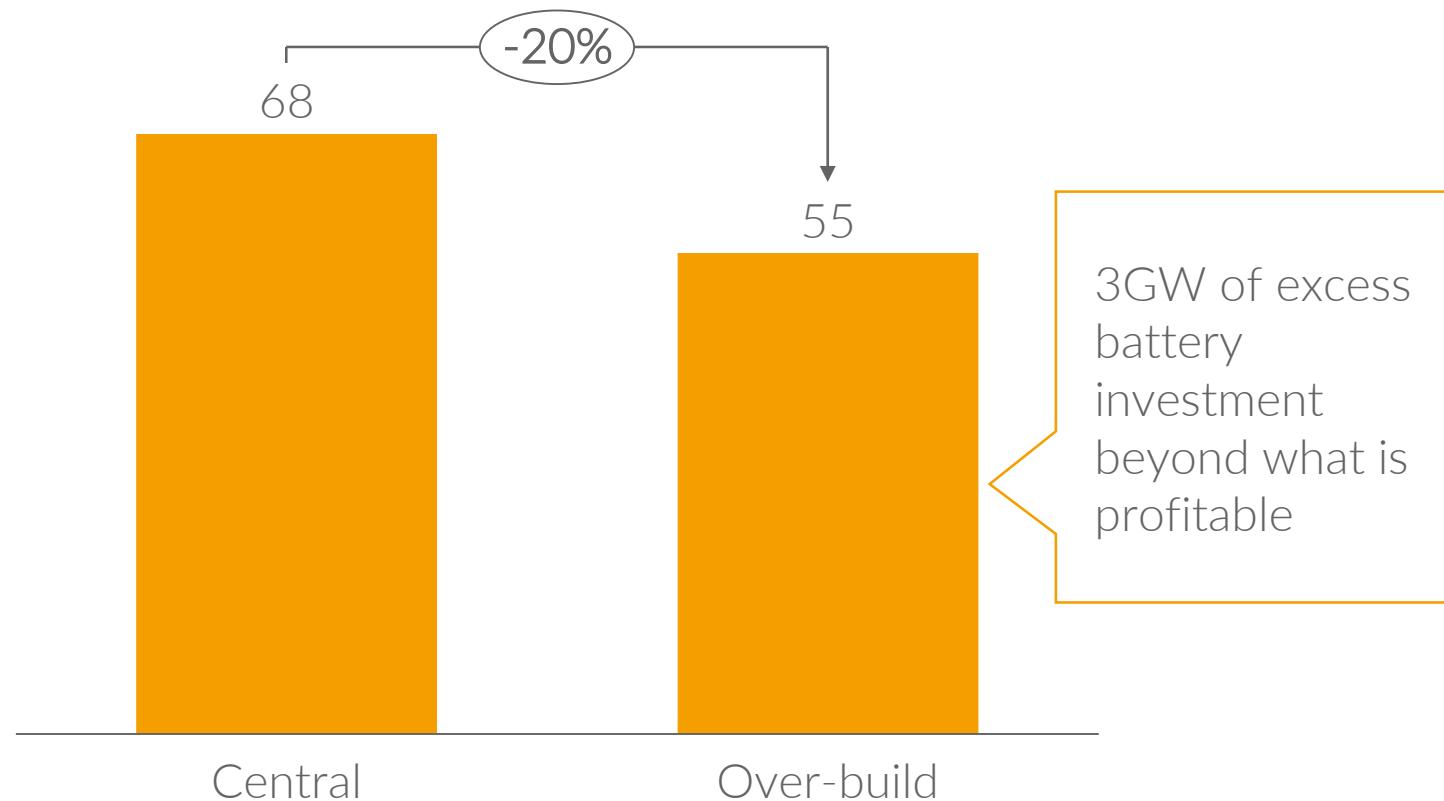


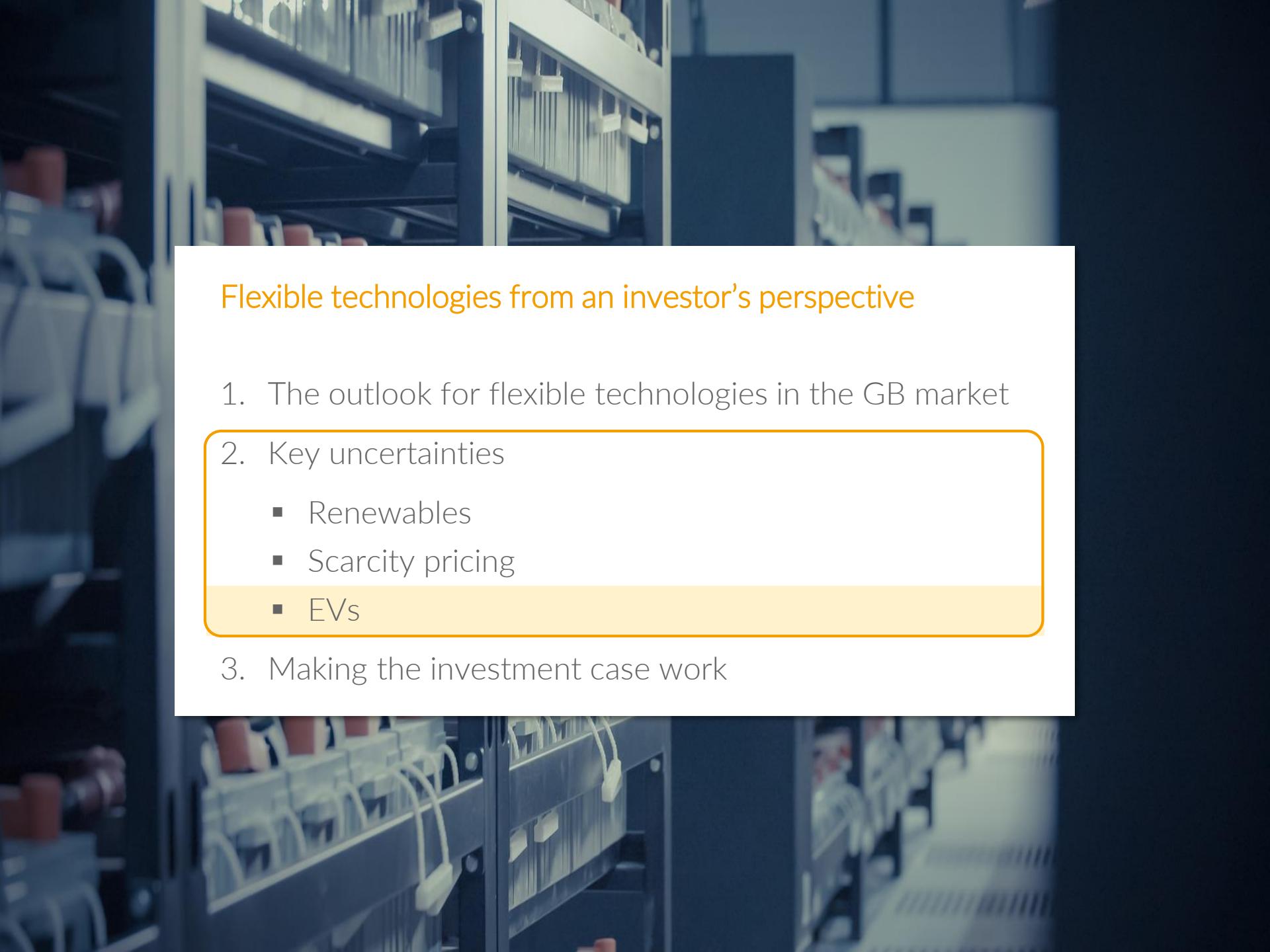
# As a result, Aurora expect some scarcity pricing to persist, even as flexibility grows



