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National Infrastructure Commission
1 Horse Guards Road
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[08/01/2016]

Dear Sir/Madam,

Re: National Infrastructure Commission – call for evidence

RenewableUK is the leading trade association in the UK in the renewable sector, with over 500 corporate members across all parts of the value chain in the wind, wave, and tidal energy industries. Having the ability to connect renewable energy generation to the electricity network and being able to use those networks cost effectively is very important to our members. It is also very important for the UK's plan to transition to a low-carbon economy.

The electricity networks underpin every facet of modern life, and so when questions are posed which ask how the UK's national infrastructure will develop and operate, then considering the electricity infrastructure is of vital importance. Making the wrong strategic decisions at this point will lock the UK into a much higher carbon emitting future than will be possible to correct for as we move into the 2020s and beyond. A low-carbon future needs a decarbonised electricity sector, and this presents challenging problems when it comes to maintaining the balance between supply and demand.

The renewables which we need to make up the bulk of the decarbonised electricity sector are historically more variable in their output than conventional fossil fuelled generation. This is changing, with new offshore wind turbines forecast to operate at a capacity factor of 47.7%[1], and with onshore wind farms operating at above 30%, broadly in line with the capacity factors for gas plant[2]. Maintaining the balance between supply and demand on an hourly or on a second-by-second basis, however, will still require National Grid, as the GB System Operator, to have much more access to balancing and ancillary services. We support the development of these services from renewable sources in ways which are fair to both providers of the services and to consumers, who are ultimately paying for the services.

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[1] The Renewables Obligation for 2016/17, p. 7: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/464685/Renewables_Obligation_Level_Calculations_for_2016-17.pdf
[2] DUKES 2015 report, p.143: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/450302/DUKES_2015.pdf

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

The UK has legislated for Carbon Budgets[3] via the Climate Change Act 2008, and it is clear that if we are to meet these targets, renewable generation will be a significant part of the generation mix for the foreseeable future. The Committee on Climate Change's recent paper on power sector scenarios up to 2030[4] shows contributions of renewables of 45-55% of the generation mix for the scenarios where the carbon intensity is under 100gCO_2/kWh, with the variable technologies of wind and solar making up 35-45% of the mix by themselves. It is therefore clear that the electricity network will have to operate in a radically different paradigm than the one in which the network was originally conceived and built. Balancing the system in the long run will mean the application of many different forms of technology than those used in the main today.

The challenge faced is two-fold: firstly, it is to have the right physical infrastructure, so that power can be generated, stored, transmitted, and shifted in the most efficient manner possible; secondly, it is to have the right legal and regulatory environment for the grid of the future, where charging and operation are fairly dealt with as the system evolves.

We believe that there is no need for the National Infrastructure Commission to propose any reforms to the Balancing Mechanism (BM), as the reforms to the way that imbalance prices are calculated in the BM, which were put in place by the Electricity Balancing Significant Code Review (EBSCR)[5], have yet to come fully into force[6]. These reforms, which are primarily to what is known as the 'cash-out' price, will have far-reaching effects on the actions taken by parties to maintain the balance between supply and demand.

The key outcome of the EBSCR reform is to begin a move, not yet fully implemented, to make the cost to a BM Party for being 'out of balance' against the system the same as the cost of the most expensive MWh which National Grid has to purchase to correct that imbalance. Prior to the EBSCR, the cost to BM Parties was the volume weighted average cost of the most expensive 500MWh which National Grid had to purchase through the BM to correct the system. This had the effect of diluting the cost of the most expensive – and therefore most critical – grid balancing actions, disguising the true value of the services which offer the needed flexibility to National Grid, an issue known as the "missing money" problem.

The transparent and market based price which will result from the full implementation of the EBSCR will be a key signal to those service providers who can most efficiently and cheaply increase system stability. We suggest that the effects of the EBSCR reforms should be allowed to run their course and to be tested in the market before any further market based reforms to the BM are initiated.

However, if the National Infrastructure Commission considers the term "balancing market" to encompass both the Balancing Mechanism and the set of Ancillary Services which National Grid procures for the purposes of ensuring system stability, then we support further reforms to the "balancing market". National Grid's recently launched System Operability Framework[7] has fired the starting gun on what will be a marathon race to develop and bring to market new and innovative solutions intended to balance the system. New solutions may very well require new market access routes to be opened up and will doubtless need an open mind on the part of regulators in order to accommodate technologies which may be round pegs for what are today square holes.

