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The Potential Impact of Demand-Side Response on Customer Bills

Prepared for EnerNOC, Kiwi Power and Open Energi

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Executive Summary

The Department of Energy and Climate Change (DECC) is planning to introduce a capacity market in Great Britain as part of its Electricity Market Reform (EMR) package. This report investigates the circumstances in which the rules surrounding the participation of DSR in the capacity market increase the costs of the capacity market to British consumers.

In particular, this report identifies the potential impact of DSR on customer bills under a range of plausible policy alternatives and a range of DSR volumes. In the scenarios we examined, changing the rules surrounding DSR participation reduced customer bills by up to £359m in the first year alone.

DECC's aims for the capacity market include ensuring that British consumers receive a secure supply of electricity at the lowest cost. However, with respect to its treatment of Demand-Side Response (DSR), the market rules may result in consumers facing a higher cost than is necessary. In particular, the rules governing the Transitional Arrangements (TAs) for 2015-17 discourage DSR from providing security of supply in the four-year-ahead (T-4) auction in favour of the year-ahead (T-1) auction. The limited contract lengths available to DSR may discourage DSR from providing capacity at all.

Our scenarios examine cases where removing the disincentive on DSR to compete with other forms of capacity in the T-4 auction reduces capacity prices and the cost to consumers. The effect of increasing competition in the T-4 auction is particularly stark because National Grid will procure roughly twenty times the capacity in the four-year ahead auction as in the T-1 auction. Accordingly, any price-reducing effect that DSR may have in the T-1 auction will only have one twentieth of the impact on consumers that the same price-reducing effect in the T-4 auction would have.

Changing the rules to encourage DSR to participate in the T-4 auction will reduce costs to consumers when:

- DSR is a cheaper source of capacity than at least some existing and new generation in the T-4 auction (it is "inframarginal");
- More DSR becomes available than National Grid currently forecasts, because DECC relaxes the eligibility rules or rules on contract length or otherwise; and
- The need for capacity in 2018/19 is lower than currently forecast.

We quantified the impact of DSR on British consumers in these circumstances using our model of the British capacity market. Our analysis included different assumptions about the volume of capacity that National Grid might procure in the T-4 and T-1 auctions. National Grid has admitted it does not know what volume of DSR is likely to participate in the Capacity Market. For each scenario we also tested a range of levels of DSR participation, ranging from National Grid's estimate of 2.5 GW up to the proportion of total demand seen in the Pennsylvania, New Jersey, and Maryland (PJM) market.

1. Introduction

The Department of Energy and Climate Change (DECC) is planning to introduce a capacity market in Great Britain as part of its Electricity Market Reform (EMR) package. EnerNOC commissioned NERA to investigate the circumstances in which the rules surrounding the participation of DSR would increase the costs of the capacity market to British consumers.

DECC's objective is to increase security of supply for British electricity consumers by offering market participants a payment in exchange for taking on an obligation to generate at times of system stress, backed up by a penalty for non-delivery. National Grid will allocate capacity agreements through two auctions, four years and one year ahead of the period of delivery (the T-4 and T-1 auctions respectively). The first T-4 auction will be held in December 2014 for delivery in the winter of 2018/19.

All capacity that is not otherwise receiving support under government programmes is eligible for support from the capacity market. However, the arrangements for that support differ:

- All capacity is eligible to enter either the T-4 or the T-1 auctions. DSR is eligible for additional support between 2015 and 2017 through Transitional Arrangements (TAs). The TAs allocate contracts to DSR as well as obligations to deliver security of supply before 2018/19. However, any DSR provider which has received support in a T-4 auction may not participate in the subsequent year's TA.
- Existing capacity and DSR can only obtain one-year capacity agreements. All companies investing in refurbishment or new plant above the minimum expenditure levels defined by DECC can obtain longer term agreements of three to fifteen years if awarded an agreement in the T-4 auction.

Our analysis is not attempting to be a complete description of the possible evolution of the capacity market or the role of DSR. In particular, we have not been asked to examine the likely evolution of the costs of DSR or the quantity of DSR that is likely to become available. Instead, our scenario-driven approach illustrates that changing the rules on eligibility for the T-4 auction and on contract length may decrease the costs to consumers if:

- DSR displaces more expensive capacity in the T-4 auction;
- More DSR is available than National Grid currently anticipates; and/or
- The capacity procured at the T-1 auction is lower than National Grid currently anticipates.

Our modelling shows, that in these circumstances where customer bills are reduced, the magnitude of these savings is up to £359 million per year.

This report proceeds as follows:

- Chapter 2 describes the British capacity market and the role of DSR within that market;
- Chapter 3 describes the circumstances in which changing the rules for the participation of DSR in the capacity market would reduce the cost of the capacity market to British electricity customers and examines the effect of those scenarios; and
- Chapter 4 concludes.

2. The Role of DSR in the Capacity Market

This chapter introduces the British Capacity Market. In particular, it describes the economic motivation and history behind its creation, discusses the effect DSR can have in the capacity market and describes some of the rules which govern the market, with emphasis on those which specifically affect DSR units.

This chapter proceeds as follows:

- Section 2.1 describes the economic theory behind the need for a capacity market in Great Britain;
- Section 2.2 describes existing capacity markets in the United States, particularly with respect to the role DSR has played.
- Section 2.3 describes the two types of auctions which will procure capacity and states the announced parameters for the upcoming auction;
- Section 2.4 discusses rules which disincentivise DSR units from participating in the T-4 auction;
- Section 2.5 explains who will fund the capacity market; and
- Section 2.6 discusses the potential negative impact of excluding DSR units from the T-4 auction.

2.1. The British Capacity Market Seeks to Ensure Security of Supply

In Great Britain, wholesale electricity is currently provided by an energy-only market. Energy-only markets are in principle capable of delivering a generation mix that is both allocatively efficient (demand is met at least cost every half hour) and dynamically efficient (sufficient investment takes place to ensure future demand is met optimally). Because generator capacity is limited, prices in an energy-only market will occasionally rise to the "Value of Lost Load" (VOLL) in times of scarcity. At those times, demand is met by an efficient mix of generation and load-shedding. Such "price spikes" are needed to offer peaking plants and other generators the opportunity to recover their fixed costs.

In practice, market failures mean that energy-only markets may not encourage efficient investment in generator capacity. Significant political and regulatory risk diminishes the value to investors of markets that rely on prices rising to VOLL. Regulatory and political institutions tend to react adversely to price spikes, and many energy market rules explicitly cap wholesale prices below the level of VOLL. Even if such *explicit* caps are absent, as long as regulators remain averse to price spikes, market participants will face a risk that regulators intervene to prevent high prices from occurring. This *threat* of regulatory intervention places an *implicit* cap on prices. Any cap on prices (whether explicit or implicit) creates a problem of "missing money" – a shortfall in the revenue required to cover the cost of investing in generator capacity.

Limited participation by consumers (the demand-side) in energy markets is likely to compound this problem. The limited scope for consumers to participate in energy markets means that the demand curve for electricity is very "inelastic", i.e. demand does not respond to price movements. Inelastic demand makes electricity prices more volatile, heightening the regulatory and political risks surrounding the reliance on high prices, diminishing expected revenues and deterring investment. An inelastic demand curve also facilitates the exercise of market power, which invites more regulatory interventions. Limited participation in the associated market for long-term contracts means that the forward curve of prices does not give investors reliable signals about the future need for capacity.

As a result of these market failures or potential market failures in the current energy-only market, the Department of Energy and Climate Change (DECC) is introducing the Great Britain Capacity Market. The capacity market is designed to correct under-investment due to "missing money" by making an additional payment to capacity providers. The objective of this "capacity payment" will allow firms to recover the fixed costs of providing capacity without the need for large price spikes and unreliable service. Renewables and capacity in receipt of other forms of support are excluded from the capacity market.

2.2. DSR Can Compete With New Supplies to Offer Capacity

Capacity markets are not a new concept and several have existed in the United States since the late 1990s - particularly in California, the Upper Midwest, New York, New England and the Mid-Atlantic States. Each capacity market operates with its own set of rules which define the responsibility for procuring capacity obligations, the form of the obligation to provide capacity as well as the eligibility rules for participation.[1] Some markets are decentralised, whilst others rely on centralised auctions.

The main participants in US capacity markets by volume are existing generators, but US markets also feature the participation of other sources of capacity which may be lower cost than new investment. Energy storage facilities, which convert electricity into storable energy and back, provide an alternate source of supply-side capacity. On the demand-side, the major source of non-generative capacity is from demand-side response units (DSR). DSR providers contract with customers to reduce their consumption at times when the system's generator capacity is near its limit. This lowers the demand for energy at peak times and easing the strain on the grid.

For example, the Pennsylvania, New Jersey and Maryland market, PJM, operates in parts of 13 states between North Carolina and Illinois. PJM shares some similarities with the capacity market in Great Britain, including consisting of centralised auctions held every year with delivery several years in advance.[2]

DSR has played a major role in the PJM market, which has attracted nearly 15,000 MW of demand resources.[3] For the upcoming delivery year of June 2015-May 2016, nine per cent of auctioned capacity is made up of DSR.[4] The influx of DSR in PJM, in part, "postponed the

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1 Spees, K, Newell, S and Pfeifenberger, J (2013), "Capacity Markets—Lessons Learned from the First Decade," *Economics of Energy and Environmental Policy, Vol 2, No 2,* page 22.

2 Specifically, delivery in the PJM market is three years after the primary auction, similar to the four year gap between the T-4 auction and the year of delivery in the British market. Spees et al., page 10.

3 Spees et al., page 22.

4 PJM (2012), "2015/2016 RPM Base Residual Auction Results," page 1.

need for costly new generation investments by almost a decade, while capacity market prices were generally far below the cost of new entry. Overall, this PJM experience strongly demonstrates the benefits of maintaining resource adequacy through non-discriminatory procurement".[5] By competing in the capacity market and securing capacity agreements, DSR exerts downward pressure on the capacity price and displaces more expensive alternatives to the benefit of consumers.

Some market participants have questioned whether DSR is providing a service that is equivalent to the service provided by generators, and have argued that "DSR fatigue" from frequent dispatch may make DSR an unreliable alternative. However, in practice, the evidence suggests that "demand resources have performed well and there is no evidence yet that these concerns will occur".[6]

2.2.1. The T-4 auction will procure most of the capacity

National Grid will allocate contracts to provide capacity using capacity market auctions. National Grid will hold two capacity auctions in advance of each "capacity year":[7]

1. The primary auction occurs four years before the commencement of the year and is known as the T-4 auction. DECC chose the schedule to give enough time for parties awarded capacity agreements to build new capacity that matches their capacity obligation for that capacity year. The lead-time was also chosen to be short enough to avoid excessive uncertainty on capacity needs. DECC intends the design of this auction to be particularly advantageous towards new gas-fired plants.[8]
2. The secondary auction occurs the year before the commencement of the capacity year and is known as the T-1 auction. DECC intends this auction to give enough time to fill any remaining capacity requirement with DSR and existing generating plants, but is close enough to delivery that DECC can increase or decrease the capacity target with adequate certainty of capacity needs. Due to the short lead-time, generators cannot build new plant after being awarded a capacity agreement. This auction is not available to capacity market units (CMUs) which were awarded a capacity agreement in the year's T-4 auction.[9]

In advance of a capacity year's T-4 auction, the Secretary of State responsible for the auction will announce a total amount of capacity required, and a proposed split between the T-4 and T-1 auction. The Secretary of State will also announce a set of prices and quantities which define the capacity market's demand curve. Both auctions will operate as a descending clock

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5 Spees et al., page 19.

6 Spees et al., page 22.

7 Delivery years run from 1 October until 30 September.

8 DECC (23 June 2014), "Electricity Capacity Market – Capacity Market, Impact Assessment," page 46.

9 DECC (2014), "Capacity Market Rules," Rule 3.3.3

auction in which bidders withdraw capacity as the price drops until the amount of capacity remaining roughly equals the desired amount for the auction. [10,11]

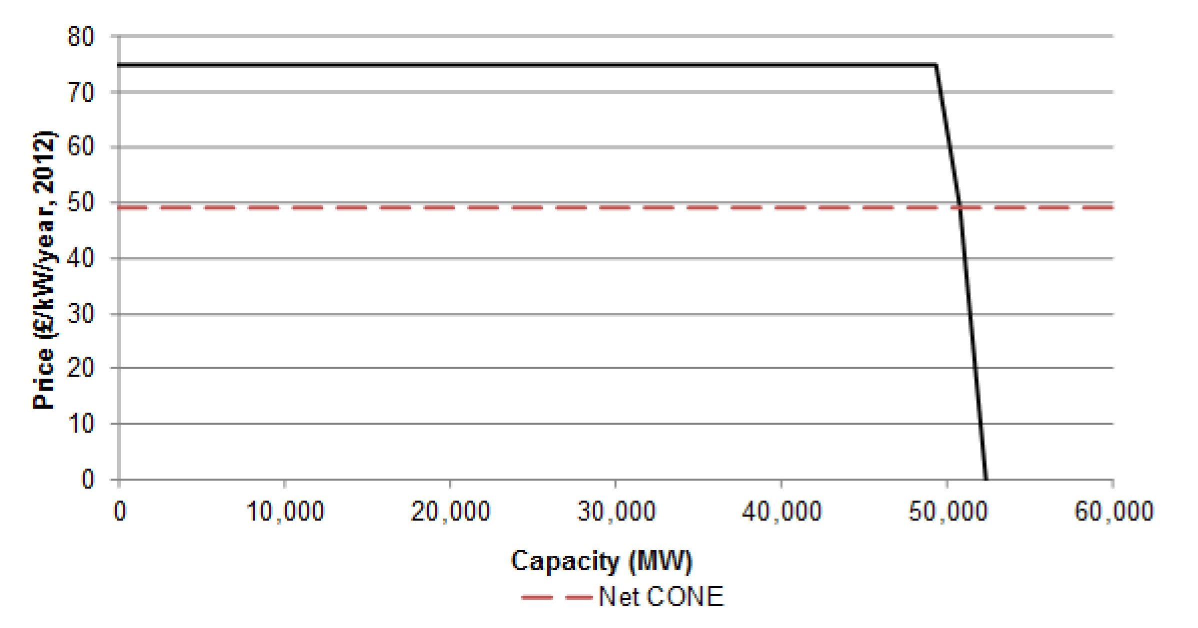
2.2.2. The structure of the T-4 auction for 2014 has been published

As described in the Section 2.2.1, the Secretary of State has defined the following auction parameters which define the demand curve for the auction:[12]

- The target capacity for the 2014 T-4 auction is 50.8 gigawatts (GW), with an additional 2.5GW set aside for the 2017 T-1 auction;
- The price that the auctioneer is willing to pay for this target level of capacity is the "net cost of new entry" (i.e. the capital and other fixed costs of a new entrant generator, net of profit from the energy market) or "net CONE", which DECC estimates at £49/kW/year (in 2012 prices);
- The price cap (from which the price initially descends) is £75/kilowatt (kW)/year;
- The auctioneer will procure capacity within a window of plus or minus 1.5GW of the target capacity. At the price cap level, the auctioneer would purchase 1.5GW less than the target (49.3GW) and at £0/kW/year it would purchases 1.5GW more (52.3GW).

This demand curve is illustrated below in Figure 2.1.

Figure 2.1
2014 T-4 Auction Parameters



10 National Grid (2014), "Capacity Market Auction Guidelines – 2014 Four year ahead Capacity Market Auction", page 14. In practice, within each auction round, in which the prevailing price level drops by £5/kW, the parties will be able to submit sealed "exit price" bids.

11 DECC (2014), "Capacity Market Rules – Chapter 5: Capacity Auctions", pages 54-66.

12 Ed Davey (2014), "Confirmation of Demand Curve Parameters for the First Capacity Auction", 1 August 2014.

In 2017, the T-1 auction will meet the remaining need for capacity. National Grid has recommended that the Government procure a total of 53.3GW for capacity year 2018 and "assumes a total level of DSR of 2.5GW in 2018/2019. However, at this point in time, no information is available to the National Grid on how much of this would either participate in the year ahead (T-1) auction or opt out[13] of the Capacity Market."[14]

The Secretary of State accepted these procurement guidelines for the 2014 auction in his decision to procure 50.8GW, but the 2.5GW withheld for the T-1 auction in 2017 is not binding. Regulation 7(4)(b) requires that National Grid recommend a procurement level for a T-1 auction in the annual electricity capacity report of the year of that auction.[15] The Secretary of State must then officially announce the auction parameters in advance of that auction.[16] In other words, the demand parameters for the 2017 T-1 auction will be based on market conditions in 2017, not 2014.

2.3. DSR Faces a Significant Disincentive to Participate at T-4

2.3.1. Transitional Arrangements are in place in advance of 2018

The Government has implemented "Transitional Arrangements" (TAs) to help ensure security of supply before 2018. The main features of these arrangements are two transitional auctions for DSR held in 2015 and 2016 for delivery of capacity the following year. Aside from differing eligibility requirements, these auctions will function under similar rules and regulations as the standard T-4 and T-1 auctions. National Grid "will provide an assessment of the potential growth of DSR for each delivery year. This analysis will be presented to the Government who will make the final decision on the amount to procure".[17] DECC has stated that the purpose of these auctions is to "help grow the demand-side industry and ensure effective competition between traditional power plants and new forms of capacity; driving down future costs for consumers".[18]

2.3.2. Transitional auctions exclude DSR that takes part in the T-4 auction

The eligibility requirements in the transitional auctions and the standard T-4 and T-1 auctions are different.[19] Unlike the standard auctions, the transitional auctions are only open to:

- DSR; and

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[13] National Grid's use of the phrase "opt out" is inaccurate in that it implies that all relevant DSR already exists but may choose to exit the market if the terms are unfavourable. In reality, this DSR does not exist yet. The amount that ultimately materialises depends on whether the terms are favourable enough.

