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The impact of capping Capacity Market penalty exposure; illustrative examples

Preamble

Over the past number of months there has been much discussion on the interdependent issues of incentives, penalties, penalty caps (hard and soft) and the necessary and sufficient conditions for the timely development of secondary market(s).

This note has been produced by DECC and Steven Stoft to explain and illustrate why we believe that a penalty cap will help Capacity Providers manage their risk exposure in a cost effective manner and will not interfere with the development of a secondary market. This paper does this by presenting and testing 8 practical examples and posing and answering some Frequently Asked Questions. The accompanying spreadsheet can be used to check the examples provided and to invite testing and/or the presentation of further scenarios or examples.

At this time, we are not minded to provide a 'platform' but DECC is willing to keep this under review and in general we are open to lending our support to a process which will develop a secondary market.

Preface:

In any half hour a generator may be asked to supply capacity due to a power shortage or to pay a compensation charge—a penalty. Because this obligation is not purely physical, it is particularly easy to define a financial forward capacity obligation. For example a financial capacity obligation could specify that the seller would (financially) provide 1 MW of capacity during the month of July for up to 2 shortage hours. This would mean the seller would pay the standard penalty, P^*, on 1 MW in July for up to 2 shortage hours.

This is just an example and of course products will develop by the ingenuity and imagination of the participants. All that is required is that this (standardized) product bears a (high) degree of compatibility with the actual risk that the generator seeks to hedge. In this example the product is perfectly correlated i.e. the risk the generator wishes to hedge is the risk of paying 2 hours of penalties in July (e.g. while he is on outage); the product obliges the uncapped seller to pay the exact same penalty if a shortage occurs in those hours.

Forward markets are bilateral markets that trade individualized products. These are not particularly liquid markets. Generally, once enough volume develops in such a market, a standardized product is designed that is a reasonable approximation to the individual forward contracts, and this standard product is traded on an exchange. This is a futures market, and these markets are generally much more liquid.

It might seem that developing a standard futures contract for a capacity obligation would be difficult in the face of a soft cap, which reduces the penalties after the market has experienced a sufficient number of shortage hours in a particular year. This is not the case. A generator that needs 100 MW of capacity at a penalty rate reduced to 60% of the standard rate, can simply buy 60 MW of the standard product and this will perfectly fit 100 MW of capacity obligation under the reduce-rate penalty. This takes care of the problem that penalties can vary: the risk that the generator wishes to hedge may change but the product used to hedge the risk is the same and all a generator needs to do is to buy a little more or a little less of that same product.

Given the proposed soft cap, it is an easy matter for any generator to calculate its penalty reduction in subsequent shortage hours, and simply apply this reduction to the amount of the hedging product it would purchase without a soft cap.

Because the product is easily standardized and fits all parties perfectly (after adjusting the quantity to be purchased), the product can and should be traded on an exchange. This makes trading much more efficient and liquid than it would be in a cumbersome bilateral market. Because the product is standard and financial, the market can and should include speculators—parties that do not own generation and do not need to hedge. They will sell financial obligations at a price somewhat above the expected cost of the pay-out they will have to make in case there actually is a shortage hour. The mark-up will cover their cost of risk.

But speculators will also buy hedging contracts from generators that want to hedge upside risk. These are generators that expect a reward in the case of a shortage hour, but would prefer a small sure payment (the price they are paid for selling the hedge to the speculator) in place of a small chance of a big reward. These generators do not want to risk “winning the lottery,” because they are risk averse. Since speculators can buy and sell, hedges, they will be exposed to much less risk for a given volume of hedges sold, and this will reduce the cost of hedging downside risk.

Most of the comments concerning the difficulties of a secondary market have implicitly assumed bilateral trading, non-standard contracts and difficulty in matching buyers and sellers. Fortunately, the product is easily standardized (in fact there is no reason to use a non-standard contract), and this makes bilateral trading unnecessary and indeed undesirable. This means there is no problem matching buyers and sellers. A party that needs 600 MW of hedge simply buys that amount form the exchange, and the exchange provides that by making purchases from any number of sellers without regard to whether they are near their cap, whether their generators are likely to be running, or even whether or not they own generation. Futures trading is so simple that financial institutions need to create artificial barriers to it, so that amateurs do not take on risk they do not understand.