The renewables industry will participate as fully as possible with the developing balancing markets in order to access new and existing revenue streams from the provision of Ancillary Services. As the provision of flexibility through balancing services becomes as much a part of project revenue as the

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[3] https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/
[4] https://www.theccc.org.uk/publication/power-sector-scenarios-for-the-fifth-carbon-budget/
[5] https://www.ofgem.gov.uk/electricity/wholesale-market/market-efficiency-review-and-reform/electricity-balancing-significant-code-review
[6] https://www.ofgem.gov.uk/sites/default/files/docs/2015/04/p305d_1.pdf
[7] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

provision of electricity, consumers will save money in a market which is more stable, which requires less network reinforcement, and which avoids the costs of building expensive and dirty peaking plant.

In order to manage the transition to an energy infrastructure in which flexibility plays as big a role as the electricity itself, we support the consideration of a move to create an Independent System Operator (ISO) role in the UK, which would have the responsibility to maintain system security.

We hold that the costs of Capacity Adequacy are not solely the responsibility of the renewables sector to shoulder. It is the case that an individual wind farm will be more volatile in its output when compared to a CCGT plant across a given period of time; however, it is also the case that system imbalances are caused by myriad factors, and the prevalence of renewable power on the system is but one of them. We call attention to three things which support the view that renewables do not disproportionately imbalance the system, and indeed they both play their part and are poised to contribute more to system stability:

- The first thing to note is the Notice of Inadequate System Margin (NISM) which was called by National Grid on 4 November 2015[8]. Whilst the system maintained its stability across the length of the NISM warning period, the volume of generating capacity to which National Grid had access over this time became very small, and with such a tight margin the safety valves, if not exactly opened, certainly had a tensed hand poised on the spigot. 35% of the coal fleet was unavailable to generate during the NISM, compared to the 12% which is National Grid's working assumption for such periods, and the IFA Link Interconnector was under repair during this time. The contribution of the wind industry to this particular tightening of margin was merely one component amongst many of that day's issues.
- The second thing to highlight is that the renewables sector is already fully exposed to costs in the BM, like any other generator. The costs of system and energy balancing actions fall on wind and other renewable generators in the same way as they apply to conventional plant. The renewables sector contributes to the operations which ensure system security in a fair and open manner.
- The third thing to note is that the costs of Frequency Response services are socialised across all market participants in much the same way that Capacity Adequacy costs are socialised across all market participants. National Grid must pay for access to a minimum volume of power in order to manage the risks to the system from the largest single in-feed loss. It is the scale of this largest potential drop-off from the supply side which drives the cost of procuring Frequency Response services, and these scales have long been set by nuclear and conventional generators. It is not the case, however, that these large generators shoulder the burden of the procurement of Frequency Response services – rather, the costs are shared amongst market participants. It is with reference to this state of affairs, therefore, that any considerations regarding the assignment of Capacity Adequacy costs to the Renewables sector must be framed.

4.2 What are the barriers to the deployment of energy storage capacity?

The electricity network has historically been about moving power from controllable, centralised plant to remote and passive consumers. This paradigm is changing radically, with a growing volume of our generation fleet dependent on the availability of natural resources such as wind and sunshine, with much of our conventional generation fleet aging and needing to be replaced in the near future, and with an increasing number of consumers playing an active role in the balancing of the system.

Renewables pose a particular challenge to the development of a modern grid as they are both further away from and closer to demand than traditional generators. The best renewable resources tend to be where people are not. For instance, commercial scale onshore wind tends to be built in Scotland, and offshore wind is built, by definition, some distance from population centres. On the other hand, as

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[8] https://sandbag.org.uk/blog/2015/nov/5/coal-too-old-be-useful/

renewable resources are to an extent available everywhere, there can be installations where people live and work. Tidal lagoons, for instance, present an opportunity for reliable and long term renewable energy generation at scale close to population centres. The network of the future has to cater for the huge growth in Distributed Generation (DG) and 'prosumers'.

This leads to the need to invest both in large transmission assets, including interconnectors with other markets, and in the distribution networks, particularly in 'smartness'. Due to the technological and business change that is ongoing, it is not clear which investment route will be the optimal one, and so there is the possibility that we will overinvest in some assets. We should be clear that investing in networks which facilitate multiple options when we are not sure which options we will prefer is a rational approach, and therefore we should not be paralysed from action by the risk that some of these actions may lead to assets becoming 'stranded'. Assets can always be reused, and economic signals can ensure that any underutilised portions of the grid can become targets for new connection customers.