[14] National Grid (12 June 2014), "Electricity Capacity Report June 2014", page 61.

[15] DECC (31 July 2014), "Electricity Capacity Regulations", Regulation 7.

[16] DECC (31 July 2014), "Electricity Capacity Regulations", Regulation 11.

[17] DECC (June 2014), "Implementing Electricity Market Reform," page 116.

[18] DECC (2014), https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform.

[19] DECC (31 July 2014), "Electricity Capacity Regulations", Regulation 29.

- Certain other generating units with generation no larger than 50MW.[20]

Units that would otherwise be eligible to provide capacity are unable to participate if they have been awarded a contract in the previous years' auctions (other than another transitional auction). The Capacity Market Rules states that an application must not be submitted for any DSR "that includes any generating unit or DSR CMU Component that forms part of a CMU that has been awarded a Capacity Agreement in a Capacity Auction (other than a Transitional Capacity Auction) in any previous year".[21] [22] DECC confirmed that its policy position is to prevent DSR from receiving support under the TAs and the T-4 auction:

> "[e]ligibility [in the transitional auctions] is limited to non-CMRS CMUs and DSR CMUs which have not participated in the Capacity Market or in the Balancing Mechanism and include generation no larger than 50MW."[23]

In practice, this means that:

- If a DSR provider wins a capacity agreement in the 2014 T-4 auction, it would forego the potential to win a capacity agreement in the 2015 and 2016 TA auctions; and
- If a DSR provider wins a capacity agreement in the 2015 T-4 auction, it would forego the potential to win a capacity agreement in the 2016 TA auction.

DSR will therefore face a significant disincentive to participate in the T-4 auctions. Winning a capacity agreement in the first two T-4 auctions requires a DSR provider to forego two or three years[25] of revenue from capacity agreements obtained through other auctions. Unless the provider expects the price in the T-4 auction to be much more favourable than in the T-1 auction for the relevant delivery year, it would likely be unwilling to disqualify itself from the transitional auctions.

DECC's stated purpose in holding the TA auctions is to help grow the DSR side of the industry, but disincentivising DSR from participating in the T-4 auction through the TA auction eligibility rules may instead hinder the DSR growth DECC is seeking.

2.4. DSR Can Only Access the Shortest of Three Contract Lengths

The current capacity market rules state that there are three maximum agreement lengths available in the T-4 auction (and only in the T-4 auction):

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20 Specifically, this is limited to non-CMRS generating units. A CMRS generating unit is defined in the Capacity Market Rules as a "Generating CMU, each Generating Unit of which Exports electricity to a Distribution Network where the Metering System for the corresponding BM Unit is registered in the Central Meter Registration Service in accordance with the BSC".

21 DECC (2014), "Capacity Market Rules 2014", Rule 11.3.2.

22 We found no explanation for this exclusion.

23 DECC (June 2014), "Implementing Electricity Market Reform," para 443.

25 The opportunity cost of a DSR being awarded a contract in a T-4 auction includes being excluded from that capacity-year's T-1 auction

- **One year**, for CMUs proposing to spend less in capital expenditure than the three-year minimum £/kW threshold.[26] This threshold is set at £125/kW of de-rated capacity for the 2014 T-4 auction.[27] This maximum bid length is intended for DSR and existing generating plants not planning major refurbishments.[28]
- **Three years**, for CMUs proposing to spend between the three-year and fifteen-year minimum £/kW threshold. The fifteen-year minimum £/kW threshold is £250/kW of de-rated capacity for this auction. This maximum bid length is intended for existing generating plants which are planning major refurbishments.
- **Fifteen years**, for CMUs proposing to spend above the fifteen-year minimum £/kW threshold of £250/kW. This maximum bid length is intended for new generating plants, though the Rules and Regulations technically allow a plant undergoing refurbishments above that level to qualify for a fifteen-year bid.

However, DECC has identified some inconsistencies between these definitions and a soon-to-be-released State aid decision. In its view, "the State aid decision (to be published shortly) does not allow a 15 year capacity agreement to be offered to existing plants carrying out refurbishment work," if that work exceeds the £250/kW threshold.[29] DECC is actively consulting on how to align this policy with the State aid decision.

The capacity market rules plainly state that the "Maximum Obligation Period […] in respect of the T-1 Auction, means one Delivery Year for all CMUs."[30]

2.5. Electricity Customers Ultimately Pay the Capacity Market Costs

The final version of the capacity payment regulations is not currently available. However, the current drafts suggest that electricity suppliers pay for the capacity market indirectly through charges collected by the settlement body. The annual amount that an electricity supplier pays is equal to the total amount paid to capacity providers that year scaled down to a measure of the suppliers' share of total electricity consumption.[31] A supplier's share of electricity supply in a capacity year is determined by its estimate of customers' demand (in MWh) between 4pm and 7pm on weekdays between November and February. Once outturn data becomes available, these estimates are reconciled with actual usage.[32] Suppliers are also responsible for paying administrative costs associated with the market.

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26 DECC (31 July 2014), "Electricity Capacity Regulations", Regulation 11.

27 De-rated capacity is a CMU's capacity scaled down by factor based on its broad technology class. For example, a nuclear plant's de-rated capacity is 81.39% of its connection capacity per the 2014 Auction Guidelines. The de-rating factors this year range between 81.39% (nuclear) and 97.38% (storage).

28 DECC (23 June 2014), "Capacity Market Impact Assessment", pages 49-50.

29 DECC (1 August 2014), "Capacity Market Launch – Frequently Asked Questions," page 1.

30 "Capacity Market Rules", page 15.

31 DECC (2013), "The Electricity Capacity (Payment) Regulations," Reg. 19.

32 DECC (23 June 2014), "Electricity Market Reform: Consultation on proposals for implementation—Government Response," page 107.

In a competitive market, suppliers will pass through the costs they incur to customers in the long run. In the short run, suppliers' prices will reflect changes to the marginal costs of serving customers. DECC's analysis confirms this: "distributional analysis shows that this cost is largely borne by consumers through electricity bills".[33] Since the annual cost of the capacity market to each supplier will depend on their customers' consumption in that winter, it is likely that suppliers will pass the costs of the capacity market through to their customers within a short timeframe.

2.6. The Rules Discourage DSR from Competing in the T-4 Auction

The British capacity market is an attempt to replace the "missing money" problem and ensure that consumers receive the efficient level of security of supply. The capacity market design, like other designs across the world, allows DSR to compete with existing generators to ensure that the security of supply standard is reached at the lowest cost.

However, the capacity market design discourages DSR from competing with existing generators in the primary, T-4 auction. DSR can only access one-year contracts whereas new entrants may sign fifteen-year contracts, so DSR could offer added flexibility to the market if it displaced longer-term capacity providers in the T-4 auction. Alternatively, if DSR were able to offer lower prices in exchange for signing longer term contracts, it would be able to exert further downward pressure on the cost of the capacity market to customers. Ultimately electricity customers will pay the costs of the capacity market and it is therefore in customers' interests that the costs of the capacity market are kept to a minimum.

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[33] DECC (23 June 2014), "Electricity Capacity Reform—Capacity Market, Impact Assessment," page 2.

3. DSR in the T-4 Auction: Theory and Empirics

This chapter summarises the scenarios we examined for this report, both theoretically and empirically. All scenarios essentially model the same rule change that currently disincentivise from participating in the T-4 auction are relaxed. In the text below we assume that all DSR chooses to enter the T-4 instead of the T-1, for expositional clarity. However the direction of the effects would be the same albeit with smaller magnitude if less DSR were to switch to the T-4 auction. Our scenarios cover a range of plausible policy alternatives for the procurement and administration of the auctions after the rule change. In all scenarios, we assume that DSR is cheaper than the marginal unit of generation capacity (i.e. that it is “inframarginal”). The alternative, in which DSR is not awarded a contract in the T-4 auction, has no net effect on costs.

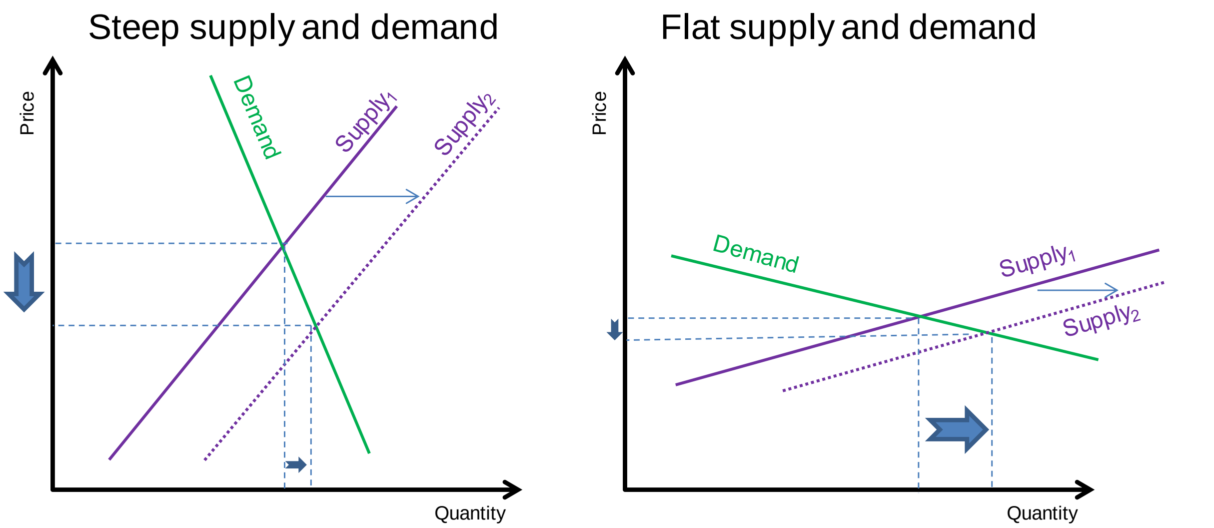
This chapter proceeds as follows:

- Section 3.1 describes each scenario from a conceptual point of view. In particular, it describes the conditions which determine the size of the bill impact of the various policy alternatives. A more exhaustive treatment of this section can be found in Appendix A; and
- Section 3.2 summarises the results of our empirical analysis of each scenario. In particular, it discusses the results’ sensitivity to different levels of DSR participation and bidding behaviour. A more exhaustive treatment of this section can be found in Appendix B

3.1. Conceptual Treatment of Our Scenarios

This section discusses the theoretical implications of plausible policy changes to the capacity market rules on consumer bills. The scenarios examine the impact of changes in the rules for participation of DSR that remove the disincentive on DSR participating in the T-4 auction under different procurement policies by National Grid and for a range of DSR participation levels .

Figure 3.1
The Impact of Shifting Demand and Supply Between Auctions Will Depend on The Underlying Steepness of Supply and Demand Curves



When supply (S) grows (shifts right), prices fall and quantities rise. When demand (D) grows, prices rise and quantities rise. The amount that prices and quantities change when supply or demand shift depends not only on how large the shift is, but also on how steep the lines are (see Figure 3.1). If both supply and demand are steep (or inelastic), the price change will be large and the quantity change will be relatively small. If supply and demand are both shallow (or elastic), a shift in either line will translate into a large change in quantity but a small change in price.

In Scenario 1, we discuss the case in which DECC changes the eligibility rule to encourage DSR to participate in the T-4 auction, while maintaining the same target procurement level and intent to procure the remaining capacity in the T-1 auction.

In Scenario 2, we discuss the case in which DECC changes the eligibility rule to encourage DSR to participate in the T-4 auction, but changes its target procurement level to obtain all 53.3GW of expected capacity needs in the T-4 auction. The T-1 auction remains to “true up” any unexpected capacity needs, but in this case we assume there are no remaining capacity needs and the auction is cancelled.

In Scenario 3, we return to the policy change examined in Scenario 1 but assume that DECC’s procurement target in the T-1 auction falls below 2.5GW because the outturn level of demand is lower than anticipated four years in advance. Slow demand growth means the volume of capacity that must be procured at the T-1 stage is lower than anticipated four years ahead.

3.1.1. Scenario 1: Procurement targets remain the same

If DECC adopts the rule change, DSR leaves the T-1 auction in order to participate in the T-4 auction. As DSR is inframarginal, its addition to the T-4 auction forces out more costly generation capacity, which drives down the clearing price of that auction. The decreased volume of DSR available in the T-1 auction means that capacity in that auction is significantly more expensive.

These price changes are larger if more capacity switches auctions, as well as if the supply and demand curves are steep. However, because the price decrease in the T-4 auction applies to 20 times as much capacity (50.8GW) as the price increase in the T-1 auction (2.5GW), the total cost to consumers falls as long as the price increase in the T-1 auction is not more than 20 times larger than the price decrease in the T-4 auction.

If DSR volume is higher than 2.5GW, the price in the T-4 auction falls further and the price in the T-1 auction rises less, resulting in greater savings from the rule change.

3.1.2. Scenario 2: DECC increases its procurement target

The volume of capacity National Grid intends to procure in the T-1 auction under the current rules is equal to its forecast volume of DSR. If in practice that DSR will not available at T-1 then part of the purpose of the T-1 disappears, which may cause DECC to opt instead to procure all the required capacity four years in advance. In this scenario, DECC shifts its target capacity in the T-4 auction upward by 2.5GW in conjunction with changing the rules to encourage DSR participation in that auction.

In this scenario, the direction of the impact on customers depends crucially on the amount of DSR that turns up.

If the volume of DSR is equal to National Grid’s forecast of 2.5 GW, increasing demand by 2.5 GW in the T-4 auction exactly offsets the effect of adding DSR competition. As a result, the price in the T-4 auction remains the same. This rule change is more expensive for consumers than the status quo.

Under our assumption that DSR is inframarginal (i.e. cheaper than the marginal source of generation capacity) and consumers paid a lower price for DSR in the T-1 auction under the Status Quo. After the rule change, consumers must pay the higher price that previously prevailed in the T-4 auction for DSR capacity as well.

However, if DSR volume is higher than 2.5GW, DSR participation in the T-4 auction drives down that auction’s price, likely resulting in a cheaper outcome under the rule change.

3.1.3. Scenario 3: Low T-1 demand

In this scenario, we assume that DECC intends at the time of the T-4 auction to procure capacity through both a T-4 and T-1 auction, with the capacity targets at each auction the same as in the status quo. However, in practice, slow demand growth means that DECC does not procure the full 2.5 GW in the T-1 auction because that level of capacity was not necessary to achieve security of supply.

When DSR is allowed to participate in the T-4 auction under these assumptions, the clearing price of that auction falls. The limited demand in the T-1 auction means that the clearing price of that auction doesn’t rise very much. Furthermore, the price increase in the T-1 applies to an even smaller volume of DSR than the 2.5 GW described in scenario 1.

Accordingly, and for the same reasons as described in scenario 1, the rule change in this scenario is very likely to be cheaper than the status quo.

This scenario can be expanded to include the case in which DSR volumes are higher than predicted by National Grid. This would further lower the clearing price of the T-4 auction and would further limit the price increase in the T-1 auction. This is even more likely to be cheaper than the status quo.

3.1.4. Summary

The results of these scenarios are summarised in Table 3.1, with the high DSR sub-scenarios included.

Table 3.1
Including DSR in the T-4 Auction - Effects across Scenarios

Scenario	1	1a	2	2a	3	3a
Description	No demand shift, 2.5GW DSR	No demand shift, High DSR	2.5GW demand shift, 2.5GW DSR	2.5GW demand shift, High DSR	Muted T-1 demand, 2.5GW DSR	Muted T-1 demand, High DSR
Net Savings	Likely Positive	Very Likely Positive	Negative	Likely Positive	Very Likely Positive	Very Likely Positive

3.2. Empirics

3.2.1. Market Modelling

Using our standard modelling framework, we examined the possible effects of the three scenarios we defined above. We used data on the forecast supply and demand of capacity, taken from market sources and supplemented this with our own judgement where necessary. Detailed assumptions that we used are presented in Appendix C.

The demand curve for capacity in the T-4 auction is already known, and not subject to uncertainty. However, both the *quantity* of supply that will be available, and the *slope* of the demand curve is not known. We therefore examine the effects in each scenario under a range of assumptions.

- **Quantity**: The development of DSR is difficult to predict, as the market and precise products that will be offered are new. National Grid admits as much in its own forecast of DSR penetration [Section 2.2.2]. Therefore we model a range of quantities of DSR entering the T-4 auction, from National Grid's own estimate of 2.5GW to 5.5GW (a quantity comparable to that seen in mature markets such as PJM).

- **Slope**: The slope of the demand curve will be affected by how generators try to recover their costs in the capacity market. In particular, existing generators that face the prospect of ongoing losses before the first capacity delivery year in 2018/19 may submit bids that attempt to recover these losses. The shorter the timescale over which generators recover these losses, the steeper the supply curve for capacity will be. (See Appendix C.2 for a full description of different modes of bidding behaviour).
  - A plausible model of bidding behaviour which would lead to a relatively flat supply curve is one in which generators do not attempt to recover losses from pre-2018. We term this “no amortization of losses”.
  - A plausible model of bidding behaviour that would lead to a relatively steep supply curve is one in which generators attempt to recover their losses from pre-2018 over five years of capacity payments. We term this “amortization of losses over 5 years”.

