Introduction

Over the past decade we have seen infrastructure creep up the agenda to a point that it is now firmly placed at the heart of the political debate. With investment in major transport, energy and utility projects increasing to record highs and the development of the National Infrastructure Plan to set out key Government priorities, we have reached a stage where infrastructure is a nationally significant issue that transcends party political ties.

The formation of the National Infrastructure Commission last year was greatly welcomed by the industry and provided a great level of confidence in the deliverability of major projects and enables the current Government and future administrations to speed up decision-making on vital transport, energy and housing programmes that Britain needs to continue to grow its economy.

CH2M is a global engineering and programme management company that works in the areas of areas of water, transportation, environmental, energy, facilities and defence. With over 2,500 people employed in the UK, CH2M is currently working on some of the most iconic infrastructure programmes including Crossrail, High Speed 2, Thames Tideway Tunnels, Crossrail 2, the decommissioning of Dounreay and was one of the leading partners in CLM, Delivery Partner to the ODA for the London 2012 Olympic & Paralympic Games.

Given our experience of working on the development and delivery of major UK infrastructure projects, we felt it may be helpful to share some of our thoughts around the points laid out in the NIC's call for evidence in order to share the lessons learned for the efficient delivery of future infrastructure priorities. In particular, this document presents our views for regarding Electricity Interconnection and Storage. We have made separate submissions outlining our views for infrastructure priorities for London and Northern Cities.

Electricity Interconnection and Storage

Q1 – 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?

As large quantities of electricity cannot be stored easily, the key function of the system operator is to balance generation and demand to ensure a reliable supply of power to consumers and prevent damage to infrastructure such as power lines, transformers and generation plant. Within this context, National Electricity System Operator (NETSO), as the system operator for Great Britain (GB), has an obligation to balance the GB transmission system. Ofgem, the regulator of the GB market, operates a Balancing Services Incentive Scheme (BSIS) to incentivise National Grid to act economically and efficiently in performing its balancing role.

There are two broad categories of balancing actions available to the system operator (SO):

- Energy imbalance actions address overall mis-matches between generation and demand at a national level across the settlement period as a whole.
- System imbalance actions tackle local or regional constraints in the capacity of the transmission network, or short-term variations between demand and supply within a settlement period. Constraint actions can result in compensation ('constraint payments') for generators which lie behind a constraint barrier.

A recent assessment by the National Audit Office confirmed that the total cost of balancing services has considerably increased since 2010. The assessment concluded that this increase in cost of balancing services was predominantly due to growth of constraint costs. The increase in constraints was attributed mainly to unavailability of some transmission assets due to ongoing investment programmes of transmission owners in Scotland and elsewhere. In addition, the introduction of the 'Connect and Manage' policy, which allows certain types of generation to connect ahead of the required increase in transmission capacity was also identified as a driver for growth in constraints.

The 'Connect and Manage' policy was developed to facilitate a step change in renewable deployment across the GB market, by removing barriers for connection. Although largely successful in achieving this objective, in some isolated cases the policy has resulted in connection agreements for intermittent generation in areas where the transmission network is weak. Such agreements could result in further increase in constraint costs and impact adversely on balancing costs for the GB system. Considering the growth achieved in renewable generation capacity over the past decade (as well as additional Connect and Manage capacity expected to get connected in

the coming years), and the typical lead times for implementation of major transmission upgrades, there is a need to closely monitor that the 'Connect and Manage' is achieving its objectives without adding disproportionately to constraint costs. If necessary, there may be merit in reshaping the policy in the future.

Given the emissions target and forecasts for carbon prices, the GB market is likely to see a significant reduction of thermal fleet. This could result in tightening of the capacity, which can have further impacts on system balancing costs. A significant proportion of this capacity is likely to be replaced by inflexible nuclear or further intermittent transmission connected and embedded generation, posing further pressures on system balancing. The recently introduced capacity market auctions provide a way tackling some of these pressures. However, as identified by the National Audit Office, there may be merit in reviewing current arrangements for balancing services as a whole fit for purpose in the light of current and future developments (including the growth of intermittent and embedded generation).

