Written evidence submitted on behalf of the Power Systems Group at Newcastle University to the National Infrastructure Commission call for evidence's on “Electricity interconnection and storage”

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Introduction

Power Systems Group, Newcastle University

The work of the group has a particular focus on the emergence and critique of 'smart' energy systems and seeks to understand how this relates to broader shifts in systems of infrastructure service provision. The research seeks to gain a deeper understanding of the extent to which 'smart' can assist in planning, managing and facilitating future energy systems that are flexible, complex and uncertain.

Lecturer, Dr Pádraig Lyons CEng

Dr Lyons joined Newcastle University in July 2013 having served a number of roles within industry and academia in the UK and Ireland. He was a senior smart grids researcher at Newcastle and Durham Universities where he lead the network flexibility trial design and analysis for the Customer Led Network Revolution (CLNR) which is the largest UK smart grid project thus far. Dr Lyons leads the development of the smart grid laboratory in collaboration with Siemens and also leads a number of smart grid projects including a collaboration with UTAR Malaysia under the British Council's Newton Fund.

Senior Research Associate, Dr Neal Wade

Dr Wade is the project lead and researcher on a number of projects in the electricity distribution and off-grid power sectors. These projects are addressing the need to cost efficiently decarbonise the power sector over the next thirty years, by investigating the innovative network integration of new generation and demand technologies. Computer simulation, laboratory investigation and demonstration projects are used together to produce the new knowledge that delivers this need. He is an established researcher with ten years' experience in numerous university research and teaching roles and previous experience working in the electronics industry. He works with team of research associates and supervises PhD and MSc researchers.

Director, Professor Phil Taylor CEng, FIET, SMIEEE

Professor Phil Taylor is Director of the Institute for Sustainability and Professor of Electrical Power Systems at Newcastle University. He is a member of the RCUK scientific advisory committee on energy, and a non-executive Director of Northern PowerGrid. Professor Taylor is an active member of the EC ETP on Smart Grids, and also works as a scientific advisor on energy to Singapore, Dutch, Norwegian, and Estonian governments. Professor Taylor was the academic lead for the Customer Led Network Revolution, a £54 million Low Carbon Networks Fund project involving Northern Powergrid and British Gas. Professor Taylor and his research team are behind EPSRC funded £2m energy storage test bed facility at Newcastle University.

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 design of the electricity market needs to consider not only the changes to the market itself, but also those in the overall electrical energy system, including other actors in the space, such as consumers, prosumers, aggregators, energy suppliers and community energy projects. Furthermore due to the increasing integration and reliance of the transport and heat sectors on the electrical energy vector, the role of an energy architect to consider the design and operation of the energy system including its associated markets, in a holistic way, is critical. Crucially, the architect could consider the energy system as a whole including customers, to build plans that resolve how heat, power, water and transport systems are all linked together at least cost to the overall energy system. This will enable delivery of a low carbon energy system, that provides the required security of supply, by ensuring that the supply and demand in the system are balanced, in real time and long term, along with sustainability at the lowest cost to UK PLC.
2. The decarbonisation of the UK economy will require a paradigm shift in the planning and operation of the energy sector, due to developments such as the widespread electrification of the heat and transport sectors, and electricity generation becoming increasingly reliant on intermittent renewables. This increased dependence on electrical infrastructure could significantly increase social and economic vulnerability; these potential vulnerabilities could arise from a reduction in the overall redundancy of the entire energy system, if existing design and maintenance approaches are left as they are. The distances between generation and demand, particularly urban zones, are forecast to greatly increase (for example, due to the increase in offshore wind generation). Increased reliance on ICT will require investment in these systems, as well as a new approach to operate, maintain and ensure security of the network.
3. To enable these changes and ensure that the future electrical energy network provides the reliability required to support a UK low carbon energy infrastructure, the electrical infrastructure will need: -
   a. To be intensively monitored, particularly at distribution network level, through network monitoring and smart meters, to enable network operators to operate and plan their networks effectively and economically now and in future scenarios;

b. To be flexible, dynamic and be able to quickly respond to changes in the network and have the capability to heal itself where appropriate to enable high levels of security of supply;
c. To integrate demand side response technologies such as vehicle to grid (V2G), real-time thermal ratings, energy storage and active distribution network management need to be part of business as usual in order to economically deliver a zero carbon electrical system which is the aim for 2050;
d. To ensure that domestic and commercial electricity customers to be fully engaged and financially benefiting from their local renewable generation and flexible load;
e. To have low cost energy storage commonplace and financially viable at domestic, commercial and network level (requiring regulatory and markets changes to enable the real value of this technology to be realised);
f. To have electrical energy infrastructure integrated with other systems such as transport, heat, gas and water such as the infrastructure proposed at the Science Central site in Newcastle-upon-Tyne

4. If the UK industry can be a leader in these fields, then the benefits could be felt both financially and environmentally. The projects run under the Low Carbon Network Initiative (LCNI) have already resulted in world leading progress, and it is important to continue to fund projects such as these for both the development of new solutions and technology, and moving the methods from previous projects into business as usual.
5. An ancillary service market at distribution network level is required to give clear price signals for the location of new technologies that can provide services to several energy system entities. Energy storage is a prime example of this; it can participate in operating reserve and frequency response markets for the TSO, defer or remove the need distribution network reinforcement for the DNO and participate in the energy market via Supply Companies. The DNO service is location dependent, the TSO and Energy Market services are not. DNOs have very limited means to give the locational signals needed to encourage energy storage developers to design their systems to support the DNO. The same issue exists with other technologies in the area of Demand Response.
6. Large quantities of energy storage and distributed generation embedded in distribution networks may reduce network could reduce the use of the distribution network assets and reduce a key revenue streams for DNOs. If DNOs or DSOs could sell ancillary services into transmission level markets this could provide them with a revenue stream that would incentivise them to facilitate the connection of energy storage.