# However, battery overbuild would soften peak prices and undermine investment returns

Gross profits for 1h battery under arbitrage business model, 2020 entry  
£/kW/year (Average 2020 – 2030)





## Flexible technologies from an investor's perspective

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# EVs could significantly alter the daily electricity demand curve

2035 annual average

GW

60

55

50

45

40

35

30

25

Evening  
charging would  
substantially  
increase peak  
demand

Central (13m EVs)

High (26m EVs) - not smart

+9GW

00

06

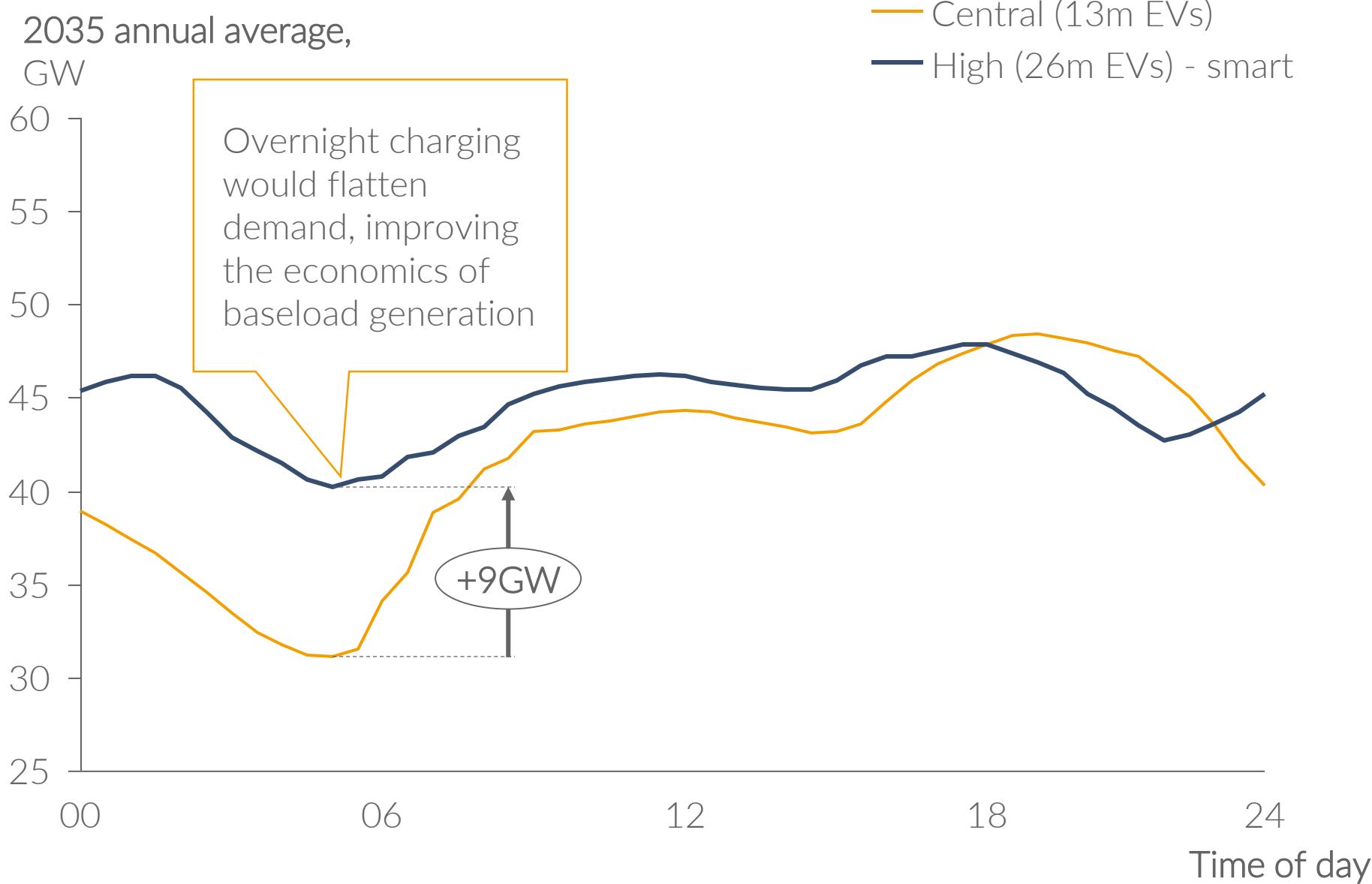
12

18

24

Time of day

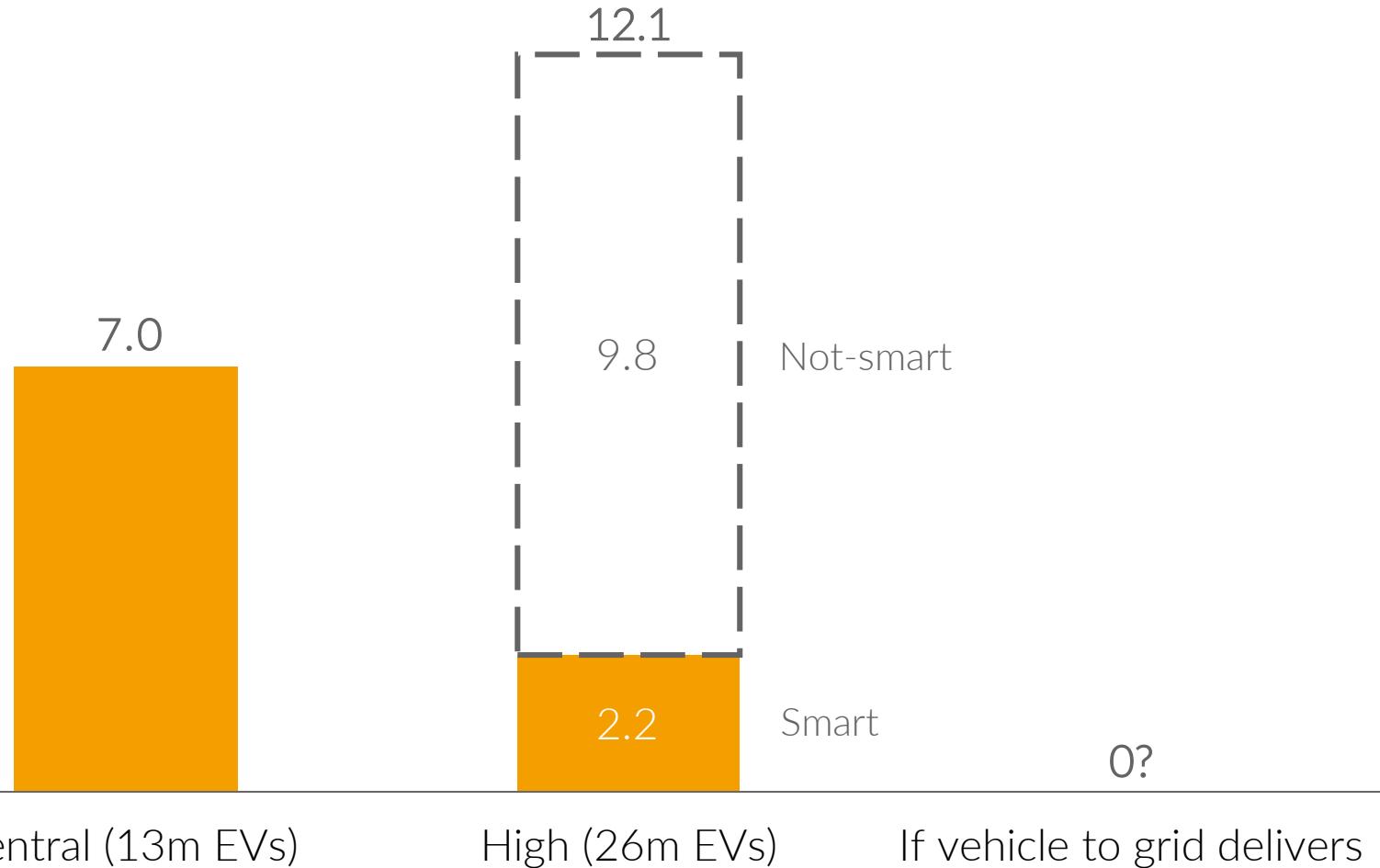
# EVs could significantly alter the daily electricity demand curve