The System Operator already plays a critical role in the capacity auctions. It also monitors the impact of 'Connect and Manage' policy on constraint costs. However, an independent SO (ISO), if necessary, could play a vital role in redesigning a forward looking 'Connect and Manage' policy, which could minimise the GB consumers' exposure to constraint costs. Equally, an ISO with greater authority could more actively transfer certain costs of imbalances in the system to respective players in the market, than it currently does. Furthermore, with extensive knowledge of the system, an ISO could facilitate creation of zonal markets to manage inefficiencies and reduce constraints. Equally, an ISO or an enhanced SO (ESO) could facilitate competition and ensure cost efficient and timely implementation of non-build solutions (e.g. demand side response) and new transmission assets, further reducing the GB consumers' exposure to system balancing costs. Both ISO and ESO could also play a critical role in facilitating the development of necessary cross border interconnection, which supports greater efficiency in system balancing costs.

The current incentives for system balancing costs, which are based on profit or loss sharing, are more suitable for a joint transmission ownership and system operation licence. Such incentives may continue to be suitable for an ESO, whose liabilities are borne by the parent transmission owner. However, considering the critical nature of the system balancing function, there may be merit in reassessing the caps on profit and loss sharing arrangement. On a different note, the current package of incentives will not be feasible for an ISO, who will predominantly be performing a revenue based public service.

Q2 – What are the barriers to the deployment of energy storage capacity?

Under current arrangements within the GB electricity market, storage is considered as a 'generator' like any other non-synchronous fuel types. However, unlike all other intermittent generation, net production based asset utilisation of storage plant is affected through the market prices. In particular, such units generate revenue and profit through price arbitrage based actions within the market (unless they are directly linked to a cross border interconnector). Hence, under current market arrangements they are not incentivised to operate in a manner which could deliver economic externalities such as reduction in energy prices and improved efficiency in system balancing costs.

This inability of the market to extract economic externalities from energy storage demonstrates the market failure. Furthermore, storage has the potential to act as an alternative to significant transmission investment. However, the GB market's current arrangements limit transmission companies from development and ownership of storage assets under most network conditions, as they are considered as 'generation'.

The GB market currently has less than 4 GW of transmission connected storage capacity. If incentivised through income guarantees which fully recognise their potential for delivering the basket of economic impacts and go beyond the current arrangements, the existing storage capacity has potential to deliver some reductions in GB's electricity costs as well as system balancing costs. However, the size of the impact could be noteworthy if such new market mechanisms were also offered to attract new private sector investments, which could deliver a critical mass of strategically planned transmission connected storage. Furthermore, there may be merit in considering a review of licence arrangements for transmission ownership, such that existing transmission owners and any new entrants to the market, can deliver additional storage capacity as an alternative and / or complementary to new transmission assets.

Smaller scale storage, based on technologies such as batteries, is less advanced. Subsequently capital costs of such developing technologies are not economically efficient yet. However, such storage technologies have good potential at micro level such as domestic use. In particular, they can complement the growing critical mass of embedded generation, facilitate demand management at distribution level and subsequently make further impact

on the market's energy prices. However, there may be merit in considering some upfront capital support for households and small and medium enterprises for the short term, until the costs become economically efficient.

Q3 – What level of electricity interconnection is likely to be in the best interests of consumers?

The Barcelona agreement in 2002 set a non-binding aspirational target of interconnection of 10% of installed capacity for all member states. The European Commission (EC) is currently reviewing this position and determining more appropriate objectives to ensure the correct level of interconnection. This is not least because interconnection between member states is considered as a key driver for EC to implement the Single Energy Market (SEM) policy across Europe, which aims to maintain affordability of energy, whilst ensuring security of supply and delivering target levels of renewable generation and reduction in carbon emissions.

There is currently 4 GW of interconnection between Great Britain (GB) and other European electricity markets (including All Islands Irish market). Considering approximately 75 GW of installed capacity in the GB[1] in 2015, this equates our market's interconnected capability of some 5% of the total installed capacity. The five interconnectors which have been awarded Cap and Floor support (IFA2, Fablink, NSN, Viking and Greenlink) over the past twelve months along with Eleclink and NEMO (interconnector projects in advanced delivery stage which are being developed as merchant projects) will increase GB's interconnected capability to 11 GW. If all this interconnected capacity is delivered by 2020, it will momentarily increase the GB interconnected capability beyond 10% of our installed capacity. However, with increase in generation capacity between 2020 and 2030, our interconnected capability will drop again below the 10% target.