Storage will be a key component, alongside Demand Side Management and Distributed Generation, of the smart grids needed to manage the non-traditional flows of electricity on the grid of the future. To generate when the natural resources are most abundant, to store as much unconsumed power as possible, and to call on that stored power at night, or when the wind isn't blowing – this will be the new paradigm. It should be a simple proposal to install storage at or near to the sites of renewable generation, so that power can be fed onto the grid in a more constant flow, increasing and decreasing output as need arises with zero fuel cost, but it should be noted that this is only one of a myriad of different approaches to the use of storage.

However, storage is not a homogenous mass – there are many different types with many distinct characteristics. Batteries, tidal lagoons, and pumped storage – amongst others – may offer the ability to provide flexibility and ancillary services. The priorities of the codes and the legislation governing the electricity industry are not clear on the issue of storage, on how it is to be handled, on how it is to be charged, and how it is to be supported. For instance, only projects of a single technology class can bid at any one time for a Contract for Difference (CfD), meaning that a wind farm which installed batteries to store and deliver its renewable power to the market would be classed as being composed of two different technology categories and would be ineligible for support. Allowing hybrid projects to bid for CfD contracts would immediately open a huge market for storage facilities by facilitating innovation in and broadening the scope of technologies such as tidal or from the development of hybrid wind projects.

Work Stream Six[9] (WS6) of Ofgem's Smart Grid Forum recommended that the regulatory treatment of storage be clarified, and that National Grid investigate the scope for standard contracts for multiple service provision (services to DNOs, as well as to the SO). WS6 also recommended that the 'heat maps'[10] produced by DNOs to illustrate where their networks are stressed should contain more information in order to facilitate the creation of new services. An understanding, for instance, of the amount of available capacity in a locality could help to direct a nascent storage provider to the most appropriate, and most valuable, sites.

With regards to arranging for storage to connect to the grid, at present there is a risk that grid capacity will be reserved for either storage or generation, leading to only one being able to connect, when in reality they would use the same capacity and together provide more flexibility to the system. The actions of storage have yet to be defined by Ofgem, and 'behind the meter' actions should be fully integrated into the relevant subsidy mechanisms. Better recognition for the benefits of the capabilities of storage in the codes and regulations governing the electricity industry, and a fuller appreciation of where the value of storage lies in the subsidy schemes affecting the electricity industry, are the first stages to lifting barriers for storage in GB.

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[9] https://www.ofgem.gov.uk/electricity/distribution-networks/forums-seminars-and-working-groups/decc-ofgem-smart-grid-forum/workstream-six-ws6-commercial-and-regulatory-issues

[10] For instance, Northern Powergrid's Generation Availability Map: http://www.northernpowergrid.com/generation-availability-map

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

Interconnectors are a TSO–TSO operation, meaning that the right interconnection to the right extra-GB system can help to reduce network reinforcement costs in GB and help to reduce the need for building expensive baseload or peaking plant. As the volumes of interconnection rise, the GB electricity market will develop stronger couplings to the electricity markets of the Continent. When the wind is blowing and power is cheaper and plentiful in GB then interconnectors should facilitate access to a much larger market for that power. For the UK consumer, more closely coupled markets will increase competition and result in cheaper electricity when prices on the Continent are lower.

We are supportive of interconnectors for the following reasons:

- **Balancing wind output.** As a variable technology, the generation of electricity from wind will not always correlate with demand. Interconnectors allow excess wind supply to be sold when system or energy limits would otherwise prevent this.
- **Reducing price volatility.** The capacity to export could help to reduce the wholesale price depression associated with high wind output, which would benefit generators supported by the Renewables Obligation and Feed-In Tariff schemes and reduce the need for further (consumer funded) support for renewable generation through the CfD.
- **Reduction in cost of Transmission Reinforcement.** An interconnector from Scotland to Norway may be a better investment than transmission network upgrades along the East Coast of GB or elsewhere, considering the related cascade of upgrades such a reinforcement may require. Power would flow to where it could most cheaply and efficiently be either stored or used. Interconnectors may reduce, or in some cases obviate, the need for Transmission Reinforcement work.
- **Transmission bottlenecks might be avoided.** A connection from Scotland to Ireland and back again into England may be a better way to flow electricity around current north-south bottlenecks. Filtering energy into Continental markets, as a form of storage, may also be an efficient way to manage north-south bottlenecks.
- **Service Provision.** The Moyle interconnector is bidding into the Enhanced Frequency Response scheme. This serves as an illustration for the possible Ancillary Services which may be provided by interconnectors.

