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Dear recipient

Our comments below are in response to the question of future energy

https://www.gov.uk/government/consultations/national-infrastructure-commission-call-for-evidence/national-infrastructure-commission-call-for-evidence

1. What changes may need to be made to the electricity market to ensure that supply and demand are balanced, whilst minimising cost to consumers, over the long-term?

The electricity market allows benefits to accrue to different stakeholders in a seemingly fragmented way resulting in the 'broken value chain' problem. This is especially relevant in constraining smart grid development. An independent system operator can be influential in deciding when and how to use flexibility (DSR – Demand Side Response) for system balancing vs local network congestions. All existing actors will want to guard their own benefits whereas an independent body might ensure maximisation of overall system benefits. Risk evaluation cannot be conducted easily for all actors in the current regime and risks can be taken blindly leading to uncertain investment outcomes.

Large scale batteries are too expensive and frequency support for batteries applies not for DNOs but for large scale renewable generators but because they pay for connection capacity. This effectively doubles the amount energy they can sell[1], see for example. Energy storage particularly at micro level is very expensive although it avoids distribution costs. Renewable generators might benefit from energy storage, for example for large PV operators in northern England.

- What role can changes to the market framework play to incentivise this outcome:

[1] Koch, S. "Assessment of Revenue Potentials of Ancillary Service Provision by Flexible Unit Portfolios" in Energy storage for smart grids", editors Du and Lu.

- Is there a need for an independent system operator (SO)? How could the incentives faced by the SO be set to minimise long-run balancing costs?
- Is there a need to further reform the “balancing market” and which market participants are responsible for imbalances?

Regulatory changes allowing energy storage would help DNOs. It would help to better regulate the use of energy storage by DNOs by resolving constraints (e.g. overloaded assets, frequency problems and disconnect DNO from energy market) and for TSO (Transmission Service Operator – National Grid) balancing purposes. The TSO has a larger interest and so can draw from broader geographical range. The DNO would be using storage to resolve problems in local areas. There would need to be rules prioritizing between DNOs and TSO.

Engaging in and purchasing energy, charging and dis-charging at different price points, is not supposed to happen but does and leads to profit-making. Current policy is to segregate the market and to have non-overlapping load for each player.

- To what extent can demand-side management measures and embedded generation be used to increase the flexibility of the electricity system?

Flexibility is the ability to accommodate unexpected demand and supply in the short term, see Lund et al (2015)[2]. The Falcon project suggests that DSR does not improve flexibility. Similar findings are suggested by the Smart Networks work-stream 7 project. DSR does not create capacity. Traditional reinforcement for example creates capacity.

Two approaches to building capacity are possible thereby creating flexibility. First, an evolutionary approach is suggested in Falcon to deal with adaptation and increase flexibility. Starting with the current network and modifying it using new approaches based on comparison of value to existing approaches, adopting the fittest solution, allows the network to evolve. Second, a top-down planning approach can be taken, starting with an aspiration targets, such as 2050 carbon targets, and then back-casting, or forward-planning to reach the end point/goal. For example CASCADE plans for 2050 targets by increasing renewable penetration thus meeting anticipated demand for electric vehicles (EV) and heat pumps, etc.

Flexibility is needed because in an electricity system especially in an energy system with renewables meeting base load, peak demand would be at different points from peak generation. It may be possible to de-charge car batteries in the day to create flexibility but the electricity charging infrastructure would need upgrades for de-charging, e.g. 3.7 lithium ion 2.5 to 4.2 depending on state of charge, 36-96V - close to sequential batteries, so power electronics quite expensive. A decay in the state of charge of battery 5% per day for lithium

[2] Peter D. Lund, Juuso Lindgren, Jani Mikkola, Jyri Salpakari, Review of energy system flexibility measures to enable high levels of variable renewable electricity, Renewable and Sustainable Energy Reviews, Volume 45, May 2015, Pages 785-807, ISSN 1364-0321, http://dx.doi.org/10.1016/j.rser.2015.01.057.

ion is suggested, and efficiency would decrease with the distance travelled from de-charging to use.

Embedded generation such as PV, Combined Heat and Power (CHP), or diesel provide short-term assistance. On a daily basis it could be 10-20 times more expensive than traditional approaches. The problem is with reliability. Embedded generation could compete against traditional re-enforcement provided there are strict reliability controls, to provide “n-1” functionality above 1MW. If customer has more than 1MW capacity, then should be able to supply to the customer. The implications for the regulator in operator mode is that networks need to be over-designed. “n-1” is probabilistic, and so may not happen for years but the system needs to cope in the event it occurs. If distributed generation is present the DNO is not paying for it and it is possible to use the capacity of firms to cope with “n-1” and specific voltage over-loading conditions, but both are very rare. Contracts would be needed with social infrastructures, such as hospitals, and with businesses. Even with contracts, reliability would be a problem. Testing would be needed not only of the hardware but of the links and networks to companies. Falcon found only 50% despatch reliability and in the second phase of published trials with one week advance notice to predict when generation needed results 90+% reliability.

DSR at the distribution level is challenging as there is minimal industrial participation. There are no mechanisms in place, manual, contracted, nor automated. There is the potential for some UPS aggregation providing potential business opportunities.