3.2.2. “What if” Scenario Results

In each Scenario 1 – 3, we measured the cost of the capacity market under the “Status Quo”. We then compared this with the cost of the capacity market when DSR enters the T-4 auction, using the range of assumptions on quantity (2.5-5.5GW of DSR) and supply (flatter and steeper supply curves). Table 3.2 presents a summary of the results of this analysis: across the scenarios we examined, the possible saving could be as great as £359 million.

Table 3.2
"What if" DSR Enters the T-4 Auction – Summary

Scenario	Range of Savings *(£ million, 2012)*
"What if" DSR displaces capacity at the T-4 auction?	58 - 309
"What if" all capacity is procured at T-4?	(60) - 159
"What if" demanf at T-1 is lower than expected?	61 - 359

Table 3.3 breaks down these results in more detail. If the supply curve of capacity reflects amortized losses, and DSR is able to displace capacity from the T-4 auction to the T-1 auction (as assumed in Scenario 1), then the range of savings is between £141-309 million. If DSR is able to displace capacity, but all requirements are met four years ahead (as in Scenario 2), then the saving is in the range £-60-159 million. Finally, if DSR is allowed to enter the T-4 auction and a subsequent shock to demand removes the need for a one year ahead auction (as in Scenario 3), the saving could be in the range £208-309 million. With a bidding curve that does not reflect past losses, the net savings that we estimate are lower (and conversely for a “steeper” supply curve, the net savings would be greater).

Table 3.3
"What if" DSR Enters the T-4 Auction - Range of Results

	DSR Participation T-4 (GW)	Scenario (1) (£ million)	Net Saving Scenario (2) (£ million)	Scenario (3) (£ million)
No Amortization of Losses				
Status Quo	0.0	0	0	0
2.5GW DSR	2.5	58	-3	61
3.5GW DSR	3.5	59	8	61
4.5GW DSR	4.5	61	61	61
5.5GW DSR	5.5	61	61	61
Losses Amortized Over 5 Years				
Status Quo	0.0	0	0	0
2.5GW DSR	2.5	141	-60	208
3.5GW DSR	3.5	152	18	209
4.5GW DSR	4.5	159	158	209
5.5GW DSR	5.5	309	159	359

Full details of each of these scenarios, as well as the cost of the T-4 and T-1 auction in each, can be found in Appendix B.

4. Conclusion

DECC's aims for the Capacity Market include ensuring that British consumers receive a secure supply of electricity at the lowest cost. However, with respect to its treatment of DSR, the market rules may result in consumers facing a higher cost than is necessary. In particular, the rules governing the Transitional Arrangements (TAs) for 2015-17 disincentivise DSR from providing security of supply four years in advance and the limited contract lengths available may also disincentivise DSR from providing capacity at all (see Chapter 2, above).

In some plausible scenarios, the rules surrounding the participation of DSR in the capacity auction may impose additional costs on consumers. In particular, when DSR is a cheaper source of capacity than at least some existing and new generation in the T-4 auction (it is "inframarginal"), allowing it to participate in the T-4 auction may reduce costs for consumers. In addition, a net saving is likely to accrue to consumers if DSR's ability to participate in the T-4 auction creates strong enough incentives for providers to make more capacity available than is currently forecast. Similarly, if the need for capacity in 2018/19 is lower than currently forecast, such that there is no need for a year-ahead auction, consumers may lose out by not procuring less expensive DSR four years ahead.

We have not been instructed to review the costs of DSR or the likely volume of the capacity market and as such our analysis is a scenario-driven approach. Our analysis examines the market outcomes, given assumptions about the evolution of the market. Using these assumptions, we quantified the size of these effects in some plausible "what if" scenarios for the procurement policies that DECC and/or National Grid might apply given a change in the rules:

1. "What if" DSR can participate in the T-4 auction, and displaces more expensive capacity to the T-1 auction?
2. "What if" DSR can participate in the T-4 auction, but all capacity is procured in the T-4 auction?
3. "What if" DSR can participate in the T-4 auction, and lower than forecast demand removes the need for a T-1 auction?

For each scenario we also tested a range of levels of DSR participation, up to the proportion of total demand seen in the PJM. We found a range of bill impacts across different scenarios up to £359 million in a single year.

National Grid has admitted it does not know what volume of DSR is likely to participate in the Capacity Market. Our scenarios demonstrate that the market rules could lead to significant increases in the cost of the Capacity Market, depending on the evolution of the DSR in Great Britain.

Appendix A. Conceptual Scenarios

This appendix expands upon Section 3.1.

As described in the main body of this report, the capacity market rules discourage DSR from competing in the T-4 auction and prevent DSR from offering lower prices and/or additional volumes for long term contracts. Generally, additional competition to provide capacity will reduce costs to customers. However, there are some circumstances in which this may not hold, for instance if additional competitors are "out of merit", where additional competition increases costs elsewhere or is accompanied by an increase in demand.

This appendix describes the circumstances in which revising the rules to encourage DSR to compete in the T-4 auction would decrease costs to customers. Accordingly, we only consider cases where DSR is a cheaper technology than generation (it is "inframarginal"). We also assume throughout that exclusion from the Transitional Arrangements is a sufficient disincentive to prevent any DSR participating in the T-4 auction under the current rules. This assumption is for expositional clarity and relaxing this assumption would reduce but not eliminate the effects shown. One key variable that will significantly affect the results of any rule change is how National Grid adjusts the target volume procured in the T-1 auction based on the volume of DSR procured in the T-1 auction. Our scenarios examine the implications of different policies by National Grid.

This appendix proceeds as follows:

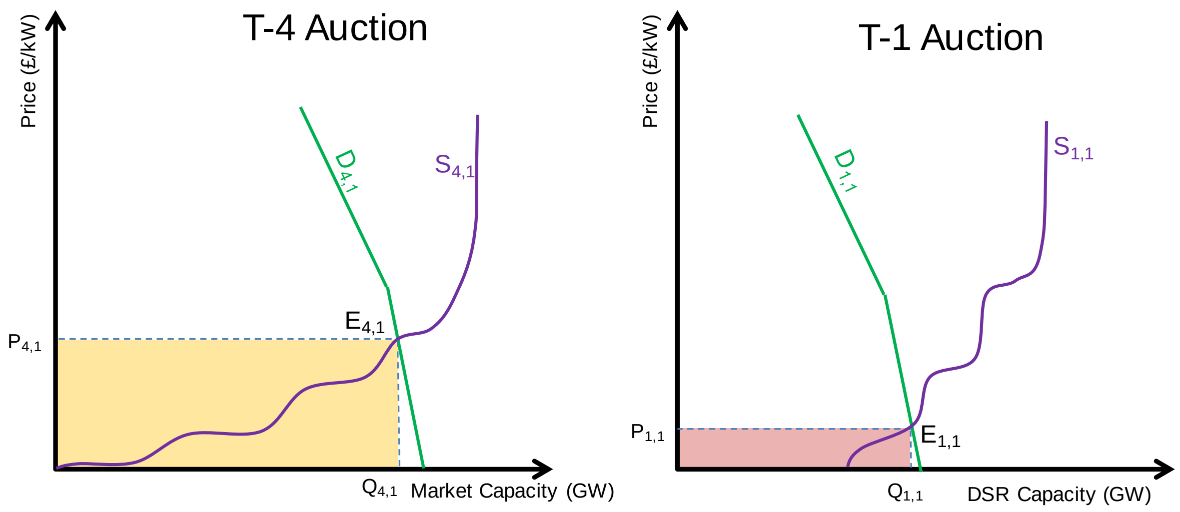
- Section A.1 describes the market under the current rules and sets out the price and quantity outcomes in the capacity market for comparison (the "status quo");
- Section A.2 examines the implications of changing the DSR eligibility rule, assuming that National Grid continues to hold a T-1 auction for 2.5GW; and
- Section A.3 examines the implications of changing the DSR eligibility rule and reducing the volume procured through the T-1 auction to zero;
- Section A.4 examines the implications of changing the DSR eligibility rule, assuming that National Grid continues to hold a T-1 auction, but whose target capacity is unexpectedly low;
- Section A.5 concludes.

The scenarios and sub-scenarios we examine are not intended to be a complete taxonomy of all the possible outcomes that could happen in the market for DSR or its regulation. Instead, they comprise a list of relevant cases in which the cost of the capacity market might fall if DECC were to change the DSR eligibility and contract length rules. Our scenarios demonstrate that, in most cases, allowing DSR to participate in the T-4 auction lowers the total cost of the capacity market, which translates to lower energy bills for consumers.

A.1. Supply and Demand Set Prices in the Capacity Market

Figure A.1 illustrates our status quo scenario in which DSR does not participate in T-4 auction and DECC splits its procurement targets to obtain 50.8GW of capacity in the T-4 auction and 2.5GW of capacity in the T-1 auction. The left hand panel of the diagram is a representative, schematic supply and demand diagram for the auction at T-4. The right hand panel represents the auction at T-1.

Figure A.1
The Status Quo



Source: NERA Analysis.

In this status quo, the supply and demand curves in the T-4 auction are given by $S_{4,1}$ and D $_{4,1}$, while the supply and demand curves in the T-1 auction are given by $S_{1,1}$ and $D_{1,1}$. The equilibrium outcomes € consist of prices (P) and quantities (Q) and are defined by the intersection of supply and demand in each auction. The cost of each auction to consumers is determined by multiplying the equilibrium price by the equilibrium quantity (e.g. the cost of T-4 auction to consumers is $P_{4,1} \times Q_{4,1}$). This total is represented in by the shaded area on each diagram.

Every component of every diagram in this chapter is indexed by two subscript numbers:

- The first identifies the auction it relates to, taking a value of "4" for the T-4 auction and "1" for the T-1 auction. For example, an equilibrium price in the T-4 auction is written as $P_{4,x}$; and
- The second describes whether that component relates to the status quo rules or to an adjustment to those rules. For example, the equilibrium price in the T-1 auction is given by $P_{1,1}$ under the status quo rules and by $P_{1,2}$ if DECC changes the participation rules.

Furthermore, all subsequent diagrams leave dashed lines in place of the status quo supply and demand diagrams.

A.2. Scenario 1: DSR Displaces Capacity at the T-4 Auction

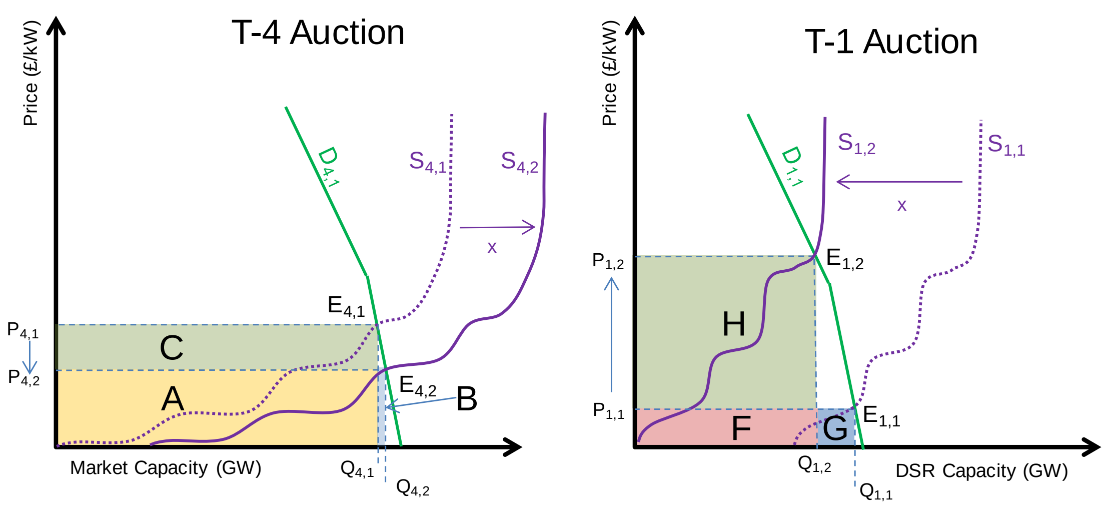
In Scenario 1, we assume that DECC changes the eligibility rule to encourage DSR to participate in the T-4 auction, while maintaining the same target procurement level and intent to procure the remaining capacity in the T-1 auction. The impact of DSR on the capacity market depends on the net supply of DSR in the T-4 and T-1 auctions. We examine two possibilities, in each case comparing the impact of the rule change:

- **Scenario 1.1**: National Grid is correct about the volume of DSR that is likely to materialise and the likely need for additional capacity in the T-1 auction;
- **Scenario 1.2**: National Grid has underestimated the volume of capacity that is likely to come forward in the DSR market but correctly forecast the likely need for additional capacity in the T-1 auction. This scenario could also be used to describe circumstances where allowing DSR to obtain a longer term contract increases the quantity that might come forward.

A.2.1. Scenario 1.1: National Grid Forecast of DSR

Figure A.2 shows the outcome of the T-4 and T-1 auctions before and after a rule change to encourage DSR to participate in the T-4 auction.

Figure A.2
Scenario (1.1): DSR Substitutes from the T-4 to the T-1 Auction



Note: Dotted lines refer to the status quo. Solid lines apply to the policy alternative.

Source: NERA Analysis.

Cost under Status Quo

The demand curves in the T-4 and the T-1 auctions are shown as $D_{4,1}$ and $D_{1,1}$ respectively. The status quo supply curves are represented in dashed purple lines $S_{4,1}$ and $S_{1,1}$. The status quo equilibria are given by $E_{4,1}$ and $E_{1,1}$, at the points where supply and demand intersect, which are the same as those shown in the Status Quo scenario in Figure A.1. The cost of the T-4 auction is the price, $P_{4,1}$ multiplied by the volume, $Q_{4,1}$, i.e. the area A+C. The cost of T-1 auction is the price, $P_{1,1}$, multiplied by the volume, $Q_{1,1}$, i.e. the area F+G.

TOTAL COST: A+C+F+G.

Cost under Change in Rules

Allowing DSR to participate in the T-4 auction will result in some amount *x* of DSR switching from the T-1 auction under the status quo to the T-4 auction under the rule change. This shifts the supply curve to the right by *x* (to $S_{4,2}$) and lowers the equilibrium price in the T-4 auction and has an offsetting and opposite effect in the T-1 auction (to $S_{1,2}$). The new market equilibria are $E_{4,2}$ in the T-4 auction and $E_{1,2}$ in the T-1 auction. The price in the T-4 auction falls to $P_{4,2}$ and the volume rises to $Q_{4,2}$. The price in the T-1 auction rises to $P_{1,2}$ and the volume falls to $Q_{1,2}$. The new total cost is given by price multiplied by quantity in each auction.

TOTAL COST: A+B+F+H.

Change in Total Cost

The change in cost is given by subtracting the cost under the status quo from the cost after the rule change:

Change in cost	=	Cost after change in rules – Cost of status quo
	=	(A+B+F+H) - (A +C + F + G)
	=	H-C+B-G

The change in cost consists of two effects:

- *Quantity effect* from the increase in volume procured in the T-4 auction and the reduction in volume procured in the T-1 auction (B-G in the above expression); and
- *Price effect* from the fall in the price in the T-4 auction and the increase in the price in the T-1 auction (H-C in the above expression).

Without conducting any empirical analysis, we can make a brief, initial assessment of the size of these effects.

The *quantity effect* (B-G) is likely to be negligible because the demand curves in both auctions are steep and the volume of DSR shifting between the T-1 and T-4 auctions is likely to be small relative to the size of the market as a whole.

In practice, therefore, the total bill impact of allowing DSR to participate in the T-4 auction will depend mainly on the *price effect* and in particular (H-C). The relative sizes of H and C depend on:

- Their widths, or the amount of capacity that is subject to the changing prices. Under the announced auction parameters, the target capacity in the T-4 auction is about 20 times larger than in the T-1 auction (50.8GW ÷ ~2.5GW), so C will be 20 times wider than H;
- Their heights, or the amount that the price changes in each auction. DECC has already announced the parameters for the capacity market, including the demand curve. The demand curves for both auctions are likely to be steep. For instance, the announced demand curve for the T-4 auction covers a range of quantities of just 3GW and a range of prices from £75/kW to £0/kW. The supply curve is also likely to be steep in the capacity auction.[34] Accordingly, in both the T-1 and the T-4 auctions, the price changes from the

[34] In any capacity auction, a significant chunk of existing capacity is likely to be covering its fixed costs and is therefore available to the capacity market at no cost. DECC estimates that new entrants will require a price of around £49/kW.

movement of supply from one auction to the other may be significant due to the relatively steep supply and demand.

A priori it is not possible to determine whether the price in the T-1 auction will increase by more as a result of the substitution of DSR to the T-4 auction than the price in the T-4 auction will fall. However, unless the price increase in the T-1 auction is 20 times greater than the price decrease in the T-4 auction, there is a net savings from including DSR in the T-4 auction. In other words, the total cost will fall as long as the price in the T-4 auction falls by at least £1/kW for every £20/kW increase in the T-1.

