AURORA ENERGY RESEARCH

Capacity Market 2018: Results, implications and potential policy reforms

Public report

Agenda

1. Against a backdrop of falling demand, the latest CM auctions cleared at lower prices than previous auctions due to competitive bids by DSR and interconnectors

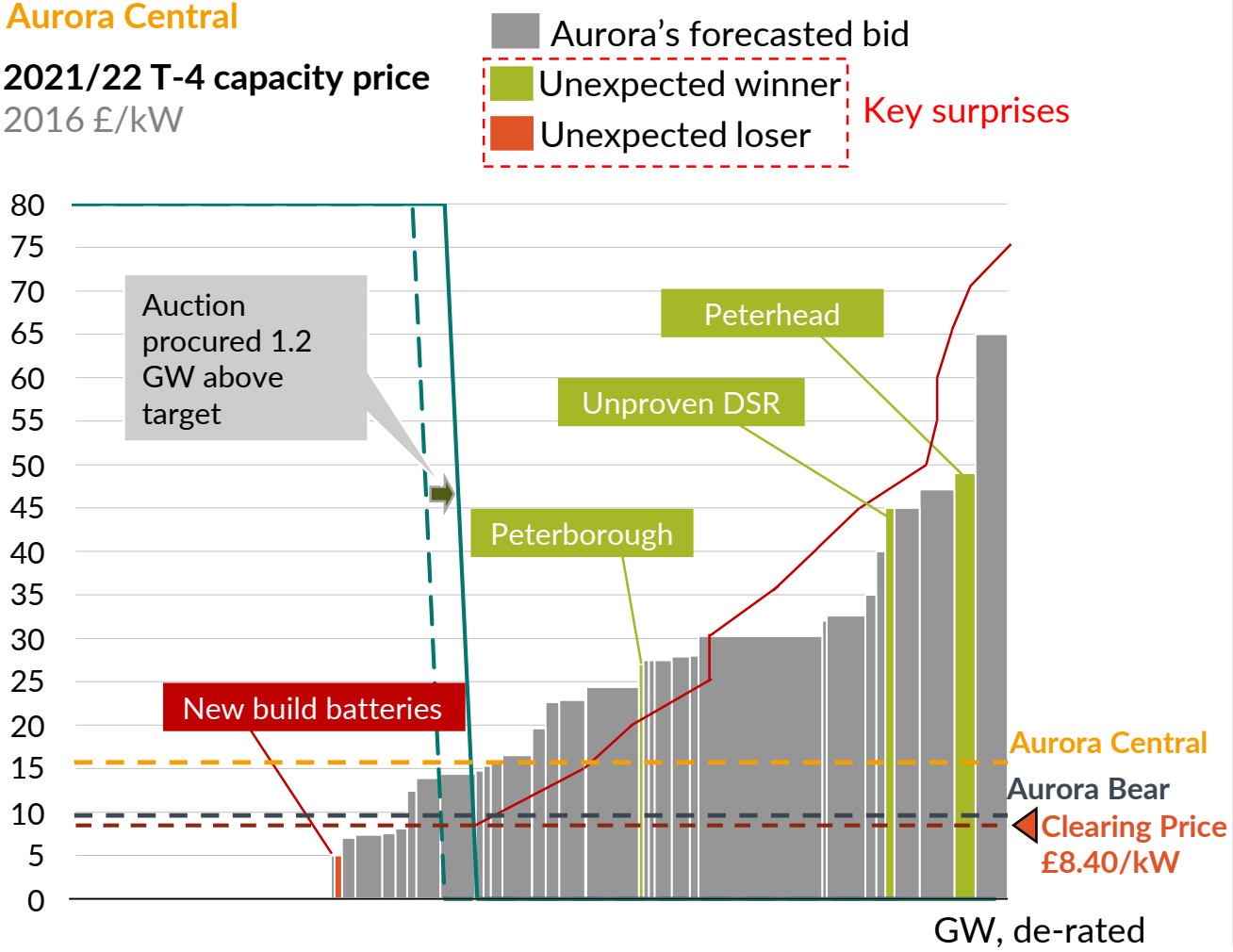
2. Average CM prices in the 2020s are expected to be in the mid £20s/kW, with limited CCGT buildout unless the nuclear programme is further delayed

3. Future CM auctions could see the active participation of subsidy free renewables; reforms will have to correctly reflect their contribution towards security of supply

Entry of three interconnectors and aggressive DSR bids saw T-4 CM clear at £8.40/kW, in line with Aurora's Bear scenario

Aurora Central

2021/22 T-4 capacity price
2016 £/kW



- The T-4 auction saw 74.2 GW participate against a 49.2 GW target
- 50.4 GW capacity awarded contracts, including 4.1 GW new build comprising mainly of interconnectors (2.2 GW) and DSR (1.2 GW)
- Out of six coal plants participating, only two secured contracts
- Unexpected winners, include Peterhead (1 GW), and Peterborough (peaking plant)
- Additionally, ~0.5 GW more new build DSR won contracts than expected
- Out of the 536 MW of batteries expected to win, only 158 MW[1] de-rated capacity was awarded contracts

Notes: 1. Equivalent to 406MW nameplate capacity

Source: Aurora Energy Research, National Grid

Low prices in latest CM auctions were driven by 3 main factors: capacity surplus, interconnectors and DSR