Note that if one of the big six, say Company A, expects to produce more than its load share in a given period, then it can reduce its risk by selling hedges on the exchange. If, at the same time, smaller players are finding the market illiquid, this means the price for hedges is high. In this case Company A has a chance to get paid by smaller players for reducing its own (A's) risk. It is hard to believe that the price of hedges would go too high before someone would take advantage of this and clear the market. I think the reason some are afraid this would not happen is because they don't understand that upside risk is still risk and that Company A will reduce its risk by selling (not buying) a hedge. Risk is risk of losing more money than expected or gaining more money than expected.

One can imagine that something will go wrong with the exchange and the market will be less liquid than we would like. So far this has been blamed on the presence of caps. But caps cause no problem and simply remove the difficulty of needing a product that handles unlimited risk. Since the main reasons (based on caps) for suspecting illiquidity in secondary trading have shown to be groundless (above), serious consideration should be given to the possibility that other, less explicit, pessimistic arguments are similarly flawed. After all, penalties translate more readily into financial products than do pork bellies, and anyone can trade pork bellies.

Example 1: Hedging maintenance time without a cap

K=100, DRK=80, LS=100%, Out=100%, PrbS=50%, capRate=$1, penRate=$1, Hedge=(0 | 80)

- A generator has a derate factor of 80% and nameplate capacity of 100 MW. Suppose that the load-share factor is 100%. In this case, the generator will be rewarded at a rate R for "overproduction" above 80 MW, and penalized at the rate R for "underproduction" below 80 MW if there is a shortage hour.

- Suppose the generator will be out of service for a major repair for a certain time period and there is a 50% chance of one shortage hour and a 50% chance of no shortage hours during this period. The generator would like to hedge this risk.

- Suppose there is an exchange selling this hedging product for the outage time period: **Hedge Product:** If there is a shortage hour the owner will be paid £R, and £0 otherwise.

- If the generator does not hedge it will lose either £80R or £0. The expected loss will be £40R, and the standard deviation (SD) of that loss is £40R. The SD is a measure of risk, but it is not the risk premium because that depends on risk aversion, which we do not need to specify in these examples, because we only need to make relative comparisons for a given player, and the result will be the same for any level of risk aversion.

- But suppose the generator buys 80 units of the hedge product. In that case its loss will definitely be £0 with a SD of £0. So it is perfectly hedged. But the cost of that hedge will be roughly £40R because the seller of the hedge expects to pay that much on average.

- So the generator still has an expected loss of about £40, but the risk is gone.

Example 2: Naïve hedging with a cap

K=100, DRK=80, LS=100%, Out=100%, PrbS=50%, capRate=$0.5, penRate=$1, Hedge=(80)

- The same as example 1, except the soft cap has reduced the reward/penalty rate to R/2. Again the generator wants to hedge, but being naïve, buys exactly the same hedge.

- If there is no outage it will lose the cost of the hedge 80 × £R/2[1] = £40R. And if there is an outage, it will suffer a penalty of 80 × £R/2 = £40R, but be paid £80R by the hedge, and still need to pay £40R for the hedge. This comes to a ***loss*** of £40R − £80R +£40R = £0. So the expected loss (E) is (40+0)/2 = £20R and the SD is £20R (see spreadsheet for SD).

- From here on R is set to 1 for convenience.

- So without a cap the hedged generator faces a loss of (E=£40, SD=£0) (see Example 1), and with a cap it faces a loss of (E=£20, SD=£20). So which is better? Without assuming a value for risk aversion, we can find the answer by looking at the payoffs. Then the question is, which loss is preferred (£40 or £40) without a cap, or (£40 or £0£) with a cap. No matter what your risk aversion, you will prefer having a 50% chance of no loss to a 100% chance of a £40 loss. So you are much better off with a cap.

[1] This divide-by-two is because hedges only pay off half the time and not because the soft-cap divides the penalty by 2.

- Now why is this an example of “naïve” hedging? Because with half as much risk you should buy half as much hedging product, but the generator completely ignored this obvious point and did not by any less at all.

Example 3: Brilliant hedging with a cap

K=100, DRK=80, LS=100%, Out=100%, PrbS=50%, capRate=$0.5, penRate=$1, Hedge=(40)

- The same as example 2, but with perfect hedging. This time the generator buys only 40 units of the hedge product, at a cost of only £20R. So his loss will be either £20 if there is no shortage hour, or with a shortage, 40 (penalty) –40 (hedge payment) +20 (cost of hedge) = £20. So the expected loss is £20 and the SD is £0.