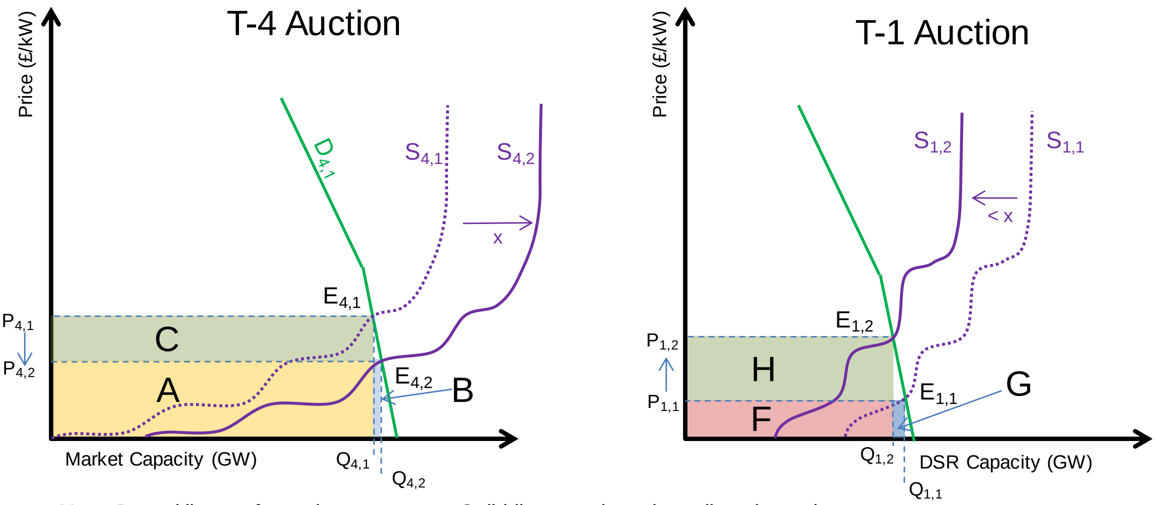
A.2.2. Scenario 1.2: High DSR

Figure A.3 shows the impact of the change in the eligibility rule combined with changes in the quantity of DSR in the T-1 auction. Specifically, we now assume that the rightward supply shift in the T-4 auction is not fully offset by a leftward supply shift in the T-1 auction. This could occur because:

- Lower competition (and higher prices) in the T-1 auction attracts additional DSR units to enter the auction; or
- Relaxing the contract length rule means more DSR is available at low prices; or
- In principle, the extra capacity could consist of low-cost existing plants becoming available in time for the T-1 auction.

In Figure A.3, we demonstrate this with a rightward supply shift of *x* in the T-4 auction and a leftward supply shift of less than x in the T-1 auction.

Figure A.3
Scenario (1.2): More DSR than Forecast Substitutes into the T-4 Auction



Note: Dotted lines refer to the status quo. Solid lines apply to the policy alternative.

<u>Cost under Status Quo</u>

The cost under the status quo remains the same as in Scenario 1.1 and is given by A+C+F+G.

TOTAL COST: A+C+F+G

Cost under Change in Rules

Similar to Scenario 1.1, the cost under the rule change is given by A+B+F+H, but these boxes are not necessarily the same size as they were in Scenario 1.1.

TOTAL COST: A+B+F+H

Change in Cost

The change in cost from the rule change is equal to the cost after the rule change minus the cost under the status quo:

(A+B+F+H) – (A+C+F+G) = (H – C) + (B – G)

Like in Scenario 1.1, the *quantity effect* (B – G) is likely to be negligible, so the change in cost primarily depends on the *price effect* (H – C). Due to the scale of capacity volumes in each auction, the total cost will again fall as long as the T-4 clearing price falls by at least £1/kW for every £20/kW increase in the T-1 clearing price.

Because of the influx of DSR supply, the T-1 clearing price will rise by less than it does in Scenario 1.1, while the T-4 clearing price falls by the same amount. Thus, if the rule change in Scenario 1.1 results in a net savings, the rule change in Scenario 1.2 results in a greater net savings.

A.3. Scenario 2: National Grid Procures All Capacity Four Years Ahead

National Grid anticipates that the primary capacity that will be available in the T-1 auction will be DSR. In practice, if large volumes of DSR were available in the T-4 auction, National Grid may instead opt to procure all of its capacity in the T-4 auction. The remaining role of the T-1 auction would only be to "true-up" capacity between the outturn and forecast level of demand and the expected level of capacity procurement would be zero.

Scenario 2 assumes that National Grid includes DSR in the T-4 auction and no longer withholds capacity for the T-1 auction. In this scenario, we assume that the Secretary of State cancels the T-1 auction, which is an option under limited circumstances.[35] We consider two cases:

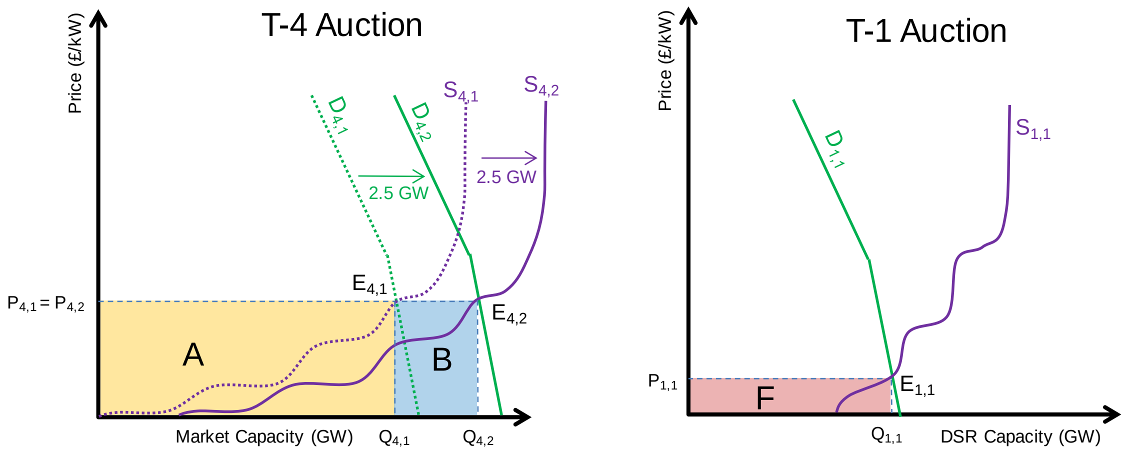
- **Scenario 2.1**: National Grid is correct about the volume of DSR that is likely to materialise and the total capacity requirement; and
- **Scenario 2.2**: National Grid has underestimated the volume of capacity that is likely to come forward in the DSR market but correctly identified the total capacity requirement.

[35] DECC (31 July 2014), "Electricity Capacity Regulations", Regulation 10(3)

A.3.1. Scenario 2.1: National Grid correctly estimates DSR availability in the T-1 auction

National Grid believes that 2.5GW of DSR capacity will be available in the 2017 T-1 auction. In Scenario 2.1, represented by Figure A.4, we assume that its estimate of 2.5GW of DSR is accurate and that 2.5GW would be available in the T-4 auction if DSR were allowed to participate.

Figure A.4
Scenario (2.1): Demand and Supply Shift Out Equally at T-4



Note: Dotted lines refer to the status quo. Solid lines apply to the policy alternative.

Cost under Status Quo

The equilibrium price and quantity under the status quo is determined by the intersection of $S_{4,1}$ and $D_{4,1}$ in the T-4 auction and by the intersection of $S_{1,1}$ and $D_{1,1}$ in the T-1 auction. The T-4 auction costs $P_{4,1}$ times $Q_{4,1}$ (box A) and the T-1 auction costs $P_{1,1}$ times $Q_{1,1}$ (box C).

TOTAL COST: A+F

Cost under Change in Rules

Under this rule change, DECC decides to include DSR in the T-4 auction. Since we assume that DECC is correct about DSR volumes, the supply curve shifts rightward by 2.5GW to $S_{4,2}$. DECC also increases its target procurement level by 2.5GW, which is shown by a rightward shift in demand by 2.5GW to D $_{4,2}$. Since both supply and demand shift equally, the equilibrium price ($P_{4,2}$) remains unchanged. The price of the T-4 auction is now A+B. DECC no longer has any capacity needs in the T-1 auction, so that the expected cost of the T-1 auction is zero.

TOTAL COST: A+B

Change in Cost

The change in cost from the rule change is cost after the change in rules minus the cost under the status quo:

(A+B) – (A+C) = B – F

The auctions under the rule change are unambiguously more expensive than under the status quo because:

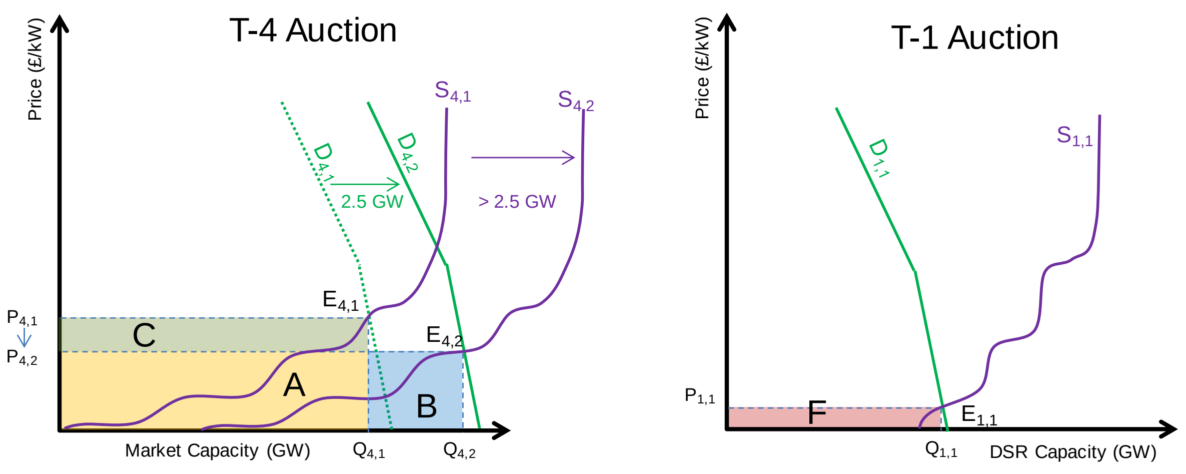
- B and F have exactly the same width (2.5GW); and
- B is taller than F because we assume that DSR is inframarginal. In other words, the T-4 auction clears at a higher price than the T-1 auction.

Changing the eligibility rule costs more than the status quo if National Grid procures all capacity through a single auction. Under our assumption that DSR is inframarginal, DSR units earn more than they would in the status quo in which they drive down the price of the T-1 auction. However, if allowing DSR to enter the T-4 auction is accompanied by combining the T-1 and T-4 auction, DSR's participation in the T-4 auction will not drive down the auction clearing price.

A.3.2. Scenario 2.2: National Grid underestimates available DSR

In Scenario 2.2, we now assume that National Grid's estimate of 2.5GW of DSR is inaccurate. More than 2.5GW of DSR may be available for the T-1 auction and/or more than 2.5GW would be available for T-4 auction if DSR were eligible to participate in the T-4 auction. Figure A.5 demonstrates the bill impact of that scenario.

Figure A.5
Scenario (2.2): Supply Increases More than Demand at T-4



Note: Dotted lines refer to the status quo. Solid lines apply to the policy alternative.

Cost under Status Quo

The cost of the T-4 auction under the status quo is the same as in most of the previous scenarios: A+C. The high volume of DSR in the T-1 auction means that that auction is relatively cheap and costs F.

TOTAL COST: A+C+F

Cost under Change in Rules

Like in Scenario 2.1, the rule change shifts T-4 demand rightward by 2.5GW. Unlike in Scenario 2.1, T-4 supply shifts rightward by *more than* 2.5GW. This puts downward pressure on prices as it pushes marginally expensive capacity out of the market. Thus, the cost of the T-4 auction is A+B. The T-1 auction costs nothing because no capacity is procured.

TOTAL COST: A+B

Change in Cost

The change in total cost associated with the rule change is the cost after the rule change minus the cost under the status quo:

(A+B) – (A+C+F) = B – C – F

The sign of this change is ambiguous, but is more likely to be negative (signifying a net savings) if:

- The amount of DSR present exceeds the predicted amount by a significant amount;
- The T-4 supply and demand curves are relatively steep; and
- The T-4 auction is designed to procure the vast majority of that year's capacity. In other words, C would be much wider than B. In the context of this scenario, C has a base of about 50GW, while B and F are approximately 2.5GW wide.

Since the downward price pressure applies to such a large volume of capacity, that effect likely outweighs the effect of paying DSR units more than their marginal cost.

A.4. Scenario 3: Demand at T-1 is lower than expected

In Scenario 3, we consider the case in which DECC has not correctly anticipated its capacity needs in the T-1 auction. In particular, we now assume that DECC unexpectedly requires less than 2.5GW because:[36]

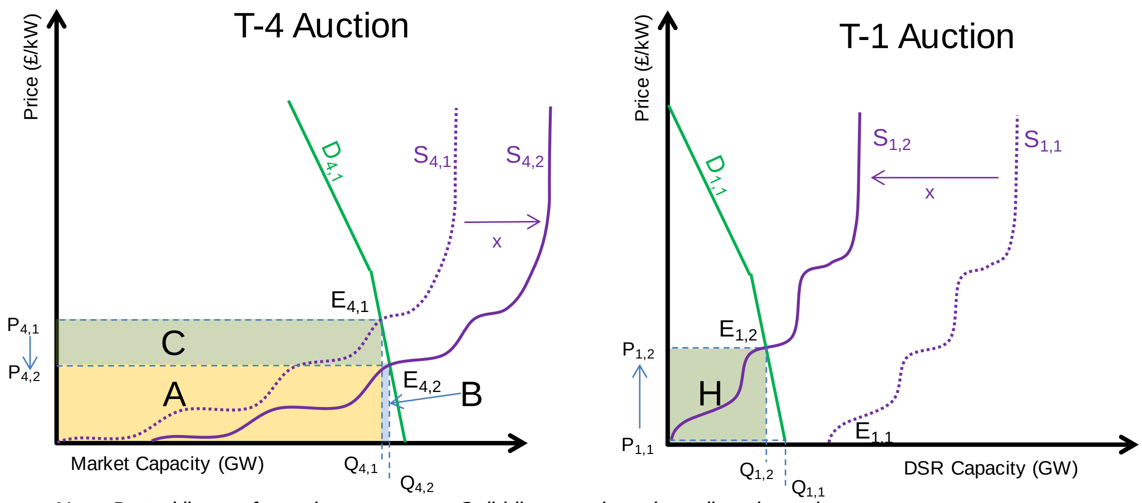
- Low-carbon plants (which are excluded from the capacity market but still provide capacity) develop more quickly than expected; or
- British electricity demand grows more slowly than expected.

Scenario 3 further reverts to the rule change established in Scenario 1 (DECC includes DSR in the T-4 auction but does not adjust its capacity target) and to the assumption that the supply shift in the T-4 auction is perfectly offset by a supply shift in the T-1 auction. Figure

[36] This can become apparent immediately after the T-4 auction. If it became apparent before, DECC would likely lower its procurement target for the T-4 auction so that they still target 2.5GW of DSR in the T-1 auction.

A.6 demonstrates this with a T-1 demand curve ($D_{1,1}$), that is significantly lower than in Scenario 1.[37]

Figure A.6
Scenario 3: An Unexpected Fall in Demand at T-1



Note: Dotted lines refer to the status quo. Solid lines apply to the policy alternative.

Cost under Status Quo

The cost of this scenario under the status quo rules is given by A+C+F+G. This representation shows the case in which DECC can satisfy its minimal DSR requirements at essentially no cost, so boxes F and G have disappeared, and the price and cost of the T-1 auction is zero.

TOTAL COST: A+C

Cost under Change in Rules

The change in the eligibility rule encourages DSR to enter the T-4 auction, shifting the supply curve in the T-1 auction to the left and the supply curve in the T-4 auction to the right. Prices in the T-4 auction fall from $P_{4,1}$ to $P_{4,2}$, and the quantity rises slightly from $Q_{4,1}$ to $Q_{4,2}$. The cost of the T-4 auction changes to A+B. After the supply curve in the T-1 auction shifts left by "x" GW, the price in the T-1 auction rises from zero to $P_{1,2}$ and the cost of that auction changes to H.

TOTAL COST: A+B+H

37 For the purposes of this chapter, we view the "status quo" as referring to the policies which affect DSR participation. An unexpected shift in demand is not a change from the status quo, so is not labelled as such.

Change in Cost from Rule Change

The change in combined auction cost from the rule change is given by the cost after the rule change minus the cost under the status quo:

(A+B+H) – (A+C) = B + (H – C)

The change in combined auction cost from the rule change is given by a negligible *quantity effect* (B) and a *price effect* (H – C). The change in cost is determined by the *price effect*. C is more likely to be larger than H, signifying a net savings, if:

- Demand and supply are relatively steep, which creates a larger *price effect* in the T-4 auction
- Demand is substantially reduced in the T-1 auction, which narrows box H.

If T-1 demand falls by just 0.5GW to 2.0GW, a £1/KW decrease in T-4 clearing price can be met with an increase of up to £25/KW in the T-1 clearing price and still yield a net savings. If T-1 demand falls to 1.0GW, a £1/KW decrease in the T-4 clearing price will have to be met with a £50/KW increase in the T-1 clearing price to not result in a net savings.[38]

This scenario assumes that the supply shifts in the T-4 auction and T-1 auction are offsetting, but there is no reason why that must be the case. Following the same logic as in Scenario 1.2, an influx of DSR in the T-1 auction would unambiguously result in a higher net savings from allowing DSR to participate in the T-4 auction without eliminating the T-1 auction.

A.5. Conclusion

In summary, we have described the bill impact of inclusionary rule changes in several scenarios. The results are summarised below.

[38] This ignores the *quantity effect*.

Table A.1
Including DSR in the T-4 Auction - Effects across Scenarios

Scenario	1.1	1.2	2.1	2.2	3	3a (not diagrammed)
Description	No demand shift, offsetting supply shifts	No demand shift, non-offsetting supply shifts	Supply shift offset by demand shift, no T-1 auction	Supply shift partially offset by demand shift, no T-1 auction	Muted T-1 demand, offsetting supply shifts	Muted T-1 demand, non-offsetting supply shifts
Net Savings	Likely Positive	Very Likely Positive	Negative	Likely Positive	Very Likely Positive	Very Likely Positive

In all but one of the analysed scenarios, allowing DSR to participate in the T-4 auction is likely to decrease the bill impact of the capacity market because of the downward price provided by inframarginal DSR. As described in Chapter 2, DSR units may participate in the upcoming auction if they so choose, but the rules strongly disincentivise it. Our analysis suggests that these rules are likely to increase the consumer burden of the capacity market.