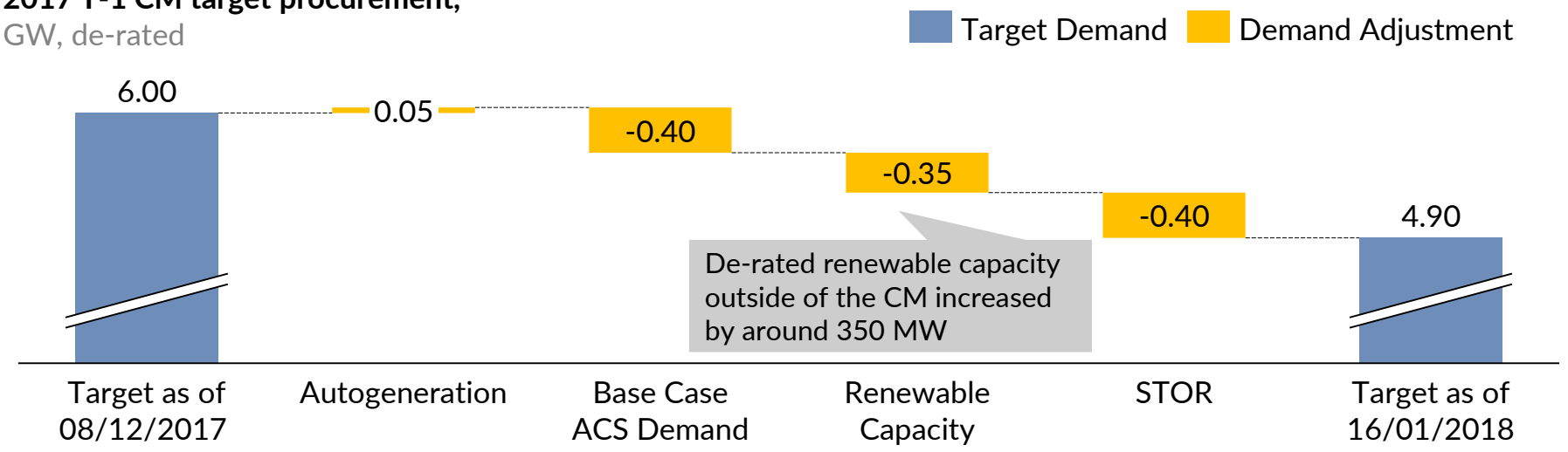
Key factors	Description	Implications for future CM price
A Capacity surplus	▪ Lower than expected power demand resulted in downward revision in procurement targets ▪ Both auctions were oversubscribed, with existing capacity alone exceeding targets	▪ Falling demand is likely to persist and dampen CM price in the medium term ▪ Longer term outcome depends on nuclear buildout and EV growth
B Interconnectors	▪ Interconnectors benefit from Carbon Price Support, Cap-and-Floor regime and subsidies[1] ▪ Entry of 3 interconnectors (2.15 GW de-rated) bid down CM prices	▪ GB sees over 13 GW of projects in the pipeline ▪ Success and impact on price depends on market coupling post Brexit, CPS
C DSR	▪ DSR benefits from lower CAPEX and less stringent testing and penalties, allowing projects to withstand low CM prices	▪ An estimated 1 GW of new-build DSR dropped out in the low £10s/kW ▪ Future participation will place downward pressure on CM prices
D Battery and gas peaking	▪ Some batteries took contracts despite de-rating changes due to lucrative FFR contracts ▪ Despite EB reform, well sited peakers still receive attractive GDUoS benefits	▪ Peakers and batteries will remain competitive, but could see bids rising to the high £10s/kW as favourable sites or ancillary contracts become scarce
E CCGT and Coal	▪ Baseload plants struggled to be competitive ▪ No new-build CCGTs, despite site specific benefits and bids in the £20s/kW ▪ Non-IED coal assets are likely to phase out ahead of 2025 deadline	▪ Low bids from CCGTs with site-benefits continue to put downward pressure on CM prices ▪ Non-IED coal assets could downscale operations to remain competitive

Notes: 1. Amongst others, interconnectors can qualify for EU funding under "Projects of Common Interests" and are also exempted from grid connection charges.

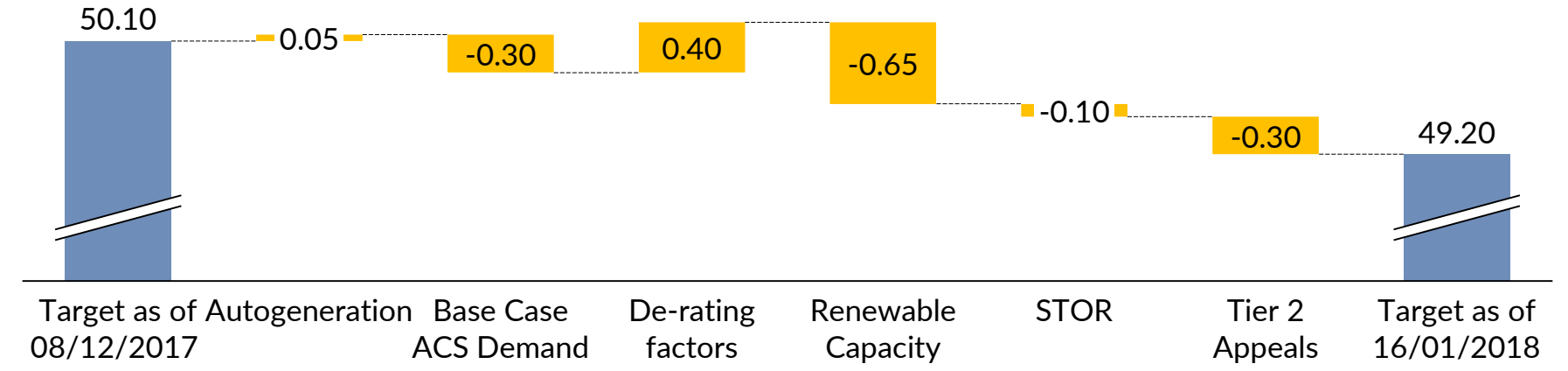
Sources: Aurora Energy Research, BEIS

Target procurement revised down in CM auctions to reflect system changes, exacerbating competition for new-builds