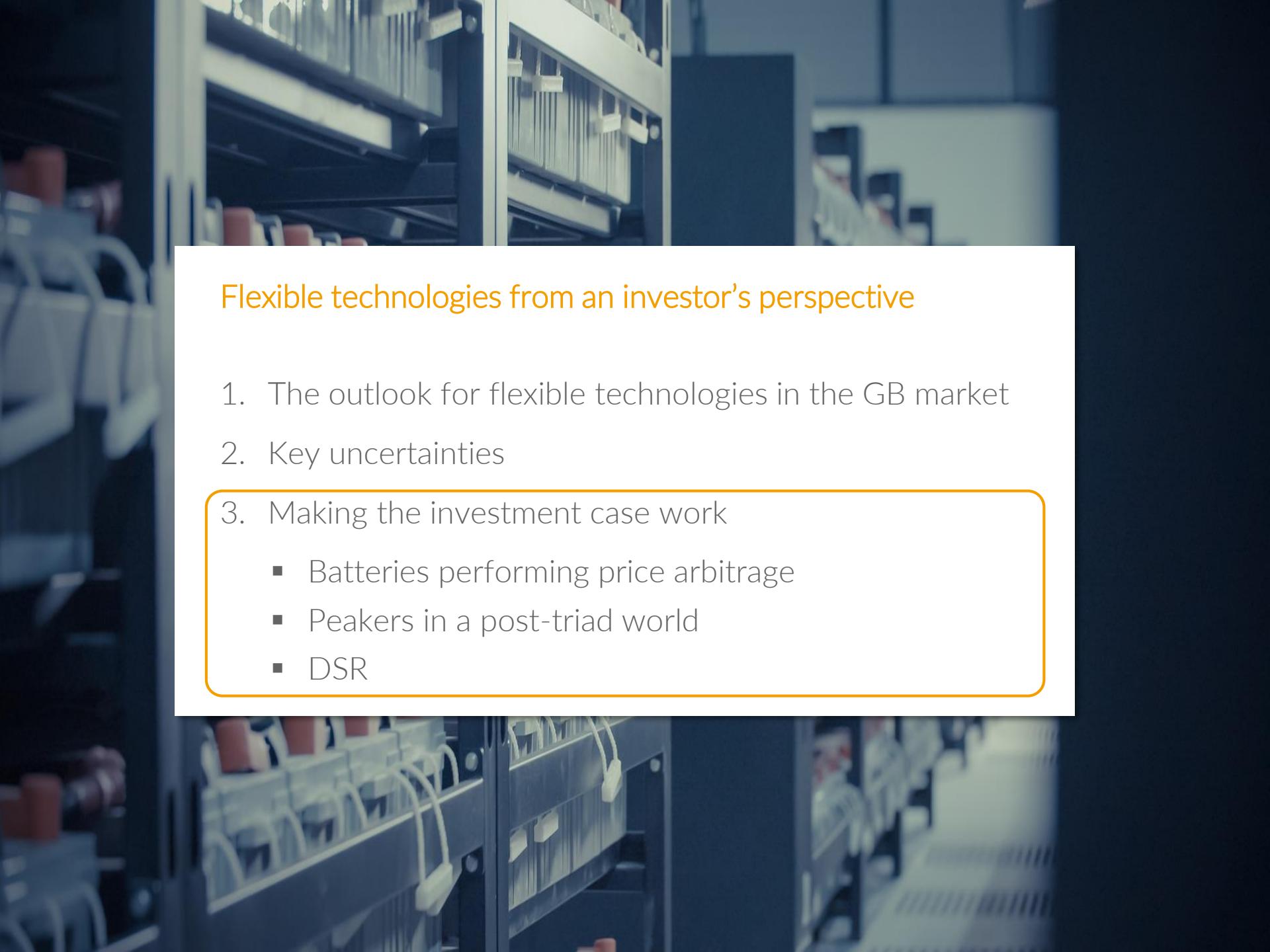


# A high EV future with smart charging would reduce the opportunity for grid scale batteries

Non-EV battery capacity in 2035

GW



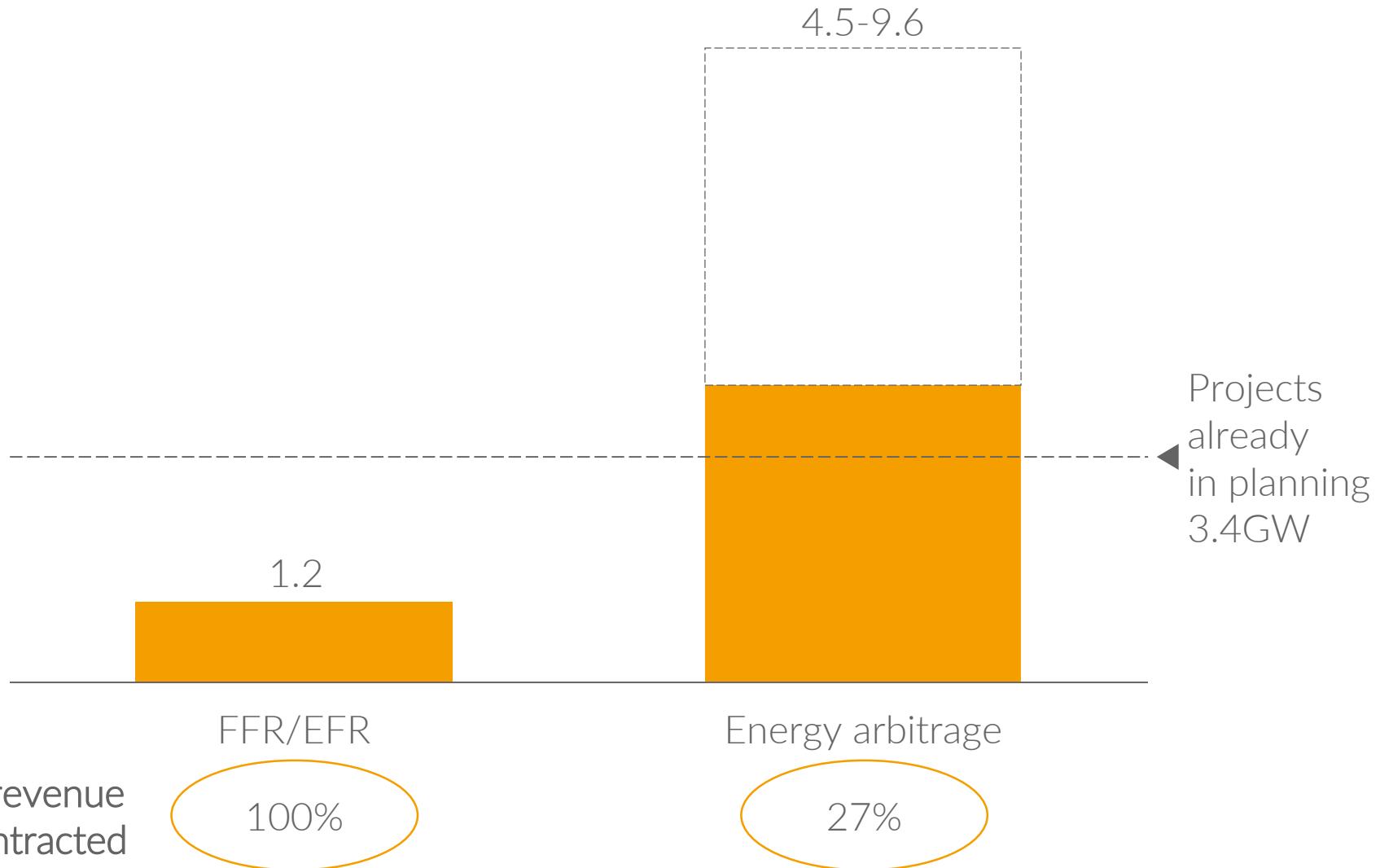


## Flexible technologies from an investor's perspective

1. The outlook for flexible technologies in the GB market
