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National Infrastructure Commission, Call for Evidence:
Electricity Interconnection & Storage

A response from National Grid, European Business Development (EBD)

EBD is a ring fenced division of National Grid, responsible for business development activities in line with our core capabilities and outside of National Grid's onshore regulated activity. We welcome the opportunity to contribute to this Call for Evidence and the work of the National Infrastructure Commission. In particular, to share our recent experiences from developing both our interconnector portfolio and other project opportunities in smart grids and storage.

We recognise that the UK electricity system faces considerable challenges over the coming decades, including the changing GB generation mix and the new patterns of demand. By 2020, according to UK Renewable Energy Roadmap[1], more than 30% of UK electricity demand will be met by renewable generation. To meet the government decarbonisation objectives, the electricity sector will also need to become increasingly decarbonised in the period 2030-2050. Without significant development in demand side response, introduction of more flexible generation, increased interconnectivity and the potential use of large scale volume of storage, the cost of providing energy to the consumers could increase significantly. We are responding to this challenge in several areas of our business development work.

One of our major areas of work is developing National Grid's UK Interconnector portfolio. We are developing several new interconnector businesses and exploring new ways to use interconnection to resolve the energy trilemma. Over the last five years EBD has worked closely with the UK regulator Ofgem, as well as project partners in Belgium, France, Norway, and Denmark, to support their development of a new regulatory mode and realise the next generation of investment in interconnection (the "cap and floor"). Today, we have a further 4.8GW of projects to mainland Europe and Scandinavia in development (IFA2 and Viking Link) and construction phase (NEMOLink and NSL). National Grid Group also operates two interconnectors (IFA and BritNed) that represent three quarters of the UK's 4GW of interconnected capacity.

We are using our interconnector expertise to open up the opportunity for offshore grids; supporting export of renewables and renewables trading. Through projects such as Icelink, we are exploring opportunities to harness the interconnector resource and relationships in innovative ways. EBD is also active in the area of Smart Grid solutions. We are exploring new business models and novel capacity products. We support the development of new and innovative markets that have the potential to reduce the total cost for the end consumer, as well as supporting system operation challenges across Europe.

This means we have a critical interest in the call for evidence from the National Infrastructure Commission, seeing it as an enabler of the longer-term transitions that the UK energy system needs and an important initiative that our project portfolio can play a part in delivering.

Ian Graves
Director, European Business Development

[1] HM Government, 'The UK Renewable Energy Roadmap', July 2011

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 challenge of balancing supply and demand is met by the UK System Operator, incentivised by the Balancing Services Incentive Scheme (BSIS), to efficiently manage balancing costs on behalf of consumers.

This challenge is set to increase in the future energy system, where intermittent renewable generation plays a greater role, and the distribution networks transform into active networks hosting two-way flows of power. The UK System Operator (SO) has suggested that the need for some system services will increase dramatically to meet this changing generation mix. For example, primary frequency response requirement could increase by 30-40% in the next 5 years, and by 2030 the response requirement will be between 3 and 4 times today's level[2]. Given this context, the UK needs new solutions to expand the diversity and breadth of balancing service provision.

Traditionally, these balancing services (such as voltage control, frequency control and constraint management) are provided by large, synchronously connected generators. As the energy industry is changing, many of these traditional suppliers look set to disappear e.g. due to plant closures. The new generating fleet is increasingly dominated by non-synchronous and/or embedded forms of power generation. This generation includes HVDC interconnection (bringing in power from neighbouring countries), wind and solar. These new sources of power, together with increasingly novel forms of demand-side management, facilitated by information technology progress, are potential new providers of Balancing Services.

This poses the question: Are the current market frameworks sufficient to incentivise appropriate service providers, including new entrants, to provide the balancing services our SO needs?

Our analysis, based on the experience of developing business models to support investment in interconnection, indicates that the market frameworks need adaptation to really incentivise the most efficient services to come forward. We note a lack of long-term investment signals in the relatively short-term Balancing Services contract as a barrier to making investment in interconnection as a balancing tool. This lack of price signal is also likely to impact investment in other technologies, such as storage, in the same way.

