Methods to manage capacity constraints

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1. Imagine an area of the country with about 200MW of business electricity demand served by a distribution system with a secure capacity of 100MW.

2. In the past, diversity of demand had been such that there was no capacity constraint. But growth has now led to a situation in which demand at peak time would be 120MW, more than the network's secure capacity, unless something is done.

3. The peak time period is 1,000 hours a year. The relevant costs are as follows:

   (a) The long-run cost of the distribution system of interest is estimated at £25/kW/year. Allocated to peak-time use, this would lead to a distribution charge of 2.5 pence per peak-time kWh.

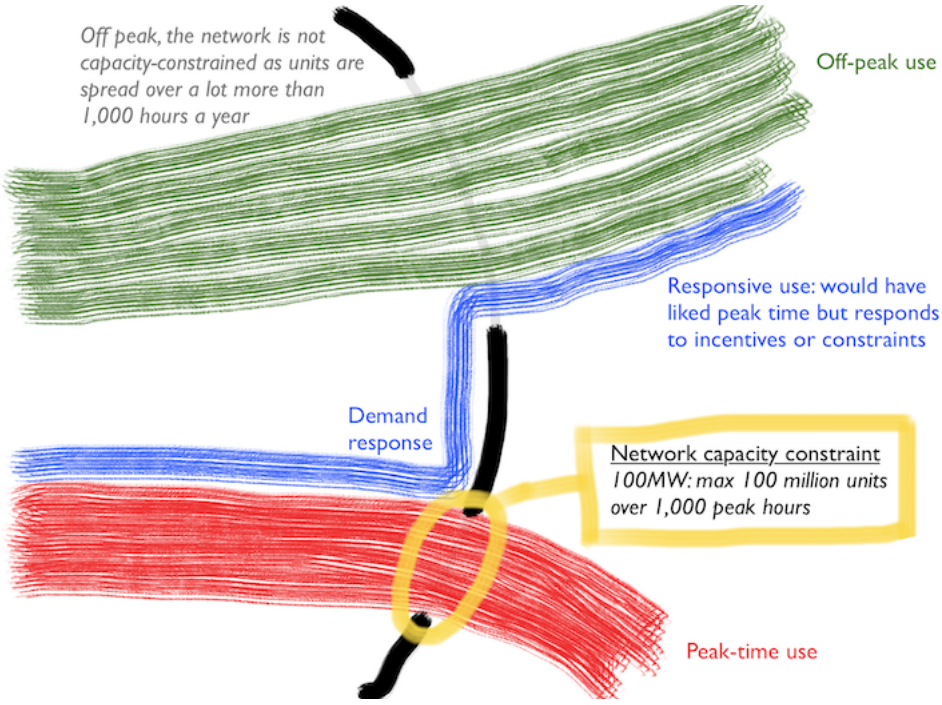
   (b) The charges for energy, levies and the rest of the electricity transmission and distribution system come to 6 pence per kWh off-peak and 7.5 pence per kWh at peak time.

4. Without capacity constraint management, the prices would therefore be 6p/kWh off-peak and 10p/kWh at peak time: a 4p/kWh premium for peak-time consumption.

5. The total demand is 250 million units a year, and the most relevant form of demand response is to shift between peak and off-peak consumption.

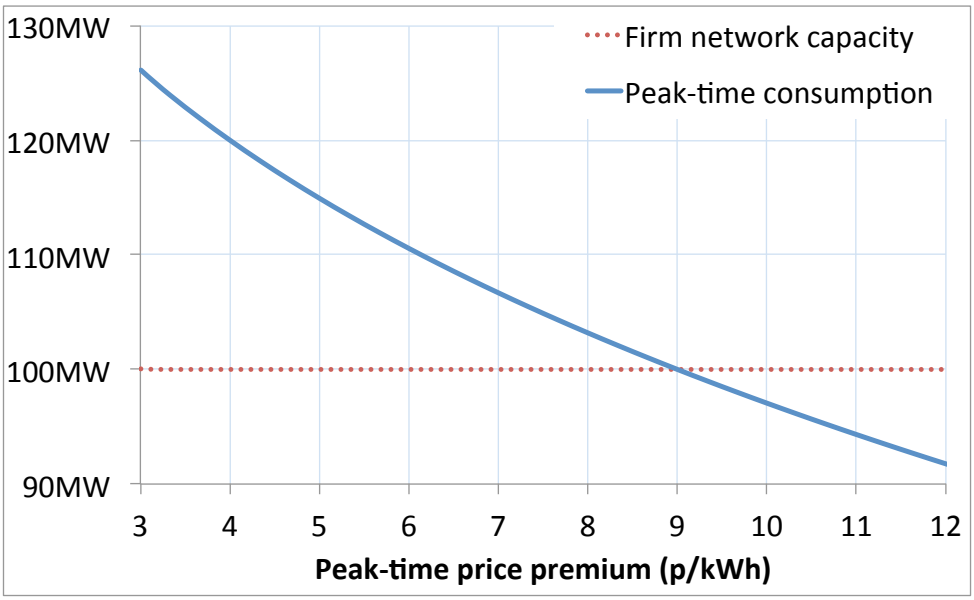
6. Figure 1 provides an illustrative visualisation.