2. Key uncertainties
3. Making the investment case work
  - Batteries performing price arbitrage
  - Peakers in a post-triad world
  - DSR

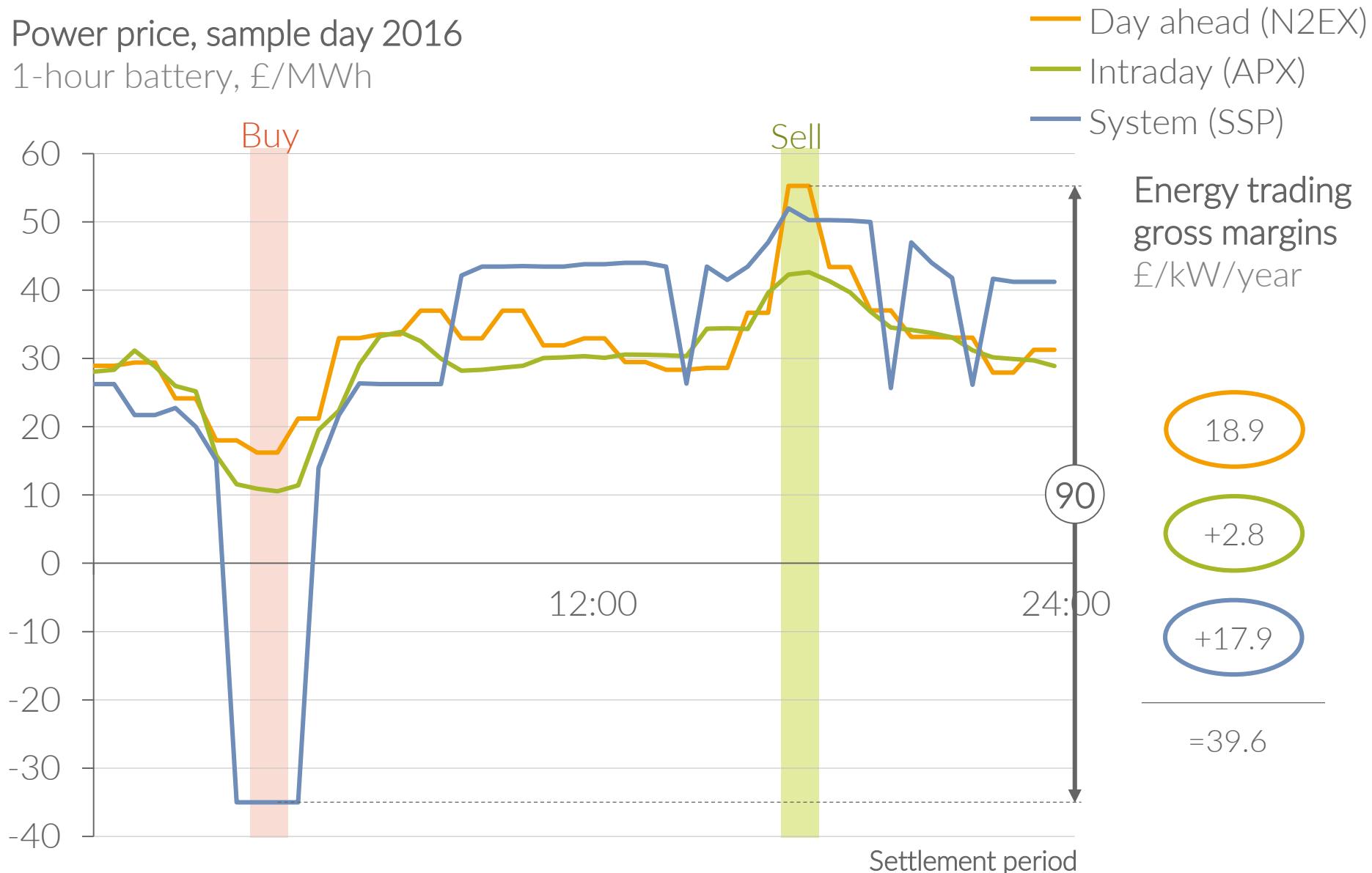
# Frequency response allows batteries entry now, but energy arbitrage is ultimately a bigger market