For example, the business cases for our interconnector portfolio are primarily based on the value associated with cross-border capacity used in energy trading in the Wholesale Energy Market. We are alert to new revenue streams and opportunities for our projects, to add additional value to the UK energy system. We regularly review whether we should specify additional components for our projects (for example, to provide reactive or overload capability for provision of enhanced voltage or frequency control services). As we cannot pinpoint the future value of the services, and our regulatory scrutiny drives minimisation of Capex (unless a robust business case can be provided demonstrating consumer value), this pushes us away from anticipatory investment and limits this kind of discretionary incremental capability.

To bring diversity in service providers that support system balancing at least cost to consumers, longer-term price signals are needed from the balancing market to support investment in new technologies.

2. What are the barriers to the deployment of energy storage capacity?
Because storage is both generation and demand, it does face barriers that are not faced by other balancing technologies. In EBD, we see two particular challenges:

i) The lack of clarity on the legal and commercial status of storage, particularly in relation to ownership of storage assets.

Components of the business case for storage are held by many different market actors and any one of them could be compelled to develop market opportunities in storage. Ultimately, a key outcome of

[2] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

any intervention and decision on legal definitions should a strong marketplace enriched with a diversity of market participants, it should not unnecessarily preclude participants that are able to contribute to building a competitive marketplace.

ii) Insufficient incentive to invest because storage projects are underpinned by complex business models that rely on multiple revenue streams accruing to different parties, invariably governed by different regulatory or legislative regimes.

New business models supported by new regulatory and legislative frameworks are needed to catalyse market-led deployment of energy storage capacity. The regulator working alongside storage developers, the System Operator and Network Owners on specific projects and challenges is likely to yield results. In our experience, collaborative working on real pilot projects is the most constructive approach to create workable new frameworks; particularly where alignment of multiple objectives from multiple parties is needed (e.g. to capture maximum value for consumers and ensure an appropriate and stable investment framework for developers).

Our recent interconnector investment successes are an example of this – we worked side-by-side with our project partner Elia to support the development of the new regulatory regime for interconnection developed by Ofgem and their partner regulator CREG and piloted on NEMOLink. And we replicated this success, testing the new regime with a similar level of collaboration with partners, and interaction with Regulators and Government in the UK and Norway on NSL.

3. What level of electricity interconnection is likely to be in the best interests of consumers?
Following signing of multiple EPC (Engineer, Procure, Construct) contracts totalling over €2.5bn, the UK is getting two new power connections to Norway and to Belgium. These projects will realise significant benefits for UK consumers through lowering our electricity prices. This positive investment climate has been generated by the simple win-win of the consumer story, recognised by both the Regulator and Government with the development of a "cap and floor" regulatory regime and inclusion of interconnection in the UK capacity market.

Maintaining this momentum in investment and getting the right levels of cross-border capacity is the next challenge. UK consumers need interconnection built in response to market signals. Interconnection is infrastructure that complements home-grown generation, demand response and storage by providing access to support from the energy systems of the European Internal Energy Market. Interconnection is a new tool for the System Operator (SO) to provide much needed flexibility. To do this, we may need new markets to stimulate investment in additional cross-border capacity, and maximise the benefits to UK consumers of integration with the Internal Energy market (IEM).

Responding to this new challenge of maintaining momentum in investment raises several questions:

i) What are the benefits of interconnection?
ii) What drives more interconnection capacity and how much is optimal for the UK?
iii) What are the market failures stopping efficient and optimal new investment and how can we overcome them?

i) What are the benefits of interconnection?

Interconnectors reduce prices, make our system more secure, deliver flexible system operation services and facilitate renewables

Interconnection brings benefits to UK consumers through increasing the size of the market that they can access. This gives consumers access to lower cost generation, and new sources of renewable and low carbon generation. In addition, interconnection can make an important contribution to security of supply through providing links to energy networks in other countries.

As part of this, interconnection can also become an important tool in the System Operator's toolbox – supporting the management of the system in ancillary services through exchange of reserves between System Operators across Europe. Below, we give you some examples of how National Grid's existing and planned interconnector can provide these benefits now, and in the future.

