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Modelling the GB Renewable Electricity CfD Auctions – the cost of excluding onshore wind and maintaining separate pots

A project for Citizens Advice – Final Report

Project Team

Daniel Radov
Alon Carmel
Konrad Borkowski
Sam Forrest
Dr Clemens Koenig

October 2015

Insight in Economics™

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1. Project overview and key results

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Project overview

- We have used our model of the CfD auction to analyse the costs to consumers of different policy choices the Government could make, to provide Citizens Advice with answers to two questions:
  - Question 1: What could be the savings to consumers of merging the established and less-established technology pots into a single technology neutral auction?
  - Question 2: What could be the cost to consumers of excluding onshore wind from future CfD auctions?
- We also discuss some alternative policy approaches to limiting onshore wind that the Government could consider.

Key results

- **Merging Pot 1 and Pot 2 in a 2017 auction** could deliver significant savings to electricity consumers. Consumers could save around £1bn over the term of the CfD contracts, equivalent to around £50m/year.
- **Excluding onshore wind from a 2017 auction** imposes significant costs on electricity consumers. Consumers costs could increase by around £0.5bn over the term of the CfD contracts awarded, equivalent to around £30m/year.
- Re-running the **2015 auction**, we found impacts of similar magnitude. Consumers could have saved £0.7bn from a merged pot auction, and excluding onshore wind could have cost £0.6bn. However, these results are more uncertain, as in the 2015 auction fewer bidders may have come forward given the option of electing support under the Renewables Obligation (RO), rather than from a CfD contract.

2. Approach to modelling the CfD auctions

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The CfD auctions - background

- The GB auctions for renewable CfD contracts were introduced in 2014 and the first auction was held in February 2015
- There are separate auction "pots" * or budgets for established technologies (like onshore wind and solar), less established technologies (like offshore wind) and biomass conversion. This means there are up to 3 separate auctions (as budget cannot be moved between pots within an auction round). There has been no budget released for Pot 3 so far.
- The auction design is a sealed bid, second price format where bidders receive the clearing price (pay-as-clear) rather than the price they have bid, as long as the clearing price is below their (technology-specific) maximum price (the "administrative strike price"). If the clearing price is above the maximum price for a technology, then successful bidders from that technology would receive the administrative strike price only.
- Projects can submit up to 10 separate bids with different capacities, prices and commissioning years.
- The auctions cover a number of potential future delivery years – e.g. in the 2015 auction projects could bid in capacity to be commissioned in any of the four following years – 2015/16-2018/19 (offshore wind projects can also phase their project over 3 years)
- The budget needs to cover the expected difference between strike prices (the auction clearing prices) and the reference price (defined separately for intermittent and baseload technologies) for all the successful contracts.
- The auctioneer (National Grid) stacks all the bids according to price (irrespective of delivery year) and clears the auction based on the lowest cost capacity within each pot that is affordable within the budget limit (and subject to any maxima or minima)

* The pots are: Pot 1 (established technologies): Onshore wind (>5MW), Solar Photovoltaic (PV) (>5MW), Energy from Waste with CHP, Hydro (>5MW and <50MW), Landfill Gas and Sewage Gas; Pot 2 (less established technologies): Offshore Wind, Wave, Tidal Stream, Advanced Conversion Technologies, Anaerobic Digestion, Dedicated biomass with CHP, and Geothermal; and Pot 3: Biomass conversion.

2. Approach to modelling the CfD auctions

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Our analytical approach

- We have used a scenario approach to compare the costs to consumers from some different policy decisions the Government could take by comparing baseline scenarios (in 2015 and 2017) against policy scenarios
  - Baseline – no change in auction design (two pots and allowing onshore wind) and the Government sets auction budgets at the same levels as in 2015
  - Merged pots– merging Pot 1 and Pot 2 but including onshore wind (we decreased the single pot budget compared to the baseline to achieve the same volume of renewable electricity as in the baseline)
  - No onshore – excluding onshore wind but keeping two pots (we increased the Pot 2 budget to achieve the same volume of renewable electricity as in the baseline)
  - Merged pots, no onshore – merging Pot 1 and Pot 2 and excluding onshore wind (we decreased the single pot budget compared to the baseline to achieve the same volume of renewable electricity as in the baseline)
- We have used NERA's CfD auctions model and data published by DECC on technology costs and wholesale prices (see Appendix B). We have created a supply curve based on published costs and project information rather than proprietary information in order to allow greater transparency about the results.
- We have made relatively conservative assumptions – e.g. calibrating the costs and supply curve to the 2015 auction results and assuming that at least some projects will be able to bid as low in a future auction (indeed lower as there is a learning rate built into the cost data).
- We aggregate bids for all years (based on our valuation model and costs from DECC 2013) in a single "bid stack" to model the workings of the auction. NERA's auction model allows for more sophisticated bidding strategies, but we have not applied them for the current analysis.

NERA's CfD Auction Model

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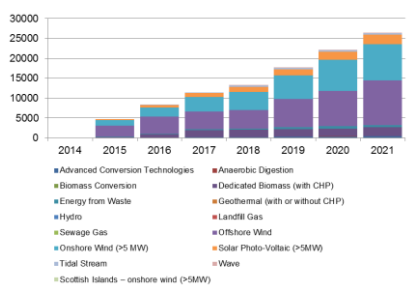
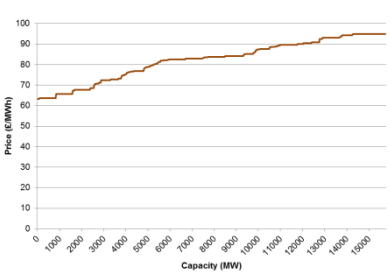
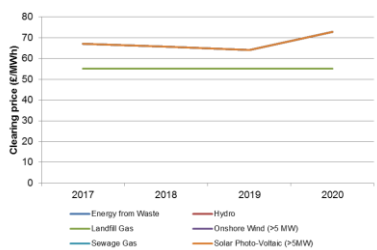
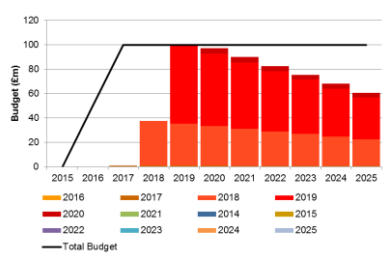
We use our valuation model to build a supply curve and our auction model to analyse different design options – e.g. merging of Pot 1 and Pot 2

	CfD Valuation Model	CfD Auction Model
Inputs	▪ Projects sourced from DECC's Renewable Energy Planning Data ▪ Cost data e.g. from DECC Electricity Generation Costs 2013 ▪ Forecast wholesale prices, CM market prices ▪ Hurdle rates, asset lives and load factors (e.g. from DECC)	▪ Supply curve from Valuation model ▪ LCF budget ▪ Auction rules (e.g. reserve prices, pots, maxima and minima) ▪ Bidder strategic parameters
Approach	▪ A cash flow model for each project is developed based on the expected costs and revenues over the life of the asset, including post CfD ▪ For each project the model solves for the CfD strike price that would give an NPV over the life of the asset of zero.	▪ Taking contract valuations as a baseline, bid prices can be manipulated to reflect potential strategic effects or key uncertainties ▪ Bids are then passed through the auction allocation mechanism which determines strike prices, allocations and budget usage ▪ The model can then iterate through future auctions with updates to wholesale prices and LCF budget based on previous auction outcomes
Outputs	▪ Pipeline of projects with expected commissioning years ▪ Valuations of CfD contracts for each project – i.e. a supply curve **Project pipeline**  **Distribution of contract valuations** 	▪ Allocations awarded and strike prices ▪ Budget usage by project by year ▪ Project portfolio values and surplus **Strike prices**  **Budget allocation** 

