E3G RESPONSE TO NATIONAL INFRASTRUCTURE COMMISSION CALL FOR EVIDENCE

Critical challenge 3: improving how electricity demand and supply are balanced while minimising cots to the consumer over the long term

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The Commission is well placed to advance existing efforts to address this challenge. Balancing of UK supply and demand at lowest cost must be seen in the context of requirement to transform to a near zero carbon electricity systems by 2030 and zero carbon economy before 2050. Successful delivery will depend on the Commission's ability to:

(1) exploit synergies across technology types, sectors and national borders;
(2) develop common, consistent and robust scenarios to underpin infrastructure planning without foreclosing options; and
(3) shift infrastructure decision making down to those who can control the level of demand at a city and regional level to build-in flexibility and preserve optionality.

If the Commission's recommendations deliver on each of these three points then a transformative reduction in the cost of electricity balancing will become inevitable within this Parliament.

Global decarbonisation – accelerated by the recent Paris Climate Agreement – has stimulated new waves of technological innovation in clean energy, efficiency and storage which are converging with parallel trends in "smart systems" and big data to expand the options available to the UK to meet its long term energy service needs at least cost. Making best use of these innovations will require fundamental reform of how the electricity system is managed and how it relates to the infrastructure for heating, cooling and transport each of which are likely to be significantly electrified over the coming decade.

In this changed landscape regulatory and market governance should aim to achieve economic efficiency by:

- ensuring a level-playing field for investment and purchasing of all types of demand side, supply, infrastructure and storage solutions to energy service provision taking into account their full-lifetime costs over a realistic range of future demand, technology and fuel price scenarios;
- ensuring a level-playing field for centralised and distributed energy solutions;
- avoiding unjustified discrimination between use of UK domestic and international electricity sources, capacity, storage and flexibility; and
- ensuring funding for RD&D and early stage deployment to potentially strategically important technologies such as CCS, storage, demand flexibility etc is adequate and timely to deliver their optimal potential contribution to reducing system costs.

The current UK system fails to deliver any of these objectives and in many areas is significantly underperforming against global and European best practice. These failures risk over investment in a new generation of costly energy infrastructure which will not be capable of delivering the UK's security or decarbonisation goals. Specifically the Committee should address the following barriers to lowest cost balancing:

- Under investment in cost-effective flexibility and energy demand reduction.
- Failure to stress-test the economic performance of UK energy infrastructure choices under the full range of likely scenarios resulting in low levels of economic resilience.
- Failure adequately take into account the implications of electrification of heating and transport which will result in the increasing integration of electricity, gas, transport and building infrastructure choices.
- Under investment in interconnection with other European countries which will cost UK consumers when ample lower cost capacity exists in Europe.
- Discrimination against decentralised and distributed energy solutions which have lower access to affordably priced capital than in many other European countries.

- Underinvestment in CO2 infrastructure - failure to bring forward viable CCS technology for gas before 2030 could lead to stranded gas assets and a crash programme of renewable build out to meet the UK's legal carbon budgets, both increase costs to consumers.

The response to the questions below address each of these areas in detail and present potential solutions to remedy these problems and achieve lowest cost security of supply in the context of the move to a zero carbon UK energy system. These responses are based on extensive research and modelling at UK and EU level which is referenced below and can found at: http://www.e3g.org/showcase.

The experience of world class bodies such as UK Foresight and the Climate Change Committee shows how complex and uncertain trends and technologies can be assessed in an open and participatory way to inform a comprehensive energy infrastructure strategy. The Commission should draw upon expertise in bodies like the Climate Change Committee to develop common, consistent and robust scenarios to underpin all infrastructure planning. **The aim must not be to try and predict the future but to ensure that the future is not being wilfully ignored in order to simplify decision making.**

The Carbon Budgets

The UK is on track to meet the Second (2013-17) and Third (2018-2022) Carbon Budgets but recent policy changes have undermined investor confidence[1] and in the UK energy market and Government's plans to meet the Fourth (2023-2027) and Fifth (2028-2032) Carbon Budgets[2].

The Committee on Climate Change (CCC) have demonstrated that the lowest-cost trajectory to the UK's legally binding carbon targets requires that the carbon intensity of power generation decreases from around 450 gCO2/kWh in 2014 to 200- 250 g/kWh in 2020, and to below 100 g/kWh by 2030[3]. Under this lowest-cost trajectory low-carbon generation reaches a total share of around 75% of generation by 2030. The CCC's analysis shows that the demand side has an important role in increasing the flexibility of the power system, alongside interconnection, storage and flexible back-up capacity; supporting the Commissions initial focus on lowest-cost balancing[4].

- ➔ **The Commission's recommendations and future work should be informed by the CCC's conclusion that the 2020s are a crucial decade for the future of the power sector.** Their findings show that onshore wind and ground-mounted solar deployment should be the priority in the first half of the decade, and nuclear, offshore wind and potentially carbon capture and storage (CCS) in the second half of the decade.
- ➔ **The Commission should address the risk that, instead of delivering this essential transformation, current policy will result in no deployment of additional onshore wind and CCS and only a limited deployment of offshore wind[5]**. Department of Energy and Climate Change *Energy Trends* data shows that this risk to low carbon deployment could present a significant barrier to balancing supply and demand as a generation gap of over 100TWh is set to open up in the mid 2020s rising to 200TWh by 2030 (see Figure 1 below).

