Designing Markets for Ancillary Services

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- Work with Seungwan Kim and colleagues at Seoul National University to TSO-DSO contracts.

Topics

- Good auction design
- National Grid’s (NG) current auction designs
- Suggested auction design for frequency response
- Contract design for DSOs with respect to balancing

GB Balancing Services 16/17

- Total expenditure £1127m
- (£843m 15/16; £821m 14/15)
- (c. 7% of wholesale power costs)
- Of which:
- Frequency response £174m
- (£178m 15/16; £176m 14/15)
- Reactive power £86m
- (£72m 15/16; £70m 14/15)

Source: Monthly Balancing Services Summary, April various years, National Grid.

Good auction design

Guidelines for designing a good auction

According to Klemperer (2002) auctions should:

- Attract entry.
- Prevent collusion.
- Prevent predatory behaviour.

According to Ausubel and Cramton (2011) auctions should:

- Enhance substitution (distinguish the lots from each other).
- Encourage price discovery (of interest if descending).
- Induce truthful bidding.

Second price auctions better than pay-as-bid.

In general should always aim to:

- Welfare maximise if a public good.

NG's current design

Examples of NG Procured Services

NG procure some 30 products (ENA, 2017, p.36-37) for ‘reserve, frequency management, voltage management and other capability’.

NG-Product	Feature	Mechanism	Conducted
Frequency Response			
Firm Frequency Response, (FFR)	Primary: Response within 10s, duration at least 20s Second: Response within 30s, duration at least 30s High: Response within 10s, duration is indefinitely	Pay-as-bid	Monthly
Enhanced Frequency Response	Response within 1s, duration at least 15s	(Pay-as-bid)	Annual
Reactive			
Reactive Power	Voltage control	Pay-as-bid	Every 6 months

Problems of current design(s)

The System operator's (SO) utility function

1. SO does not have a utility function for the product offered – need a better tool to manage the network.
2. SO is not allowed to express complex and consistent preferences to balance the system.

The products offered/mechanism design

1. Why 1s, 10s or 30s products and not 1/2s product etc for frequency response.? Let the market reveal these.
2. Failure to simultaneously clear interrelated markets.
3. Does not allow for package bidding, miss out the opportunity to gain from cost synergies.
4. Not based on social welfare, even if delivery and reliability are referred to as a public good.
5. Does not incentive truth-telling about cost or efficiency, i.e. the chosen allocation that maximises total value across bidders.

Exchange rate between products

- NG does have a preference for the products for sale
- These are exchange rates.
- Still need to anchor one value (say max willingness to pay for 1 MW of PFR), to get a u-function.

Table 1:	Baseline	Narrow	Wide
EFR (MW)	-	200	200
Primary (MW)	2,800	2,145	1,970
Secondary (MW)	1,170	970	970

Source: National Grid (2016a)

Opportunities for package bidding?

- Potentially between EFR, PFR and SFR.
- But also between EFR, PFR.
- Also between voltage products (e.g. at the transmission level vs voltage at the distribution level) which are currently ill defined. (Power Potential NIC Project)

Suggested design for frequency response

The features of our design

- SO is part of the auction process by submitting a 'complex bid', a utility function.
- Bidders submit bids on all products at the same time.
- Bidders are allowed to submit package bids; either a bidder gets its desired products or not, can benefit from benefit cost synergies.
- It is based on social welfare.
- It is a Vickrey-Clark-Groves (VCG) mechanism - the allocation (vectors) and payment rules are of interest.
- It is set to deliver the optimal length of response time.

