National Infrastructure Commission: Electricity interconnection and storage

The Electricity Storage Network is the UK's industry association for the promotion of electrical energy storage. Current members include electricity storage manufacturers and suppliers, developers of electricity storage projects, users, electricity network operators, consultants, academic institutions and research organisations.

The Electricity Storage Network works on behalf of its members to respond to and address issues affecting the development and utilisation of electricity storage within the UK power system. This includes special interest meetings, liaising with the media, responding to consultations, providing a unified point of contact for those interested in electricity storage and promoting the value of storage within the UK power system.

We strongly support UK energy storage solutions for the UK electricity system and by promoting local innovation in electricity storage we support wider UK industry.

Introduction

The National Infrastructure Commission seeks views on how the nation can deliver the infrastructure that is will create the electricity system we need now and in the future, while retaining secure energy supplies and delivering the fit-for-purpose future system in the most cost effective way.

Essentially we are moving from a centralised, top-down system, to a more distributed and integrated approach to electricity. This is particularly the case for low carbon generation, which, in the case of solar generation, is often installed at the domestic level, on the distribution system. However many of the entities in our system, such as National Grid, large generators, suppliers and Elexon, are not moving rapidly enough to accommodate the decentralised system that consumers and communities want. There is an over-arching desire to retain the outdated business models and processes of the past and without fundamental change we cannot empower the consumer to take control of their energy needs.

The current model for our electricity system is that demand is almost completely unconstrained and generation is modified to meet this varying demand. This approach is no longer appropriate when a proportion of generation is variable and not always able to match demand. While large-scale thermal plant (non-nuclear) is able to respond to changing demand, it is high carbon and does not address climate change. This type of plant is being removed from the system. Nuclear plant, while providing carbon dioxide free electricity is not flexible, so does not meet the needs of system approach that is demand-centric. In addition new nuclear is not likely to be on the system before the loss of significant high carbon thermal plant. This means there is an increasing need for flexibility in our electricity system.

Flexibility can be provided by interconnection, demand-side management and electricity (energy) storage. This response will focus on the potential role for electricity storage in providing that much needed flexibility, but will also address the potential role for other sources of flexibility.

Electricity storage technologies are able to provide a broad range of different services and able to be deployed at various levels in the GB electricity system, from the transmission level, distribution level, community level and in household, behind the meter. Critically electricity storage supports a system with a significant deployment of renewables, while supporting even greater deployment of renewables and providing the necessary system services to ensure security of supply. Additionally there are a number of UK companies with innovative ideas and products for electricity storage that have the potential to create business and jobs in the UK.

General Comments

There is a great deal of interest in the potential for electricity storage in the UK and a very widespread recognition at all levels that storage is essential for stable operation of the electricity system. Electricity storage on the distribution network has an important role to play in supporting novel connection approaches on a constrained network and allowing communities and householders to use their low carbon generation more efficiently. By incorporating energy storage into the distribution network, both electricity storage and heat storage (behind and in front of the meter) local generation can be used locally reducing the need to transport electricity great distances from centralised large-scale generation, typically high carbon, and reducing line losses that currently amount to about 10 % of all electricity generated. Since peak demand is ~50 GW, these line losses represent 5 GW or about 5 large-scale centralised power stations.

Until there real change in the way we operate the electricity system we will be forced into a less than ideal "solution" based on the incumbent centralised models and processes, which favours large-scale high carbon plant and high-carbon reserve plant.

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?

Significant changes have already been made to imbalance costs to incentivise suppliers to better manage their position (November 2015), however at the moment the tools a supplier has to minimise their imbalance costs, but being in balance, are generally market based. There may be an opportunity for suppliers to use electricity storage to manage their position and there are a variety of business models for this approach. One such model currently being tested is the Ofgem Low Carbon Network funded UK Power Network "Smarter Network Storage" (SNS) project, which amongst other things, allows a supplier to access the 6 MW battery at Leighton Buzzard.

However the supplier has indicated that the unintended consequences of the taxes to fund the low carbon generation incentives (Climate Change Levy (CCL), Feed-in-Tariff Obligation and Renewable Obligation) mean that an operator, not just suppliers, of an electricity storage device are double charged on this taxes. For the SNS project it means the battery is uneconomic for the supplier to operate outside of the winter season. This is because electricity storage was not defined as not being an "end user" when these taxes were set. For the SNS project HMRC have taken a pragmatic approach on the so that the tax is levied once at the _final_ end user. This ruling needs to be available to all future electricity storage projects. However Ofgem administer the other taxes and have not yet agreed to resolve the problem, but are assessing the issue. This could be resolved rapidly and would make a very material difference to the investability of electricity storage project on the GB system.