2017 T-1 CM target procurement,
GW, de-rated



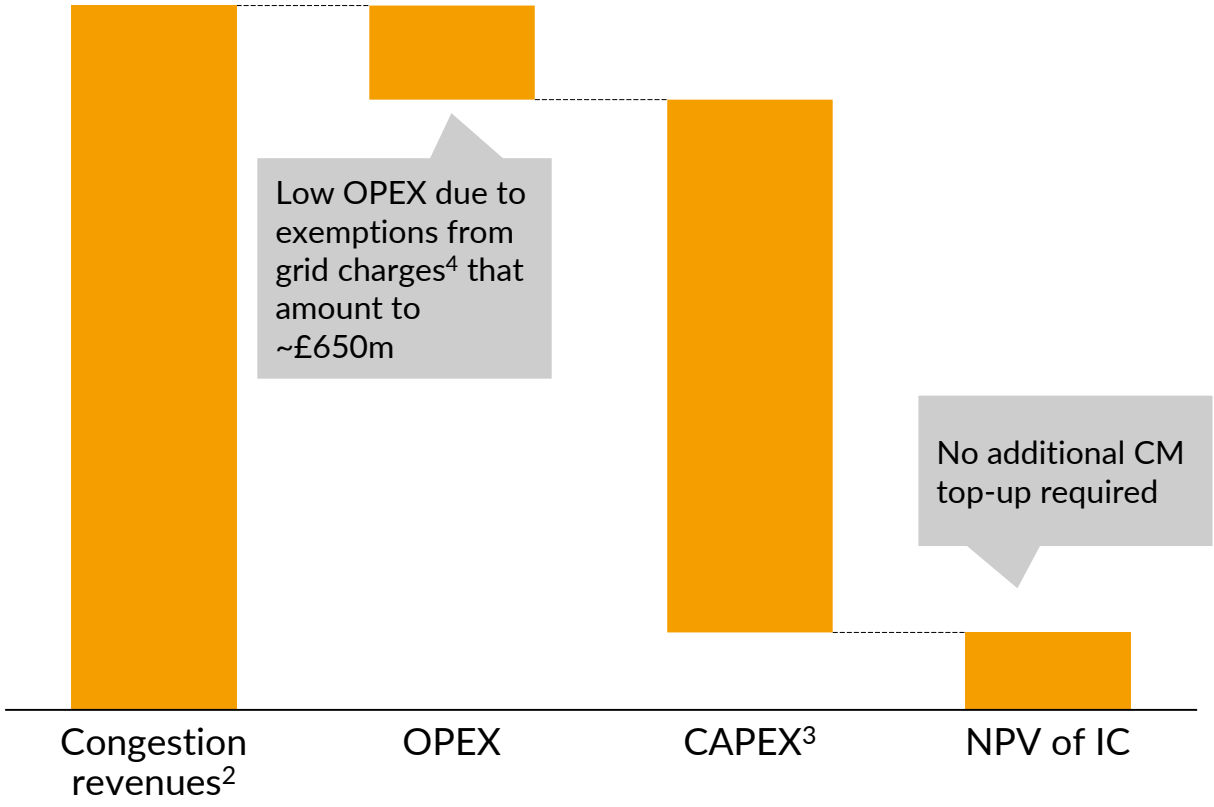
2017 T-4 CM target procurement,
GW, de-rated



Source: Aurora Energy Research, National Grid

With CPS in place, interconnectors can bid competitively into CM even without Cap-and-Floor support

Example 1 GW French Interconnector cost and revenues[1],
2016 £m, delivered in 2021



- In addition to merchant revenues, interconnectors gain additional support from the Cap-and-Floor regime[5] and EU's Projects of Common Interest fund
- The UK's Carbon Price Support results in a carbon and power price differential between UK and continental Europe, providing developers with attractive returns
- Interconnectors which do not participate in the Cap-and-Floor regime, such as Eleclink, could therefore still bid competitively into the CM
- Outcomes of Brexit could reduce market coupling, impacting business case of interconnectors

1. Revenues discounted at 11%, costs discounted at 6%.Assumes 25 year lifespan. 2. Assumes availability of 66% per annum based on the average de-rating factor for interconnectors from France in latest CM auction. 3. Based on IFA2 which is expected to cost €650m. 4. Interconnectors do not have to pay BSUoS and TNUoS charges. 5. For instance, IFA is guaranteed a floor of £60m p.a. in 2013£.