Security of Supply:
Our two interconnectors to mainland Europe just participated in the UK capacity auction. Both cleared in the auction, acknowledging the value for money that interconnection can provide in delivering secure power to the UK system. The contribution of these links for 2019/20 will be:

Interconnector	Derated capacity
BritNed	828MW
IFA	1033MW

Interconnection also provides services to national System Operators (SOs) at times of system stress. On BritNed and IFA there is up to 3GW of capacity available in Emergency Situations to support the GB or neighbouring transmission systems. Our new links, NSL and NEMOLink will also provide these services through close SO to SO working.

For example, during the Solar Eclipse on March 20th 2015, there were concerns that a reduction in output from solar generation in Germany could cause problems. To help address this, capacity was made available on IFA and BritNed to help SOs in Mainland Europe manage the changing flows[3].

System balancing between SOs:
Interconnectors offer the possibility for National SO's to exchange balancing energy. National SO's can offer excess power to neighbouring systems or find more cost effective ways of accessing generator availability in other countries. This type of service is currently provided by IFA between Rte and NGET[4]. The European Network Code for Balancing promotes development of common cross-border balancing products, and has looked at the IFA solution as a template for others.

Provision of balancing and ancillary services:
As electricity cannot be stored, National Grid must balance supply and demand on a second by second basis to achieve a target frequency of 50Hz. Frequency response is one of the balancing services that National Grid procures to keep the frequency at the target level. Interconnectors can be an effective provider of frequency response. Interconnectors can react extremely quickly in response to a frequency deviation. BritNed currently delivers 100MW of this service to GB and through this has already provided significant operational security support to the GB system, as well as cost savings to the National TSO.

Energy market liquidity:
A fundamental of a healthy functioning market is liquidity in energy trading. This is improved by any measures that reduce barriers to cross-border trade, and increase competition. IFA and BritNed already make a positive contribution to these objectives.

The planned projects in our portfolio and in construction will make an incremental difference. For example, at 1GW IFA2 would represent an increase of 50% in the capacity available across the France-UK border, as will non-physical financial products associated with the interconnector flows. Any new players in the interconnector market will automatically increase the breadth and diversity of participants thereby improving competition in energy supply.

Integration of renewables:
Interconnection facilitates the deployment of renewables by reducing the costs of renewables integration.

A recent Imperial College / NERA Study for the Committee on Climate Change[5] found that the system integration cost of low-carbon generation technologies will significantly depend on the level of system flexibility; enhancing system flexibility would reduce system integration cost of

[3] http://www.telegraph.co.uk/news/earth/11433786/Solar-eclipse-to-disrupt-power-supplies.html
[4] http://clients.rte-france.com/lang/an/visiteurs/vie/contrat_angleterre.jsp
[5] https://d2kx2p8nxa8ft.cloudfront.net/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf

renewables *by an order of magnitude.*

For instance, the whole system cost disadvantage of wind generation against nuclear reduces from circa £14/MWh in a low flexibility system to £1.3/MWh in a fully flexible system achieving 100 g/kWh emission intensity. At the same time, the whole-system cost of solar PV reduces from being £2.3/MWh higher than nuclear to being £10.7/MWh lower than nuclear as the result of improved flexibility.

Interconnection is an important part of the mix of flexible options available (alongside more flexible generation technologies, energy storage, demand side response) and therefore essential in a future world with a higher renewables penetration.

ii) What drives more interconnection capacity and how much is optimal for the UK?

10% interconnection is "no regrets" for the UK, >10% is highly likely to bring additional benefits

We build interconnection to realise all the benefits described above. Depending on the energy mix in the UK and the countries we connect to, the signals to build more interconnection will come from different drivers and result in different levels of cross-border capacity.

Our work to establish the size of market opportunities for investment in interconnection has identified a no-regrets level of interconnection that is roughly equivalent to 10% of the installed generation capacity in the UK. Under our range of scenarios, this level of interconnection (equivalent to around 8-10GW of capacity) provides benefits to consumers of up to £1billion/year in wholesale energy -market price reductions from 2020[6].