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

Half hourly settlement for all participants in the GB system (including domestic customers) would allow the full value of providing demand-side response to be realised by the party providing that response. Because domestic loads are small, the potential income from shifting that domestic load is also small and may not represent sufficient incentive, particularly if the less than ideal current settlement arrangements do not allow that small value to flow to the service provider. Even when domestic loads grow with the addition of electric vehicles, one DNO has estimated that it would only be worth about £40 year to shift an individual household's load up to 15 times in that year(Customer Led Network Revolution (CLNR), (2013), Initial Load Profiles from CLNR Intervention Trials, Northern Power Grid).

National Grid, in a recent innovation study (http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Technology-reports/), indicated that a householder may gain up to £25 per year for direct control of the charging of an electric vehicle to provide frequency response (it should be noted that the £25 does not take into the account the probable costs of reinforcing the distribution network to ensure that such a direct control service could be accessed).

Additionally a UK Power Network project, Low Carbon London (UK Power Networks (UKPN), (2014) Residential Demand Side Response for outage management and as an alternative to network reinforcement, UK Power Networks Holdings Limited, London, UK [available at: http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-%28LCL%29/]), has indicated that demand-side response from domestic customers is expensive to procure and expensive to keep customers engaged (up to £2000-4000 per kW of flexibility). Therefore the focus is on industrial and commercial providers, with National Grid launching their "Power Responsive" programme in mid-2015 (http://www.powerresponsive.com/), to explore ways to support more I&C demand-side response onto the system.

- **Is there a need for an independent system operator (SO)?**

  Is not National Grid as the Transmission System Operator (TSO) not already independent? Do we need an _unregulated_ independent TSO? Or do we need an independent "system architect" to oversee the development of the system (which is more of a _network_ operator task)? The IET have suggested that the UK needs an independent system architect, but we do not need yet other large entity (like Elexon and National Grid). Determining the future of the _network_ could be a role for the National Infrastructure Commission, since the electricity system already falls within its remit and the electricity system is clearly a vital piece of national infrastructure.

  If National Grid is not our independent TSO then we certainly need one. National Grid occupies a very large space (electricity (system and network operator), gas (system and network operator) and interconnection, plus activities in the USA) in the UK energy space and there is some argument that the SO functions should be more obviously separated from the wider and more commercial of National Grid's operations. The 2015 Future Energy Scenarios (FES), published by National Grid (TSO) in July 2015, certainly had a key role for National Grid's gas transmission business and an increasing role for gas – this is clearly good for National Grid businesses, but not necessarily good for achieving a low carbon energy system. The FES has been seen a semi-independent and much valued forward look at the energy system, but it is clearly now a vehicle to support National Grid's wider commercial aims.

  It will be essential in the very near future that Distribution Network Operators (DNOs) transition to Distribution System Operators (DSOs), with a function for not just maintaining and managing the wires in

their network, but also managing and balancing the energy flows. This represents a real challenge to the current TSO, but is the only way to effectively and efficiently manage our more distributed system. DNOs are keen for this transition but have just started a new price control period that locks them in to a regulator approved business plan until 2023 (RIIO-ED1). The transition to DSOs needs to happen well before then.

DSOs will need to purchase local services for balancing and this will develop novel business models and local supply opportunities. It is a radical shift from the way we currently operate our system and one that will need careful thought and planning.

It should be noted that National Grid are already actively seeking to have more control down to the meter, rather than the Grid Supply Point and as the current only purchaser of services is in a position to make it very difficult for DSOs to purchase their own services.

The Energy Network Association had a "Shared Services" group that was exploring how the DNOs/DSOs and the TSO would share services, since a single asset on the distribution network could provide services to both. This group and its activities appears stalled, but setting up these arrangements (which may need to be codified) will incentivise the development of both electricity (energy) storage and demand-side response services.

- **How could the incentives faced by the SO be set to minimise long-run balancing costs?**

The SO is currently incentivised to mimimise balancing costs. This requirement, to exclusion of all other incentives, such as balancing the system at _lowest carbon emissions_, does not help to develop the low carbon balancing services we will need on our future sustainable electricity system. If "lowest cost" is the only motivator then diesel generator farms will continue to sprout across the UK.