- So without a cap and with perfect hedging, the loss is (E=£40, SD=£0) and with a cap and with perfect hedging the loss is (E=£20, SD=£0). In other word the generator is perfectly hedged for half the cost. This is actually pretty obvious. The soft cap cut his risk in half so hedging the remaining risk costs half as much. Caps provide free hedging. That’s a “problem” generators can live with.

Summary of examples 1, 2 and 3.

- If the soft cap cuts the penalty in half, it cuts the risk of the penalty in half. If it is known that the penalty has been cut in half, the generator will simply buy half as much hedge and (when it’s out of service) be fully hedged for half the cost. If the generator is completely ignorant of the soft cap, it will buy too much hedge product but will still be much better off than if it were not capped. If the generator misestimates the effect of the cap it will end up somewhere between “much better off” and cutting its hedging costs in half. This is good for the generator.

Example 4: When hedging doesn’t work

K=100, DRK=80, LS=100%, Out=20%, PrbS=50%, capRate=$1, penRate=$1, Hedge=(0 | 20)

- The same as example 1, but the generator is open for business. It still has performance risk. It has a 20% chance of failure during the shortage hour. So it has a 20% chance of an £80 loss and an 80% chance of an £20 gain, for an expected reward of E = £0 in a shortage hour and an SD = £28.28 (see spreadsheet)

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- Notes that its chance of delivery exactly equals its derate times its nameplate, so its derate is exactly right at this time.

- Suppose it attempts to hedge its performance risk by buying 20 MW of the hedge product. Then its expected reward will still be £0. This is because we have assumed that the sellers of hedges are risk neutral and sell hedges at their expected cost. (We will discuss this assumption later.) In this case buying a hedge does not cost anything on average, so it does not change the expected reward, but it can change risk—and that is the point of a hedge.

- With a 20 MW hedge the SD of the net reward (or net penalty) is £30.00, which is slightly more than without the hedge. This hedge has increased the generator's risk. This is because penalties/rewards are assessed relative to the derate. This would be a bit hard to prove, but it can be easily checked with the spreadsheet.

- It also turns out that any other amount of hedging increases the generators risk—this can be tested with the spreadsheet.

- We will call this un-hedgeable risk "performance risk" and the risk in examples 1 – 3, "market risk."

What's the difference between "performance risk" and "market risk"?

- Think about a generator with a derate factor of 100%, and a system that is always short. Any time the generator breaks down, it is penalized. It would like to reduce this risk. The only contract that will do this is one that says "When you break down we will pay your penalty." This is very different than a contract that says "When there's a shortage hour we will pay the penalty on 1 MW of capacity." The first is an insurance contract and the second is a hedge contract. The difference is that an insurance contract has moral hazard. It depends on an event that the insured party can influence.

- If you insure your £100,000 house for £200,000 then you have an incentive to burn it down. This is moral hazard. Insurance companies worry about this a great deal and have staffs to investigate suspicious behavior and rules to avoid over-insuring. If you sold the above generator an insurance contract, you would worry that the plant operator would sleep in and let you pay for his losses. But if you sell that generator a hedging contract then you have no such worry. He can sleep in, and you suffer no damage. The problem is that the hedging contract won't reduce the generator's risk. Only an insurance contract can do that.

- We will define ***performance risk*** to be the risk than cannot be hedged in a market that sells hedging contracts. That's the risk we saw in example 4.

Example 5: When hedging doesn't work, a cap does

K=100, DRK=80, LS=100%, Out=20%, PrbS=50%, capRate=$0.5, penRate=$1, Hedge=(0)

- Same as example 4, but with a soft penalty cap that cuts the generator's penalty rate in half. This does not change the fact that the risk is pure performance risk, so there is no use in buying a hedge. But cutting the penalty in half obviously cuts the risk in half. So the cap, to the extent it binds, perfectly hedges performance risk. And it does this whether the generator is naïve or brilliant. It just works.