2. What are the barriers to the deployment of energy storage capacity?

- Are there specific market failures/barriers that prevent investment in energy storage that are not faced by other ‘balancing’ technologies? How might these be overcome?
- What is the most appropriate scale for future energy storage technologies in the UK? (i.e. transmission network scale, the distributed network or the domestic scale.)

A key issue is that currently DNOs are not allowed to own storage because storage is defined as generation. The regulatory framework needs to change. However, would storage at the DNO scale be best placed for national system balancing or to resolve network congestions at local level? To overcome the national balancing problem, city or region balancing could be considered especially as meso-level solutions such as the Swansea 320MW tidal barrage come on line with improved predictability of renewables contribution. Trading could occur between lower scale operators who have excess capacity which can be sold to the market.

3. What level of electricity interconnection is likely to be in the best interests of consumers?

- Is there a case for building interconnection out to a greater capacity or more rapidly than the current ‘cap and floor’ regime would allow beyond

2020? If so, why do you think the current arrangements are not sufficient to incentivise this investment?

- Are there specific market failures/barriers that prevent investment in electricity interconnection that are not faced by other ‘balancing’ technologies? How might these be overcome?

Given the expectations concerning the future generation portfolio, the growth in electricity demand and a CO_2 price, the cross-border transmission capacity expansion by 2025 expected by ENTSO-E will reduce dispatch costs by 1%. However, the impact of cross-border transmission investment on the electricity bills of the European consumers will depend on the impact of the investment on electricity prices (not necessarily related to dispatch costs) and on the capital costs of such investment.

A higher renewable energy sources penetration causes higher variability in the supply curve and therefore increases the demand for arbitrage in the system. In a future generation scenario with doubled wind and solar installed generation capacities than expected by ENTSO-E, the demand for hydro pumping decreases with higher cross-border transmission capacity. The reason for this behaviour is that cross-border transmission and pumped hydro storage are partly substitutes. Cross-border transmission can spread fluctuations in supply geographically, thereby reducing the impact per system, but because it does not offer inter-temporal arbitrage its potential to flatten residual load is limited.

The expected expansion of cross-border transmission capacity by 2025 has a limited impact on unserved load in the face of the expected low growth rate of electricity consumption in Europe (0.9%). However, if demand grows at the historical rate of 2%, the expected development of cross-border transmission will be needed to maintain the current level of security of supply in 2025 by avoiding 20 TWh of unserved load in Europe. Moreover, statistics of 18 European countries since 2002 show that as the normalised sum between remaining margin and import capacity increases, the frequency of major fault events in a European network between 2002 and 2011 decreases considerably.

4. What can the UK learn from international best practice in terms of dealing with changes in energy technology when planning to balance supply and demand?

In countries with high renewables penetration, such as Germany with close to 30% of power on an average basis, some peak days, solar and wind supplied close to 80% of peak power demand at specific times of the day. In the near future, the UK is targeting a 20% average share by 2020 and a 50% average share by 2030.

The most important reasons on why Germany has a stronger position to accomplish EU goals are: (1) the existing strength of its power grids; and (2) flexible operation of coal and nuclear plants (and to a lesser extent gas and pumped hydro). In addition, Germany has managed quite well because of: (3) better design of the balancing (ancillary) power markets, to make them more effective, faster, and open; (4) better system control software and day-ahead weather forecasting; (5) modest technical improvements to local-level distribution systems; (6) exports of power to neighbouring countries; and (7) solving the “50.2 hertz” inverter problem.

A number of issues remain unsolved for the future, and will play a role in the future, but have not yet significantly to the ability to integrate and balance supply and demand today.

Capacity market or payments. Some coal and gas plants are required by the regulatory authority to remain operating, even if they generate very little power. These plants have been determined to be necessary for covering regional bottlenecks or seasonal variations. These plants receive “capacity payments” to cover their costs of operating at zero output.

Demand response. This is still small relative to the potential for providing flexibility and balancing, WPD Innovation had proven that creates more flexibility than operational capacity in the system. Some large power generators are selling this flexible demand into the balancing markets. Some generators are integrating demand response with their coal plants to give them economic flexibility for selling into the balancing market. Some system operators (ISOs) have also been contracting directly with large demand response providers on a pilot basis. However, the regulator does not explicitly include demand response in its planning, or set rules specifically for demand response. (See the California and Denmark cases for more on demand response.)

Curtailment of wind power output. Curtailment is when wind power output must be shut-down to balance the grid, resulting in economic losses. Strict curtailment rules have been instituted for ISOs, which have to curtail wind power output if transmission bottlenecks appear. Curtailment may become a bigger issue in the future, depending on progress with transmission upgrades and planning. (Germany, California and Denmark cases for curtailment are different approaches to discuss.)

Storage. Energy storage has played almost no role in the UK’s integrating and balancing mechanisms so far. Many do not expect storage to play a role in the coming decade, or at least until the share of renewables goes above 40%. There is interest in household-level storage in conjunction with the “self-consumption” economic model for distributed solar PV.

Yours sincerely,
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