While accepting that the future electricity system needs to also be cost effective as well as secure and sustainable, there are way to achieve this that does not rely on small- and large-scale high carbon plant. The approach taken in the USA and in California in particular, which requires utilities to install electricity storage on their networks has shown that 1 MW of electricity storage displaces 3 MW of peaking high carbon plant and is able to support and balance the system without carbon emissions. Large-scale thermal plant now operates in the UK as "peaking plant" rather than continuously running "baseload". This changes the economics of operation of such plant and because the plant is part loaded it is likely to be running inefficiently and producing more emissions. In this way distributed electricity storage can replace centralised large high carbon plant and support the development of a decentralised electricity system, which is likely to be more resilient in the face of bad weather and system problems.

- **Is there a need to further reform the "balancing market" and which market participants are responsible for imbalances?**

Imbalances costs were recently reformed (November 2015) and it would seem unfair to increase the imbalance costs further without giving participants the tools to manage imbalances. The only tools available currently are market based.

Sources of imbalances are many and varied – forecasting wind and solar generation, particularly the latter, is tricky and while great progress has been made for wind forecasting, forecasting solar remains problematic. This is an issue for the TSO as much as suppliers/generators. Domestic demand is becoming increasing mobile

as use of electricity and small devices increases. Aggregators are currently unregulated, and this possibly helps them to be innovative, but means that there is no requirement for them to notify the "system" when they take an action. At the moment the loads are relatively small (in system terms), but as industrial and commercial demand-side response increases, suppliers may find themselves increasingly out of balance. The Ofgem Flexibility project is actively assessing the role of aggregators and whether any future regulation is required, but another issue is the role of smart meters and the potential implications of Consumer Access Devices (CADs), which, while the devices are registered with the Data Communications Company (DCC), the actions taken using that device are completely independent of the DCC, since communications with the device do not pass via the DCC. An energy action made via CADs (via the internet/mobile network) will not be notified to the system in any way and the first thing a supplier will now, is that they are out of balance. This is not only a problem in terms of imbalance costs, but could also mean that a supplier takes an action to correct that imbalance that then invalidates the original demand-side response action (providing a system balancing service) and causing more system issues. This is a problem that was raised with the DECC Smart Meter specification team by Workstream 6 of the DECC and Ofgem Smart Grid Forum, but has yet to be resolved.

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

Demand-side response will be an important tool, particularly at the industrial and commercial scale where the size of potential loads, understanding of energy and potential financial benefits to the provider will incentivise involvement. Demand-side response at the domestic scale is currently expensive to procure and maintain and because the loads are small (and even in the future when loads are larger) the value is small on a household by household basis. The cost of smart appliances to the householder is not currently factored into the cost of providing domestic demand side response and it would be very helpful to see a technical study on the true costs and benefits of domestic demand-side response.

Embedded generation, where it meets low carbon goals, has an important role in providing system flexibility and system support. Embedded electricity (energy) storage also has an important role in managing energy at all scales. Intelligent behind the meter domestic energy storage has the potential to manage roof-top solar generation, but if the domestic storage is unconstrained and "dumb" it may well have reached full charge (maximum temperature, if heat storage) before peak solar generation, which causes significant system problems. The benefits of industrial and commercial scale behind the meter (embedded) storage should not be underestimated and can be achieved through managing heat and cold and through uninterruptable power supplies (UPSs). UPSs are designed to provide electricity during a mains failure and potentially have the opportunity to provide system services (to the TSO and the DNO/TSO) as well as take a demand off the system at times of system stress. UPSs are a low carbon solution to providing back up power, for short duration situations and may be a reasonable replacement for diesel generation.

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?**

The issue of double charging of environmental levies has been covered earlier and this a specific market failure than affects only electricity storage.

The fact that other low carbon (generation) assets have received support, while electricity storage has not has dis-incentivised the deployment of storage. There has never been any requirement in the GB for connecting variable generation to be dispatchable or provide system services. This has led to a "connect and forget" approach from developers and we are now trying to resolve the issues of variability on the system.

Like low carbon generation, electricity storage has high up-front costs and low operating costs. We accept that our industry will not receive deployment incentives, but we would ask that the market place reflects the need for low carbon balancing and the development of services such as National Grid's Enhanced Frequency Response, is welcome. Although far more consultation with industry and the DNOs should have been made prior to seeking expressions of interest as DNO connection teams are creaking under the load of multiple connection applications for storage on already constrained networks.

In general there is a complete lack of interaction between the TSO and the DNO/DSO, which leads to delays and problems.

Connecting storage to networks needs to be resolved as it is currently connected on one side as demand and as generation on the other, requiring two connection methods and charging regimes. This is largely the result of an energy Act (1989) that does not define electricity storage as an activity and may unintended consequences flow from this omission that prevent easy deployment. DECC and Ofgem are actively working on these regulatory issues, but clarity is needed soon as Natation Grid would like the Enhanced Frequency Response service to be available in mid-2017 and the tender is due in April 2016, which means potential developers will have to tender into an uncertain regulatory regime and this is not helpful for investors.