3. Results 2017 auction

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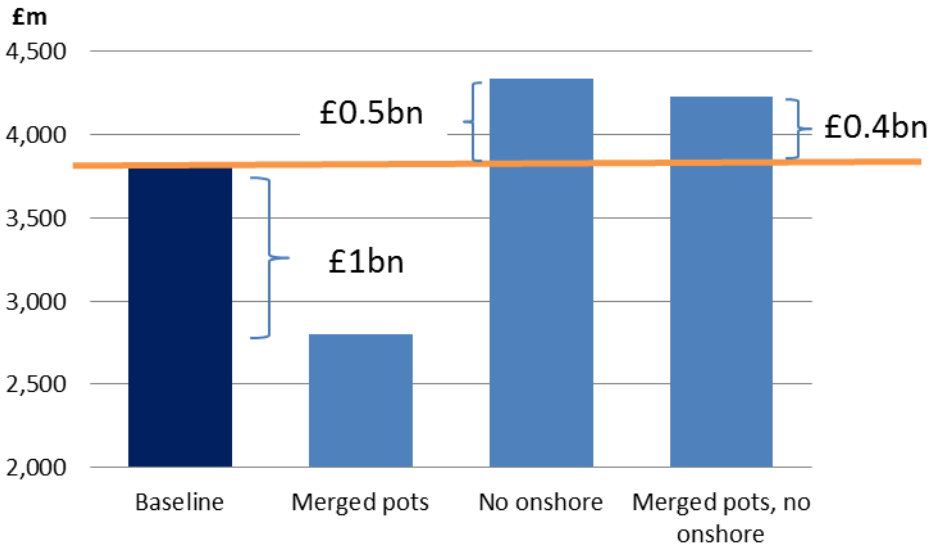
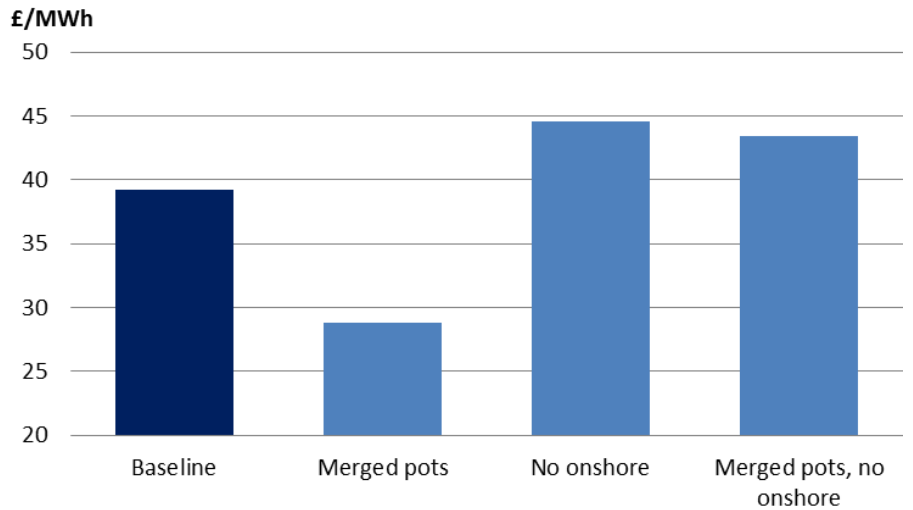
Cost to consumers



Average subsidy cost



Note: These are the cumulative additional CfD support costs (undiscounted, but in real terms).

Discussion

- Merging Pot 1 and Pot 2 could save consumers around £1bn (in real terms, undiscounted, over the life of the CfD contracts awarded).
  - The savings average around £50m per year – almost the amount the Government released for Pot 1 in the 2015 auction (£65m) which was sufficient for around 900MW of renewable capacity.
- Excluding onshore wind could cost consumers around £0.5bn (again, in real terms, undiscounted, over the life of the CfD contracts awarded).
- Excluding onshore wind and merging the pots could mean additional costs to consumers that are almost as high as excluding onshore wind with two pots.
- The average subsidy cost (the top-up relative to the CfD reference price for the mix of technologies and contracts signed) is significantly reduced by merging the pots (from around £39/MWh to around £29/MWh).
- Excluding onshore wind increases the average subsidy from £39/MWh to almost £45/MWh, a 14% increase.
- Excluding onshore wind but also merging the two pots would *still* increase the average subsidy, by almost as much as excluding onshore wind within the current two pot system.

3. Interpretation of 2017 auction results

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Benefits of merging Pot 1 and Pot 2

- If the Government were to merge Pot 1 and Pot 2 in a future auction (e.g. 2017) consumers could save around £1bn in cumulative support payments over the term of the CfD contracts awarded, equivalent to around £50m/year.
- With a merged pot and "technology-neutral" auction the lower cost technologies (like onshore wind and solar) win and displace the higher costs technologies like offshore wind. So the overall budget (and cost to consumers) can be reduced while still achieving the same volume of renewable electricity.
- No CfD contracts are awarded to less established technologies like offshore wind (unless some of the lower cost technologies are excluded as in the "Merged pots, no onshore" scenario).
- If onshore wind is excluded most of the savings from merging pots are lost. This is because *offshore* wind then sets the clearing price. This means that the other technologies (e.g. solar and EfW) are paid their administrative strike prices, which are higher than the clearing price in a two-pot auction. Hence the costs of this scenario are similar to those for the "No onshore" scenario despite producing a very different technology mix.
- If onshore wind costs were lower, the savings could be even higher. Similarly, if the costs of *offshore* wind were in fact higher than in our assumptions, the savings from merging the pots could also be higher.

Cost of excluding onshore wind

- The cost to consumers of excluding onshore wind from the 2017 CfD auction could be around £500m in cumulative additional support over the life of the CfD contracts, equivalent to around £30m/year.
- Excluding onshore wind from the CfD auctions would increase costs to consumers because onshore wind is one of the cheapest technologies available at scale in the UK.
- Our approach (as set out above on slide 4) is to assume that even though it has excluded onshore wind, Government still wishes to achieve the same amount of renewable generation (in TWh), and does so by increasing the budget for Pot 2.
  - The Government could also take other approaches, such as deciding not to contract for as much renewable electricity, or increasing the Pot 1 budget, which would lead to significant increases in the amount of solar.
- The overall cost of excluding onshore wind is sensitive to assumptions about technology costs and wholesale prices, as well as about the pipeline of available projects. *Unless* significant amounts of solar became available at the same cost as onshore wind, then excluding onshore wind will impose additional costs. If solar costs are higher than assumed, the cost of excluding onshore would be higher.
- Conversely, if the costs of *offshore* wind were lower than assumed in DECC's generation cost data, then the cost of replacing onshore wind with offshore wind would be lower.

3. Results – Sensitivity analysis

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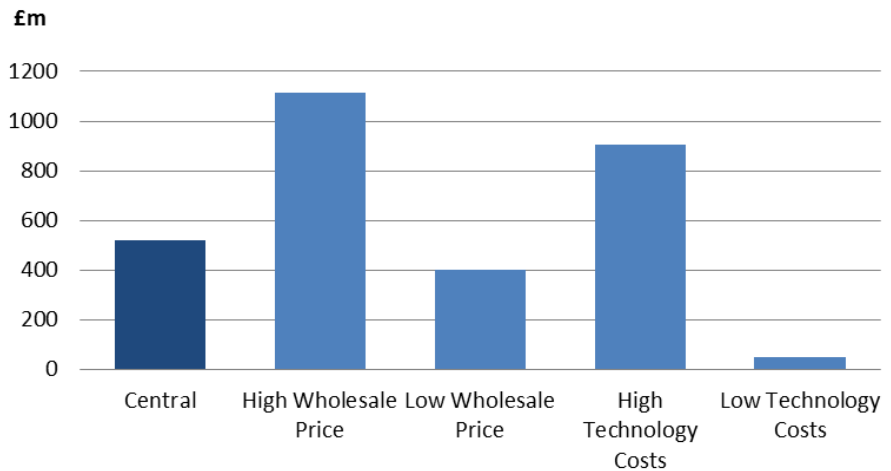
Cost of excluding onshore wind



Note: These are the cumulative additional CfD support costs (undiscounted, but in real terms) of excluding onshore wind from CfD auctions, relative to each scenario's corresponding reference case.