The benefits of interconnection beyond this level are dependent on the underlying characteristics of the UK energy system, and those systems that surround us. Additional investment in interconnection could be viable and valuable for consumers beyond this level to:

1) Further reduce GB wholesale power prices (if UK prices remain materially higher than mainland Europe)
2) Increase security of supply and diversity of generation sources
3) Provide the System Operator with additional tools and capacity to operate the system efficiently and flexibly
4) Integrate greater levels of renewable generation in the UK, and provide a route to market for the UK renewable resource
5) Realise the objectives of the Integrated Energy Market in Europe and promote pan-European socioeconomic welfare benefits

Different scenarios would increase the value of cross-border transmission capacity beyond the 10% level. For example:

- **High levels of offshore wind generation and other intermittent renewable generation and a robust carbon price:** *greater levels of interconnection would allow UK renewables to be exported at times of surplus (rather than curtailed). Additional interconnection capacity would allow UK renewables to find new markets elsewhere in Europe. Additional interconnection also supports the economic and efficient outcome that sees renewable resources being supported in areas where the natural resource can be most efficiently harnessed – e.g. wind in the North Sea, and solar in southern Europe. Under this kind of scenario – our analysis indicates that UK consumers may benefit from more than 10% of our generation capacity being matched by interconnection to facilitate export of our renewable power at times of surplus. Evolving interconnection to offshore grids (i.e. meshed networks that connect offshore generation in to point-to-point interconnection) may bring considerable efficiency savings under high wind generation scenarios.*

[6] "Getting More Connected" (2014) http://www2.nationalgrid.com/About-us/European-business-development/Interconnectors/

- **Low offshore wind deployment coupled with increased demand response or a rise in the economic efficiency of storage technologies:** *this kind of energy future would see a focus into the distribution networks. Interconnection is still helpful and beneficial to consumers at the no-regrets level. Because new technologies and new players are more active in the market, UK consumers are not looking to non-GB generation for cheaper sources of energy. Interconnection may also become useful to allow for export for these new demand or distribution led services if similar transitions have not happened in other systems across Europe. Under this scenario – particularly if it is also correlated with low ambition in transmission connected renewable generation, we see little more than 10% of generation being matched by interconnection.*

- **High commitment to EU Member State cooperation to ensure secure and diverse supply of energy, maximising the potential for supporting the EU energy needs with resources from within the EU region:** *Considering world events, energy security is also impacted by our reliance on energy imports from elsewhere in the world. Interconnection offers a route to create greater physical connections between the EU member states that can dramatically improve system-system cooperation, and facilitate the development of an energy union that can work towards minimisation of reliance on external sources of energy resources through reliance on low-carbon and distributed energy resources as well as the natural resources found across the region. Greater political union and commitment to physical connection to promote energy security and stability could be a new driver of interconnection beyond the 10% level.*

iii) **What are the market failures stopping efficient and optimal new investment and how can we overcome them?**

The current regulatory arrangements and energy policy framework will support timely delivery of 8-10GW of interconnector capacity. New markets for balancing and reserves and enabling trading of renewable power across borders will support additional investment in interconnection.

With the current regulatory regime (i.e. Ofgem's "cap and floor") we believe that the UK can reach the no-regret, 10% level of interconnection to mainland Europe and Ireland. This can be achieved by completing NEMOLink and NSL, and realising projects like IFA2, ElecLink and VikingLink. A portfolio of around 8-10GW of interconnection would be both beneficial for UK consumers and investible under the current "cap and floor" regime.

Critical to this stable environment and realising these benefits is maintaining access for interconnection to the new capacity markets, and ensuring a fair representation of the value that interconnection brings to security of supply in the UK.

The European Network Codes and related legislation as part of the European "Third Energy Package" are important factors in achieving accurate price discovery and efficient operation of interconnectors in response to underlying system conditions. For example, removal of market entry and exit tariffs is a critical component required to realise the benefits of free-trade of energy across borders. In the UK, preventing layering of charges on cross-border trades has led to the removal of system charges on interconnector flows.