Example 6: Selling hedges without a cap

K=100, DRK=80, LS=50%, Out=20%, PrbS=50%, capRate=$1, penRate=$1, Hedge=(0, −40)

- Same as example 4, but the load-share factor is 50%. In this case the generator only needs to produce 50% of 80 MW to avoid a penalty. The result is that when there's a shortage hour, the generator has an 80% chance of a £60 reward and a 20% chance of a £40 penalty. But since a shortage hour only has a 50% chance of occurrence in the relevant time period, the expected reward is £20, and the SD is £34.64. As can be checked with the spreadsheet, selling 40 units of the hedge product will reduce the SD to £28.28, and this removes all market risk, leaving only performance risk.

- In other words the generator has, in effect, 80 MW of capacity, but only 40 MW is required to reach the break-even point from penalties and rewards, so by selling a hedge product of 40 MW, the generator returns to the sweet point, where its market risk is minimized. Exactly why this works in not transparent, but it can easily be checked with the spreadsheet.

- The important point here is that in the summer, generators that are running will want to sell hedges because they are over-hedged by the load-following rule. This increased supply of hedging product tends to keep the price down, even though generators that are off in the summer want more hedge than they normally would. These trades reduce the risk of both types of generators.

Example 7: Selling hedges with a cap

K=100, DRK=80, LS=50%, Out=20%, PrbS=50%, capRate=$0.5, penRate=$1, Hedge=(−20 | −40 | 0)

- Same as example 6, but there is a soft cap that reduces the generator's penalty rate by 50%. In this case, the generator's risk will be reduced from SD=£28.28 to SD=£14.14, which is not surprising. This assumes it's brilliant and sells half as much hedge. If it is naïve and sells the same amount, then its risk will only be reduced to SD=£17.32, which is almost as good. And if the generator is naïve in the other direction and sells no hedge at all, the SD will still be £17.32. So there is no need for the generator to be brilliant at evaluating the soft cap. If it does anything remotely reasonable, it will be hedged much better and at less cost with a cap than without one.

- Again, this is not surprising. The cap is a free hedge. In fact its better than a free hedge, it's a free combined hedge and insurance policy. The fear of penalty caps is no more sensible than thinking you don't want speeding ticket costs to be reduced by a slightly unknown amount because then you would suffer the risk of getting a speeding ticket of unknown cost. Don't worry; knowing it will cost less is all you need to know to like the idea.

Are we worried about generators that are over-hedged?

- Returning to Example 6, we find an over-hedged generator wanting to sell hedges. What is its risk? It has a 40% chance of a £60 reward, a 10% chance £40 penalty, and a 50% chance of no penalty (no shortage hour). The risk comes mostly from the upside. Instead of getting a dependable £20 (its expected income) it is quite likely to get too much upside.

- As a remedy, is sells 40 MW of hedge, which increases its downside risk from a £40 penalty to a £60 penalty, but decreases its upside risk more. The result is less total risk.

- This is all well and good, but upside risk it is not the sort of thing bankers worry about when they loan money. This means that when allowing speculators into the market, if we are worried they will cause trouble (which is unlikely) we could allow them to only ***sell*** hedges. That way they could only help those with downside risk, but they would have no way of cornering the market (unlikely) and causing trouble. And, we would not need to worry too much about those with a little extra upside risk. But this would place more risk on speculators, so there is a cost to this restriction and it is unlikely to be necessary.

Example 8: Extreme scenario - what if England is hit by an asteroid?

- One example that purports to show a risk from caps goes like this. What if almost all the generators but one or two hit their cap and none of the capped generators wanted to sell any hedges? Then the two uncapped generators could not buy hedges when they need maintenance. There are two answers to this puzzle. First, in a financial market, the speculators would be happy to sell these generators a hedge. Since it is easy to enter a financial market (no iron needs to be sunk in the ground) there should be plenty of competition and the price should be quite reasonable.

- Second, how could almost all the generators hit their cap? In a normal shortage hour the market is only a little short, say it has 50 GW when it needs 51. So the load shares of all generators will add up to 51 GW, and there will be shortfall of 1 GW, that is penalized. Suppose a normal year has 2 shortage hours. Now VOLL for two hours should be about CONE. And the cap at 2 × CONE could only be hit by almost-all generators after 50 GW × 4 hours of penalties, or 200 normal shortages hours. The other way for this to happen would be for an asteroid to knock all generators but two off line for a couple of hours (and not reduce load). Fortunately, the speculators would still take care of our un-hedged generators. No need to worry.

- Because, the average penalty is only about 1% or 2% of the maximum penalty, it is essentially impossible to have large numbers of generators hitting the cap, unless it is a very tight cap.