Discussion

- We conducted sensitivity analysis on the costs associated with the exclusion of onshore wind.
- The central result presented above was that excluding onshore wind from the auction in 2017 could lead to additional cumulative costs for consumers of around £500m.
- This result is sensitive to assumptions wholesale price and technology cost assumptions:
  - The costs could be as low as £400m, or as high as £1,100m, depending on wholesale prices;
  - The costs could range from a little as £50m to as much as £900m, depending on technology costs.
- In a high wholesale price world the budgets stretch to a higher amount of renewable electricity in the base case. Trying to achieve the same level of renewable generation in the policy scenarios leads to higher costs as it requires going further up the supply curve, leading to higher clearing prices.
- If solar costs were to be significantly lower than DECC 2013 assumptions (as in the "Low Technology Cost" sensitivity scenario presented here), ***and*** there were a significant volume of projects that were able to be built (e.g. around 2-3GW at around the clearing price for onshore of £80-85/MWh) then all else being equal, the expected additional cost to consumers of excluding onshore wind could be relatively low.

3. Results 2015 auction

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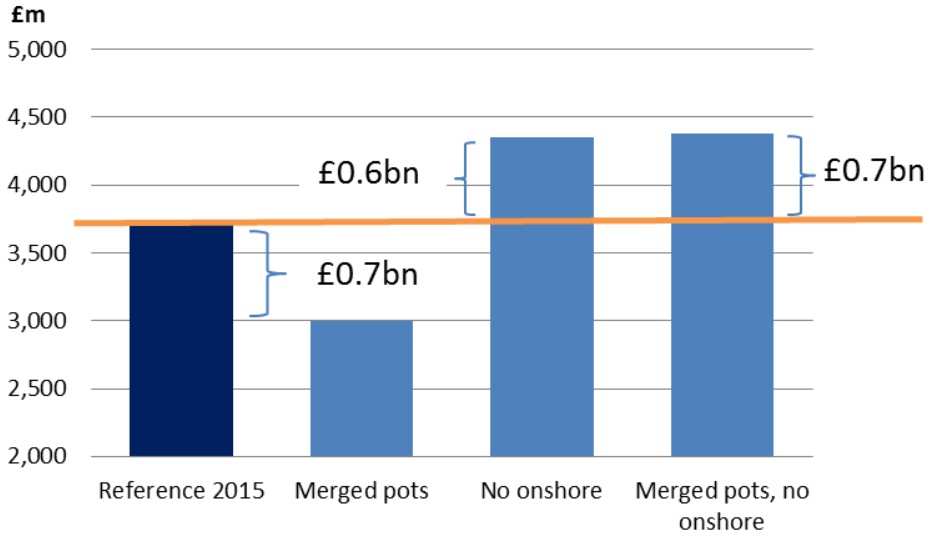
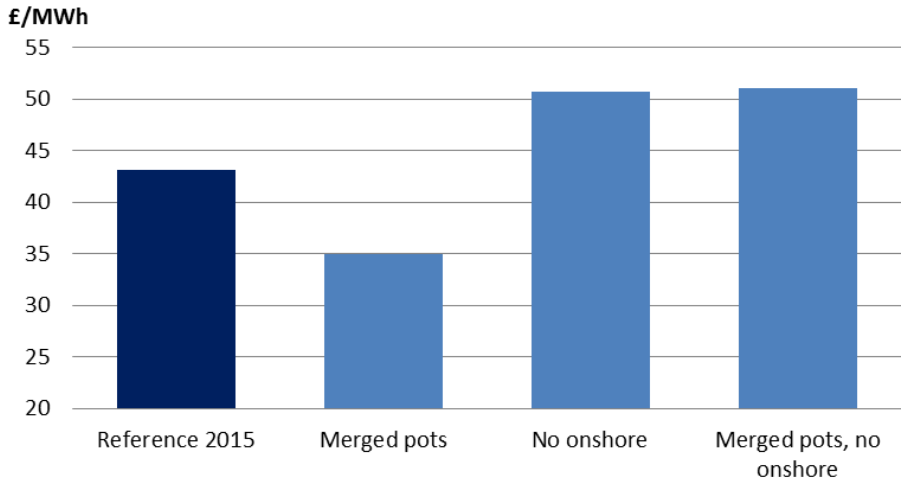
Cost to consumers



Average subsidy cost



Note: These are the cumulative additional CfD support costs (undiscounted, but in real terms).

Discussion

- Merging Pot 1 and Pot 2 could have saved consumers around £0.7n (undiscounted, over the life of the CfD contracts awarded). This is equivalent to around £40m a year.
- Excluding onshore wind could have cost consumers around £0.6bn (over the term of the CfD contracts awarded).
- Excluding onshore wind and merging the pots could mean additional costs to consumers that are as high as excluding onshore wind with two pots (and that could even be higher).
- The average subsidy cost (the top-up relative to the CfD reference price for the mix of technologies and contracts signed) could have been significantly reduced by merging the pots (from around £43/MWh to around £35/MWh).
- Excluding onshore wind would have increased the average subsidy from £43/MWh to over £50/MWh, an 18% increase.
- Excluding onshore wind but also merging the two pots would still increase the average subsidy, by around the same as excluding onshore wind within the current two pot system.

3. Interpretation of 2015 auction results

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Benefits of merging Pot 1 and Pot 2

- If the Government had merged Pot 1 and Pot 2 in the 2015 auction, consumers could have saved around £0.7bn in cumulative (undiscounted) support costs over the term of the CfD contracts awarded, equivalent to around £40m/year.
- With a merged pot, "technology-neutral" auction, the lower cost technologies (like onshore wind and solar) win and displace the higher costs technologies like offshore wind. So the overall budget (and cost to consumers) can be reduced while still achieving the same volume of renewable electricity.
- If pots had been merged we find that there could have been no CfD contracts awarded to less established technologies like offshore wind (unless some of the lower cost technologies had been excluded, such as in the "Merged pots, no onshore" scenario).
- However, if pots had been merged *and* onshore wind had been excluded, the costs would have been similar to excluding onshore wind in a two pot auction. This is because without onshore wind, the clearing price is set by *offshore* wind, so that the lower cost technologies (mainly solar) in the pot receive their administrative strike price, which is higher than if it had been set competitively in a two pot auction.

Cost of excluding onshore wind

- The additional cost to consumers of excluding onshore wind from the 2015 CfD auction could have been around £0.6bn over the term of the CfD contracts, equivalent to around £35m/year.
- Excluding onshore wind from the CfD auctions would have increased costs to consumers because onshore wind is one of the cheapest technologies available at scale in the UK.
- As set out above (slide 4) we assume that even though it excluded onshore wind, the Government would still have wanted to achieve the same amount of renewable generation (in TWh), and would have done so by increasing the budget allocated to Pot 2.

Note that these hypothetical result for 2015 are very uncertain, because many projects would have been able to build under the Renewables Obligation (RO), rather than bid for a (possibly significantly lower) CfD strike price in the auctions.

4. Alternative policy approaches

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- Excluding onshore wind completely from the CfD auction could impose significant additional costs on consumers, but there are other policies that the Government could consider:

- A "non-subsidy" CfD*: set the auction reserve price (administrative strike price) for onshore wind at a low level equal to the average wholesale electricity price over the period of the contract (15 years). This could mean that consumers would not pay any more for the electricity than if a windfarm had been built without a CfD – subject to wholesale prices developing as currently expected, on average – but at the same time provides long term revenue stability which would enable projects to raise finance at a lower cost.

- A maximum for onshore wind: this could ensure that only a maximum volume of MWs of onshore capacity was awarded CfDs in each auction. Windfarms with high wind speeds (e.g. potentially those in Scotland) would be more likely to be competitive.