Achieving levels beyond 10% depends on the visibility of price signals associated with the drivers of interconnection investment. Currently, interconnector developers see signals from the Wholesale Energy Market and the UK Capacity Mechanism and will build new capacity on this basis. Value from balancing, offering system or reserve services is not so straightforward to capture and neither is value from import / export of renewables. The capacity mechanism and the development of a pan European Capacity Market will also play a part and potentially drive further investment as the value of cross border connections are realised in the context of security of supply.

We believe that the cap and floor regulatory regime is a helpful wrapper that can support investment under any scenario whereby the benefits of interconnection can be reflected in an accessible market framework. Currently, the cap and floor will deliver new interconnection that can be justified on the basis of more efficient generation dispatch and contribution to security of supply through the capacity

market. Creating new markets e.g. for reserves and system services, or enabling cross border trading of renewables could allow the cap and floor to support additional investment.

Depending on the market developments and the underlying drivers for interconnection, adaptations to the cap and floor regime may be needed. For example:

1) to ensure that re-investment to realise novel services from existing interconnection is not disincentivised through the presence of a hard cap based on a pre-defined value for the regulated asset base.
2) to support hybrid structures of offshore networks that integrate the connection of offshore generation and interconnection, and may include some element of anticipatory investment.

Moving beyond point-to-point interconnection to create offshore grid networks also requires considerable commitment from the Member States Governments involved. For example, a UK-Iceland Taskforce has been set up to explore the feasibility of a connection between the two countries[7]. This kind of intergovernmental initiative is an essential ingredient of any complex cross border project integrating renewable power generation and interconnection. In particular, Government cooperation is required to integrate national support schemes for renewable generation and enable trading of renewable power across borders.

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?

The European Network Codes are the starting point towards realising future benefits of a more integrated approach to balancing services within the European Integrated Energy Market. Much work remains to be done to bring this to life and will be driven by ENTSO-E and its various working groups. There is a considerable task to standardise balancing products, define co-ordinated balancing areas (ie. a stepwise regional approach to full integration) and work out pricing methodologies, settlement algorithms and implementation plans.

These steps will take time and are pre-requisites to fully realising the potential benefits of sharing balancing services across borders. We support the importance of this work and are participating in two pilot projects: BritNed frequency control trials (mentioned above) and project TERRE[8] (Trans European Replacement Reserve Exchange). These two initiatives will provide much of the experience and knowledge necessary before more widespread implementation is possible across Europe.

A further step along the journey will be cost-benefit analysis to ensure that reforms to balancing market/operational practices are only made where there is a strong expectation that the benefits will outweigh the costs. This is relevant in considering whether a portion of interconnector capacity should be withheld from the energy market for the purposes of providing balancing services in a real-time balancing market. There would be a positive case for reservation of a tranche of interconnector capacity for balancing, if the pan-European consumer welfare benefits of utilising capacity for (energy and balancing) are greater than the consumer welfare benefits if the full capacity was dedicated to energy alone.

The North Sea Link (NSL) interconnector connecting UK and Norway is exploring the opportunity to reserve capacity in this way to support SO actions on System Balancing. SOs in Scandinavia are already active in trialling different approaches and developing markets. A recent report from efforts on the Norway-Sweden border provides some insights in this respect that could provide help shape similar work in the UK market[9]

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[7] http://uk.reuters.com/article/uk-britain-iceland-power-idUKKCN0SN16G20151029

[8] Project TERRE (Trans-European Replacement Reserve Exchange) is an initiative set up by ENTSO-E to explore the possibility of increasing social welfare value by allowing TSOs to access cheaper balancing energy in other countries. Currently, the project consists of seven European countries and is in the design phase with completion expected by Q3 2018. The IFA interconnector plays a pivotal role in the initiative as it will allow the GB System Operator to access the TERRE platform and so reduce the costs of balancing the GB network.

[9] http://www.statnett.no/Global/Hasle%20report%20StGr_150317%20(3).pdf