Appendix B. "What If" Scenarios

This appendix expands on section 3.2.

In the preceding appendix, we have outlined the conditions in which removing the disincentives for DSR to participate in the T-4 capacity auction can lead to a net saving. In this chapter we estimate the size of these savings, given a hypothetical set of assumptions on the quantity of DSR available and its price, which EnerNOC believes is within a reasonable range for investigation.

This appendix proceeds as follows:

- Section B.1 set out the high-level scenarios and assumptions we used in our analysis;
- Section B.2 quantifies the effect on our estimate of the cost of the capacity market of the scenarios in which DSR enters the T-4 auction but demand remains unchanged (referred to as Scenario 1 above);
- Section B.3 quantifies the effect on our estimate of the cost of the capacity market of the scenarios in which DSR enters the T-4 auction and demand correspondingly increases (referred to as Scenario 2 above); and
- Section B.4 quantifies the effect on our estimate of the cost of the capacity market of the scenarios in which DSR enters the T-4 auction and actual demand is lower than forecast (referred to as Scenario 3 above).

Throughout our analysis we assume that DSR has the ability to effect the price of capacity (i.e. it is "inframarginal"), as we are only interested in examining scenarios in which DSR affects the cost borne by consumers. We find that when inframarginal sources of DSR provide capacity at the T-4 auction, a lower auction clearing price leads to large savings for consumers. By testing a range of participation levels of DSR, from 2.5GW (the level which National Grid forecasts) to 5.5GW (the level of DSR participation in a mature market like PJM), we find that greater participation by DSR has the potential to increase the magnitude of these savings. Across the whole range of scenarios we examine, the savings could be as much as £359 million in a single year.[39]

B.1. Scenarios and Assumptions

EnerNOC asked us to examine the effect of a range of possible scenarios on the cost of the capacity market. We used our standard modelling framework (as described in Appendix C.1) to test the impact of each of these scenarios on the cost of the capacity market.

B.1.1. Scenario 1: "What if" DSR displaces capacity in the T-4 auction?

First, we consider the effect of the current policy, in which DSR is effectively disincentivised from participating in the T-4 auction due to the rules governing "transitional arrangements". To do so we define a baseline for comparison, which we term the "status quo":

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[39] All prices are stated at their 2012 level, unless otherwise noted.

(1) **Status Quo**: the T-4 capacity auction proceeds as planned, targeting 50.8GW of capacity with 2.5GW "set aside" for the T-1 auction. DSR does not participate in the T-4 auction. 2.5GW of DSR participates in the T-1 auction.

We consider "what if" DSR were to enter the T-4 auction, and consequently more expensive capacity were displaced from the T-4 auction to into the T-1 auction We consider a scenario with "Forecast DSR" and "High DSR" participation in the four year ahead auction.

(1.1) **Forecast DSR**: in this scenario, 2.5GW of DSR enters the T-4 auction. This is the amount of DSR that National Grid includes in its most recent modelling.[40]

(1.2) **High DSR**: in this scenario, 5.5GW of DSR enters the T-4 auction. In mature capacity markets, such as PJM, DSR provides up to nine per cent of capacity (see Section 2.2, above). 5.5GMW is approximately nine per cent of National Grid's forecast of peak demand in 2018/19.[41]

In both the Forecast and High scenarios, we are assuming that all DSR substitutes from the T-1 to the T-4 auction. In fact, interim cases are possible where a limited amount of substitution takes place. In these cases, any effect on costs would likely be similar (but smaller in magnitude).

B.1.2. Scenario 2: "What if" National Grid procures all capacity four years ahead?

Second, we consider the possible policy response to entry of DSR into the T-4 auction, namely increasing the capacity targeted in that auction to the full requirement of 53.3GW. So, we are estimating the effect of (1) DSR increasing the available supply in the T-4 auction and (2) a corresponding increase in the demand for capacity. The baseline for making this comparison is the same "Status Quo" we defined in Section B.1.1:

(2) **Status Quo**: the T-4 capacity auction proceeds as planned, targeting 50.8GW of capacity with 2.5GW "set aside" for the T-1 auction. DSR does not participate in the T-4 auction. 2.5GW of DSR participates in the T-1 auction.

If 2.5GW (or more) DSR were to enter the T-4 auction, a plausible policy response would be for National Grid to procure the full requirement of 53.5GW four years ahead (i.e. the current 50.8GW target plus the 2.5GW of DSR "set aside"). We therefore consider two variant scenarios with "Forecast DSR" and "High DSR" participation in the four year-ahead auction.

(2.1) **Forecast DSR, T-4 Only**: in this scenario, 2.5GW of DSR enters the T-4 auction, while no capacity is procured in the T-1 auction.

(2.2) **High DSR, T-4 Only**: in this scenario, 5.5GW of DSR enters the T-4 auction, while no capacity is procured in the T-1 auction.

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40 National Grid (June 2014), "National Grid EMR Electricity Capacity Report", page 11.

41 National Grid (June 2014), page 84. National Grid forecasts peak demand of 58.9GW in its "Slow Progression" scenario.

B.1.3. Scenario 3: "What if" demand at T-1 lower than expected?

Third, we consider "what if" the capacity required in the T-1 auction falls due to a negative shock to peak demand. We therefore alter the baseline for comparison, which we term "Status Quo, Low Demand":

(3) Status Quo, Low Demand: The T-4 capacity auction proceeds as planned, targeting 50.8GW of capacity with 2.5GW "set aside" for the T-1 auction. DSR does not participate in the T-4 auction. A negative shock to demand means there is no need to procure additional capacity in the T-1 auction.

We consider "what if" DSR were able to enter the T-4 auction. As above, we consider a "Forecast" and "High" participation scenario.

(3.1) Low DSR, Low Demand: in this scenario, 2.5GW of DSR enters the T-4 auction. There is no T-1 auction.

(3.2) High DSR, Low Demand: in this scenario, 5.5MW of DSR enters the T-4 auction. There is no T-1 auction.

B.1.4. Summary of "what if" assumptions

By examining the change in total cost in each scenario, relative to the baseline, we can quantify the effect of each of the "what if" assumptions on the total cost of the capacity market. Table B.1 summarises the assumptions that we vary in each scenario, while holding all others constant.

Table B.1
"What If" Scenarios

	Required Capacity 2018/19 (GW)	Auction Targets T-4 (GW)	Auction Targets T-1 (GW)	DSR Participation T-4 (GW)	DSR Participation T-1 (GW)
"What if" DSR displaces capacity at T-4?					
(1) Status Quo	**53.3**	**50.8**	**2.5**	**0.0**	**2.5**
(1.1) Forecast DSR	53.3	50.8	2.5	2.5 ▲	0.0 ▼
(1.2) High DSR	53.3	50.8	2.5	5.5 ▲	0.0 ▼
"What if" all capacity is procured four years ahead?					
(2) Status Quo	**53.3**	**50.8**	**2.5**	**0.0**	**2.5**
(2.1) Forecast DSR, T-4 Only	53.3	53.3 ▲	0.0 ▼	2.5 ▲	0.0 ▼
(2.2) High DSR, T-4 Only	53.3	53.3 ▲	0.0 ▼	5.5 ▲	0.0 ▼
"What if" demand is lower than expected?					
(3) Status Quo, Low Demand	**50.8**	**50.8**	**0.0**	**0.0**	**0.0**
(3.1) Forecast DSR, Low Demand	50.8	50.8	0.0	2.5 ▲	0.0
(3.2) High DSR, Low Demand	50.8	50.8	0.0	5.5 ▲	0.0

B.1.5. Price formation in the T-4 and T-1 auction

Table B.1 shows that, in scenario 1, DSR displaces capacity in the T-4 auction. We assume that any generators that are "out of merit" as a result of DSR's entry into the T-4 auction instead compete for a contract in the T-1 auction. Since only one-year contracts are available in this auction, the capacity available to enter the T-1 auction is therefore provided by existing generators. Therefore, in scenarios 1.1 and 1.2, existing generators that do not win a T-4 capacity agreement set the price in the T-1 auction.

B.1.6. Bidding behaviour in the capacity market

There is considerable uncertainty surrounding the price at which DSR will participate in the capacity market. One guide to the price at which DSR providers would find it economical to enter the market is the price at which they are currently able to sell their capacity for so-called "triads management".[42] In winter 2013/14, this service was offered at an annual tariff of between £11.05/kW to £33.55/kW, depending on the region of the country where the DSR is located.[43] In our scenarios, we therefore assume that DSR will find it economical to bid into the capacity market at £20/kW. We make this assumption because, first, it lies within the range of prices at which DSR providers currently make capacity available and, second, we have been instructed by EnerNOC to examine a set of scenarios in which DSR is a cost-effective means of ensuring security of supply. Therefore, we are assuming that there is a supply of DSR available which is able to affect the clearing price in the capacity market, rather than forming a forecast of what the actual price will be.

Another uncertainty that currently surrounds the market is how existing generators that face "missing money" between 2015 and 2018 will behave. These generators face a cost of accepting a capacity agreement, namely the cost of maintaining available capacity for three years in which revenues from the energy market do not cover their fixed costs. If these generators do not foresee a subsequent period of high energy prices that will allow them to recover these costs, then they must seek to recover them through the capacity market (otherwise they would be better off by closing down). So "net going forward costs" before 2018 are a real cost of accepting a capacity agreement. The rules make provision for existing plants to become "price-makers" and submit bids in this fashion.[44]

However, it is not clear over what period of time generators will seek to recover their "net going forward costs" incurred from 2015-2018. If generators seek to recover all of these costs in their 2018 capacity agreements, they will submit potentially very high bids. Conversely, if they seek to recover these costs over their forecast lifetime, they must rely on long-term forecasts of market conditions in both the energy and capacity market. In either case, they must amortize the lump sum of "missing money" from 2015-2018 into a series of annual payments, including the cost of capital of financing these "net going forward costs".

In order to capture the range of possible outcomes, we consider two different sorts of bidding behaviour:

- **No Amortized Losses**: Generators' bids reflect only the "net going forward costs" they face in 2018; and

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42 "Triad management involves reducing consumption for around two hours during expected peak periods in order to minimise these charges" in "Demand side response in the non-domestic sector", Element Energy, May 2012,. page 13.

43 We received this information from EnerNOC, via email.

44 See "Capacity Market Rules", page 138. Existing plants may apply for "price-maker" status if "the Company's estimated net going forward costs […] exceed the Price-Taker Threshold".

- **Losses Amortized Over 5 Years**: Generators' bids also reflect the "net going forward costs" faced between 2015 and 2018, which they recover through five amortized annual payments. These payments are required in addition to any "net going forward costs" in 2018 itself.

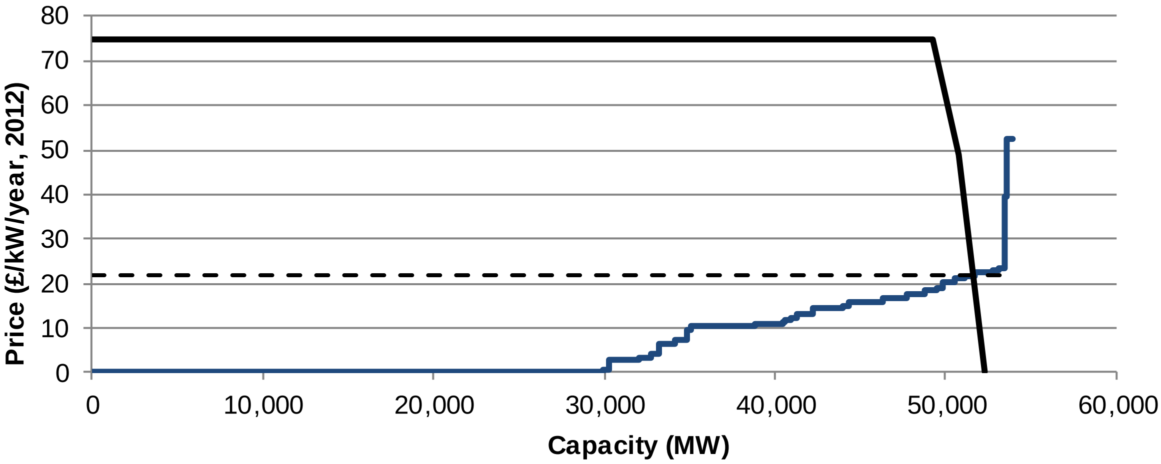
B.2. Scenario 1: "What If" DSR Displaces Capacity at theT-4 Auction?

B.2.1. Status Quo

First, we construct a model of the capacity market that represents the Status Quo assumptions. The capacity merit order is shown in Figure B.1. We model two possible modes of bidding behaviour, as described in Appendix C.2. In the first, shown in Panel A, the market clears at £21.81/kW/year, procuring 51.66W of capacity at a cost of £1,095 million. In the second, shown in Panel B, the market clears at £44.15/kW, procuring a capacity of 50.95GW at a cost of £2,249 million.

Figure B.1
(1) Status Quo: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £21.20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £44.15/kW

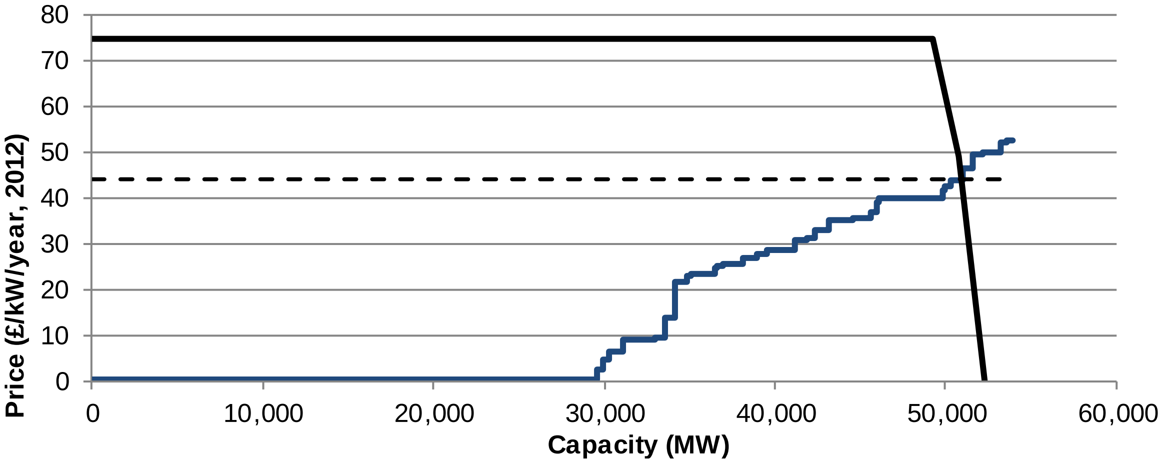
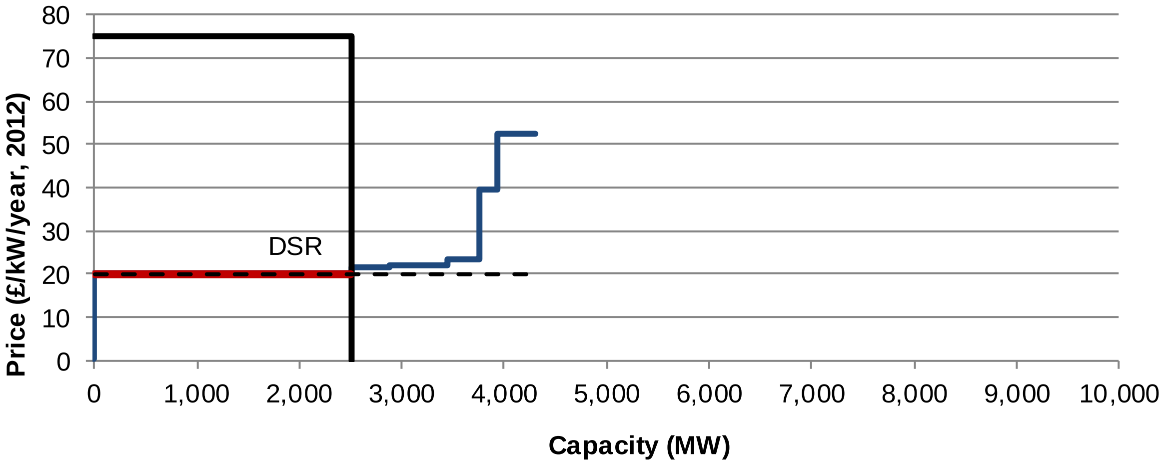


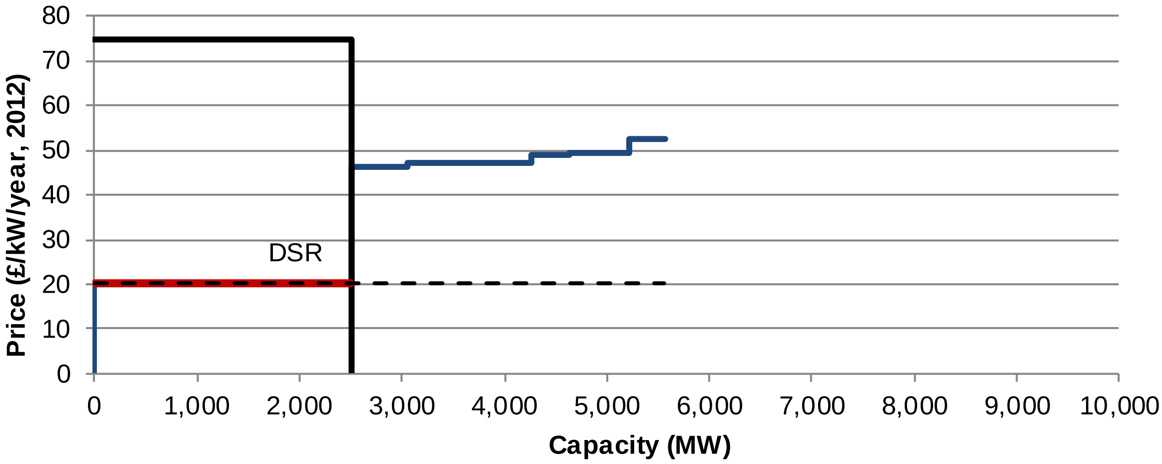
Figure B.2 illustrates the assumptions we have made about the merit order in the T-1 auction. Currently there is no information about the demand curve that will be used in the T-1 auction, other than the target capacity. We therefore model the auction with a vertical demand curve. In both Panel A and Panel B, DSR is the marginal source of capacity and sets the price at £20/kW.