Access to connections is not only a problem for electricity storage by renewable generators. The approach to connection applications, offers and agreements does not work, with the current approach "sterilising" connections when projects do not actually go ahead. For instance, the National Grid Enhanced Frequency Response service attracted 64 expressions of interest (the industry is more than ready and keen to deploy), with a total capacity of ~1.3 GW. Several DNOs are dealing with < 2 GW of storage connection applications, with only 1.3 GW to connect. This means individual projects are making multiple connection applications in multiple geographic regions. If they accept all their offers, then connection capacity will be tied up indefinitely, reducing access to any other connecting project (storage or generation). This situation needs to be resolved urgently and one option is a time limit on offers, so that connections become free if not activated within a certain time and to limit the number of applications any one asset can have.

Also DNOs are not currently able to signal where they feel storage would best support their network (usually in constrained locations, which may not suit the service specifications of the National Grid service, but this is where consultation would have helped). This ability would mean that a storage provider could have access to another business opportunity (supporting the DNO) that would strengthen the investment case for the storage developer.

- **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.)**

While there will be a limited amount of transmission connected electricity storage, it is most likely to connect (where connection is possible, see above) at the distribution level and behind the meter, but not limited to the domestic scale, as there is the opportunity for behind the meter industrial and commercial scale storage.

Care is need to ensure that behind the meter storage coupled with solar generation does not create more system issues than solar generation alone does (the "duck curve"). Solar generation is seen by the TSO as low demand (because demand is being met by local generation). Low demand causes significant system issues since there is "must run" generation plant (nuclear and some high carbon thermal) and in summer 2015 the TSO had pay wind generation to come off the system to accommodate the "must run" plant. This cannot be a sensible or long-term approach if we want to meet our carbon goals. In summer 2014 low demand saw 13 consecutive settlement periods with negative prices for generation (a very common problem in Germany, with much more solar generation), essentially generators paying for users to take its electricity. So behind the meter storage will not necessarily support the wider system.

We would like to see more distribution connected electricity storage either through the DNO or through partnerships between renewable generators and storage developers or through community owned energy storage. The DECC community Energy Strategy has remained quiet, but storage coupled with either community owned generation or with domestic roof-top solar is an alternative to behind the meter electricity storage that allows a larger asset to be managed more effectively (by energy experts, rather than the householder – managing a mobile telephone battery is tricky enough, let alone a household battery) and wouldn't necessarily need aggregation to provide system services (earning income). There are many potential business models for community storage, including partnerships with DNOs/DSOs and this is a natural fit as both are more likely to want security of supply over commercial gain.

Currently there are regulatory barriers to DNOs owning and operating electricity storage due to is default definition as "generation". Electricity storage should have its own licence and be a specific defined activity. DNO ownership and operation of electricity storage is not contrary to EU rules, just local legislation. We see the DNO as a critical market for services (in the first instance) and deployment of electricity storage and facilitating this approach should be a priority.

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?**

While interconnectors are a source of flexibility, they are a market based tool, that is, flows of energy are governed by the market and so are not reliable, given the cross-border trading and negotiations required (Department of Energy and Climate Change - Pöyry, (2010), Demand Side Response: Conflict between Supply and Network Driven Optimisation.). Additionally interconnectors do not come without system impacts when they "swing" from full import to full export and this has to be managed carefully using other system balancing tools.

Interconnectors are considered as a possible option to help secure the system during a persistent winter high pressure (very cold, low winds). However it is possible that our northern European neighbours, who would rely upon to provide interconnection support (importing) may also be impacted by the same weather system and be unwilling to export their electricity. The issue of how an interconnector operates in times of system stress and how this relates to national energy security needs more thought. As interconnectors are a market driven approach, it may be that the country prepared to pay the highest price secures the electricity needed.

There are other tools to better match demand and supply that are likely to be more cost effective and in the national interest.

- **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?**

No response.

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?

There are some interesting examples from the USA and the Ireland-Northern Irish approach and the Irish situation is a foretaste of what the GB system is likely to experience in the near future. Learning from our nearest neighbour presents a great opportunity (http://www.soni.ltd.uk/Operations/DS3/).

Dr Jill Cainey
Electricity Storage Network
Dairy Farm, Pinkney
Malmesbury
Wiltshire SN16 0NX

[phone number redacted]