RESPONSE TO NATIONAL INFRATRUCTURE COMMISSION CALL FOR EVIDENCE: ELECTRICITY INTERCONNECTION AND STORAGE

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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?

- What role can changes to the market framework play to incentivise this outcome:
  - 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?
- To what extent can demand-side management measures and embedded generation be used to increase the flexibility of the electricity system?

1. The value proposition to ensure excess renewable electricity is utilised rather than curtailed needs to be specified and made clear to all stakeholders.

2. A limit on the amount of excess energy that can be curtailed per year needs to be implemented, with associated incentives and penalties arranged within a remuneration framework, so that appropriate low-carbon balancing solutions can be implemented.

3. The electricity grid operator should be charged with achieving low carbon objectives in its operational/balancing practices; it should apply appropriate payment levels for balancing services pertaining to the conventional use of CO_2-emitting fossil power plant and the emerging use of non CO_2-emitting energy storage technologies and controllable loads.

4. The grid operator should be charged with achieving a 'carbon merit order' in the operation of the UK's power plant at all times and specifically for all grid balancing. The balancing market needs to be reformed to ensure operational practices are well aligned with maximising the year-on-year decrease in grid carbon intensity, within the limits of what the grid operator can achieve with the generators, energy storage facilities and load control options available in the year in question. The responsibility should rest with the electricity grid operator in its role to balance and achieve a greener power system.

5. The market framework needs to span both the electricity and gas sectors, to enable the transfer of excess energy from the power system into the extant gas grid by "power-to-gas" (P2G) systems. This will help limit balancing costs, electricity infrastructure upgrade costs

and also reduce the GHG emissions of the gas grid.

6. The value proposition to the gas grid to receive renewable energy from the power sector, in the form of hydrogen or synthetic methane, in order to help it decarbonise needs to be specified and made clear for all stakeholders.

7. The GS(M)R (Gas Shipping (Management) Regulation 1996) regulation which specifies the permitted hydrogen concentration in the gas grid needs urgent revision, so the UK adopts higher concentration limits that are similar to those applying already in other EU countries. In 2013 the GridGas study recommended to DECC and HSE that a volume concentration limit of 3% be adopted in 2015, but no associated adjustment of the GS(M)R regulation has yet been made.

8. DSM (Demand Side Management), embedded generation and energy storage are good methods for helping balance the electricity system. Clear remuneration arrangements need to be put in place if these are to displace the use of CO_2-emitting reserve power plant. However certain fundamentals should be kept in mind:

   a) Embedded generation can cause imbalances and require electricity infrastructure upgrades to manage voltage and reverse power flow during periods of low demand within the lower levels of the power system. Therefore an embedded generation plus storage approach is needed.

   b) The application of Power-In/Power-Out energy storage technologies follows the law of diminishing returns - as valleys in the load profile get filled and peaks get clipped by this form of energy storage, the economic justification for deploying further amounts of it decreases. Accordingly implementing a cost-effective remuneration mechanism for this type of energy storage is problematic.

   c) The application of Power-to-Gas energy storage does not follow the law of diminishing returns - as the power system de-carbonises, it can be utilised to mop up increasing magnitudes and durations of excess renewable energy from the power system as they occur without limitation, while simultaneously assisting de-carbonisation of the gas grid. Accordingly a remuneration mechanism can be implemented for this type of grid balancing, in the knowledge that the annual utilisation of a P2G plant can increase as the electricity system de-carbonises. It is important that the measures implemented appropriately motivate stakeholders in both sectors (i.e. the electricity and gas).

   d) DSM is useful but its ultimate potential is limited, because research shows that load shedding and load shifting soon infringe upon consumer/industrial behavior and end user expectations. Traditionally DSM has been applied successfully to reduce peaks in the load profile. However its application within a high Renewable Energy Source ('high-RES') power system requires loads to be operated at times of excess energy, which coincide with periods of low national demand (overnight for wind, summer afternoons for solar). The feasibility of legitimately shifting the operation of some loads to improve the flexibility of the electricity system needs to be weighed carefully against the shifting of other loads by users in an energy wasteful manner to access the remuneration mechanism (e.g. switching lights on all night unnecessarily in order to receive a balancing payment

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.)

9. The main barrier is the lack of storage targets and an energy storage policy for the UK to deal with the emerging operational issues of power sector decarbonisation (i.e. renewables integration and old fossil fuel plant closure).

10. The grid operator needs to identify availability and utilisation payments by energy storage technology type, or balancing services category, so that the requirement to use CO_2-emitting fossil plant for balancing diminishes and the use of energy storage increases.

