A system operator's utility function for the frequency response market

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Thomas Greve, Fei Teng, Michael Pollitt, Goran Strbac

National Grid (NG) is the system operator (SO) in Great Britain (GB) and therefore, it is responsible for the reliability and security of the grid. It procures ancillary services for use in the everyday operation of the grid, such as reserve and frequency response, to avoid blackouts, interruptions and to manage peak demand. For instance, to deal with sudden generation loss, NG uses services like primary frequency response (PFR), which requires a supplier to deliver response in 10 seconds (10s), and the newly designed enhanced frequency response (EFR), which is a service to deliver in 1 second (1s).

To ensure the reliability and efficiency of the system, the SO needs the right services to be delivered. However, what are the right services? A SO might have chosen to work with a 1s service, 10s service and/or 1 hour service. Why not a 0.5s service or a guaranteed delivery in 13s? Current services may have been of interest to the majority of suppliers, maybe the bigger ones, maybe they were the right services some years ago. The selling mechanism needs to be able to test the market for the right services at each allocation procedure.

Just as the suppliers want to maximise their own outcomes, a SO wants to balance the system. The current market design does not allow the SO to express complex and consistent preferences to balance the system. What the SO needs is an opportunity to express preference/willingness to pay (WTP). One way is to allow it to submit a utility function for the market to react on.

This paper presents a utility function of a SO. The function was created with GB in mind, but the idea can be applied to all countries. It connects two frequency response services (PFR and EFR) into one function and places monetary values on each of the services. It is built up in different scenarios, including different levels of demand and inertia. To simplify the analysis, we show that the exchange rate between PFR and EFR is 1.3 if demand is 60 GW, inertia is 4s and we expect to have 500 MW of EFR available in the system. In other words, if the value of 1 MW/h of PFR is £8.2, then the price of 1 MW/h of EFR is 1.3 times greater than £8.2, hence, £10.7. In another case where demand is 40 GW, inertia is 3s and we expect to have 500 MW of EFR available, the exchange rate is 3.5.

We then show, with examples, how the utility function can be applied in a two-sided Vickrey-Clarke-Groves (VCG) mechanism to sell ancillary services. In general, it can be specified with respect to multiple packaged services over a range of quantities. We apply the utility function in the VCG mechanism to show how our mechanism can let the market determine the type and quantity of very fast response that might be needed for ancillary services. This would allow the market, rather than the SO, to determine the prices and quantities of very fast frequency response to procure. This would allow the SO to market test the ability to deliver of new frequency response providers, such as electrical energy storage facilities.

Contact Thomas Greve, tg336@cam.ac.uk
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