- Planning veto for local communities: to avoid visual impacts on local areas the Government has already said it is planning to introduce a greater say in planning permission for onshore wind farms. As projects need to have planning permission before they bid into the CfD auctions, this will automatically mean that only projects that have local support will get subsidised. This would only affect projects not already consented.

* This idea has been mooted by several commentators recently, including the Committee on Climate Change (CCC) and the think-tanks Policy Exchange and Bright Blue.

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Appendix A: Detailed results

Detailed results

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List of Scenarios

Scenario		Description	Auction Year	Delivery Years	Pot 1 Budget (£m)	Pot 2 Budget (£m)
1a	Baseline 2015	Two pots, onshore included	2015	2015/16-2018/19	65	260
1b	“Merged pots”	One pot, onshore included	2015	2015/16-2018/19	Modelled	-
1c	“No onshore”	Two pots, onshore excluded	2015	2015/16-2018/19	65	Modelled
1d	“Merged pots, no onshore”	One pot, onshore excluded	2015	2015/16-2018/19	Modelled	-
2a	Baseline 2017	Two pots, onshore included	2017	2017/18-2020/21	65	260
2b	“Merged pots”	One pot, onshore included	2017	2017/18-2020/21	Modelled	-
2c	“No onshore”	Two pots, onshore excluded	2017	2017/18-2020/21	65	Modelled
2d	“Merged pots, no onshore”	One pot, onshore excluded	2017	2017/18-2020/21	Modelled	-

Detailed results

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Scenario		Capacity contracted for			Cost		
		Onshore (MW)	Solar (MW)	Offshore (MW)	Total cost (£m)	Average per year (£m)	Average subsidy* under CfDs awarded (£/MWh)
1a	Baseline 2015	720	80	1,260	3,700	206	43
1b	Merged pots	1,070	1,340	760	3,000	182	35
1c	No onshore	0	1,340	1,390	4,350	240	51
1d	Merged pots, no onshore	0	1,340	1,390	4,380	244	51
2a	Baseline 2017	850	50	1,350	3,820	212	39
2b	Merged pots	1,960	1,970	0	2,800	156	29
2c	No onshore	0	1,560	1,540	4,340	243	45
2d	Merged pots, no onshore	0	4,470	640	4,220	239	43

Notes:

* Subsidy is calculated as the top up relative to the wholesale price.

Total cost is for all the CfD contracts awarded in the auction. We set the volume to match the baseline (86 TWh or an average of 4.8 TWh/year in the 2015 auction, and 97 TWh or an average of 5.4 TWh/year in the 2017 auction).

Results have been rounded.

Administrative strike prices

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Administrative Strike prices (£/MWh)												
Technology	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Advanced Conversion Technologies	155	155	150	140	140	140	140	140	140	140	140	140
Anaerobic Digestion	150	150	150	140	140	140	140	140	140	140	140	140
Biomass Conversion	105	105	105	105	105	105	105	105	105	105	105	105
Dedicated Biomass (with CHP)	125	125	125	125	125	125	125	125	125	125	125	125
Energy from Waste	80	80	80	80	80	80	80	80	80	80	80	80
Geothermal (with or without CHP)	145	145	145	140	140	140	140	140	140	140	140	140
Hydro	100	100	100	100	100	100	100	100	100	100	100	100
Landfill Gas	55	55	55	55	55	55	55	55	55	55	55	55
Sewage Gas	75	75	75	75	75	75	75	75	75	75	75	75
Offshore Wind	155	155	150	140	140	140	140	140	140	140	140	140
Onshore Wind (>5 MW)	95	95	95	90	90	90	90	90	90	90	90	90
Solar Photo-Voltaic (>5MW)	120	120	115	110	100	100	100	100	100	100	100	100
Tidal Stream	305	305	305	305	305	305	305	305	305	305	305	305
Wave	305	305	305	305	305	305	305	305	305	305	305	305
Scottish Islands – onshore wind (>5MW)				115	115	115	115	115	115	115	115	115

Source: DECC EMR Delivery Plan 2013 set strike prices for 14/15-18/19

Note: From 19/20 onwards we have assumed for simplicity that strike price maxima remain flat. DECC may choose to “degress” maximum strike prices further, but this would not necessarily reduce costs. In some scenarios it can prematurely truncate the supply curve and can potentially result in higher overall costs.

Scenario 1a: Baseline 2015

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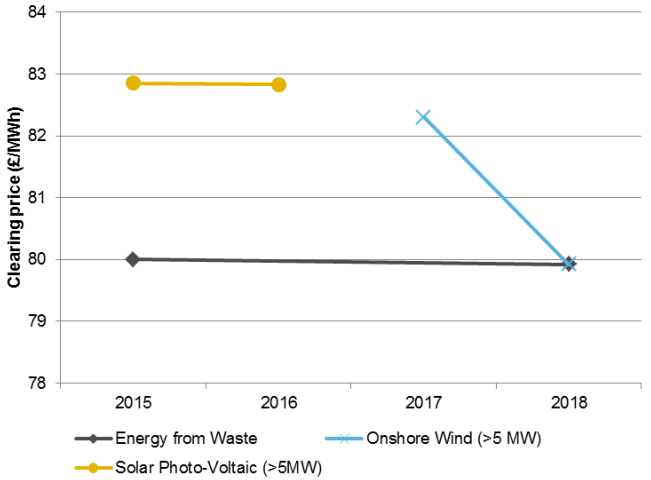
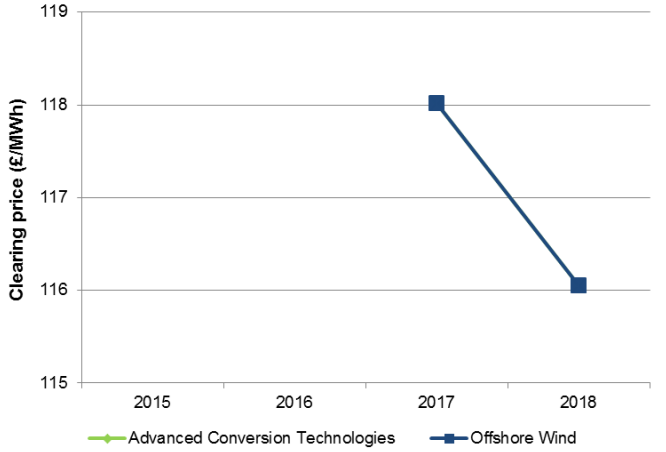
Clearing prices, Pot 1



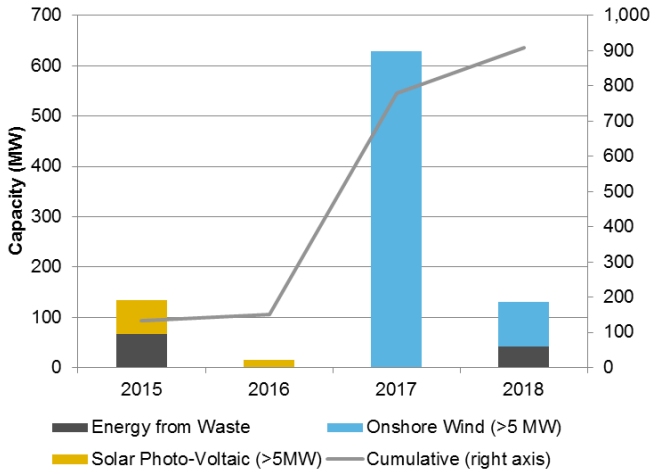
Clearing prices, Pot 2



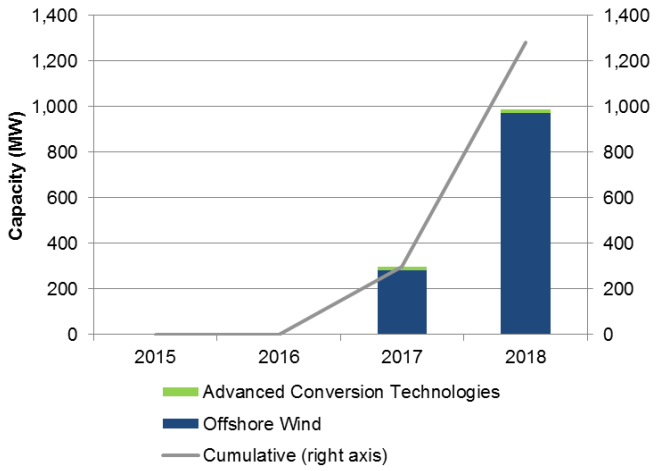
Commentary

- Clearing prices are set by solar and onshore wind in Pot 1.
- In Pot 2 clearing prices are set by offshore wind.