The correct level of interconnector development in the market will depend on the direction in which the GB electricity market wishes to take in the near future. Consumers in GB will best be served with the cheapest and most stable access to electric power. Weighted against transmission upgrades, investments in new capacity, and the need for greater flexibility, interconnectors should be considered as a viable option where they contribute to the more efficient use of carbon-free power.

It is clear that the benefits obtained by building interconnectors are not geographically consistent. For instance, constructing links to Norway will offer the UK access to qualitatively different forms of resources and will provide qualitatively different benefits than would another link to France. The value of an interconnector is related to the make-up of the generation in the connected market. The Norwegian market contains a lot of flexible hydro power resources, which would offer a convenient place to “store” electricity generated from renewables in the UK when demand is low and generation is abundant. The French market, on the other hand, consists to a high degree of inflexible nuclear generation, offering little of the flexibility which the UK market needs. We recommend that the Commission considers carefully the full range of benefits associated specifically with each new interconnector investment before investment decisions are made.

The use of interconnectors in the UK market also, it should be noted, puts European generators at a competitive advantage, as non-UK based generators are not liable for Transmission Network Use of System (TNUoS) charges. To take an extreme example, were 100% of UK demand to be met via interconnectors, then UK generators would still bear 27% of the costs of operating the networks transmitting that power, even though all the generation was happening abroad, by plant at a price advantage. UK based generators should not subsidise the systems costs for generators selling into the UK via interconnector flows. We recommend that this market asymmetry is addressed alongside any planned interconnector development.

It should be stressed as well that interconnectors should not be regarded as a method to reduce greenhouse gas emissions in the UK, and that they are not an inherently low carbon source of power. Whilst interconnectors have a place in the power industry, the power which they provide is not necessarily carbon-free, coming as it does from the interconnected Continental market in which many sources contribute to the power imported to the UK. Power generated in the UK is more efficient, facing less transmission loss, and creates greater economic value here. These beneficial physical characteristics possessed of local generation should be taken into consideration when developing new interconnector schemes.

4.4 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 Single Electricity Market (SEM) which links Northern Ireland and the Republic of Ireland is a good example of a grid restructuring to accommodate renewables. "[It] is a small moderately isolated system in which individual power stations are large and lumpy relative to peak demand (up to 10%) and the system is being adapted to handle up to 70% non-synchronous wind penetration."[11] On a truly islanded grid, Eirgrid are creating a system which will handle the largest percentage penetration of variable generation in Europe. They are having to innovate rapidly in order to deal with system inertia issues, voltage instability, and Rate of Change of Frequency (RoCoF) problems with a large fleet of non-synchronous, non-inertial generation. Eirgrid are quadrupling their Ancillary Services budget, and by the start of the 2020s they expect around half of a generator's income to come from Ancillary Service payments and Capacity payments[12].

The UK and the SEM electricity markets are settled in 48 half-hourly settlement periods per day, this being the level of granularity available for most balancing services, and the level at which the Day Ahead Market can react to system conditions. Most Continental markets employ 15 minute settlement periods in their Balancing Markets, providing a greater level of flexibility in how and when services are able to dispatch to respond to system stress, though Day Ahead Markets are at hourly granularity. The Australian electricity market operates with 5 minute settlement periods, allowing greater flexibility still, and the Californian markets are looking at emulating this.

Denmark gets 37.5% of its power supply from wind, with this share expected to grow to 50% by 2020. The Danes have set a target of full conversion to renewable energy by 2050[13].The Danish Energy Agency posits that with long term planning and a stable and supportive policy framework, the implementation of large scale wind integration is feasible at both transmission and distribution level. The Danish Wind Turbine Certification Scheme[14] was established in 2008 to establish the technical specifications[15] of wind turbines which wish to connect to the Danish grid, in light of the fact that the increased volume of renewable power has displaced many large generators and thus the system services which such large stations typically provided. In GB, the Grid Code specifies the required capabilities of connected generators, but defining the requirements for storage, and opening the market in GB to DSR, will become increasingly important in the years ahead. Denmark uses interconnectors with Norway and Sweden to balance wind generation with hydro power availability. When the wind blows, power is exported along interconnectors, reducing the draw on hydro reserves, and when the