11. Clarity is needed about the amount of excess renewable energy that is allowed to be wasted/curtailed per year as the power system decarbonises, in order to guide the deployment of energy storage.

12. A dedicated scheme is needed to encourage Power-to-Gas storage and make use of the sunk capital and hidden nature of the UK's capacious gas grid.

13. Clear distinctions need to be drawn between Power-in/Power-out storage and Power-to-Gas storage and policies adopted to achieve appropriate implementation levels for the UK.

14. The present GS(M)R regulation stipulating a maximum 0.1% hydrogen concentration limit in the UK gas grid needs to be raised to come in line with other natural gas grids in Europe (e.g. 10% in Germany, 12% in Holland), so that a power-to-gas market can commence here.

15. The HSE has expressed its support for Power-to-Gas in the UK and its belief that it will help demonstrate the safe use of an emerging and sustainable technology, provide an opportunity for HSE and other regulators to develop a template for enabling the safe introduction of the technology in support of the UK's 'growth' agenda, help to develop a sound evidence base for future changes to the permitted composition of natural gas transported in pipeline networks in the UK. In addition, adjustments to the GS(M)R regulations would support the future exploitation and use of 'unconventional gases' such as shale gas in the UK.

16. With respect to size and scale, energy storage is mainly needed to face onto and manage the effects of:

a) an increasing wind penetration, requiring multi-MW stores in the medium voltage and high voltage electricity networks,
b) an increasing solar penetration, requiring sub-MW and MW stores in the low voltage and medium voltage electricity networks,
c) a decreasing amount of system inertia due to the closure of traditional thermal power generating plant

The total amount of storage and number of plant to be realised in the UK depends on the requirement (in MW or GW) of each category of balancing service and on expected excess energy levels by target year (2020, 2030 etc.). There is a need to implement storage in a geographically distributed de-centralised manner to ensure the effects of distributed generation and the distribution networks (for gas and electricity) have appropriate levels of storage within each region.

17. Clear ownership/operator models for energy storage technologies need to be developed and introduced. Ownership and operation by the TSO, the DNOs, load aggregators, industrial third parties and consumers should be facilitated. Action on several fronts is desirable because energy storage should be applied at all voltage levels in a high-RES power system, in accordance with the balancing requirements of each level (which are driven by the associated amounts of embedded generation and demand profile). Pragmatic arrangements will be needed to achieve storage targets, because realisation will be restricted by the availability of storage technologies at the kW, MW, GW scale and the detailed feasibility of site implementation.

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?

18. Expanding interconnections with other national electricity grids will not provide a long term solution because each grid will produce excess energy from its power system which may not necessarily occur at a time when the neighboring grid can use it. Indigenous solutions are required for island countries like the UK.

19. Interconnection of the UK electricity and gas grids is needed to enable each to help the other to decarbonise efficiently. The power-to-gas approach affords an opportunity to help de-carbonise both the 300TWh flowing through the electricity grid and the 700 TWh flowing through the gas grid.

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?

20. Most countries have done nothing, they just curtail renewables or export the power across a land border when needed.

21. There are some good reports identifying the requirement and opportunities for storage. For example http://www.fch.europa.eu/publications/commercialisation-energy-storage-europe identifies that in 2050 Germany will incur 173TWh of curtailment (or nearly 30% of its projected electricity demand) unless storage is implemented.

22. There is a very low amount of storage in the UK electricity system, which is particularly unfortunate for an island nation, because islands face much greater balancing challenges than countries served by a large continental grid. We cannot look to mainland Europe for a storage policy solution.

23. The CPUC energy storage procurement targets set in 2013 for the three utility companies in California are pertinent (i.e. procure 1325 MW of new storage by 2020). The UK should set targets and base them on the principle of minimising the curtailment of renewables.

24. The incentivisation of consumers owning PV systems in Germany to deploy batteries in their homes via loans is an ineffective solution. Throughout much of the summer there is insufficient overnight demand to utilise the stored excess solar energy, so the battery cannot absorb all of the excess solar on the following day – it fails to provide an efficient storage solution so renewable energy is wasted.

25. Too often the focus here and elsewhere is placed on Power-In/Power-Out storage, but the UK has a very good reason to apply Power-to-Gas storage with its extensive gas and electricity grids. About 20 P2G plant are operating in Germany, where the injection of hydrogen and synthetic methane derived from renewable energy is being trialled. The technology is now at TRL 8/9, what's lacking is a remuneration framework to enable widespread implementation.

26. We are not aware of any policy framework in terms of international best practice for the UK to follow. The UK needs to lead the way in integrating storage to achieve an electricity system that can be balanced in a low-carbon manner.