GB battery capacity by 2030  
GW



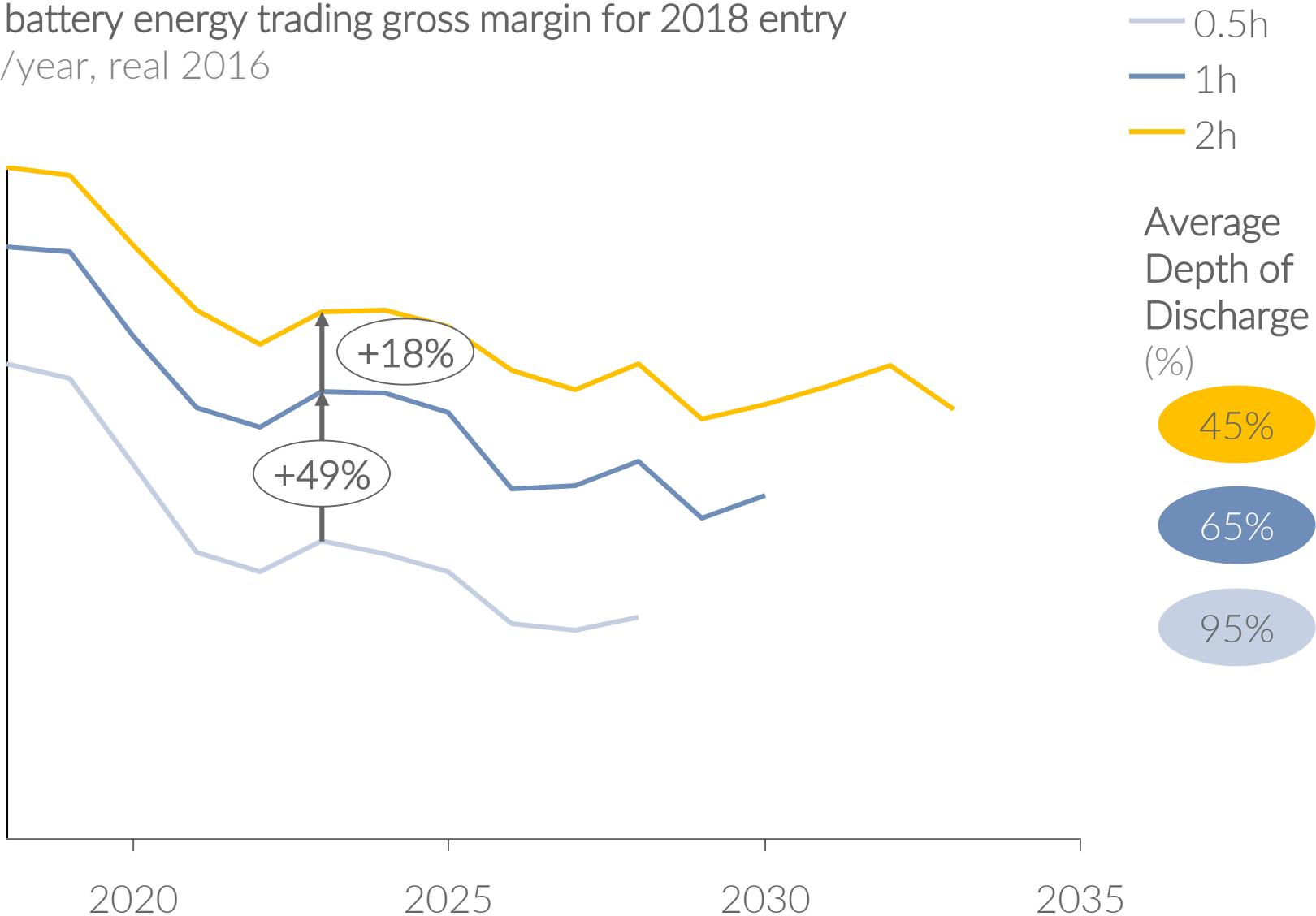
# Batteries will crack the energy arbitrage opportunity, but dispatch optimisation is complex