Figure B.2
(1) Status Quo: T-1 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £20/kW

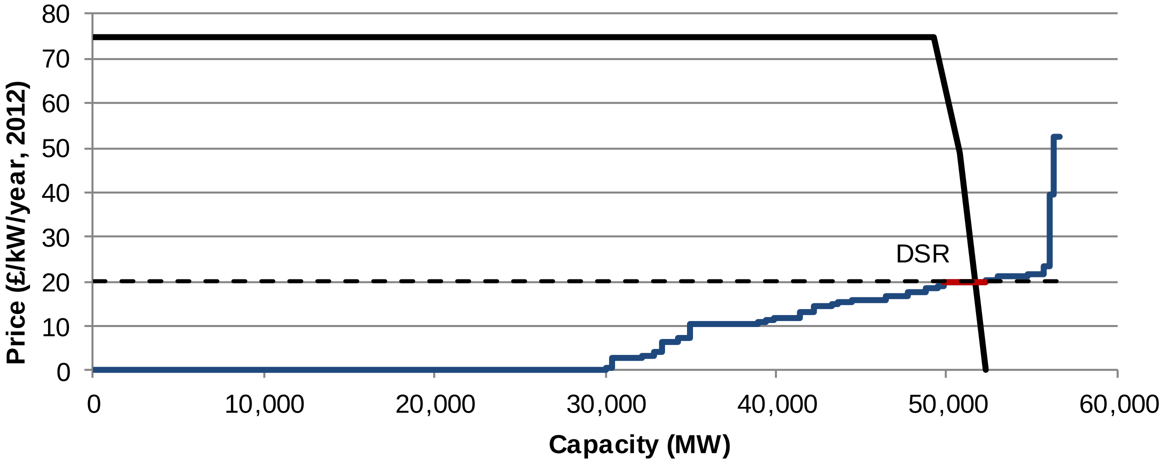


B.2.2. Forecast DSR

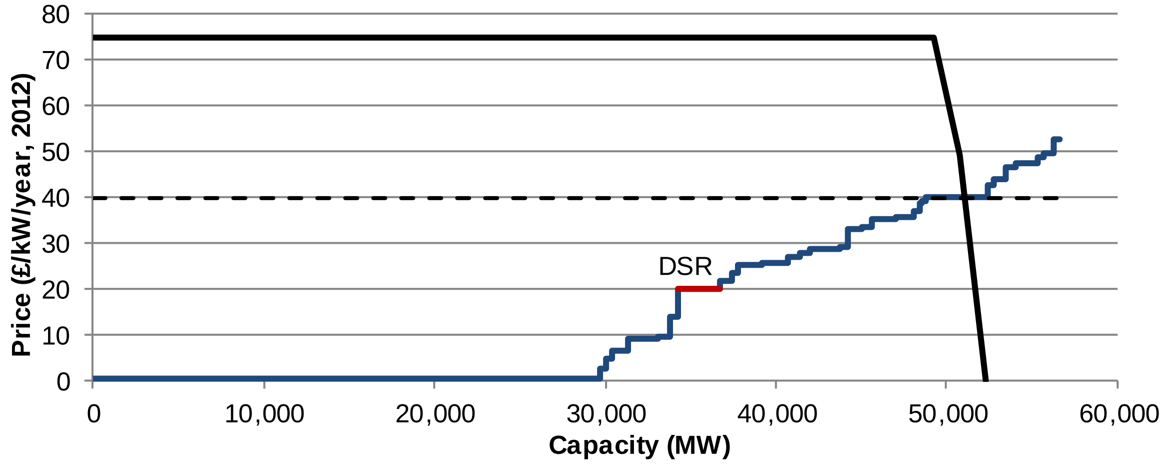
In this "what if" scenario, 2.5GW of DSR participates in the T-4 auction, displacing some existing but more expensive sources of capacity (which must then enter the T-1 auction). As Figure B.3 shows, in Panel A DSR is the marginal unit (i.e. it sets the price). Therefore, the market clears at £20/kW, at a total cost of £1,034 million. In Panel B, DSR is an inframarginal source of capacity, which causes the price to fall to £39.95/kW at a total cost of £2,042 million.

Figure B.3
(1.1) Forecast DSR: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20/kW



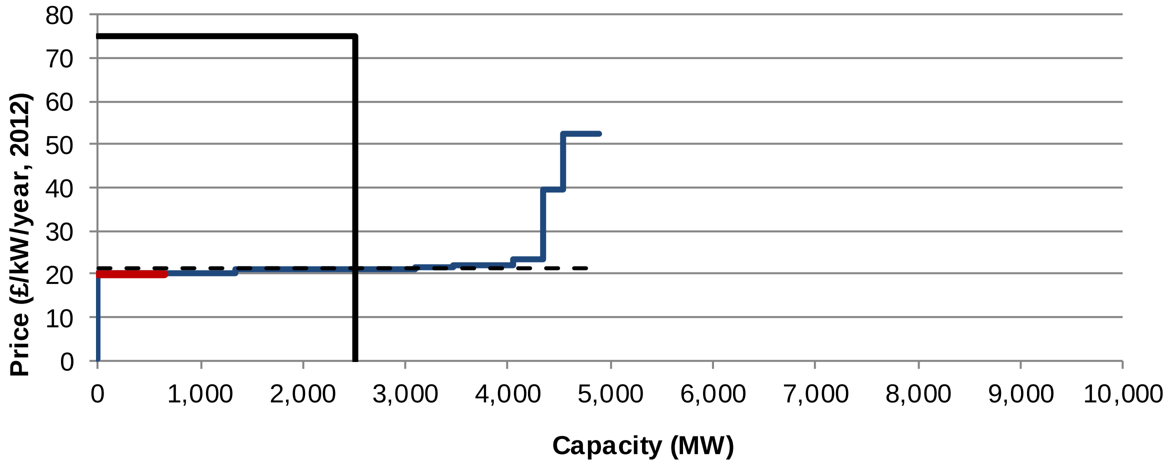
Panel B: With Losses Amortized Over 5 Years the Auction Clears at £39.95/kW



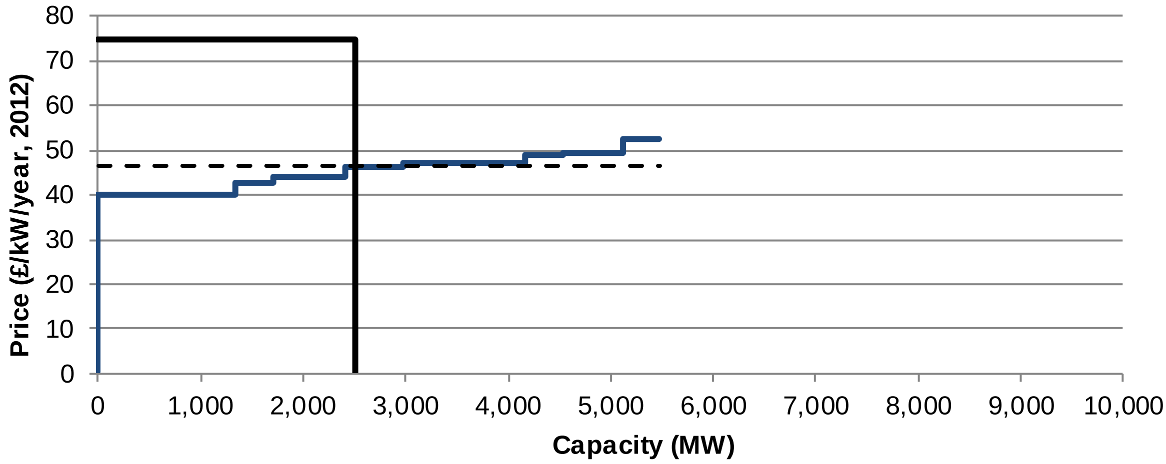
The effect of DSR entering the T-4 auction is to displace capacity provided by more expensive sources into the T-1 auction, and consequently raise the clearing price. Figure B.4 illustrates this. In Panel A, some residual DSR that does not win a contract in the T-4 auction is able to provide capacity in the T-1 auction, which clears at £21.20/kW. In Panel B, all available DSR is entirely contracted at the T-4 auction, and hence only more expensive existing capacity is available. The market clears at £46.67/kW.

Figure B.4
(1.1) Low DSR: T-1 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £21.20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £46.67/kW

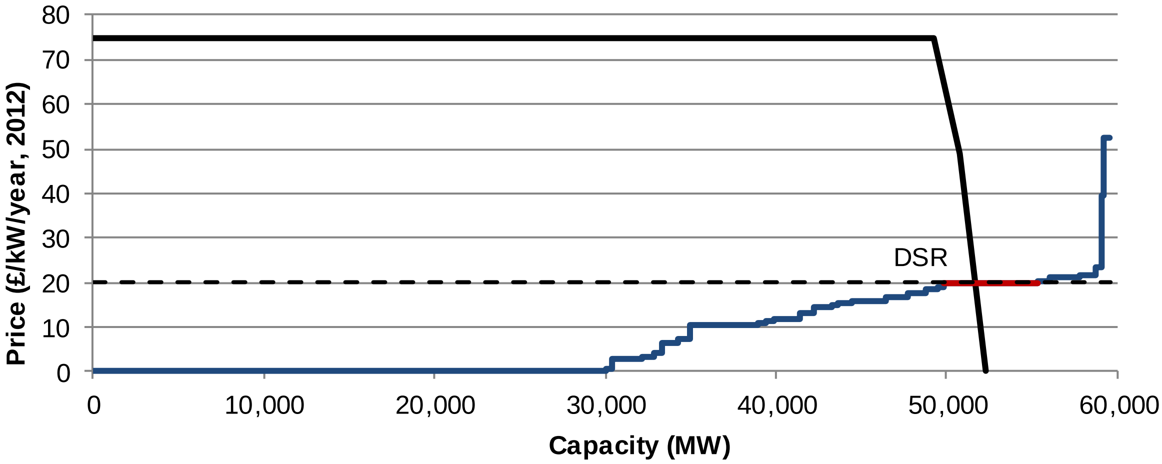


B.2.3. High DSR

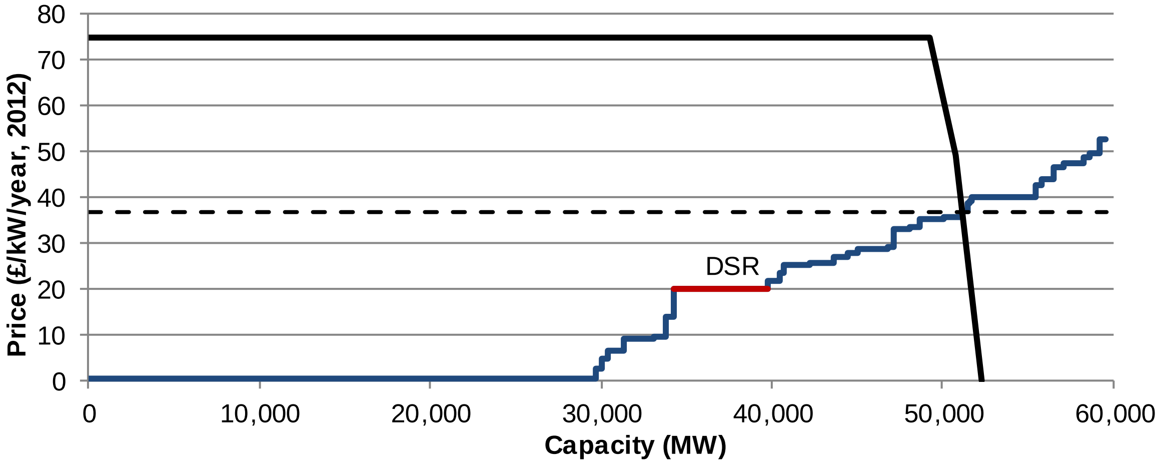
In this "what if" scenario, 5.5GW of DSR participates in the T-4 auction. As Figure B.5 shows in Panel A, when bids do not include amortized losses there is no change in the clearing price (£20/kW) versus the Forecast DSR scenario because DSR is the marginal source of capacity. By contrast, Panel B shows that additional supply from inframarginal DSR has the potential to lower the price to £36.62/kW in the T-4 auction.

Figure B.5
(1.2) High DSR: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £36.62/kW



Since in both cases shown in Figure B.5 more capacity is displaced from the T-4 auction, there is a further reduction in the total cost of the T-1 auction (to £50 million and £100 million, respectively).

B.2.4. Summary of Scenario 1

As well as the Forecast and High DSR scenarios, we examined scenarios in which 3.5GW and 4.5GW of DSR enters the T-4 auction. We summarise these results in Table B.2. Assuming (as we have been instructed to do) that DSR is an inframarginal source of capacity, in the Forecast DSR scenario we find a potential saving of between £58-141 million. In the High DSR scenario, this saving could be as much as £61-309 million.

Table B.2
"What if" DSR Displaces Capacity at T-4 - Range of Results

	DSR Participation	Auction Cost		Net Saving
	T-4	T-4	T-1	
	(GW)	*(£ million)*	*(£ million)*	*(£ million)*
No Amortized Losses				
Status Quo	0.0	1,095	50	0
Forecast DSR	2.5	1,034	53	58
3.5GW DSR	3.5	1,034	52	59
4.5GW DSR	4.5	1,034	50	61
High DSR	5.5	1,034	50	61
Losses Amortized Over 5 Years				
Status Quo	0.0	2,249	50	0
Forecast DSR	2.5	2,042	116	141
3.5GW DSR	3.5	2,041	107	152
4.5GW DSR	4.5	2,041	100	159
High DSR	5.5	1,890	100	309

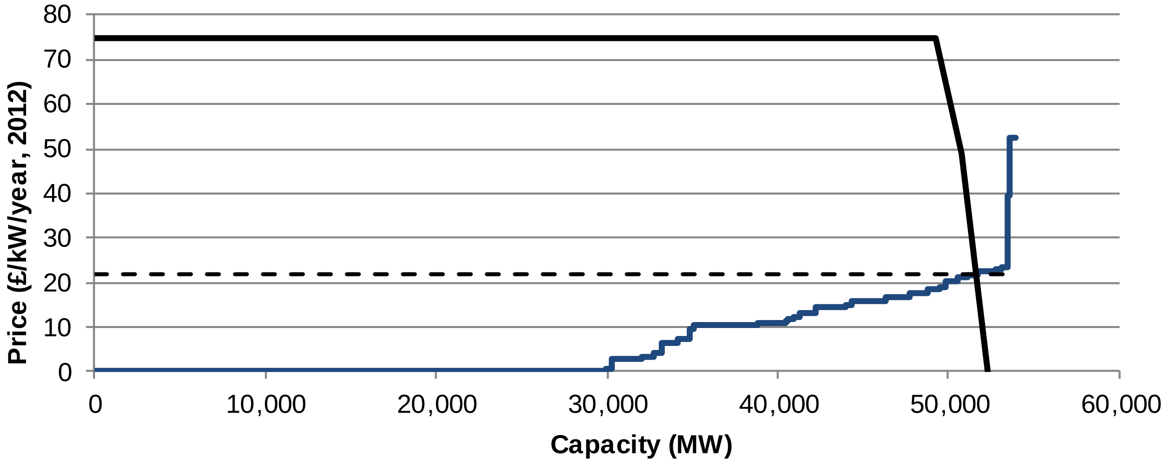
B.3. Scenario 2: "What If" All Capacity is Procured at T-4?