Figure 1 Visualisation of capacity constraint and demand response



7. Figure 2 shows the demand curve for shifting demand away from peak-time use.

Figure 2 Peak-time demand curve



Quantification of the need for constraint management

8. The main implications of the demand curve in figure 2 are as follows.

9. Without constraint management, peak-time consumption of 120MW would exceed the firm network capacity.

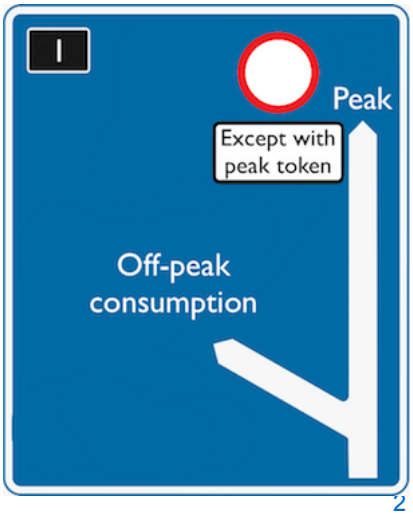
10. Of the total consumption of 250 million units a year, 130 million units will voluntarily occur off peak, as only 120 million units a year have a willingness to pay for the peak which is more than the cost difference of 4p/kWh.

11. The capacity constraint management method needs to shift 20MW, or 20 million units a year (over 1,000 peak hours a year) out of the peak time band. If done through pricing, this requires an additional 5p/kWh price differential, bringing the peak-time premium to 9p/kWh.

Option 1: Administrative capacity management

12. Option 1 is an administrative method whereby the prices remain at 6p/kWh off-peak, 10p/kWh peak, and a non-price method limits peak-time consumption to 100MW.

13. The non-price capacity management method could be, for example, a first-come-first-served queue-based regime, a lottery, or a system of tradable capacity rights or tokens.

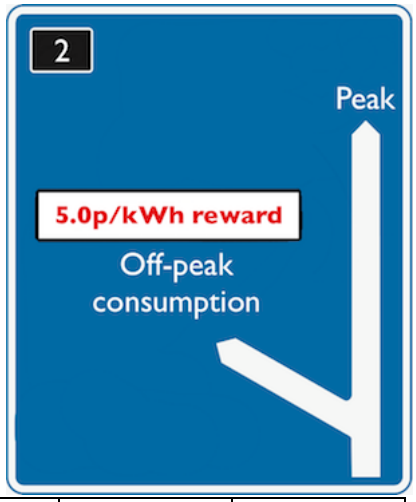


14. Table 1 shows the main financial characteristics of the outcome under option 1.

Table 1 Impact of administrative capacity management

Paid by voluntary off-peak consumption	130GWh	6.0p/kWh	£7.8m
Paid by consumption constrained to off-peak	20GWh	6.0p/kWh	£1.2m
Paid by peak-time consumption	100GWh	10.0p/kWh	£10.0m
Received by distribution system for peak units	100GWh	2.5p/kWh	£2.5m
Net revenues of 100MW distribution system operator			£2.5m
Value added by energy supply and demand response services			£19.0m

Option 2: Uncompensated demand response



15. Option 2 involves the operator of the 100MW distribution system running an auction to purchase 20MW of peak-time demand reduction.