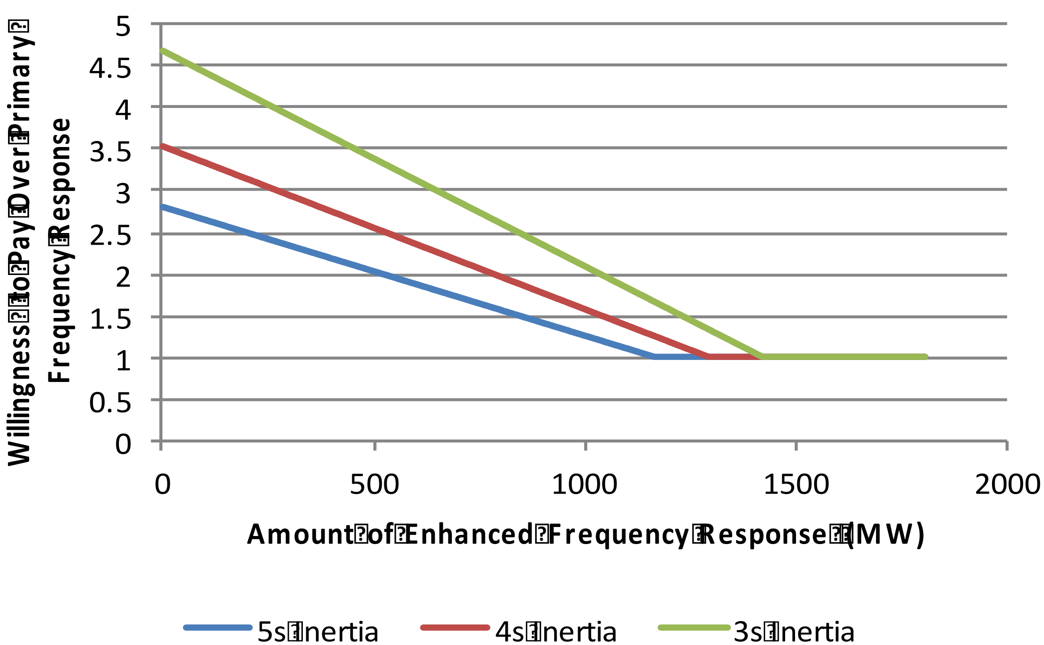
- The auctions we discuss are for half hourly frequency response products (i.e. real time system condition reflective), however they could be used in long-term contract markets.

Utility function - Methodology

Fixed demands, different inertia

MW delivered within 1 second, for minimum of 9 seconds.

Figure 3: WTP for EFR under 40GW system demand



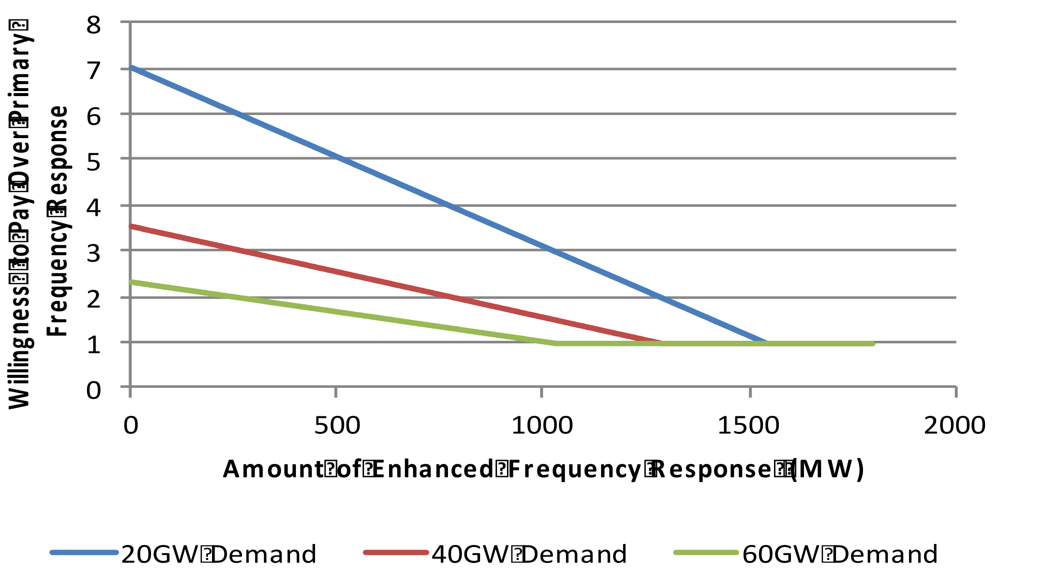
Modelled exchange rates, source: Greve et al, 2017.

Utility function - Methodology

Different demands, Fixed inertia

MW delivered within 1 second, for minimum of 9 seconds.

Figure 4: WTP for EFR under 4s system inertia



Modelled exchange rates, source: Greve et al., 2017.

Examples of basic auction design concept: Example with one winning bidder

Suppliers offer different combinations of quantities and response times.
e.g. 3 MW of 1s response (denoted as '1 and 1 and 1').