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[11] P.5 Missing Money and Missing Markets: http://www.econ.cam.ac.uk/research/repec/cam/pdf/CWPE1513.pdf
[12] See slide 49 of the System Operability Framework launch event slides, under 'SOF Launch Event': http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/
[13] Danish Energy Agency – Energy Policy toolkit on System Integration of Wind Power: http://www.ens.dk/sites/ens.dk/files/climate-co2/low-carbon-transition-unit/danish-energy-policy-toolkits/system_integration_of_wind_power.pdf
[14] The Secretariat can be found at: www.vindmoellegodkendelse.dk
[15] The technical specifications can be found at: www.energinet.dk

wind calms, the stored hydro power is exported back into Denmark. This is a model which the UK should pay more attention to, especially with the GB interconnectors due to double in capacity. Denmark's Energinet is also undertaking an R&D project aimed at demonstrating the potential for domestic heat pumps to store energy generated by wind sources at times when demand is low and supply is high[16]. The concept, a component of Energinet's 'Smart Grid' programme[17], serves to illustrate the potential for heat stores to manage wind generation.

The Australian National Electricity Market (NEM) has no concept of 'Gate Closure', with prices set every 5 minutes. Whilst there is an argument[18] that moving to a more transparent, close to real-time central dispatch model would bring about benefits to competition, such shorter imbalance periods would certainly open up the Balancing Mechanism to new players, such as DSR providers who could more fully participate by shifting demand for periods of time much shorter than the current 30 minute long periods of the BM. The similar experiences of ERCOT and Nordpool should also be considered here.

Yours Sincerely,

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[16] http://www.energinet.dk/EN/FORSKNING/Energinet-dks-forskning-og-udvikling/Sider/Fra-vindkraft-til-varmepumper.aspx

[17] https://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Forskning/Smart%20Grid%20in%20Denmark.pdf

[18] See paragraphs 22/23: https://assets.digital.cabinet-office.gov.uk/media/54f44a7be5274a145200000b/Wholesale_electricity_market_rules_working_paper.pdf

Appendix – Skills

RenewableUK supports the development of the skills needed for the UK to thrive and prosper into the 21st century and which will hasten the achievement of the Government's carbon reduction targets. Leadership at the Governmental level can drive the realisation of what should be a vital element in the development of our national infrastructure: talent.

If the Northern Powerhouse is to actually drive enhanced economic opportunity, and if the energy networks of the future are to live up to our expectations of how we will live in a post-fossil fuel world, then we strongly suggest that the National Infrastructure Commission takes the lead in incubating the talent and ability of our workforce as a central plank of the future productivity of the UK. In order to support the many thousands of jobs which the industry has the potential to support[19], RenewableUK proposes the following skills policy recommendations, on behalf of the industry, as outlined in the Skills Manifesto[20]:

1. A long-term vision for the sector's deployment to incentivise growth – the industry's ability to invest in long-term strategic skills initiatives requires confidence in Government's commitment to the future of the sector.
2. A national Government-led skills strategy – the Government should take a lead on skills initiatives by implementing a national, Government-led strategy to anticipate future requirements and opportunities. An underpinning national skills strategy is necessary for this.
3. Funding centrally channelled to meet needs – the Government should ensure skills funding is co-ordinated, planned, and based on evidence of need to ensure transparency, minimise duplication, and maximise opportunity for all.
4. Encouraging study in key areas through financial incentives – a reduced fee structure and financial contribution to academic institutions in recognition of the increased costs involved in providing key courses to reflect UK skills demand and help incentivise course uptake.
5. A flexible approach to visa restrictions – where national shortages of skilled employees exist, UK employers need the flexibility to import labour.
6. A consistent UK approach to funding – funding for skills initiatives should be consistent across national borders.
7. Attracting women into STEM subjects and careers – Government and industry should work to attract women to the workforce for the continued success of the sector.
8. Clarity on the wider anticipated skills supply – the Government should clarify and communicate future workforce resource to provide a picture of the wider cross-sector skills supply currently being nurtured.

[19] Working for a Green Britain & Northern Ireland 2013-2023, September 2013, Cambridge Econometrics, commissioned by RenewableUK and Energy & Utility Skills: http://www.renewableuk.com/en/publications/index.cfm/working-green-britain
[20] Skills Manifesto, September 2013, RenewableUK: http://www.renewableuk.com/en/publications/index.cfm/skills-manifesto