16. Given the demand curve, the auction clearing price would be 5p/kWh, for a volume of 20 million units.

17. Table 2 shows the main financial characteristics of the outcome under option 2.

Table 2 Impact of uncompensated demand response

Paid by voluntary off-peak consumption	130GWh	6.0p/kWh	£7.8m
Paid by consumption constrained to off-peak	20GWh	6.0p/kWh	£1.2m
Received by consumption constrained to off-peak	20GWh	5.0p/kWh	£1.0m
Paid by peak-time consumption	100GWh	10.0p/kWh	£10.0m
Received by distribution system for peak units	100GWh	2.5p/kWh	£2.5m
Paid by distribution system for demand response	20GWh	5.0p/kWh	£1.0m
Net revenues of 100MW distribution system operator			£1.5m
Value added by energy supply and demand response services			£20.0m

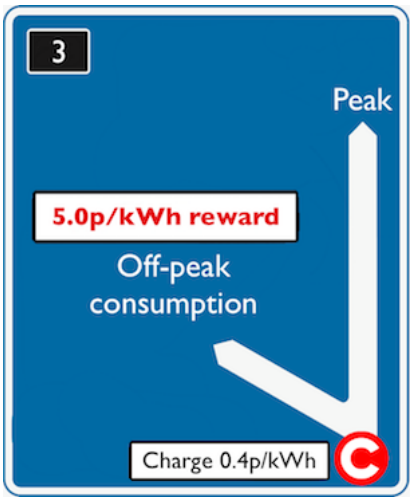
18. One interesting feature of option 2 is that it increases the aggregate value added provided by energy supply and demand response services, by recognising the

economic value (£1 million a year in this case) of the demand response service provided by customers to the distribution system operator as a separate counter-flow of value from the distribution and supply of electricity.

19. Under option 1, this value was not visible to the distribution system operator. The value might have been lost altogether, if a strict lottery or first-come-first-serve method of capacity rationing was in place and if those who had the right to use the capacity were not the ones who valued it the most.

20. But even under option 1 the value of demand response could have been captured elsewhere, in a decentralised manner. For example, if a system of tradable capacity tokens had been used as the administrative capacity management method under 1, then demand response services might have been provided by some customers to other customers through the sale of capacity tokens.

Option 3: Demand response compensated by a flat charge



21. Option 3 builds on option 2 by adding a flat charge on all consumption to compensate the operator of the 100MW distribution system for demand response costs.

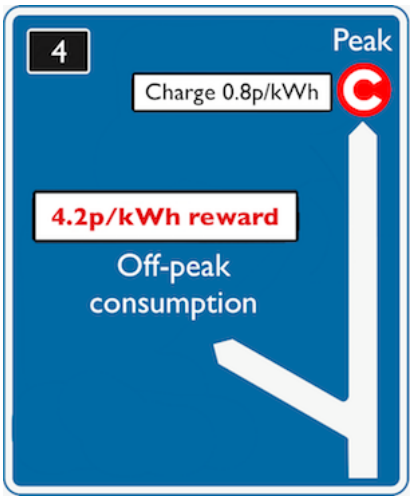
22. The charging rate required to recover the costs of demand response is 0.4p/kWh.

23. Table 3 shows the main financial characteristics of the outcome under option 3.

Table 3 Impact of demand response compensated by a flat charge

Paid by voluntary off-peak consumption	130GWh	6.4p/kWh	£8.3m
Paid by consumption constrained to off-peak	20GWh	6.4p/kWh	£1.3m
Received by consumption constrained to off-peak	20GWh	5.0p/kWh	£1.0m
Paid by peak-time consumption	100GWh	10.4p/kWh	£10.4m
Received by distribution system for peak units	100GWh	2.9p/kWh	£2.9m
Received by distribution system for off-peak units	150GWh	0.4p/kWh	£0.6m
Paid by distribution system for demand response	20GWh	5.0p/kWh	£1.0m
Net revenues of 100MW distribution system operator			£2.5m
Value added by energy supply and demand response services			£21.0m

Option 4: Demand response compensated by a peak-time charge



24. Option 4 is a variant of option 3 whereby the demand response cost recovery charge applies only to peak-time use of the 100MW distribution system.

25. By increasing the differential between peak and off-peak charges, this recovery method reduces the demand response auction clearing price.

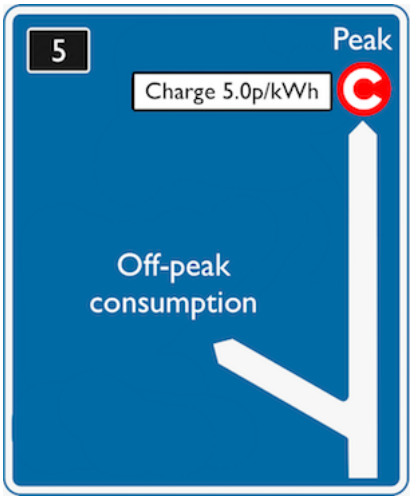
26. Solving the system of equations gives a peak-time compensation charge of 0.8p/kWh, and a demand response price of 4.2p/kWh.