Interconnectors currently generate revenue through market arbitrage and subsequent trading of their capacities. Their current economic function from the GB consumers' perspective is predominantly to deliver socio-economic welfare externality, defined as reduced energy prices in the GB market. This is primarily due to the prevailing energy mix within the GB market and the GB specific price of emissions, which typically results in higher per unit cost of electricity compared to markets in continental Europe.

Depending on the future mix of GB's generation capacity, which will be influenced by both top down national policy drivers and supporting mechanism and bottom up activities in the market, this primary economic function of interconnectors may change. For example, any reduction in deployment of renewable generation from current levels due to lack of funding or technological issues, would result in continued disparity between electricity prices in GB and European markets over the foreseeable future. Greater levels of interconnection under such a scenario will continue to offer the above mentioned socio-economic welfare externality.

In comparison, persisting with current policies and mechanisms such as increasing carbon emission prices and financial support for renewable technologies, will lead to greater continued deployment of intermittent renewable generation. This is likely to result in some cannibalisation of prices between the GB and certain continental European markets in the medium term. However, increasing levels of non-synchronous generation will lead to considerable system balancing issues (summer minimum and winter peak demand), which are not currently common to the GB market.

A critical mass of interconnection, under such a scenario, can deliver notable system operation benefits such as black start capability, frequency response and reserve response. If their location on the GB network is planned strategically, in light of the recently implemented pan-European Capacity Allocation and Congestion Management (CACM) network code, new interconnectors can support notable reduction of system balancing costs or even displace major transmission investments. Active participation of interconnectors in services which are considered as ancillary to their price arbitrage based primary revenue stream, would expand their economic function towards ensuring security of supply, increasing system flexibility and improving efficiency in system balancing costs. Introduction of interconnectors in the capacity market auctions will be a step in the right direction.

Furthermore, increased level of direct and indirect support for renewable generation coupled with maturing technology and subsequent reduction in equipment costs, can lead to even greater level non-synchronous generation. This, coupled with aggressive decommissioning of nuclear and lignite fleet in across European member states, may lead to lower prices in the GB compared with most European markets in the medium to long term. Under such a scenario, although the socio-economic welfare benefit for GB consumers would diminish, the role of interconnectors in providing ancillary services would expand significantly.

[1] Source: Europe's Ten Year Network Development Plan - Scenario Development Report, produced by European Network of Transmission System Operators of Electricity (ENTSO-E) in November 2015.

The revenue streams for interconnectors' ancillary services are poorly developed at present. Although attempts were made to establish the potential scale of GB consumer benefit of such ancillary services as part of the recent round of Cap and Floor by the System Operator, there continues to be a lack of clarity around how interconnectors can draw 'steady' income from provision of such services over the long term. Inability of the interconnectors to extract long term income from delivery of ancillary services based products, which lead to economic externalities such as security of supply, increase system flexibility and more efficient system balancing highlights the current market failure for new interconnector projects. In particular, further intervention is required to main stream an interconnector's long term revenues derived from ancillary services. This could also reduce the burden borne by the GB consumer through a new interconnector's Cap and Floor support.

Equally, there is need for strong leadership from the regulator and the system operator to ensure that appropriate products as part of CACM which will allow interconnectors to participate in system balancing activities are developed and operational soon. There may also be merit in considering improvements to enhance the planning of new interconnection projects which go beyond the recently announced Network Options Assessment for Interconnectors, by taking in account both socio-economic welfare and ancillary services benefits, as well as facilitate transfer of financial reward to interconnectors for outcomes such as increase in capacity of a major transmission boundary through formal contractual arrangements between transmission owners and project developers.

Q4 – 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?

Our response to the above questions already draws upon international good practice approaches such as the role of an independent SO, use of storage and interconnection for ancillary services (including constraint management), role of storage and interconnection in managing electricity prices within a market and creation of zonal markets for improving efficiency in system balancing costs.

We can provide further case study based evaluation on such specific issues to assist the evidence building exercise currently being undertaken by the National Infrastructure Commission.