Power price, sample day 2016  
1-hour battery, £/MWh



# Longer duration batteries capture higher gross profits, but benefit is not proportionate to duration

Li-ion battery energy trading gross margin for 2018 entry  
£/kW/year, real 2016



# Higher capex makes high duration batteries sub-optimal today, but this will change as costs decline

Li-ion battery energy IRR by year of commissioning

%

16

14

12

10

8

6

4

2

0

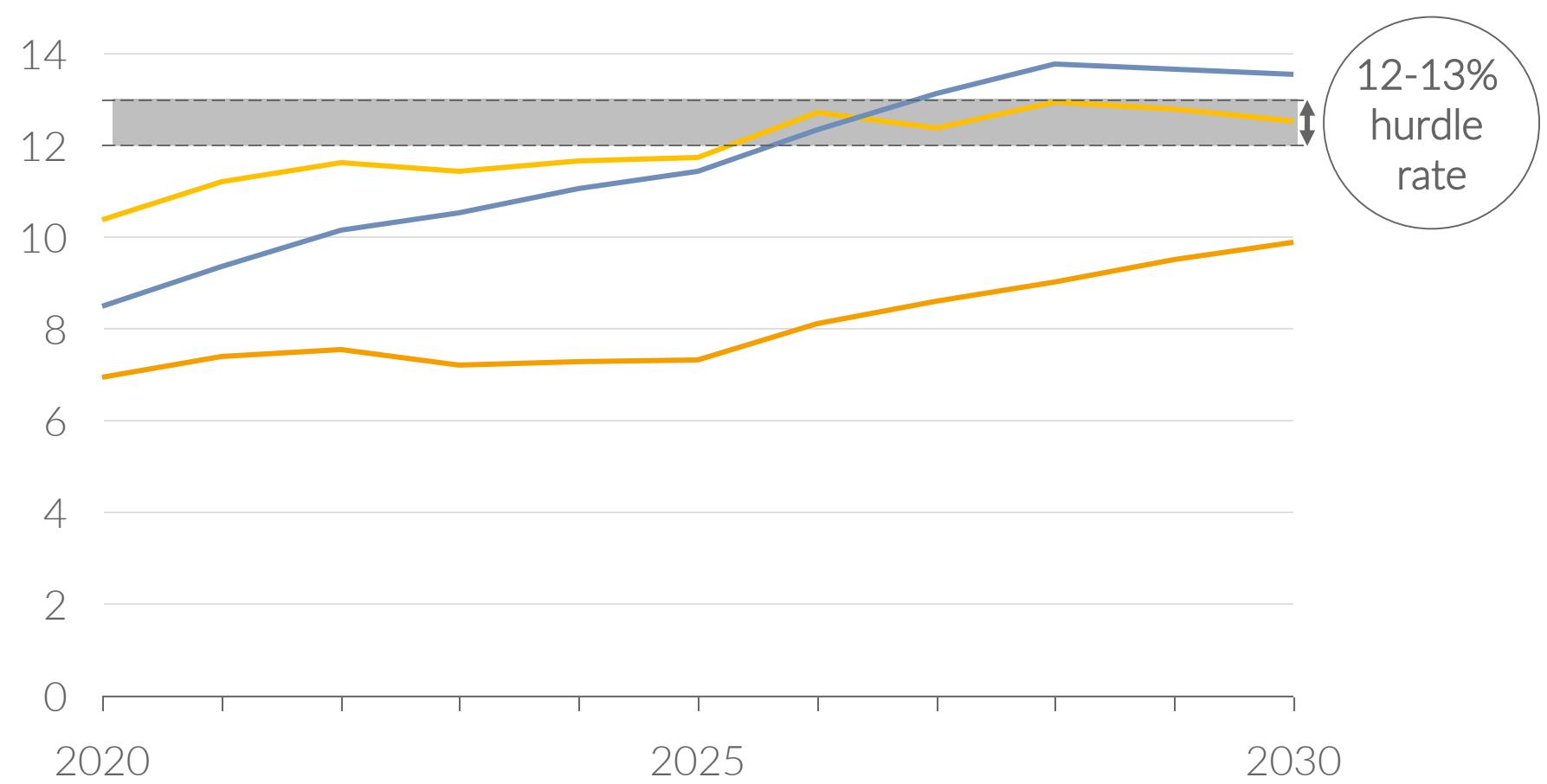
2020

2025

2030

- 2 hour
- 1 hour
- 0.5 hour

12-13%  
hurdle  
rate



## Grid-scale advantages

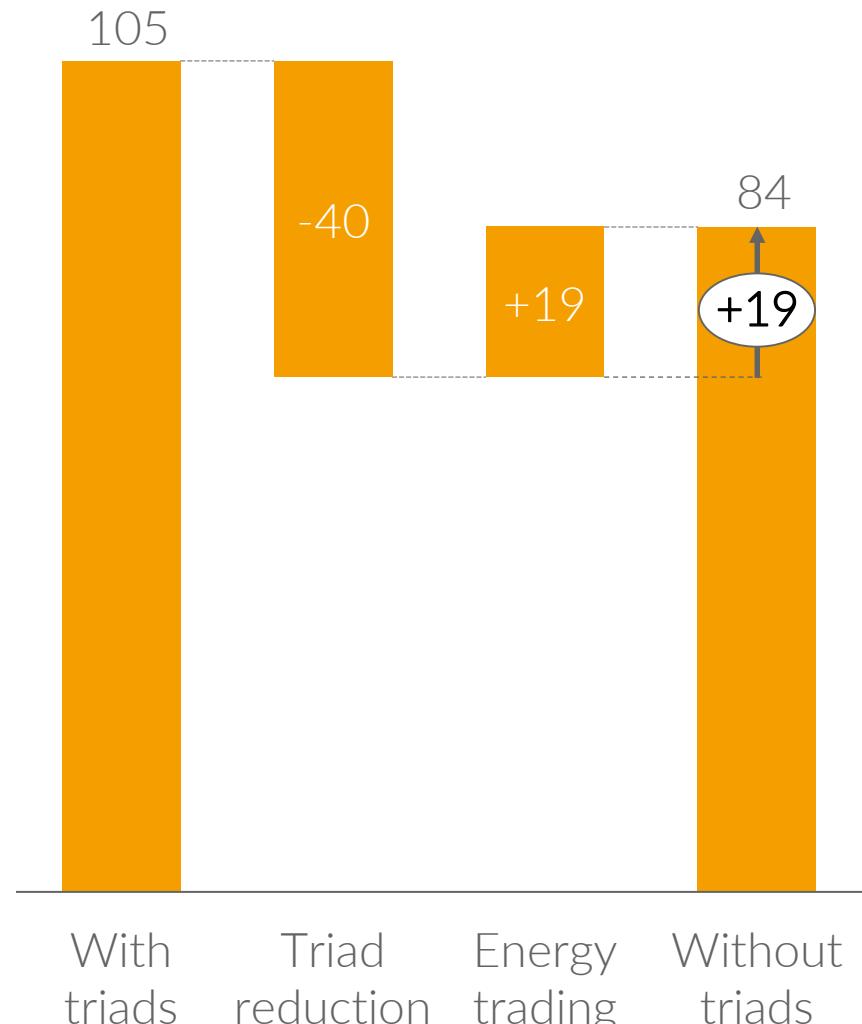
- Economies of scale drive down costs
- Larger units may decrease administrative cost/complexity of National Grid balancing actions

## Behind-the-meter advantages

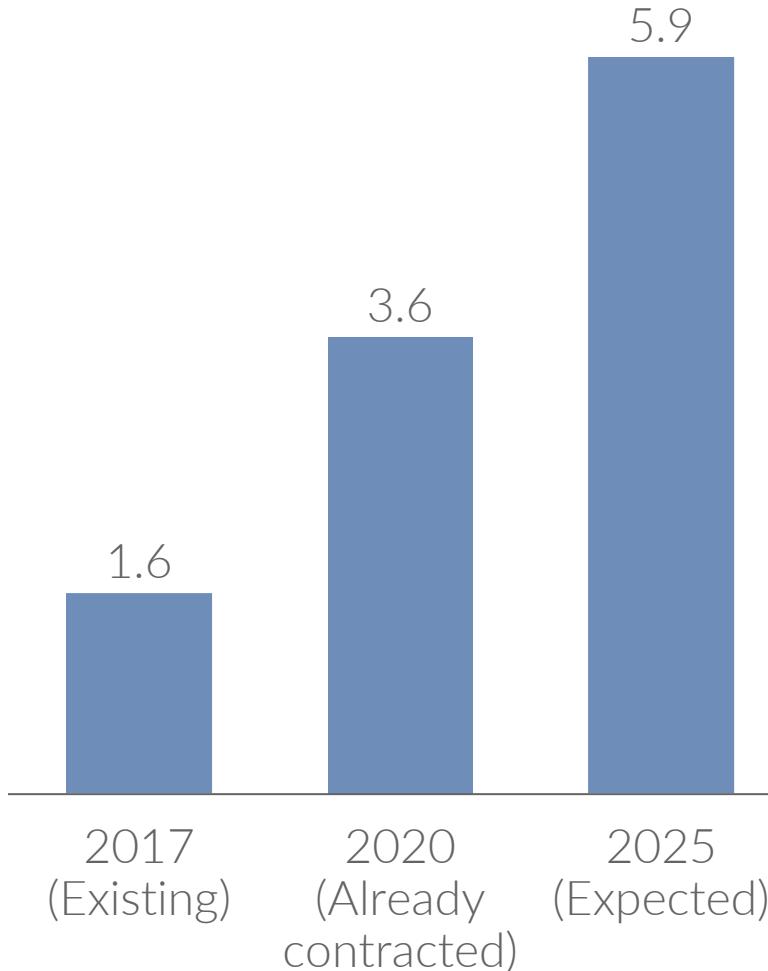
- Can help with local network congestion
- Consumer preference and return expectations
- Avoided transmission and green levy charges
- Arbitrage retail tariffs