Capacity, Pot 1



Capacity, Pot 2



Scenario 1a
Baseline 2015: Calibration

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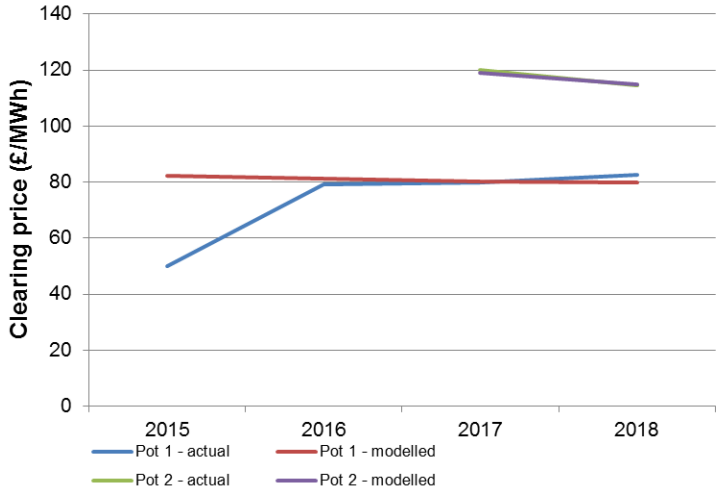
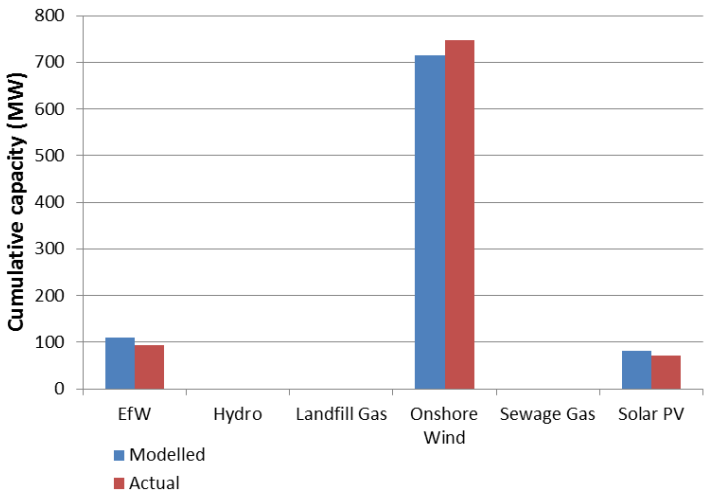
Clearing prices, Pots 1 & 2



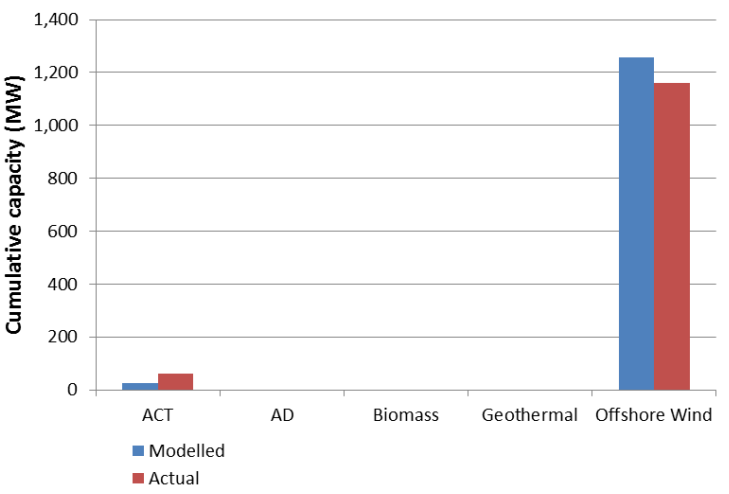
Commentary

- Clearing prices are within +/- £5/MWh – apart from in 2015 when the difference is driven by low solar bids (which have since been withdrawn).
- Onshore and offshore capacities are within 10% of actual. Solar is also close after calibration.

Capacity, Pot 1



Capacity, Pot 2



Scenario 1b
Merged pots 2015

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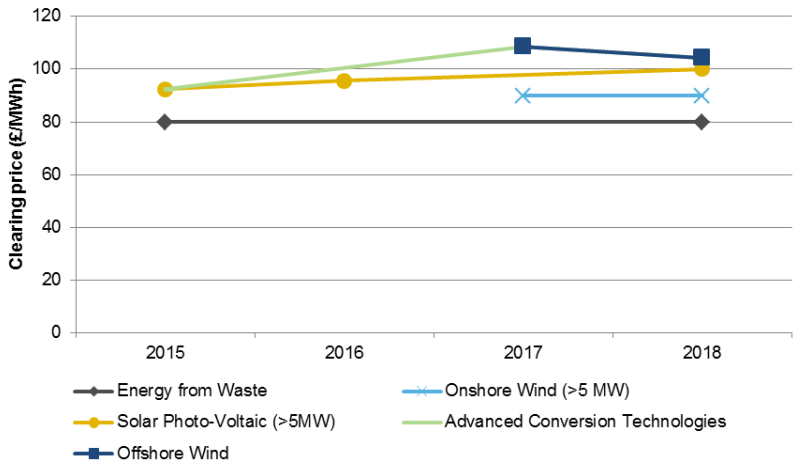
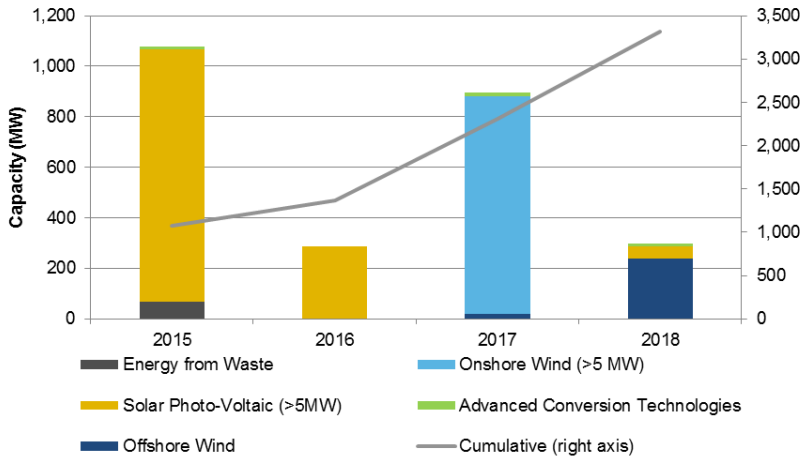
Clearing prices, single pot



Capacity, single pot



Commentary

- In 17/18 and 18/19 the clearing price is set by offshore wind. Solar and onshore wind receive their administrative strike prices.
- This illustrates that the cost savings that can be realised by merging the pots depends on there being sufficient lower-cost capacity (e.g. solar and onshore wind) in the supply curve to meet the desired level of renewable energy output.