Source: Aurora Energy Research

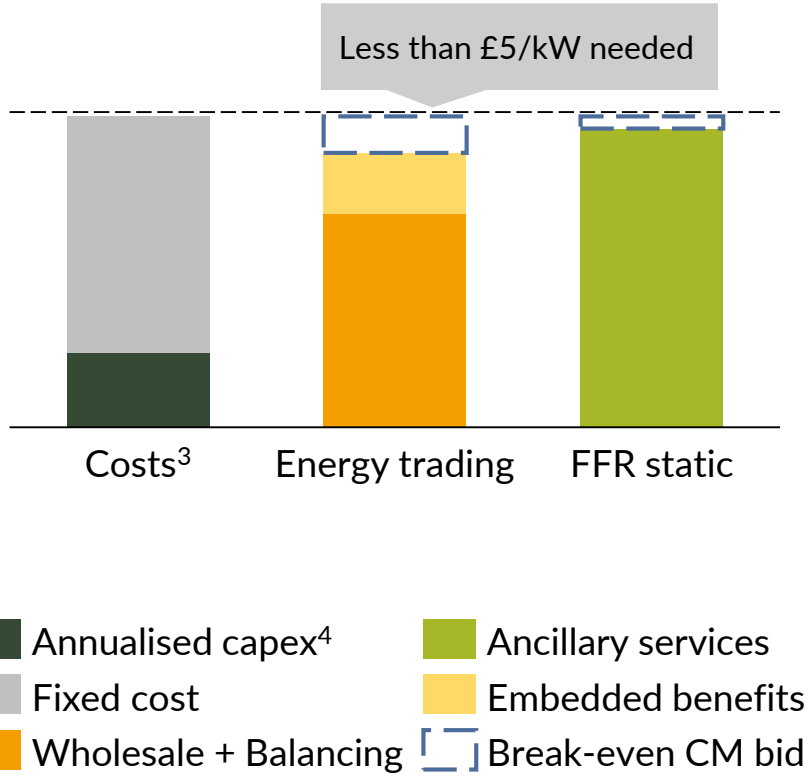
Low CAPEX and less stringent penalties allow DSR to bid competitively at below £5/kW

DSR benefits from low CAPEX and other favourable arrangements…

	Example - Background processes DSR[1]
Low capex, kW	2 – 30
Low fixed costs, £/kW/yr	10 - 30
Low utilisation/variable cost, £/MWh	Practically zero, but constrained to utilisation at approximately 25%
Fast response time, s	<2 – 10
Additional benefits	▪ Non-intrusive utilisation ▪ Subject to less stringent penalties and Credit cover obligations[2]

… resulting in CM break-even bids of £5/kW or less depending on business model

Gross margins across DSR (Background[1]) models,
Average between 2021-2030, 2016 £/kW



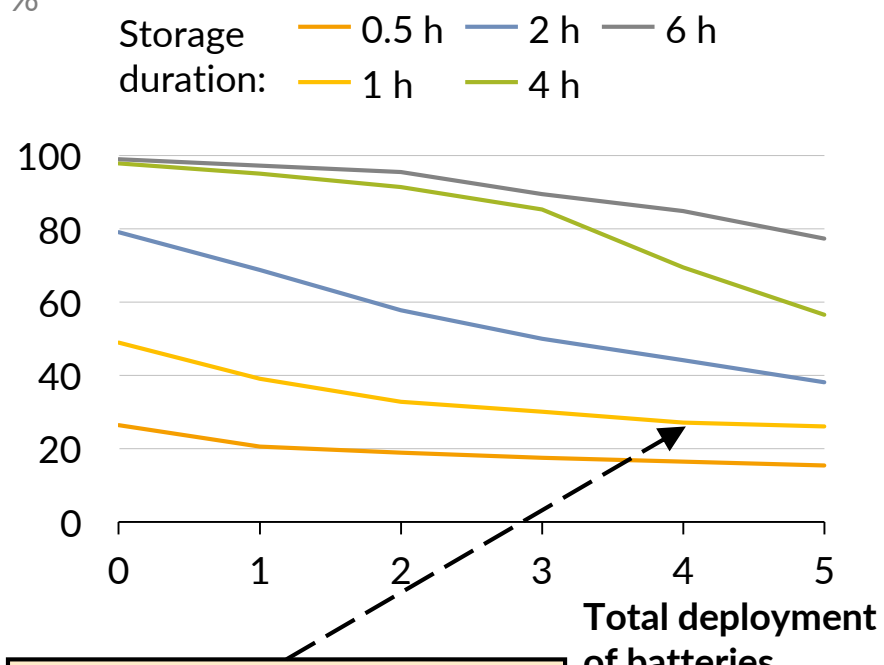
1. Background processes assume no direct impact on business operation, and includes the industrial, commercial and residential sector. For example, heating and cooling, IT (Servers) and electric lighting. 2. DSRs are subjected to termination fees of £15/kW in the event of failing to provide metering test certificates and in failure to demonstrate SPD, relative to the £35/kW faced by other technologies. DSRs have to provide credit cover of £5/kW while other technologies need to provide £10/kW. 3. Costs do not include the opportunity cost associated with ceasing operations to participate in a stress event. These are likely to be low. 4. Capex assumed to be £30/kW and is annualised over 5 years at a discounted rate of 6%.

Source: Aurora Energy Research, BEIS

New de-rating method resulted in 77 battery projects withdrawing before the auction

BEIS intends to de-rate batteries dependant on duration and deployment level to reflect their contribution towards security of supply…