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.)*

7. There is a lack of clarity on the future role of energy storage in the UK and consequently no regulatory framework for energy storage [1].
8. There are no specific licence conditions for ownership and operation of ESS, which is different because it functions as a load or generator. At present, energy storage in electrical networks to be considered a generator. This arrangement precludes transmission and distribution network operators from operating larger energy storage devices with a maximum power capacity of greater than 10 MW or greater than 50 MW if the declared net capacity of the power station is less than 100 MW.
9. There is no incentive for generation developers to invest in ESS as Renewable Obligation Certificates (ROCs) and Feed in Tariffs (FITs) reward renewable generators based on electricity output regardless of the impact they have on networks or the electricity market. They also have priority access to the grid.
10. In distribution networks where high amounts of distribution generation (DG) are anticipated, distribution network operators (DNOs) may need to reduce the real power export from DG, upgrade or reinforce their networks to maintain quality and security of supply. At the same time, under the security of supply standards (ER P2/6) which all transmission and distribution networks in the UK plan their networks under, DG is considered to be a non-network solution that contributes to system security. In contrast energy storage, which is generally considered as a possible solution to increase DG proliferation and improve quality and security of supply, is not recognised for its contribution to system security.
11. Other challenges energy storage faces in the UK are competition with cheaper, established fossil fuel based technologies, e.g. gas peaking power plants, for providing balancing and other ancillary services. In the electricity market, different contracts have to be agreed upon for the balancing and different ancillary services; this means energy storage owners need multiple contractual agreements to derive maximum benefits. There are also issues with long payback times when participating in the unpredictable electricity market. The two aforementioned factors greatly complicate the economic evaluation by energy storage owners and other stakeholders of the multiple benefits that can be provided from this technology.
12. Energy storage is not considered an asset for network or system operators, therefore they cannot recover the investment costs for energy storage as a regulated asset if used on their networks.
13. National Grid in the UK is responsible for balancing demand and supply, this limits DNOs who cannot actively manage the regional distribution networks or provide demand response. This is crucial in future scenarios which anticipate a large-scale proliferation of low carbon technologies such as electric vehicles and heat pumps; and renewables based generation, including solar and wind. These changes are likely to have large impacts on the capability of system operators, both on the distribution and transmission, level to predict load and generation and thus the power flows through their assets such as transformers, overhead lines and underground cables.
14. The conservatism of power sector stakeholders, particularly among transmission and distribution network operators, in adopting new technologies and the possibility of competition between the transmission and distribution network operators and generators when contracting for services provided by energy storage to manage the grid are also factors impeding the adoption of energy storage in UK networks.

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?*

15. Electricity interconnection provides another degree of flexibility within the electricity market and by extension the overall energy market. The level of flexibility required within today's electricity market is currently served predominantly by large, fossil fuel based generation plant. This scenario is likely to change in the future as we move away from the existing large centralised generation plant based paradigm and move to a more distributed approach with large quantities of renewables based generation on the system with limited centralised control available. The existing model will be put under further pressure by the anticipated electrification of the transport and heat energy vectors through technologies such as electric vehicles and electric heating. Therefore, the requirement for flexibility to the electrical energy system in the form of demand response, energy storage and interconnections become more valuable.
16. The level of interconnection required to best benefit consumers can only be evaluated if we view the operation of our future energy systems holistically. The most economically prudent option or options for UK PLC to provide this flexibility must enable a future energy system that is reliable, economically viable and environmentally sustainable.

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?

17. Smart meters have formed part of the smart grid in a number of countries, for example Italy, rather than being used primarily as a means of reducing the cost of meter readers for energy suppliers. The data from smart meters will become more critical for Distribution Network Operators as the existing assumptions regarding the way energy is consumed and produced (microgeneration and distributed generation) become increasingly unreliable. Therefore, this data should be applied to mitigate the growing uncertainty in the operation and planning of asset replacement and refurbishment.
18. National level island grids have reported penetrations of renewable generation that has resulted in some renewable generation reaching 100% of energy production during peak wind periods, as has been demonstrated in Ireland. Therefore, realistic aspirations for penetrations of renewables can be high and should not be limited by inflexible fundamental system limits.
19. Voltage limits for low voltage networks could be lowered without causing problems for equipment supplied by these networks.

20. We need to learn from other countries e.g. Germany that have suffered with regard to the operation of their electricity system due to the large scale penetration of PV.
21. Demand side response can make a sizeable contribution to the operation of networks as shown for example the USA.
22. Community energy systems can work and could make a sizeable contribution in enabling the UK to reach its carbon emissions targets as has been demonstrated in a number of EU projects.

[1] O. H. Anuta, P. Taylor, D. Jones, T. McEntee, and N. Wade, "An international review of the implications of regulatory and electricity market structures on the emergence of grid scale electricity storage," *Renewable and Sustainable Energy Reviews,* vol. 38, pp. 489-508, 10// 2014.