# Peakers: Aurora expect margins will remain attractive despite triad changes

Gas peaker energy gross margin  
Average 2020-25, £/kW/year, real 2016

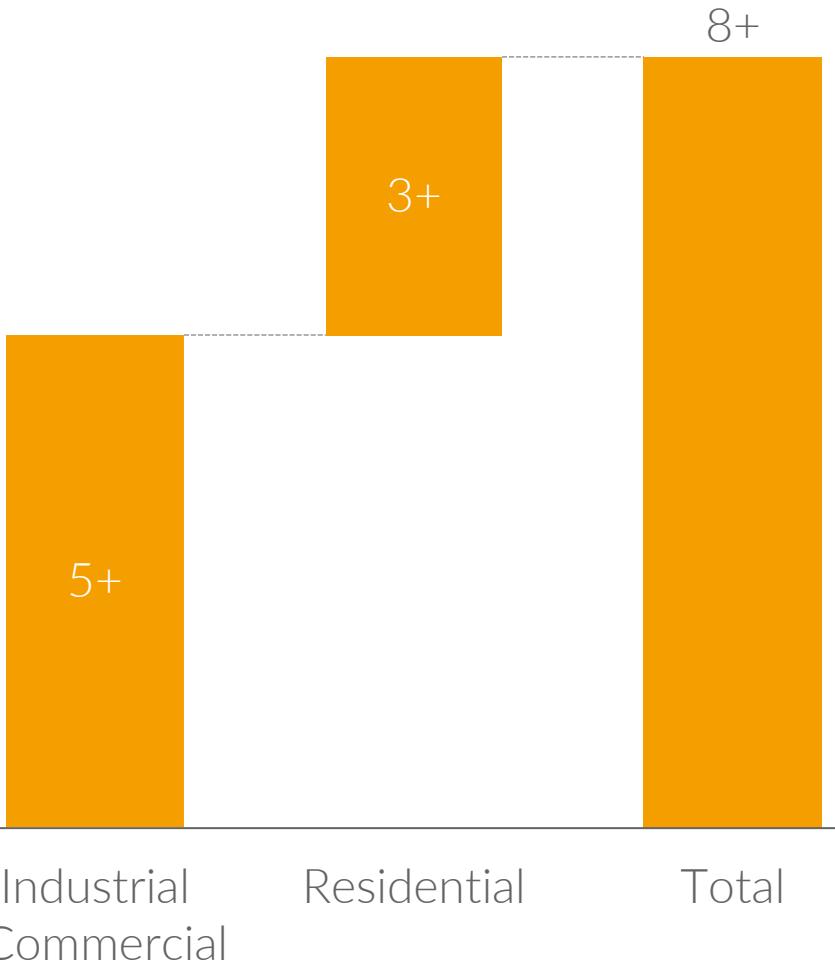


Peaker capacity  
GW



# DSR: Theoretical potential is high, but the amount that will be delivered is difficult to predict

DSR potential in GB  
GW



## Will DSR deliver?

- + Low costs
- + Success in other markets (e.g. PJM)
- + Support from policy makers
- Hard to access
- Behavioural barriers
- Limited track record



# UK Battery Storage and Flexibility Conference

**Marketing information**



# Can Aurora help you?

## Subscription-based analytics

All the market information you need to support development and financing of flexible assets

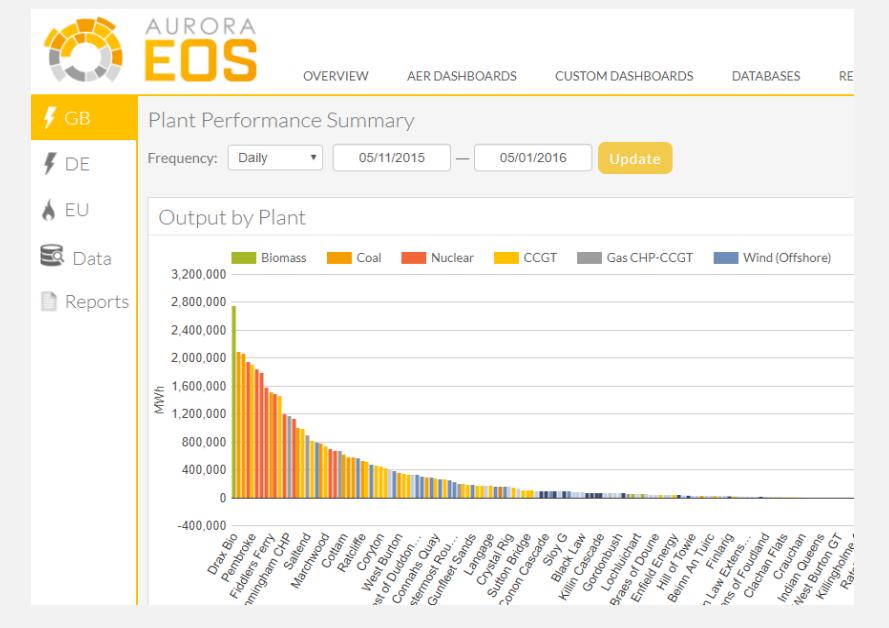
- **Data:** Forecasts of all revenue streams including balancing, running hours etc
- **Analysis:** market, policy and technology outlook
- **Updated regularly,** covers all flexible technologies and business models.

## Consultancy

- Bankable revenue stream forecasts specific to your project
- Due diligence and market advisory
- Capacity market forecasting and bidding strategies

## Coming in 2018...

- Online dispatch forecasting, tailored to your project, just enter your project-specific parameters and click go!
- Dispatch against any of Aurora's regularly updated market forecast scenarios
- Instantly receive monthly revenue data and a populated financial model

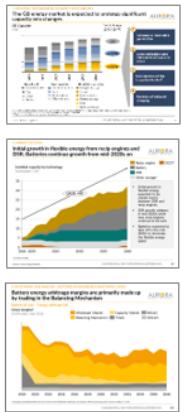


# Aurora's Distributed and Flexible Energy Service

## Market analysis and forecasts for batteries, peakers and DSR in the GB market

### What's included in the subscription package?

#### 1 Bi-annual Market Outlook on Distributed and Flexible Energy



- Overall market outlook and capacity development until 2040, with particular focus on flexible technologies (batteries, peakers and DSR)
  - Revenue forecasts for the wholesale market, balancing mechanism, capacity market, ancillary services (EFR, FFR, STOR, Fast Reserve) and embedded benefits (GDUoS, BSUoS and Triads)
  - Business model specific revenue stream stacking
  - In-depth review and outlook of policy and regulatory frameworks, including discussion of key policy uncertainties and impacts
  - Technology outlook with projections on cost and improvements in performance
  - Business/investment case analysis for batteries, peakers and DSR under various business models
  - Sensitivity analyses which are updated regularly to include significant market uncertainties and alternate scenarios
- ➡ Forecasts are bankable and have been used in many transactions and for securing financing

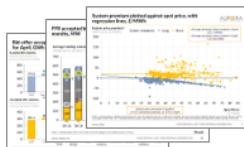
#### 2 Forecast data in xls



- Full forecast dataset in xls until 2040 (updated twice a year) including:
  - Half-hourly wholesale price forecast, balancing mechanism price and capacity market price
  - Forecasts of all other attainable revenue streams in ancillary services (FFR, STOR, Fast reserve) and embedded benefits (GDUoS, BSUoS and Triads) until 2040
  - Standardised business cases including gross margins modelled on actual deployment and dispatch

➡ Giving you everything you need to build your own investment case

#### 3 Monthly market summaries



- Monthly summary of the markets for flexibility
  - Balancing mechanism: prices, volumes and spreads vs spot
  - FFR auctions: prices, offer and technology acceptance, market volume
  - Other ancillary service markets will be added during 2018

#### 4 Group Meeting participation



- Group Meetings are forums where Aurora will release new analysis, gather feedback and facilitate discussion
- All subscribers will receive invites to our group meetings to discuss highly relevant topics with other market participants
- In collaboration with our subscribers, we select the topics, prepare in-depth analysis, present our views & implications, and invite the participants to challenge them
- Participants include developers and investors in batteries and peakers, DSR aggregators, financiers, large utilities, grid operator as well as BEIS and Ofgem
- Meetings are held twice per year in Central London