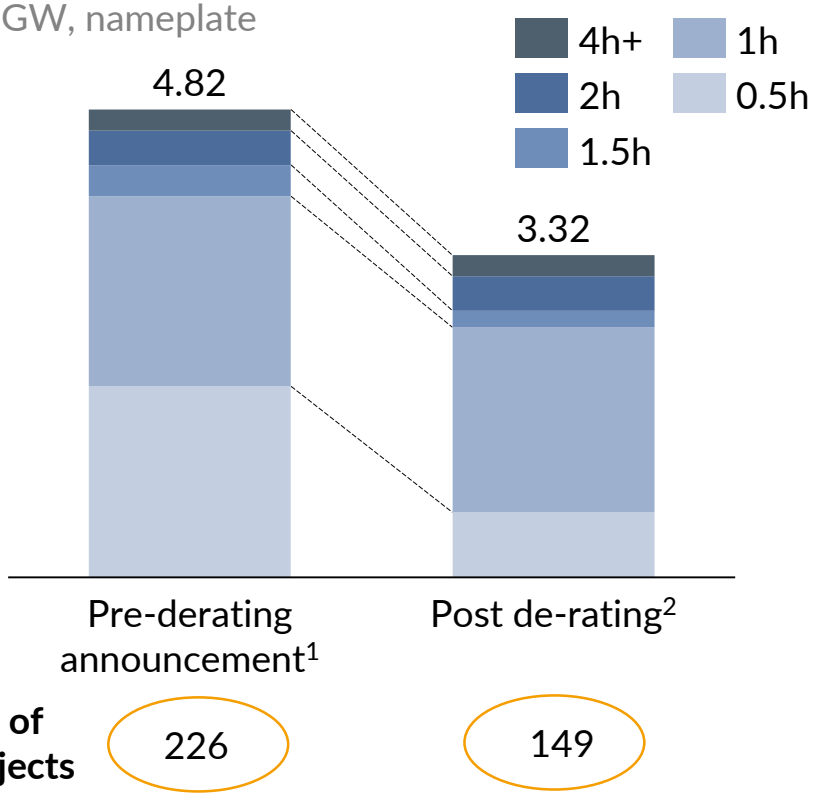
Equivalent de-rating factor,
%



4GW of 1h battery is equivalent to 1GW of firm capacity

… causing 1.5 GW of batteries to exit before the auction, with remaining batteries being low-duration

Prequalified battery capacity,
GW, nameplate



1. From latest CM register dated 1 December 2017, before CM de-rating announcement was made by National Grid on 4 December 2017. De-rating at this time was 96.1% regardless of duration of battery. 2. Post de-rating changes, taken from registry on 2 February 2018.

Sources: Aurora Energy Research, BEIS

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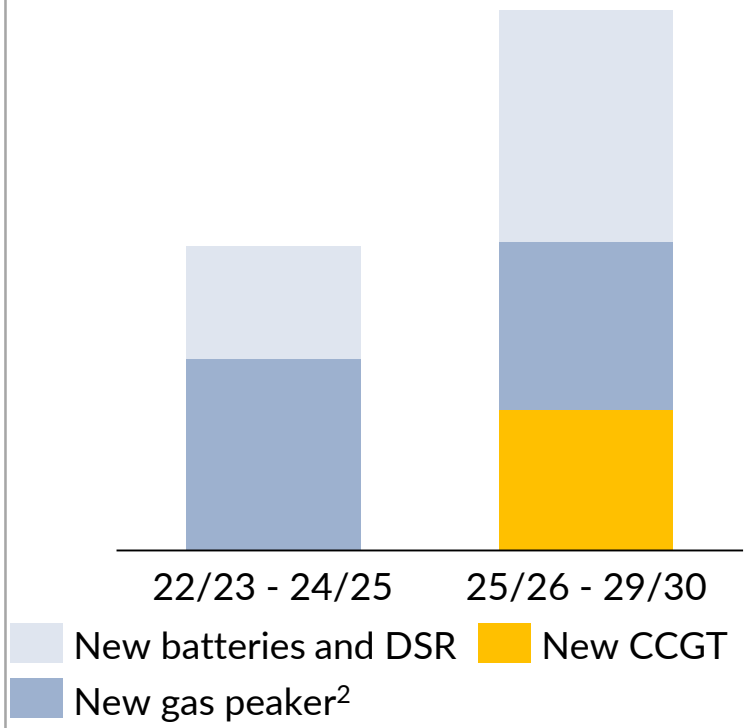
Average CM prices are expected to be in mid £20s/kW, with flexible technologies securing bulk of new-build contracts

Lower CM price	Central[1]	Higher CM price
Higher wind buildout	New Capacity, GW, de-rated	Lower wind buildout
Higher nuclear capacity		Lower nuclear capacity
Higher interconnector capacity		Lower interconnector capacity
Greater cost declines for flex		Lower cost declines for flex
Lower EV uptake &/or "smart" charging[3]		Higher EV uptake &/or "dumb" charging[3]



Modelled Not modelled

1. We model the average plants in the system. Specific site benefits or individual developer's expectations of future could result in different outcomes in the shorter term, especially for CCGT buildout. 2. New peaking plant refers to combined capacity of gas recip. and OCGTs. 3. Type of charging would have just as significant a bearing on peak demand as the turnout of EVs. Smart charging could dampen contribution to peak demand even with a high uptake of EVs. Please refer to our Jan 2018 publication on "the e-mobility revolution" for more details.

Source: Aurora Energy Research

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CM could evolve into an Equivalent Firm Power (EFP) auction with participation by subsidy free renewables

Existing frameworks

Contracts for Difference
- CfD auctions provide low carbon energy within a fixed budget

Capacity Market
- Ensures security of supply
- Penalties regime adopts binary approach of run / not-run during periods of system stress.