B.3.1. Status Quo

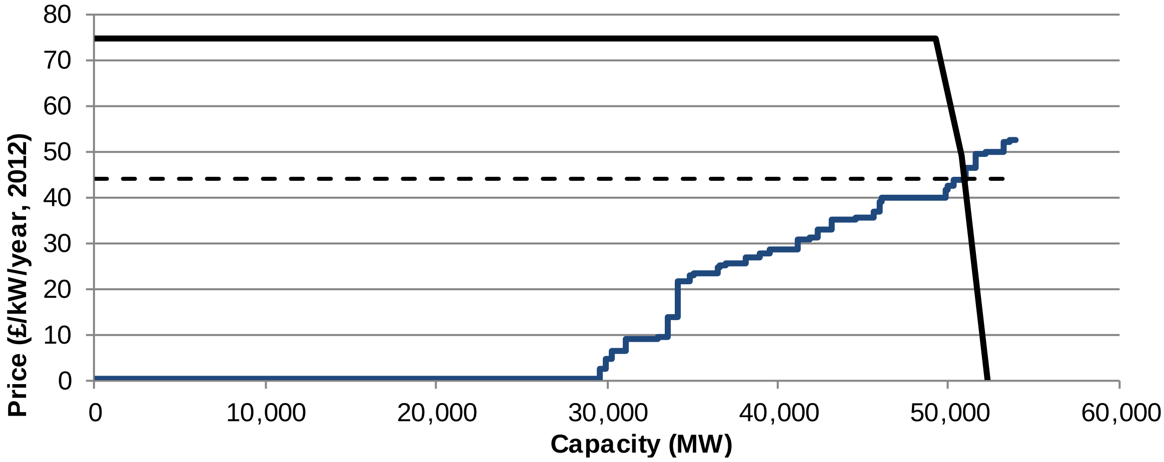
As above, we construct a model of the capacity market that represents the Status Quo assumptions. The capacity merit order is shown in Figure B.6. In Panel A, the market clears at £21.81/kW/year, procuring 51.66W of capacity at a cost of £1,094 million. In Panel B, the market clears at £44.15/kW, procuring a capacity of 50.95GW at a cost of £2,249 million. In both cases, 2.5GW of DSR is procured in the T-1 auction at a cost of £50 million, based on our assumed price of £20/kW for DSR.

Figure B.6
(2) Status Quo: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £21.20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £44.15/kW

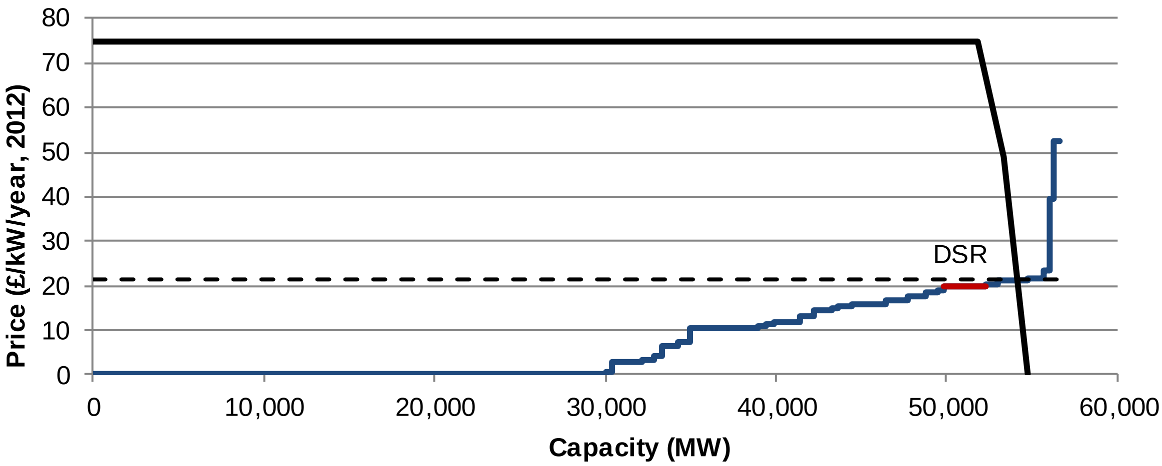


B.3.2. Forecast DSR, T-4 Only

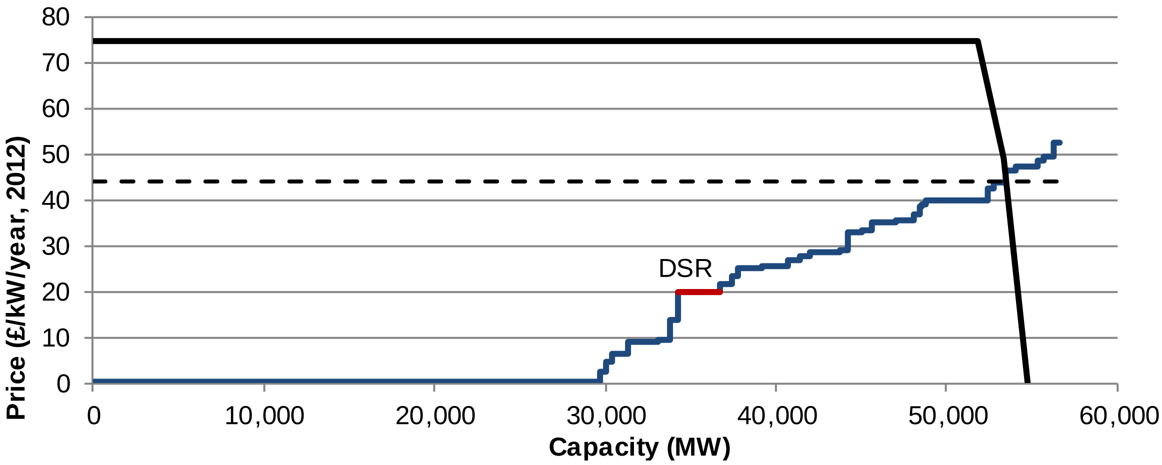
In this "what if" scenario, 2.5GW of DSR participates in the T-4 auction. All the necessary capacity is procured in this auction and, hence, no T-1 auction is held. As Figure B.7 shows, since both the supply curve and the demand curve shift out by 2.5GW the price remains the same. The quantity procured increases to 54.16GW, at a total cost of £1,148 million in Panel A, while in Panel B the quantity procured is 53.45GW at a cost of £2,360 million.

Figure B.7
(2.1) Forecast DSR, T-4 Only: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £21.20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £44.15/kW

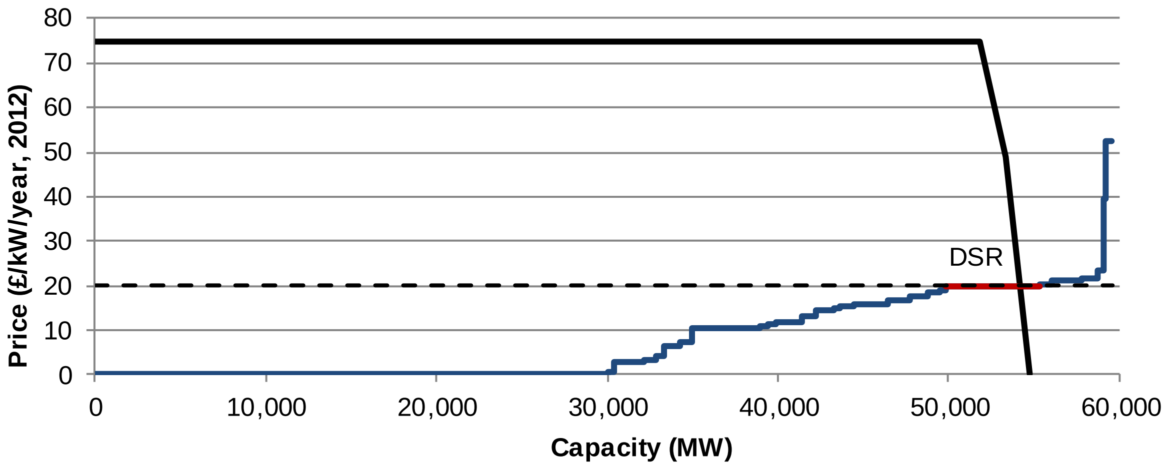


B.3.3. High DSR, T-4 Only

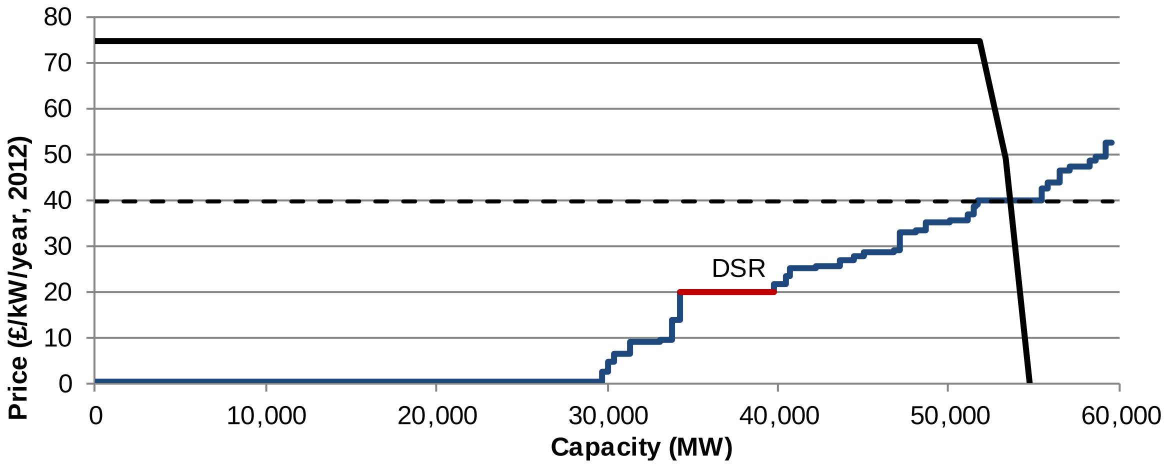
In this "what if" scenario, 5.5GW of DSR participates in the T-4 auction. As Figure B.8 shows, in this scenario DSR displaces more expensive sources of capacity. In Panel A, this causes the price to fall to £20/kW (as DSR is the marginal source of capacity) and in Panel B the price falls to £39.93/kW (as DSR is inframarginal). In each scenario, the total cost is £1,084 and £2,141 million, respectively.

Figure B.8
(2.2) High DSR, T-4 Only: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20 /kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £39.33/kW



B.3.4. Summary of Scenario 2

As well as the Forecast DSR and High DSR scenarios, we examined scenarios in which 3.5GW and 4.5GW of DSR participate in the T-4 auction. Table B.3 summarises the range of results across these scenarios, which support the same conclusions. In the Forecast DSR scenario, there is an increased cost to allowing DSR to enter the T-4 auction (between £3-60 million). However, for any quantity of capacity greater than 2.5GW there is a net saving. In our upper bound case, the saving could be as much as £61-159 million in the first year alone.

Table B.3
"What If" DSR All Capacity is Procured at T-4 – Range of Results

	DSR Participation	Auction Cost		Net Saving
	T-4	T-4	T-1	
	(GW)	*(£ million)*	*(£ million)*	*(£ million)*
No Amortized Losses				
Status Quo, T-4 Only	0.0	1,095	50	0
Low DSR, T-4 Only	2.5	1,148	0	-3
3.5GW DSR, T-4 Only	3.5	1,137	0	8
4.5GW DSR, T-4 Only	4.5	1,084	0	61
High DSR, T-4 Only	5.5	1,084	0	61
Losses Amortized Over 5 Years				
Status Quo, T-4 Only	0.0	2,249	50	0
Low DSR, T-4 Only	2.5	2,360	0	-60
3.5GW DSR, T-4 Only	3.5	2,282	0	18
4.5GW DSR, T-4 Only	4.5	2,142	0	158
High DSR, T-4 Only	5.5	2,141	0	159

B.4. Scenario 3: "What If" Demand at T-1 is Lower than Expected?

B.4.1. Status Quo, Low Demand

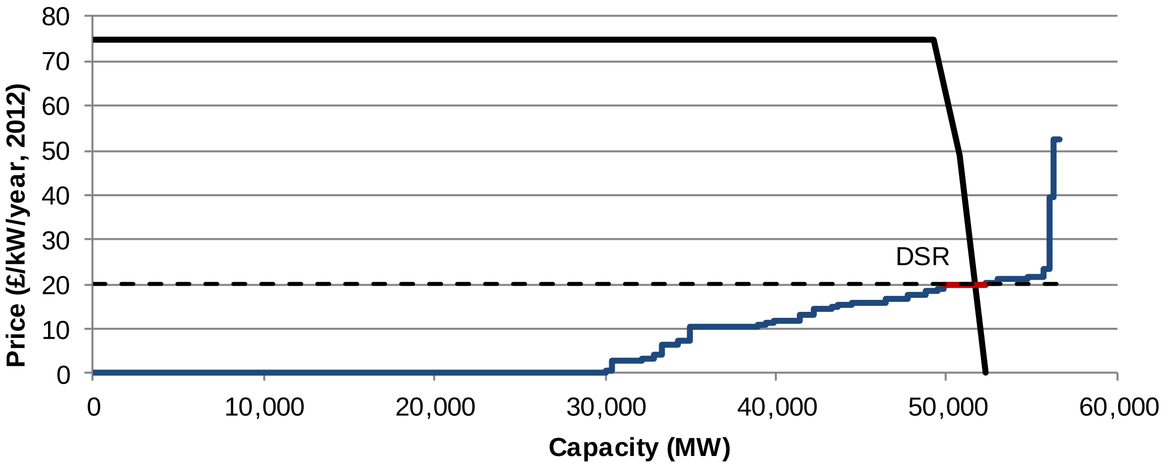
We construct our Status Quo case exactly as before, except this time we do not model the T-1 auction. The merit order and demand curve for the T-4 auction is the same as that shown in Figure B.1. Total costs are £50 million lower, as there is no need to procure an additional 2.5GW of capacity in 2017.

B.4.2. (3.1) Forecast DSR, Low Demand

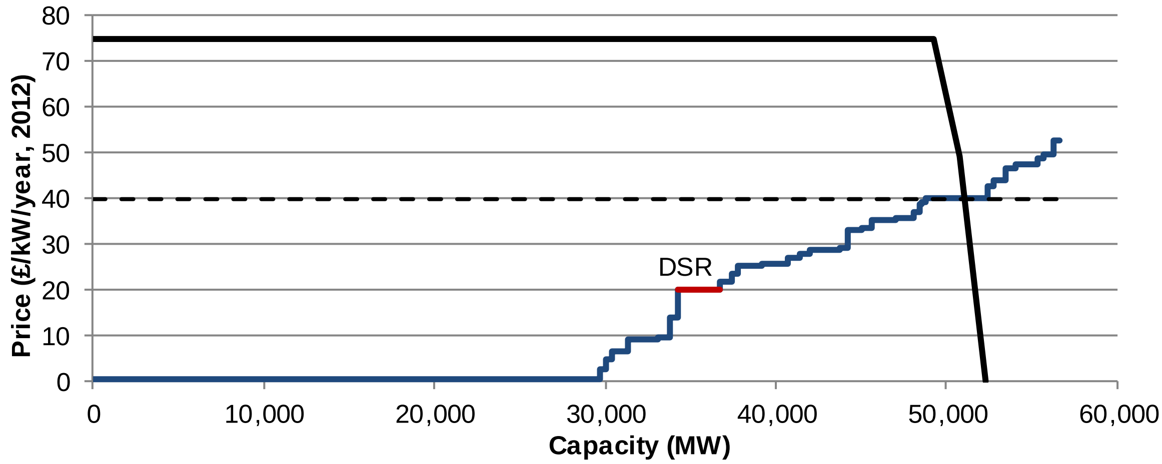
We construct this scenario exactly as before, except this time we do not model the demand for capacity in the T-1 auction. 2.5GW of DSR enters the T-4 auction, as shown in Figure B.9 which causes the price to fall to £20/kW and £39.95/kW respectively. In Panel A 51.69GW of capacity is procured at a cost of £1,034 million, while in Panel B 51.10GW of capacity is procured at a cost of £2,041 million.

Figure B.9
(3.1) Forecast DSR, Low Demand: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £39.95/kW

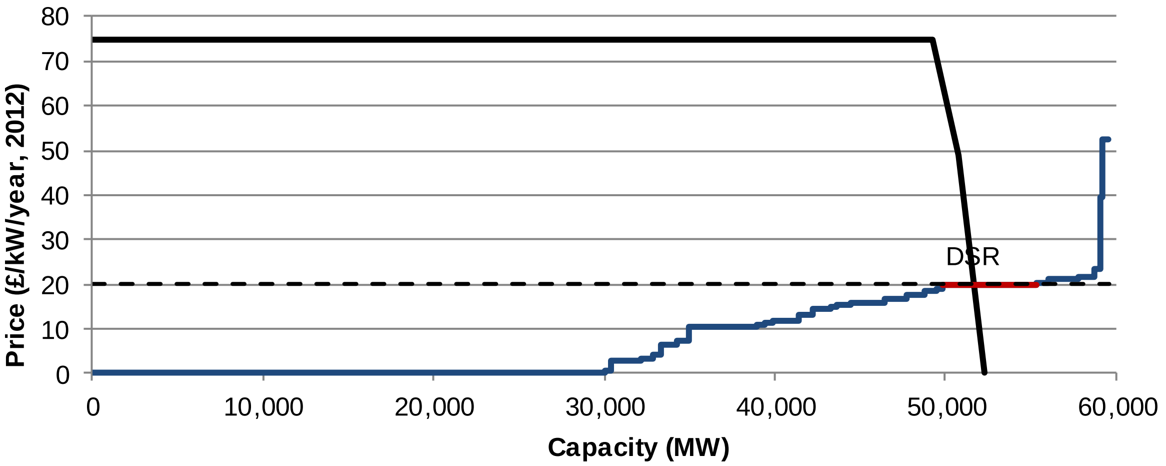


B.4.3. High DSR, Low Demand

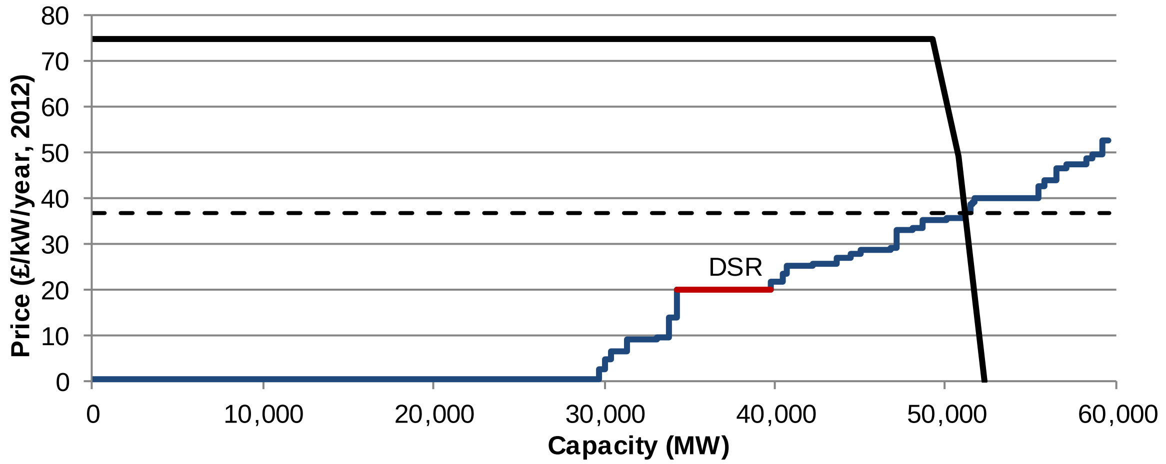
We construct this scenario exactly as before, except this time we do not model the demand for capacity in the T-1 auction. 5.5GW of DSR enters the T-4 auction, as shown in Figure B.10, which causes the price to fall to £20/kW and £36.92/kW respectively. In Panel A 51.69GW of capacity is procured at a cost of £1,034 million, while in Panel B 51.20GW of capacity is procured at a cost of £1,890 million.