Scenario 1c
No onshore 2015

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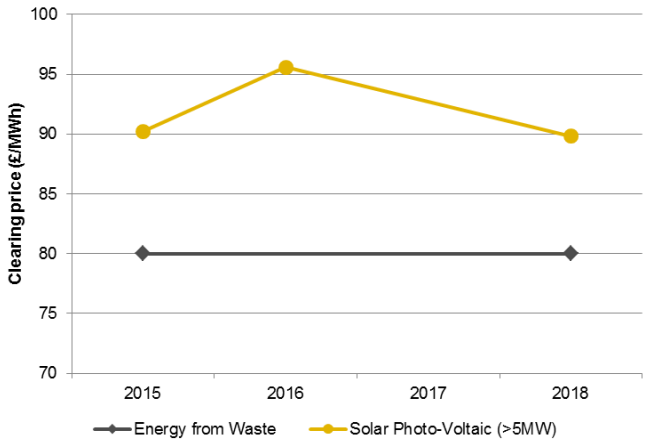
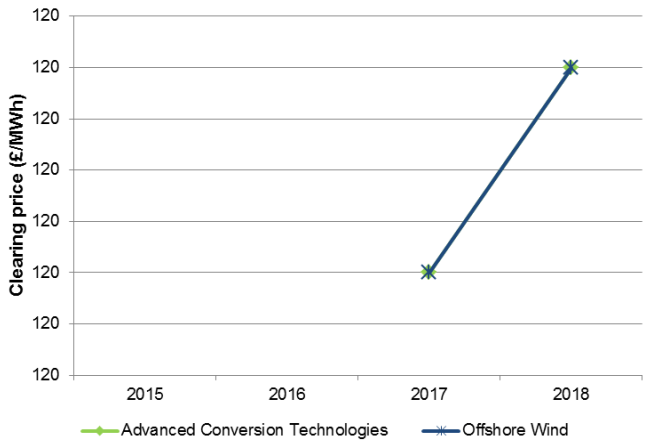
Clearing prices, Pot 1



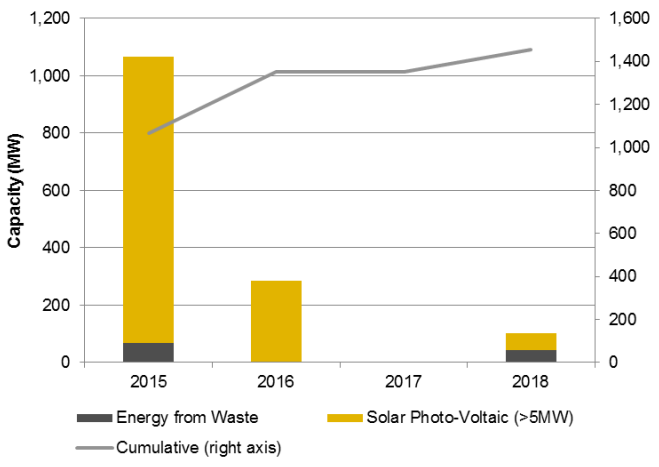
Clearing prices, Pot 2



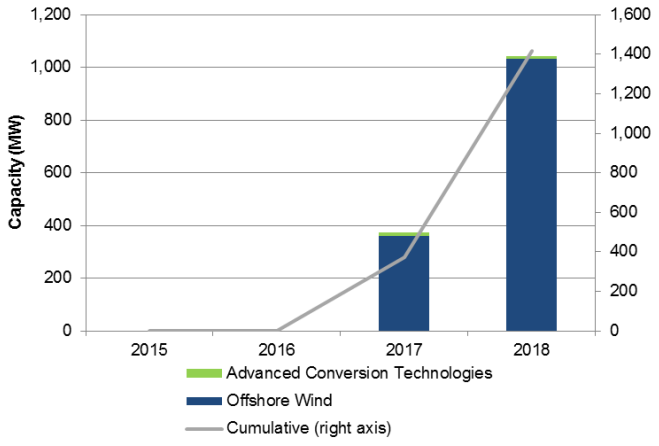
Commentary

- Clearing prices are set by solar in Pot 1.
- In Pot 2 clearing prices are set by offshore wind.

Capacity, Pot 1



Capacity, Pot 2



Scenario 1d
Merged pots, no onshore 2015

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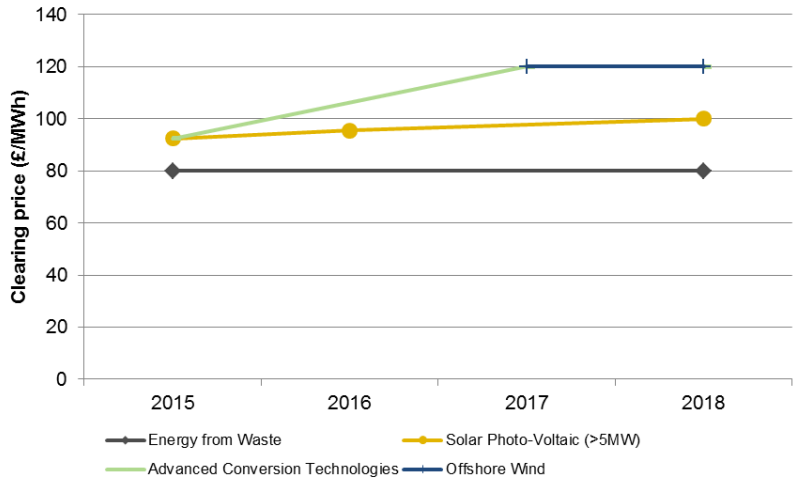
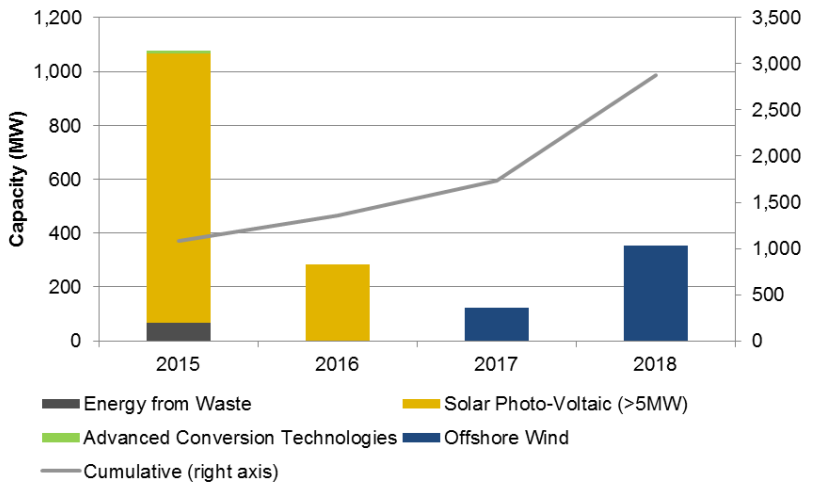
Clearing prices, single pot



Capacity, single pot



Commentary

- Clearing prices are set by solar in the early years and then by offshore wind.
- Solar receives the clearing price in 15/16 and 16/17 but its administrative strike price in 18/19.

Scenario 2a Baseline 2017

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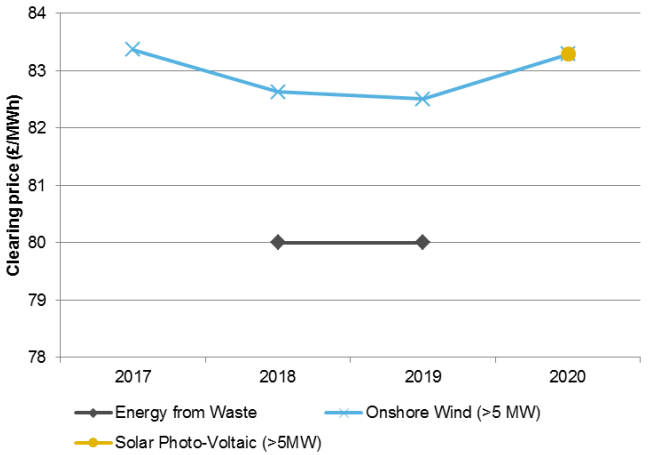
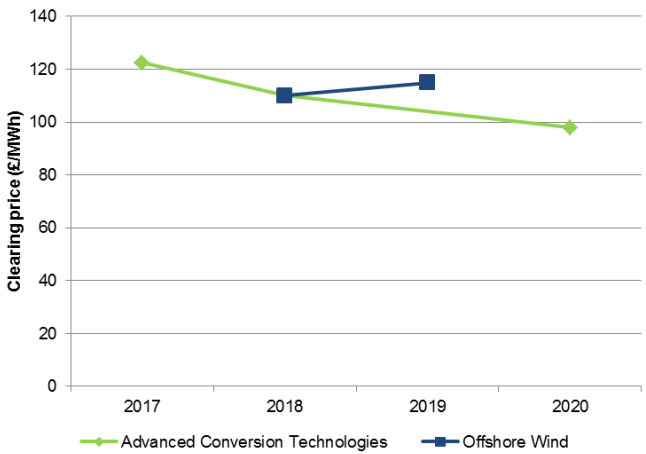
Clearing prices, Pot 1