#### 5 Bilateral meetings & research support



- Bilateral workshop with senior members and subject matter experts from Aurora's team to discuss analyses and views on the distributed and flexible generation market
- Confidential dialogue with the Aurora team to discuss business-specific implications
- Regular support from our analysts on questions arising from our analysis and forecasts

#### 6 Analytics and data platform EOS



- Access to detailed historical and real-time GB power market data
- Data includes output, load factors and margins/capture prices on all power stations and wind farms, power price and commodity price data
- Data can be viewed, charted and downloaded

#### 7 Preferential entry to Aurora's Battery Storage & Flexibility Conference



- Our by-invitation-only annual Battery Storage and Flexibility Conference in Central London brings industry leaders together to discuss the development and challenges for flexible technologies
- Confirmed keynote speakers for October 2017 include: Anesco, UKPR, LimeJump, BEIS, Ofgem, Santander, Foresight Group and Green Investment Group

For more information, contact  
Sebastian Just, Head of Commercial

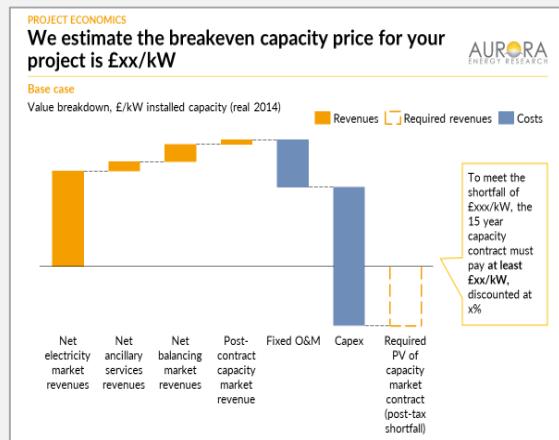
✉ sebastian.just@auroraer.com  
☎ +44 (0)7827 810 656

# Aurora can help you with your capacity market bidding strategy in T-4 and T-1 auctions

## Aurora's approach for capacity market bidding support

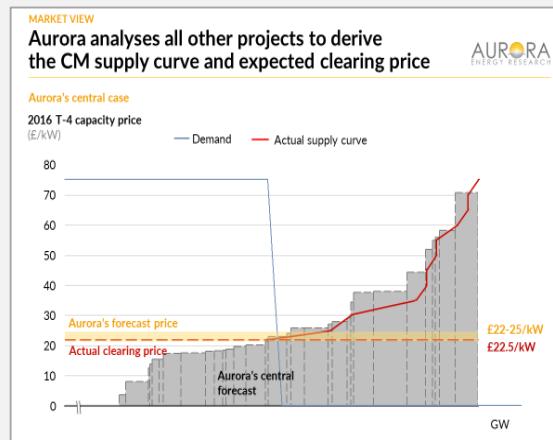
### 1 Project economics

Get a clear view on the future profitability of your project under various market scenarios



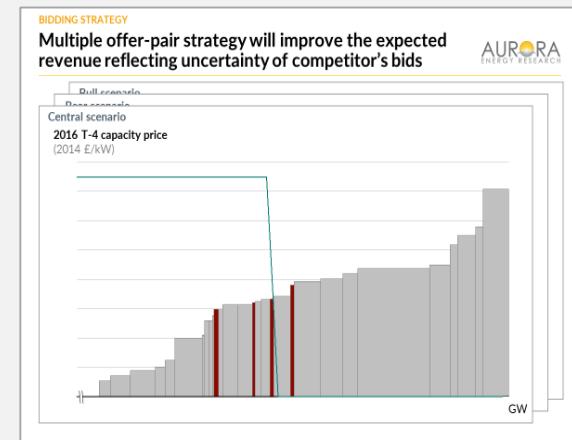
### 2 Market view

Understand the CM supply curve and economics of other pre-qualified projects under various scenarios



### 3 Bidding strategy

Derive an effective bidding strategy to maximise the expected bidding results



For more information, contact  
Ben Irons, Director and Head of Commissioned Projects

✉ ben.irons@auroraer.com  
☎ +44 (0) 7474 261 830

# Aurora Spring Forum, 20 March 2018, Oxford

## "Navigating the Global Energy Transition"



Alistair  
Philipps-Davies  
CEO  
SSE



Magnus  
Hall  
CEO  
Vattenfall



Laurence  
Tubiana  
CEO  
European  
Climate  
Foundation



Simone  
Rossi  
CEO  
EdF Energy



Klaus  
Schaefer  
CEO  
Uniper



Greg Clark  
Secretary of  
State  
BEIS



We develop, construct, finance & operate  
renewable energy

## A history of solar and energy storage innovation in the UK

- 1<sup>st</sup> commercial solar in the UK
- 1<sup>st</sup> commercial battery (2014)
- 1<sup>st</sup> batteries operating under FFR
- 1<sup>st</sup> OFGEM accreditation for batteries on RO solar site
- 1<sup>st</sup> subsidy free solar farm

## ANESCO SOLUTIONS



Battery storage –  
grid, commercial



Solar – grid,  
commercial, domestic



AnescoMeter –  
O&M



Commercial and  
Industrial



Domestic energy  
efficiency: ECO

## Gas Fuelled Peaking Station Solutions

Clarke Energy is able to offer a range of rapid response gas-fuelled power stations using GE's Jenbacher gas engines. We can supply an engine or deliver a turnkey power plant and provide the relevant support to assist with planning applications. These plants are ideally suited to peaking reserve, power and grid support applications.

### Maximising Trading Revenues

- High efficiency / low switch on price
- Increased electrical output
- Rapid start times

### Additional customer support

- Planning application assistance
- Electrical and gas connection assistance
- Emissions and noise data
- Optimal engine configuration assistance

For more information on the benefits of gas-fuelled peaking stations contact 0151 546 4446 or visit [clarke-energy.com](http://clarke-energy.com)



# What an E.ON approach can look like

## Energy efficiency and well being:

- Remote control and optimisation of site assets for efficiency and comfort
- Data transparency and data analytics
- E.ON proprietary products for lighting with integrated intelligent controls
- Integration of building's primary systems such as fire, security and access



## Flexibility and resilience:

- Cost avoidance utilising onsite generation assets
- Income generation through participation in demand side response mechanisms utilising all assets

## Generation:

- Heating and cooling
- Remote operation and maintenance
- Design, installation and financing options
- Electricity supply backed by Renewable Energy Guarantee of Origin (REGO)

## Operation and maintenance:

- 25 year O&M contract
- Performance guarantees
- Retrofit latest technology 5-10 years following construction

# Helping your smart energy projects succeed



**Our Energy team is one of the most experienced in the legal industry. For over 20 years, we've helped clients deliver their most innovative and successful projects.**

**That's why businesses turn to us for advice on complex and innovative power management and smart energy infrastructure solutions.**

**"Osborne Clarke are thought leaders in the decentralised energy and energy technology market"**

Chambers 2018, Energy

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and batteries

Energy balancing  
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Energy efficiency

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