Cost of Energy review (potential new framework)

Equivalent Firm Power Auction
- All technologies (including non-dispatchable renewables) bid on an EFC basis, reflecting contribution to security of supply
- Exposes renewables to cost of intermittency, incentivising RES to contract for backup power

Aurora view

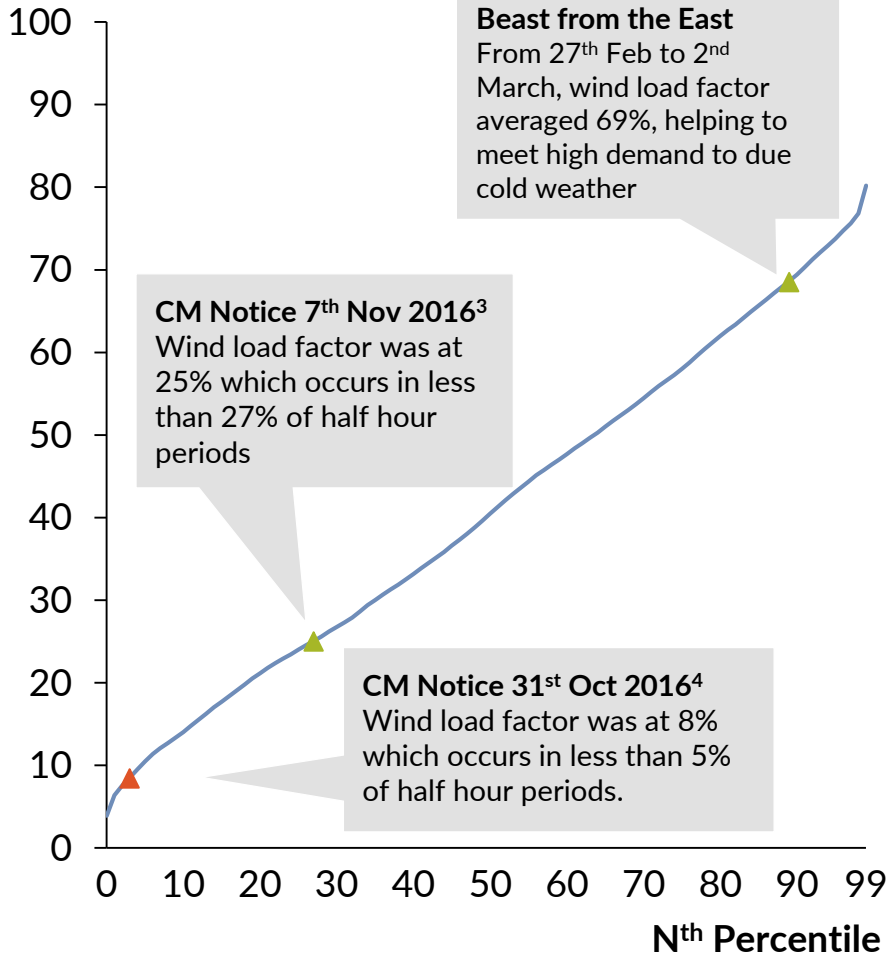
Contracts for Difference
- Auctions continue until mid 2020s to include nuclear and pot 2 technologies

Equivalent Firm Power Auction
- Evolution of current CM. Penalty regime reformed to recognise contribution of intermittent technologies at peak periods – e.g. linked to availability not output
- Includes unsubsidised wind and solar+battery but not new CfD Offshore Wind

Source: Aurora Energy Research

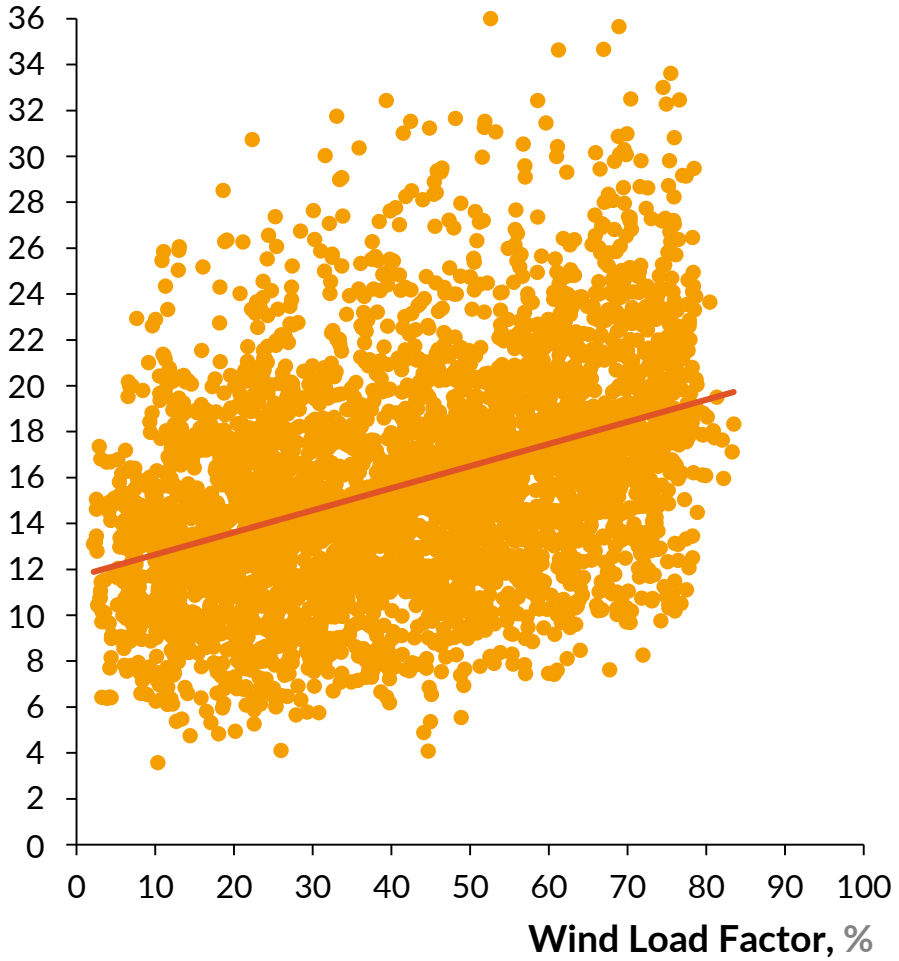
Variability limits wind's contribution to security of supply, with instantaneous fleet load factor ranging from 2-85%

Winter Cumulative Half-Hourly Wind Load Duration Curve[1], %



System Margin in Winter Peak Half-Hours[2]

GW



1. Jan 2015 to present. Winter only, defined as Oct-Mar inclusive. Load Factor for all wind (Onshore and Offshore) weighted by capacity. 2. Peak Half-Hours are from 7am-7pm. 3. Notice issued in advance of the 16:30 Settlement Period, but cancelled at 15:00. 4. Notice issued in advance of the 16:30 Settlement Period, and cancelled at 19:00.