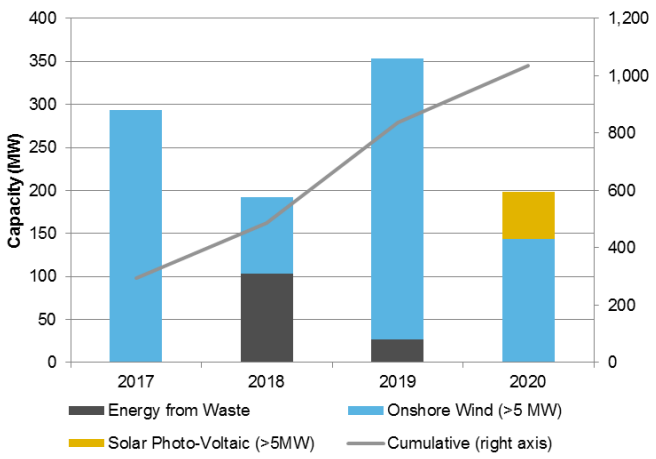
Clearing prices, Pot 2



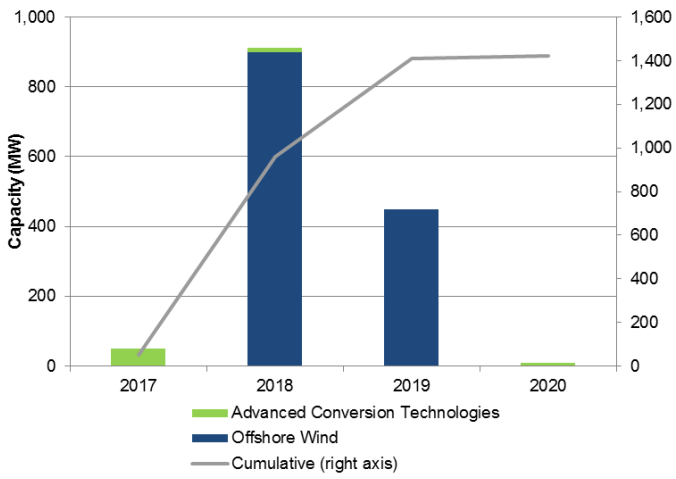
Commentary

- Clearing prices are set by onshore wind and solar in Pot 1.
- In Pot 2 clearing prices are set by offshore wind and ACT.
- Prices are higher than in 2015 as more generation is procured and so the price clears higher up the supply curve.

Capacity, Pot 1



Capacity, Pot 2



Scenario 2b
Merged pots 2017

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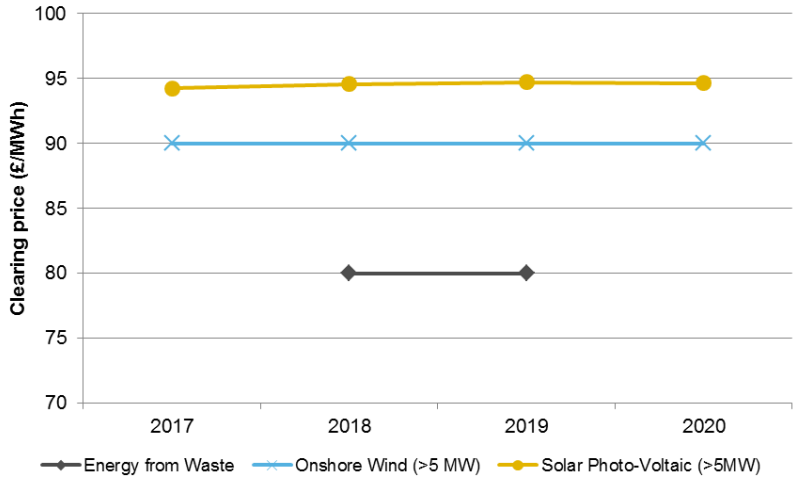
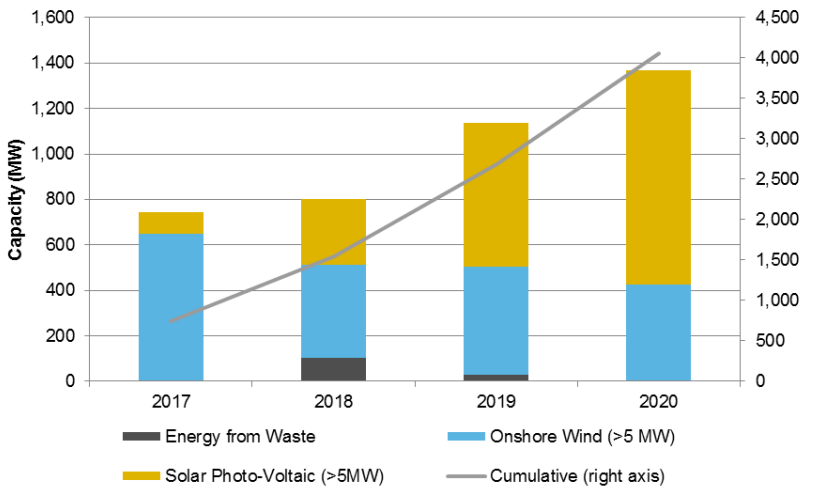
Clearing prices, single pot



Capacity, single pot



Commentary

- Clearing prices are set by solar.
- Onshore wind and EfW receive their administrative strike prices.

Scenario 2c
No onshore 2017

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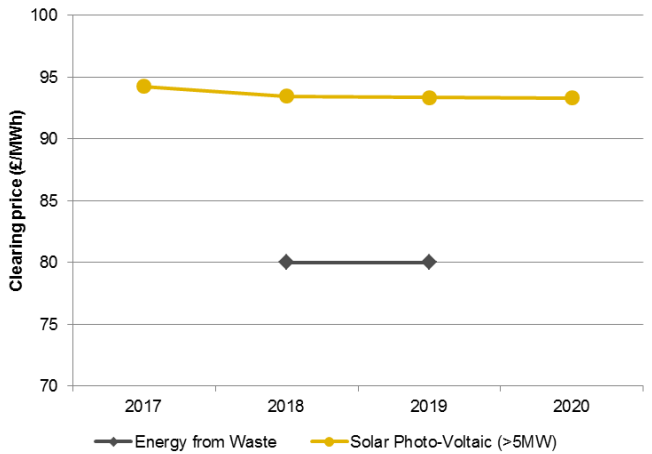
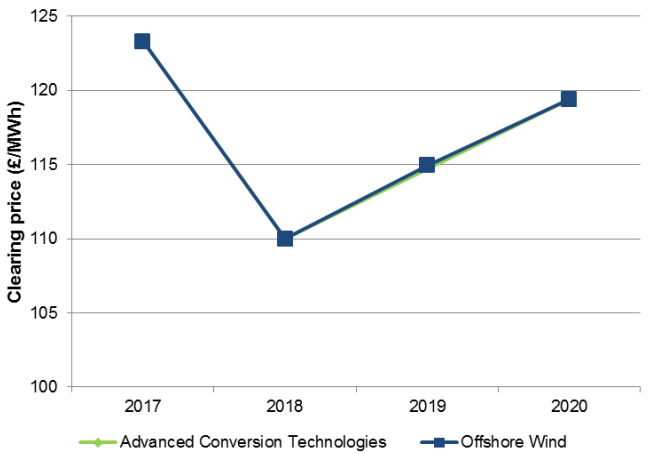
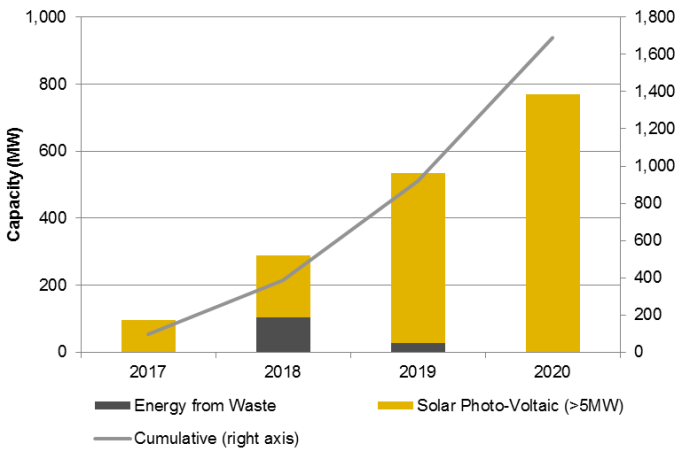
Clearing prices, Pot 1