27. Table 4 shows the main financial characteristics of the outcome under option 4.

Table 4 Impact of demand response compensated by a peak-time charge

Paid by voluntary off-peak consumption	130GWh	6.0p/kWh	£7.8m
Paid by consumption constrained to off-peak	20GWh	6.0p/kWh	£1.2m
Received by consumption constrained to off-peak	20GWh	4.2p/kWh	£0.8m
Paid by peak-time consumption	100GWh	10.8p/kWh	£10.8m
Received by distribution system for peak units	100GWh	3.3p/kWh	£3.3m
Paid by distribution system for demand response	20GWh	5.0p/kWh	£0.8m
Net revenues of 100MW distribution system operator			£2.5m
Value added by energy supply and demand response services			£20.6m

Option 5: Surge pricing with income retained



28. Under option 5, consumption is forced out of the peak by the application of a premium "surge" price to all peak use, rather than by administrative means or a demand response auction.

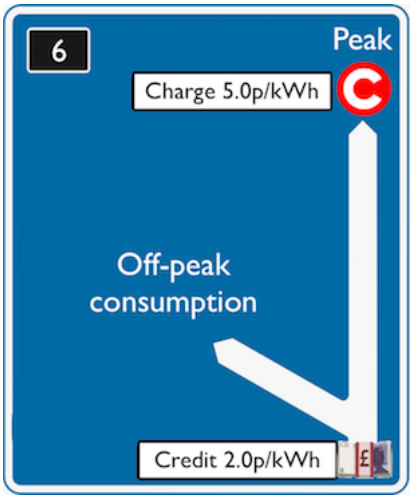
29. Given the demand curve, the surge price needs to be at a 5p/kWh premium over costs to comply with the network capacity constraint.

30. Table 5 shows the main financial characteristics of the outcome under option 5.

Table 5 Impact of surge pricing with income retained

Paid by voluntary off-peak consumption	130GWh	6.0p/kWh	£7.8m
Paid by consumption constrained to off-peak	20GWh	6.0p/kWh	£1.2m
Paid by peak-time consumption	100GWh	15.0p/kWh	£15.0m
Received by distribution system for peak units	100GWh	7.5p/kWh	£7.5m
Net revenues of 100MW distribution system operator			£7.5m
Value added by energy supply and demand response services			£24.0m

Option 6: Surge pricing with income recycled through a flat credit



31. Option 6 builds on option 5 by providing for excess income from surge pricing to be returned by the distribution system operator as a credit against other network or energy costs.

32. The credit rate is 2p/kWh (£5 million spread on 250 million units).

33. Table 6 shows the main financial characteristics of the outcome under option 6.

Table 6 Impact of surge pricing with income recycled through a flat credit

Paid by voluntary off-peak consumption	130GWh	4.0p/kWh	£5.2m
Paid by consumption constrained to off-peak	20GWh	4.0p/kWh	£0.8m
Paid by peak-time consumption	100GWh	13.0p/kWh	£13.0m
Received by distribution system for peak units	100GWh	7.5p/kWh	£7.5m
Paid by distribution system as a credit on all units	250GWh	2.0p/kWh	£5.0m
Net revenues of 100MW distribution system operator			£2.5m
Value added by energy supply and demand response services			£19.0m

Summary of impact

34. Table 7 summarises the impact of the six options outlined above.

Table 7 Summary of impact

	Income of 100MW DSO	Peak-time charge p/kWh	Off-peak p/kWh (passive)	Off-peak p/kWh (responsive)	Value added overall
Option 1	Administrative capacity management.				
	£2.5m	10.0	6.0	6.0	£19.0m
Option 2	Uncompensated demand response.				
	£1.5m	10.0	6.0	1.0	£20.0m
Option 3	Demand response compensated by a flat charge.				
	£2.5m	10.4	6.4	1.4	£21.0m
Option 4	Demand response compensated by a peak-time charge.				
	£2.5m	10.8	6.0	1.2	£20.6m
Option 5	Surge pricing with income retained.				
	£7.5m	15.0	6.0	6.0	£24.0m
Option 6	Surge pricing with income recycled through a flat credit.				
	£2.5m	13.0	4.0	6.0	£19.0m