Table 9: Submitted bids for packages of licences

Supplier	Response time (s)	Bids (£/hour)
1	1 and 1 and 1	17.2
	10 and 10 and 10	12.3
	1 and 1	11.8
	10 and 10	8.9
2	1 and 1 and 1	17.0
	10 and 10 and 10	11.9
	1 and 1	10.7
	10 and 10	9.3

Example 1: with one winning bidder
Different packages offered, auction clears, reveals less faster response

Table 10: Welfare effect

Response time (s)	SO (£/hour)	Supplier 1 (£/hour)	Supplier 2 (£/hour)	Welfare effect (£/hour)
1 and 1 and 1	25.2	17.2	17.0	+8.2
10 and 10 and 10	20.5	12.3	11.9	+8.6
1 and 1	20.1	11.8	10.7	**+9.4**
10 and 10	15.9	8.9	9.3	+7

Table 11: Welfare effect, without the winner

Response time (s)	SO (£/hour)	Supplier 1 (£/hour)	Welfare effect (£/hour)
1 and 1 and 1	25.2	17.2	+8
10 and 10 and 10	20.5	12.3	+8.2
1 and 1	20.1	11.8	**+8.3**
10 and 10	15.9	8.9	+7

Result: Winner (Supplier 2) receives £11.8, for delivering 2 MW of 1s response.

Example 2: with one winning bidder
Bids for slower response go down, auction reveals more slower response

Note: Only change in Table 12 from previous is a reduction in bids on '10 and 10 and 10'.

Table 12: Welfare effect

Response time (s)	SO (£/hour)	Supplier 1 (£/hour)	Supplier 2 (£/hour)	Welfare effect (£/hour)
1 and 1 and 1	25.2	17.2	17.0	+8.2
10 and 10 and 10	20.5	11.7	11.0	**+9.5**
1 and 1	20.1	11.8	10.7	+9.4
10 and 10	15.9	8.9	9.3	+7

Table 13: Welfare effect, without the winner

Response time (s)	SO (£/hour)	Supplier 1 (£/hour)	Welfare effect (£/hour)
1 and 1 and 1	25.2	17.2	+8
10 and 10 and 10	20.5	11.7	**+8.8**
1 and 1	20.1	11.8	+8.3
10 and 10	15.9	8.9	+7

Result: Winner (Supplier 2) receives £11.7, for delivering 3 MW of 10s response.

Contract design for DSOs with respect to balancing

DSO role in ancillary services

- Now the issues are:
  - – Increased requirements for ancillary services
  - – Decline in supply from large power plants
  - – New distributed energy resources (DER) available
  - – Quality issues with DERs vs large scale providers
  - – Complexity of optimally dispatching small DERs
  - – Managing TSO-DSO relations in service provision
    - ‘boots on ground’ vs ‘techie skills’
    - Co-ordination vs competition
    - Nature of economies of scale and scope
  - – Same problem in many jurisdictions (e.g. SEM (2013); CPUC,16; NYISO,17)

TSO – DSO relations with DSO responsibility for ancillary services (Kim et al., 2017)

- Set up: single TSO, multiple DSO areas.
- Easy to show, cost-causality based cost allocation scheme (CC-CAS) is superior to the current area energy-amount based cost allocation scheme.
- Fairly allocates DSO system balancing cost among multiple DSOs based on the cost-causality principle.
- Problem is that decentralisation is risky as DSO share of total balancing costs may be more variable.
- We propose an optimal balancing payment insurance (BPI) contract sold by the TSO which helps DSO hedge the risks associated with uncertain balancing payments.

Conclusions

Concluding thoughts

- Ancillary services (A/S) product definition needs to be clarified, too many ill-defined products.
- SO needs to justify procurement quantities and express trade-offs transparently.
- Opportunities for gaming system may well exist and be increasing as the products become more important, especially if lack of penalties for creating A/S demand.
- Optimal contracts not currently clear because of the uncertain nature of the counter-party to the SO.
- DSO-TSO conflicts need to be resolved as DSOs increase their relative ability to supply A/S.

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Comparison of current procurement and Greve et al, 2017.

Feature	Why asking for this feature?	NG's design	Our design
Can auctioneer submit an utility function?	Auctioneer can better manage the network	No	Yes
What is for sale?	setup	MW of 2 min response	1 licence of 1 MW
What is submitted?	setup	MW, availability, prices, contract length	A price per response time per licence
How are bids submitted?	stup	Sealed-bids	Sealed-bids + vector bidding
Design	setup	First-price sealed-bid	VCG mechanism
Package bidding across products allowed?	Utilities can minimise cost	No	Yes
Information revealed?	To ensure the desired MW	No	The auctioneer's utility function
Is the format based on welfare?	Delivery and reliability is a public good	No	Yes (optimal length of delivery time)