Do caps cause a non-homogeneous product?

- No. Lawyers will write down the definition of the products and everyone will trade them. Products will be differentiated by the time periods they cover, but capped generators will not need and will not get a different product.

Do caps favour portfolio players?

- No. In larger portfolios the rewards and penalties so nearly cancel out that there is essentially no chance of them hitting the cap. For small players, the chance is still small, but much greater. When they hit the cap, they benefit from a free reduction in risk and a free reduction in the expected cost of the penalty. Small players need caps more and get most of their benefit.

Do caps make the secondary market complex?

- No, they don't change the secondary market, except for the improvement of eliminating the need for hedges for unlimited risk. When a player nears the soft cap, it may want to estimate the reduction in how much it should hedge. This is not a very difficult calculation, but the answer will be uncertain. That uncertainty means its hedge will be slightly suboptimal, but the cap will provide a benefit even if this effect is completely ignored. In any case this won't happen much.

Do caps cause dangerous cash-flow mismatches?

- No. Without a penalty cap, penalties will slightly exceed rewards, so consumers will receive a small refund. Caps will tip the balance back the other way. The net flow could go in either direction, but this cost is no better or worse than the far larger cost of the capacity payment itself. Generators will take both into account when they determine their bids. If we save money by removing the cap generators will put consumers expected cap savings (and their expected loss) into their bids and this will eliminate our savings from removing the cap. Moreover, risk will rise substantially and consumers will be charged for that as well. Caps unequivocally save consumers money unless they are much stronger than contemplated and significantly distort the dispatch. We are nowhere near this balancing point.

What if the hedge product has unlimited risk?

- One can imagine a hedge product that covered all the shortage hours that occur in a given time period, perhaps over the summer. This would pay (shortage hours) × (penalty rate) per MW of product. The seller of such a product, could in principle, be liable for 1000h × £10,000/MWh = £10M/MW — essentially an unlimited liability.

- Without a cap, there would be some call for such a product because generators would be subject to unlimited liability. Even so it is unlikely that any such product would be traded, and is absolutely certain that limited liability products would be traded. So the use of such a product would be completely optional.

- Fortunately, a penalty cap will eliminate the need for such a product. No one would buy a product to hedge 1000 shortages hours, when they would hit their cap in 10 hours. Once again, caps improve the secondary market.

Will participants seize arbitrage opportunities?

- First of all, arbitrage is a good thing. That's what traders do. Traders buy where the price is low and sell where it's high, and this aligns the prices, which reduces arbitrage profits and increases the benefits to those selling to and buying from the traders. But never mind economics, the real point is that the arbitrage opportunities between capped and uncapped are no different than those between running and resting generators in the summer.

- The point of the secondary market is to let these players trade. They will make their bids and offers and there will be a clearing price and that's that. Big generators doing repairs will buy a lot. Big generators running in the summer will sell a lot. Little generators will buy and sell a little. Capped generators will buy and sell less than identical uncapped generators. This is just how normal markets work.

What price will hedges sell for?

- The first approximation is the expected payout. If you sell a 1 MW hedge and there is a 10% chance of paying out £10,000, then you will want to be paid about £1,000, just to cover your ***expected*** out of pocket costs. But, as we have seen in the examples above, selling the hedge might increase your risk or decrease your risk. So you might want to charge a bit more, or be willing to sell for a bit less. Since we should normally have a rough balance between buyers and sellers, and since being a little over or under-hedged has only a very small (second order) effect on your risk (try this in the spreadsheet), the price should stay fairly close to the expected value.

- Speculators (no this is not pejorative, its just what we call those who are not in the game to reduce their risk) should be able to diversify their risk very well, since shortage hours will be uncorrelated with most investments, such as the stock market. Also a number of parties should be able to speculate in this market, so it should be quite competitive. So, even speculators should not charge too much.

So will a simple financial hedging market really work?

- It should. But whether or not it does will have little to do with caps, and to the extent they affect the operation of the market it will be to simplify the products by limiting the number of shortage hours that need to be hedged. Caps will make a secondary market work slightly better.

- The best chance for success will be if there is a single exchange trading the smallest set of products that will do an adequate job. These will not take into account whether a generator is capped, or what its derate is, or anything else specific to any generator. (A real hedging product will base payoffs on the load-share factor, and this will make them work better. This is a simple change in the product definition.)