Source: Aurora Energy Research

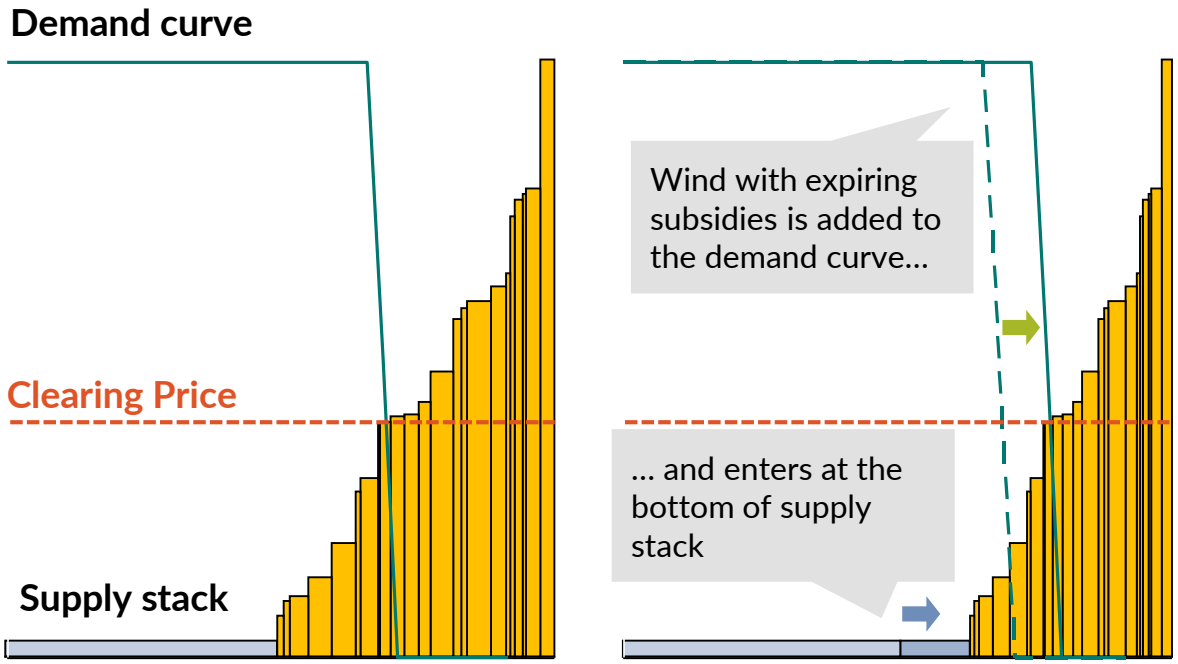
Making CM payments to existing wind farms when their subsidy ends will not alter the CM clearing price…

Subsidised wind excluded from CM

Using current methodology, the procurement target is calculated by subtracting the capacity of subsidised renewables from the demand curve **using an EFC of 20-25%.**

Wind subsidies expire

As subsidies expire, wind will be removed from the demand curve and added to supply. Provided **the same EFC is used** this will not impact the clearing price.



- Wind farm subsidies begin to expire[1] in 2022, and unsubsidised capacity will reach 18GW in 2035
- The procurement target set by National Grid in the CM auction reflects the de-rated capacity of renewables
- At zero marginal cost, assets with expired subsidies will be price-takers at the bottom of the stack and accept any clearing price

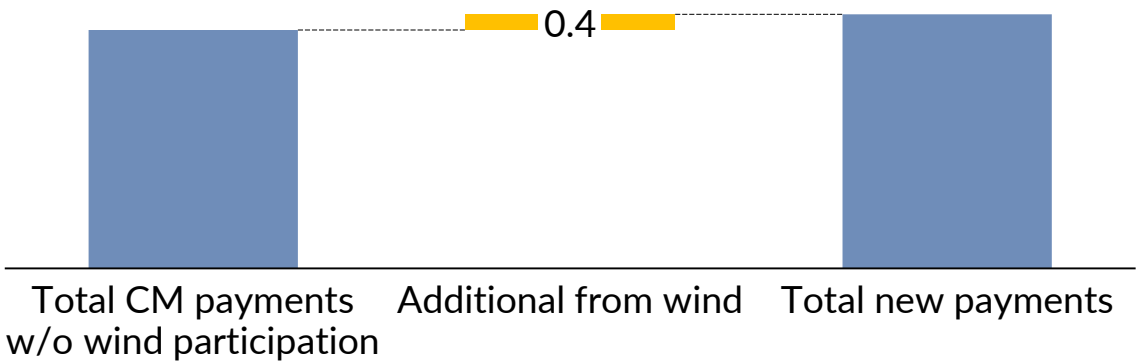
1. The earliest onshore wind farms received RO accreditation in 2002. This will expire after 20 years in 2022.