Figure B.10
(3.2) High DSR, Low Demand: T-4 Merit Order

Panel A: With No Amortized Losses the Auction Clears at £20/kW



Panel B: With Losses Amortized Over 5 Years the Auction Clears at £36.92/kW



B.4.4. Summary of Scenario 3

As before, we examined two intermediate scenarios between Forecast and High DSR. Table B.4 summarises the range of results across these scenarios. In the Forecast DSR, Low Demand scenario, there is a net saving from allowing DSR to enter the T-4 auction (between £61-208 million). This saving increases with the quantity of DSR that enters. In our upper bound case, High DSR, Low Demand, the saving could be as much as £61-359 million in the first year alone.

Table B.4
"What If" Demand is Lower than Expected – Range of Results

	DSR Participation	Auction Cost		Net Saving
	T-4	T-4	T-1	
	(GW)	*(£ million)*	*(£ million)*	*(£ million)*
No Amortized Losses				
Status Quo, Low Demand	0.0	1,095	0	0
Low DSR, Low Demand	2.5	1,034	0	61
3.5GW DSR, Low Demand	3.5	1,034	0	61
4.5GW DSR, Low Demand	4.5	1,034	0	61
High DSR, Low Demand	5.5	1,034	0	61
Losses Amortized Over 5 Years				
Status Quo, Low Demand	0.0	2,249	0	0
Low DSR, Low Demand	2.5	2,042	0	208
3.5GW DSR, Low Demand	3.5	2,041	0	209
4.5GW DSR, Low Demand	4.5	2,041	0	209
High DSR, Low Demand	5.5	1,890	0	359

Appendix C. Modelling Framework and Assumptions

C.1. Modelling Framework

As noted in Section 2.1, in an energy market that is characterised by “missing money”, some generators’ revenues from energy sales will not cover their fixed costs (namely fixed operating expenses and annuitized capital expenditure). To make capacity available, these generators require remuneration in the capacity market that is sufficient to cover these costs. A generator’s decision to make capacity available is therefore the result of a forecast of (1) the revenue they expect to receive from sales in the energy market and (2) payments they expect to receive in the capacity market. When (1) and (2) are less than a generator’s expected costs, it is economically rational to cease operations rather than sustain avoidable losses.

C.1.1. Determining Capacity Prices

To model this decision by generators, we use industry-leading software AuroraXMP®. AuroraXMP captures a generator’s decision to make capacity available, by simultaneously determining the equilibrium outcome in both energy and capacity markets. Conceptually, the model determines outcomes in these two markets as follows:

(1) For each year in which the model is run, the model produces a forecast of energy prices in Great Britain that reflects the cost of the marginal source of energy needed to balance supply and demand in each hour;

(2) For each generator that is available , the model produces a forecast of the energy revenues to be received over the course of the year, by determining in which hours the plant will be “in merit” and called on to generate. By subtracting these annual revenues from each generator’s fixed and variable costs, AuroraXMP determines the “net going forward costs” (in £/kW/year) that each generator faces. This is the price at which each generator is willing to supply capacity;

(3) For each year in which the model is run, the model selects the cheapest sources of available capacity until it meets a pre-specified reserve margin. All plants that are “in merit” then receive a capacity price equal to the price of the marginal capacity unit; and

(4) Finally, all plants that receive a capacity payment make themselves available to participate in the energy market.

C.1.2. Determining the Optimal Mix of Capacity

The equilibrium outcome in both energy and capacity markets depends on the interaction of supply and demand, where supply is capacity of generators and demand-side response units. In the long-term, older capacity will exit the market while new capacity will enter the market.

AuroraXMP models these long-term decisions as follows:

A. In the initial run of the model, the supply of capacity is made up of existing units that have not been retired and planned new units that enter regardless of market dynamics (e.g. new nuclear and renewables). This supply is used to cycle through steps (1) – (4) above, and the average prices are recorded.

B. The model then examines which existing units have the lowest net present value, and would preserve more value by retiring. It also examines which possible new entrants could enter the market, and in what year it would be most profitable to do so. The model then adjusts the stock of capacity for economic retirements and new entry, and cycles through steps (1) – (4) above, recording the average prices.

C. The model continues this iterative process of removing unprofitable units and adding potentially profitable new entrants until average prices are very similar from one iteration to the next – the model is then said to have converged on a solution.

C.2. Bidding Behaviour

AuroraXMP awards a payment for capacity at a price that is equal to the annual "net going forward costs" of the marginal source of capacity needed to meet the annual reserve margin target. Because the model cannot incorporate features of the Great Britain capacity market design, we use the data on these "net going forward costs" to construct bids that more closely reflect the likely outcomes.

C.2.1. New plants can bid for 15 year capacity agreements

As noted in Section 2.4, new plants can be awarded contracts of up to fifteen years in length. Their bids into the capacity market must therefore contain a price that is sufficient to recover their costs over the entire contract period.

We model this by first calculating the "net going forward costs" of each new entrant in each year from 2018-2032. Second, we calculate the net present value of these costs, as of 2014. Third, we amortize these costs into fifteen annual payments (the contract period). Finally, we divide this annual payment by the capacity of each new entrant to give a bid in £/kW/year for 2018.

C.2.2. Refurbished plant can bid for 3 year capacity agreements

Plant requiring major capital expenditure on refurbishment can be awarded agreements of up to three years in length. Similarly to new plants, we model these plants amortizing their costs over a three year period, which is reflected in their 2018 bid.

C.2.3. Existing plant can recover losses sustained between 2015-2017

The capacity market rules make provision for existing generators to recover their "net going forward costs" between 2015 and 2018, when no capacity market agreements are available.[45] There is significant uncertainty about how generators will reflect these additional costs in the price at which they offer to supply capacity in 2018. Therefore, as described in Appendix B, we model two alternative forms of bidding behaviour, as follows.

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[45] See "Capacity Market Rules", page 138. Existing plants may apply for "price-maker" status if "the Company's estimated net going forward costs […] exceed the Price-Taker Threshold".

- **No amortization of past losses**: for each existing generator, we calculate the "net going forward costs" they face in 2018. Their bid in to the capacity market reflects only these costs, recovered over one year.
- **Amortization of past losses**: for each existing generator (and any other unit that comes online before 2018):
  - We calculate their "net going forward costs" in each year before the start of the capacity market in 2018;
  - We roll forward the value of these costs at the WACC, to state them at their present value as of 2018; and
  - We amortize these losses into five annual payments, again using the WACC. We add these payments to the capacity market bid of each generator in the years 2018-22. Therefore, each generator recovers some historical "missing money" from the capacity market over a five year period

C.3. Modelling Assumptions

The long-term forecasts that we employed to populate our model are inherently deeply uncertain. We have used our standard method of using the most recent and reliable market data available and, where necessary, supplementing this with our own judgement about likely market dynamics in the long-term.

C.3.1. Information Date

We populated our model with a set of assumptions that reflect the most recent data available as of 30 June 2014. This includes market data (e.g. fuel prices) as well as policy announcements (e.g. renewables support, UK carbon price floor).

C.3.2. Fuel Prices

We used data available from forward markets to produce a short-term forecast of oil, natural gas and coal prices. Thereafter, we model fuel prices converging to their long term values as defined by the International Energy Agency (IEA) in its most recent *World Economic Outlook.*

For CO_2 prices, we incorporate the effect of the current "freeze" in the UK Carbon Support Rate, and assume this remains unchanged. The future trajectory of traded carbon prices is highly uncertain, so we model a weighted average of two cases – one in which EU ETS prices increase at the rate foreseen by the IEA in its *WEO*, and one in which EU ETS prices follow the current forward curve and increase thereafter at the risk-free rate.

Table C.1
Forecast Fuel Prices

	Natural Gas (pence/therm, 2013)	Coal (£/tonne, 2013)	Oil ($/bbl, 2013)	Carbon (£/tonne, 2013)
2014	49.7	49.2	105.9	15.9
2015	56.0	50.3	100.9	25.2
2016	58.8	52.0	94.8	27.1
2017	63.1	54.6	96.6	27.2
2018	67.2	59.5	103.5	27.6
2019	71.0	64.0	109.9	28.0
2020	74.4	67.8	115.7	28.5
2021	77.5	71.3	121.1	28.9
2022	79.9	73.4	123.8	29.2
2023	80.6	74.0	125.2	29.5
2024	81.2	74.4	126.6	29.7
2025	82.2	75.3	128.0	30.0
2026	83.2	75.9	129.8	30.3
2027	84.2	76.6	131.6	30.6
2028	85.3	77.2	133.4	30.8
2029	86.3	77.9	135.1	31.1
2030	87.4	78.6	136.9	31.3
2031	88.5	79.0	136.9	31.7
2032	89.7	79.4	136.9	32.0
2033	90.8	79.9	136.9	32.3
2034	92.0	80.3	136.9	32.6
2035	93.1	80.7	136.9	32.9
2036	94.3	81.2	136.9	33.3
2037	95.5	81.6	136.9	33.6
2038	96.7	82.1	136.9	33.9
2039	97.9	82.5	136.9	34.3
2040	99.2	83.0	136.9	34.6

Source: NERA analysis of IEA, Bloomberg and Point Carbon data.

C.3.3. Demand Forecasts

We collected forecasts of demand from National Grid and DECC, including forecasts of the future effect of electric vehicles and heat pumps on energy consumption and peak load.[46] We took a weighted average of DECC's Central and Baseline forecasts of load growth, with a 75 per cent weight on the Baseline scenario in which energy efficiency measures have limited penetration and demand grows more rapidly.

We assessed the implications of our weighted forecast on the energy intensity of GDP. Since our forecast of demand grows at a faster rate than National Grid's "Slow Progression" and "Gone Green" scenarios, the energy intensity of GDP (kWh/£) also falls more slowly, in line with historical trends. We assumed that peak demand grows at the same rate as total demand.

[46] *National Grid 2014 UK Future Energy Scenarios , February 2014; DECC Updated Energy & Emissions Projections - September 2013.*

Finally, we used half hourly load shapes from National Grid's 2013 INDO series.

Table C.2
Forecast Future Demand

	Peak Demand (GW)	Total Demand (TWh)
2014	59.6	346.0
2015	59.7	347.0
2016	60.1	349.2
2017	60.6	352.7
2018	61.3	357.2
2019	62.1	361.8
2020	62.9	366.7
2021	63.8	372.4
2022	64.5	377.1
2023	65.3	382.3
2024	66.1	387.1
2025	66.8	391.7
2026	67.5	396.6
2027	68.2	401.7
2028	69.2	407.8
2029	70.0	413.7
2030	70.9	419.5
2031	71.9	425.4
2032	72.9	431.3
2033	73.9	437.4
2034	75.0	443.5
2035	76.0	449.8
2036	77.1	456.1
2037	78.2	462.5
2038	79.3	469.0
2039	80.4	475.6
2040	81.5	482.2

Source: NERA analysis of DECC, NG and ONS data.

C.3.4. Capacity

C.3.4.1. Existing Capacity

For existing capacity, we used the Transmission Entry Capacity (TEC) of each generator to define its sent-out generating capacity.[47]

For coal plants that are affected by the Industrial Emissions Directive (IED), we made exogenous decisions on each plant's decision to "opt in" or "opt out" of the restrictions imposed. For the coal plants that indicated their intention to comply with the IED, we assumed these plants fit abatement technology and run without restriction for an additional

47 http://www2.nationalgrid.com/UK/Services/Electricity-connections/Industry-products/TEC-Register/.

fifteen years. For all plants that have entered into "Limited Life Derogation" we assume that these plants do not fit abatement technology, operate constrained running hours, and close by 2023.

We included life extensions to existing nuclear capacity that has been confirmed e.g. the announced life extensions to Hinkley Point and Hunterston.

For all plant, we used generic assumptions on the fixed and variable operating costs of each technology, as provided to DECC by Parsons Brinckerhoff.[48]

C.3.4.2. Renewable Capacity

The future deployment of renewable capacity is highly uncertain. DECC has stated an objective to source 30 per cent of electricity generation from renewable sources by 2020. However, this goal may not be achieved. To account for this uncertainty, we take a weighted average view between this target, and a scenario in which only projects currently "awaiting construction" projects have any chance of being completed. In our weighted case, renewables contribute 26 per cent of electricity generation by 2020.

C.3.4.3. New Entrants

For new entrants, we assumed the same operating costs as those assumed for existing plant. In addition, we used the overnight capital costs and heat rates for each new entrant as specified by Parsons Brinckerhoff and used by DECC.

C.3.5. Reserve Margin Target

To assess the contribution of thermal plant and DSR to meeting demand at peak times, we used the de-rating factors that will be used in the Capacity Market Auction, as published by National Grid.[49] We adopt Ofgem's average estimate of equivalent firm capacity for wind of 21 per cent, and use a 0 per cent contribution of solar to demand at its winter peak.

National Grid's recommended level of procurement is based on a loss of load expectation (LOLE) of three hours per year. We calculated that this is equivalent to a four per cent reserve margin. Therefore, in every year after 2018, we targeted this reserve margin.

C.3.6. Outcomes – Capacity Mix and Prices

Using the assumptions above (and others not detailed), we forecast the future mix of capacity in Great Britain, shown in Table C.

48 Parsons Brinckerhoff, "Electricity Generation Cost Model – 2013 Update of Non Renewable Technologies", April 2013.

49 National Grid, "Capacity Market Auction Guidelines", June 2014, page5.

Table C.3
Forecast Capacity Mix

	Nuclear (MW)	Coal (MW)	CCGT (MW)	OCGT (MW)	Other (MW)	Renewables (MW)
2014	10,797	22,001	28,755	384	12,345	16,228
2015	10,252	20,902	27,913	384	11,960	19,194
2016	10,252	17,636	26,613	252	9,433	22,159
2017	10,252	17,339	26,613	148	9,138	25,124
2018	10,252	17,339	26,663	140	9,131	28,090
2019	9,032	17,339	27,309	140	9,345	31,055
2020	6,492	17,339	29,742	140	9,346	34,021
2021	6,492	17,339	30,148	290	9,346	35,697
2022	6,492	17,339	30,148	1,040	9,346	37,372
2023	6,492	16,406	31,364	1,790	9,346	39,048
2024	1,258	6,820	44,975	2,240	9,346	40,724
2025	1,258	5,956	45,380	2,240	9,346	42,400
2026	1,258	5,956	45,785	2,540	9,346	44,076
2027	1,258	5,956	46,596	2,540	9,346	45,752
2028	2,858	5,956	45,632	2,540	9,346	47,428
2029	2,858	5,956	46,003	2,540	9,346	49,104
2030	3,200	5,956	44,472	4,640	9,346	50,779
2031	3,200	-	47,955	9,012	9,217	51,679
2032	4,800	-	46,098	9,000	9,206	52,579
2033	4,800	-	46,883	9,000	9,206	53,479
2034	6,400	-	46,717	9,000	9,206	54,379
2035	6,400	-	47,651	9,000	9,206	55,279
2036	8,000	-	47,416	9,000	9,206	55,279
2037	9,600	-	47,416	9,000	9,206	55,279
2038	11,200	-	47,416	9,000	9,206	55,279
2039	11,200	-	48,157	10,200	7,988	55,279
2040	12,800	-	48,157	10,200	7,988	55,279

Source: NERA analysis.

We compared the electricity prices predicted to our model the prices traded in forward markets (and collected by ICIS Heren) and found they matched them closely. In the long-term, our forecast of prices is shown in Table C..

Table C.4
Forecast Electricity Prices

	Electricity *(£/MWh, 2012)*
2014	41.9
2015	48.6
2016	53.4
2017	56.6
2018	59.1
2019	62.2
2020	63.3
2021	66.6
2022	67.6
2023	69.4
2024	67.3
2025	67.4
2026	68.5
2027	69.4
2028	69.3
2029	69.7
2030	70.7
2031	71.7
2032	72.5
2033	70.6
2034	72.7
2035	71.1
2036	71.3
2037	70.7
2038	71.8
2039	71.3
2040	71.6

Source: NERA analysis.

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