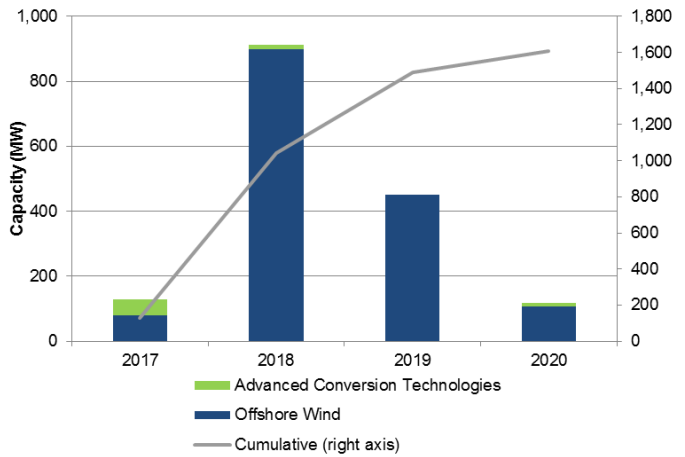
Clearing prices, Pot 2



Capacity, Pot 1



Capacity, Pot 2



Commentary

- Clearing prices are set by solar in Pot 1.
- In Pot 2 the clearing price is set by offshore wind.
- The low clearing price in 2018 is due to a representative lower cost project/bid commissioning in that year. This project could bid differently, or alternatively, a higher cost offshore wind project could bid instead. (This would lead to even higher costs under the "no onshore wind" scenario, but we have not presented such a scenario.)

Note: We aggregate bids for all years in order (based on our valuation model) in a single "bid stack" to model the workings of the auction. NERA's auction model allows for more sophisticated bidding strategies, but we have not applied them for the current analysis.

Scenario 2d
Merged pots, no onshore 2017

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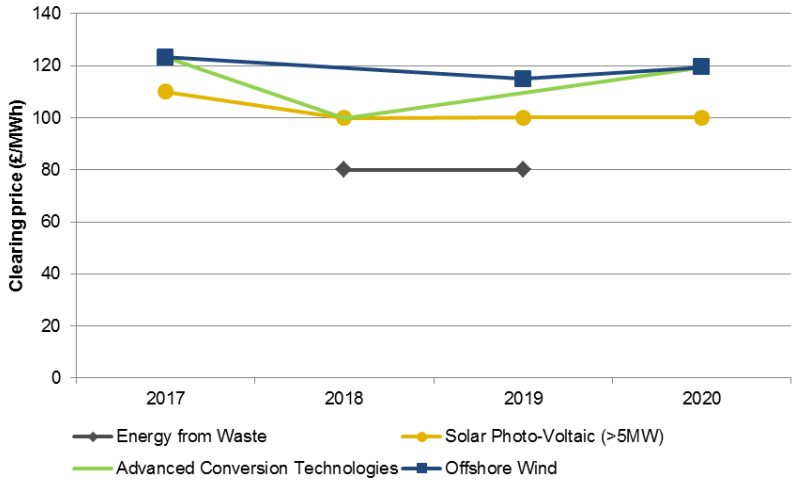
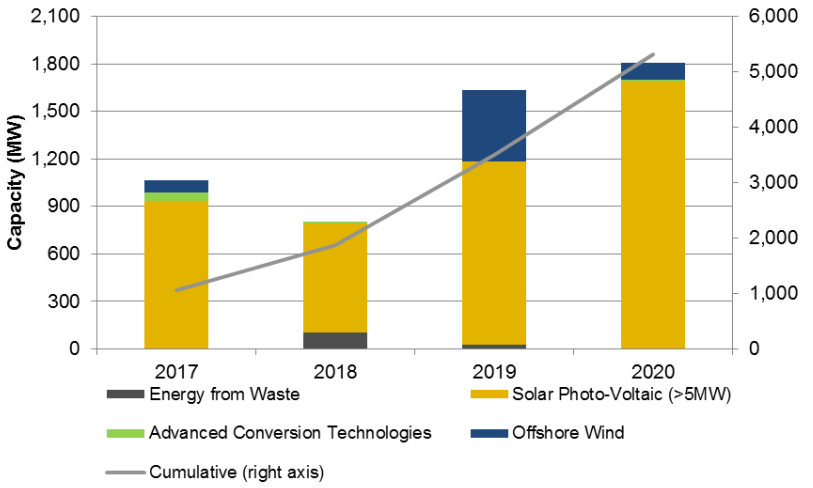
Clearing prices, single pot



Capacity, single pot



Commentary

- Clearing prices are set by offshore wind and ACT.
- Solar and EfW receive their administrative strike prices.

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Appendix B: Assumptions and data sources

Key assumptions

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- Technology costs
  - Base: DECC 2013 Generation costs (and fuel costs from consultation on the RO 2011/2012)
  - Offshore and solar calibrated to 2015 auction results (lower end of cost distribution adjusted by a factor)
  - Sensitivities:
    - Low technology costs: 30% lower for less established technologies (and solar), 20% lower for other established technologies.
    - High technology costs: 50% of DECC learning rate
- Rates of return required (hurdle rates) and build limits, load factors and asset lifetimes also aligned with DECC 2013 Generation costs report
- Wholesale prices
  - Base: DECC 2014 UEP and CfD allocation framework (c. £53/MWh in 2020, 2012 prices)
  - Sensitivities:
    - DECC 2014 UEP High (£70/MWh in 2020)
    - DECC 2014 UEP Low (£41/MWh in 2020)
- Supply curve
  - 2015: REPD database (exclude "under construction" or those without planning permission). Allow limited new entrants.
  - 2017: mainly new entrants similar to the REPD database.
  - Projects draw costs from a distribution defined using the DECC 2013 technology costs
  - Strike price bids are generated via a discounted cash flow project model. We aggregate bids for all years (based on costs from DECC 2013) in a single "bid stack" to model the workings of the auction. NERA's auction model allows for more sophisticated bidding strategies, but we have not applied them for the current analysis.
  - Administrative strike prices are as per slide 15 above. For years where DECC has not yet set administrative strike prices we assumed they remain flat.

https://www.gov.uk/government/collections/renewable-energy-planning-data

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223940/DECC_Electricity_Generation_Costs_for_publication_-_24_07_13.pdf

https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2014

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42852/5936-renewables-obligation-consultation-the-government.pdf

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Contact Us

Daniel Radov

Associate Director
NERA London
+44 20 7659 8744
daniel.radov@nera.com

Alon Carmel

Senior Consultant
NERA London
+44 20 7659 8628
alon.carmel@nera.com