Source: Aurora Energy Research

… but increases total CM payments by ~£400m between 2025-35

Total onshore and offshore wind capacity[1], GW

Total Value of CM contracts[2] 2025 - 2035, 2016 £bn



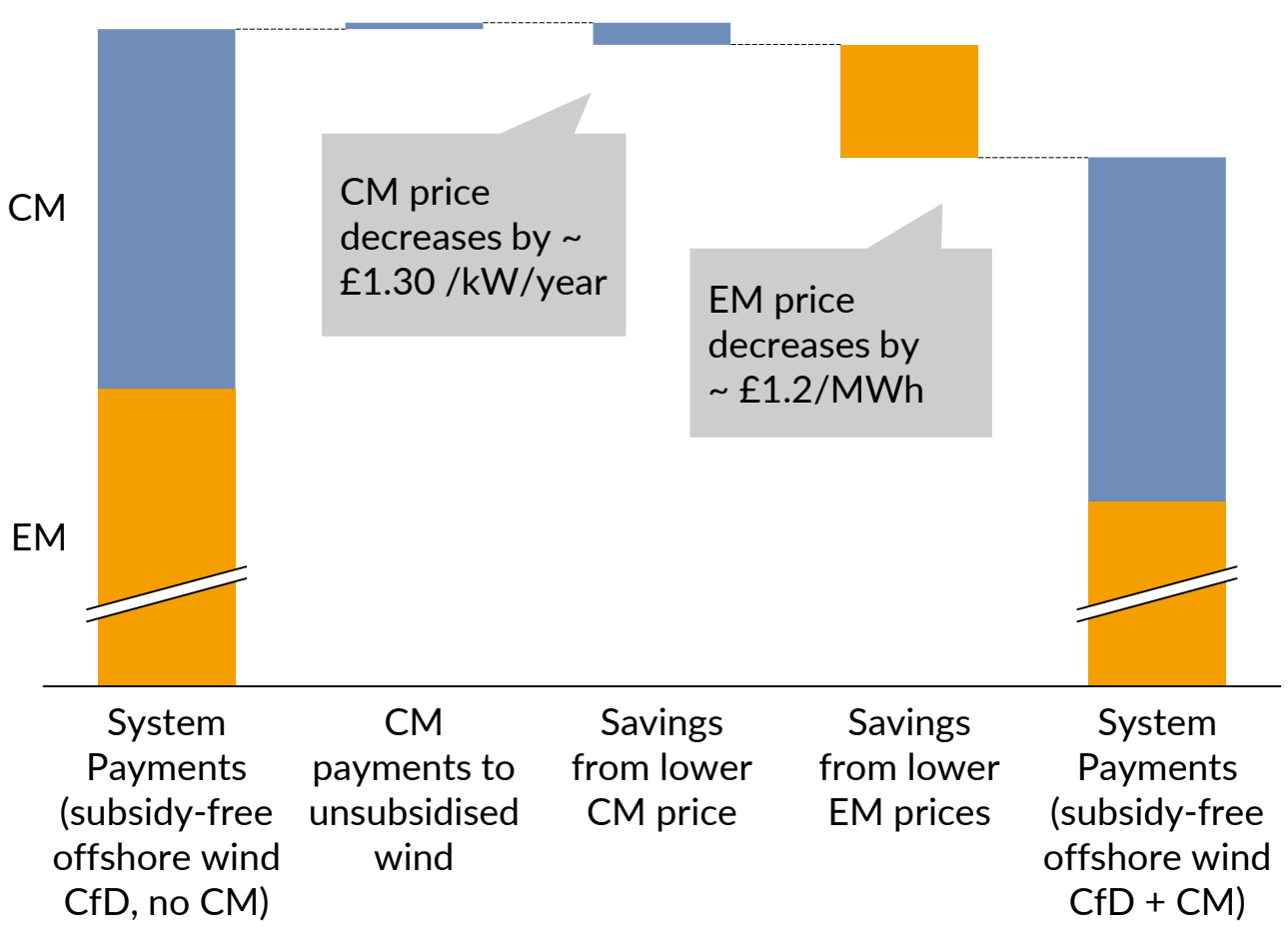
- Allowing post-subsidy wind to compete in the CM with the same EFC would have no impact on security of supply
- Post-subsidy wind capacity increases to 17GW by 2035, increasing total CM payments by £400m over the period 2025-35, and by over £110m in the year 2035 alone

1. Excludes CfD round 3 which does not matter for this analysis as assets entering through CfD round 3 would still be under subsidy by 2035. 2. CM payments based on expected EFC of 25% for offshore wind and 20% for onshore wind which are used once subsidies expire.

Source: Aurora Energy Research

Allowing zero-subsidy offshore wind to compete in the CM reduces total system costs, depressing wholesale and CM costs

System payments 2025-2035, £bn



- Allowing new zero-subsidy[1] offshore wind to compete in the CM results in 1.4GW additional deployment
- This lowers the clearing price and pushes out other more expensive forms of generation
- If capture prices are forecasted correctly, no additional payments will have to be made to windfarms through the CfD mechanism
- Total CM payments could reduce by £600m over the period 2025-35

1. Zero-subsidy implies guaranteeing wind farms their capture price, which could be through a CfD.

Source: Aurora Energy Research

Key takeaways

- Recent T-4 CM auction surprised industry with significantly lower prices due to lower than expected demand, and aggressive bids from DSR and interconnectors
- CM prices should recover as lucrative site-specific benefits for peakers and DSR become more scarce; CM is expected to clear in mid £20s/kW in the 2020s, but the buildout of nuclear, wind and interconnectors are key uncertainties
- Renewable generators could actively participate in the CM in the future, with well-designed policy changes reducing total CM payments by £600m between 2025 - 2035

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Source: Aurora Energy Research

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