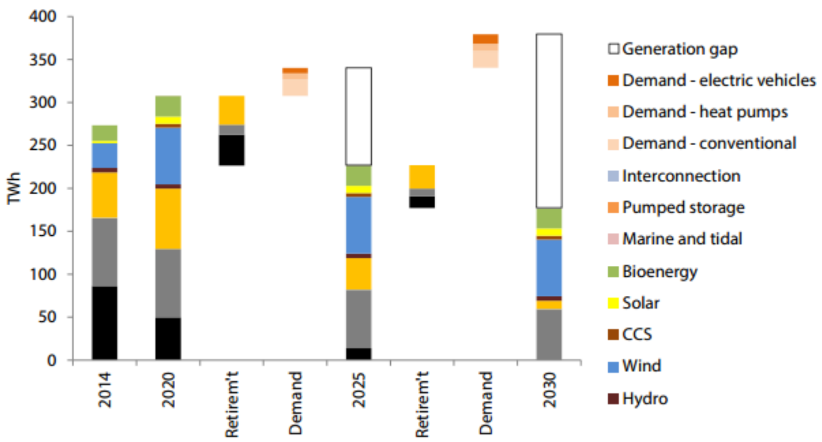
[1] Ernst&Young warned in September that "The lack of clarity and direction around UK energy policy may undermine investment" and concluded that "At best it may be a case of misguided short-term politics getting in the way of long-term policy. At worst, however, it's policymaking in a vacuum, lacking any rationale or clear intent." (EY, Renewable Energy Country Attractiveness Index -Issue 45 - country focus – UK, p35-37 http://www.ey.com/Publication/vwLUAssets/RECAI-45-September-15-LR/$FILE/RECAI_45_Sept_15_LR.pdf#page=35

[2] The Committee on Climate Change warned in September that "[t]he uncertainty created by changes to existing policies and a lack of replacement policies up to and after 2020 could well lead to stop-start investment, higher costs and a risk that targets to reduce emissions will be missed." (A letter from Lord Deben, Chairman of Committee on Climate Change, to The Rt. Hon. Amber Rudd MP, Secretary of State for Energy and Climate Change, 22 September 2015, https://www.theccc.org.uk/publication/letter-clarifying-the-direction-for-low-carbon-policy/)

[3] Committee on Climate Change, Sectoral scenarios for the fifth carbon budget – Technical report, November 2015, https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/

[4] 'Flexibility is important. To maximise the value of these investments and ensure security of supply it will be important to improve the flexibility of the power sector. That will require investment in flexible gas-fired generating capacity alongside expansion of international interconnection, flexible demand response and potentially electricity storage. The costs of these measures are included in our assessment of intermittency and system costs.' Committee on Climate Change, Power sector scenarios for the fifth carbon budget, p7, October 2015, https://www.theccc.org.uk/publication/power-sector-scenarios-for-the-fifth-carbon-budget/

[5] PWC warned in May 2015 that 'Policymakers must be mindful of industry's need for sufficient long term certainty to support the investment decisions necessary to maintain an appropriate balance between security of supply, decarbonisation and affordability' State of the renewable industry: Investment in renewable electricity, heat and transport, May 2015, http://www.pwc.co.uk/industries/power-utilities/insights/investment-in-renewable-energy.html



(Figure 1. Committee on Climate Change (2015) Power Sector Scenarios for the Fifth Carbon Budget, p32)

The falling cost of decarbonisation

Over the past five years the cost of solar PV has declined by 50%, onshore wind by 18% and offshore wind by 11%. Global markets in efficiency are now larger than new investment in supply side power production[6] whilst the cost of electric vehicle batteries has fallen by 55% and the cost of LED light bulbs by 84%[7].

More co-ordinated and strategic grid planning across onshore, offshore and cross-border regimes could save between £1.5bn and £10bn by 2030. Whilst sharing of system balancing resources with neighbouring countries can save a further £3bn each year by creating a more flexible system that has the effect of 'firming' the output from variable renewables and reducing the need for investment in low carbon generation capacity[8].

Solar generation in the UK has grown from less than 1GW in 2010 to 5GW by end of 2014. Current capacity may double by 2020 depending on government policy changes. These investments were largely unanticipated. In 2011 the Committee on Climate Change expected negligible amounts of solar power in the UK by 2030.

The UK's clean energy policy is not sufficient to meet its Paris Commitment, and needs to be consistent with a lowest-cost pathway to meet the tougher long term targets agreed in Paris. This will require stronger policies to support renewable energy, energy efficiency, low carbon heating, smart grids, clean vehicles and European interconnection.

Electricity consumption and the electrification of transport and heat

Electricity consumption is currently falling as goods like computers and fridges have become much more efficient due to advancing technology and European product regulation. The electrification of transport and heat is expected to add an additional 30TWh of demand by 2030[9]. To improve how electricity demand and supply are balanced the Commission must ensure that the electrification of transport and heat reduces balancing costs. This will require domestic efficiency improvements and a smarter grid that can transform homes and cars into an additional storage resource.

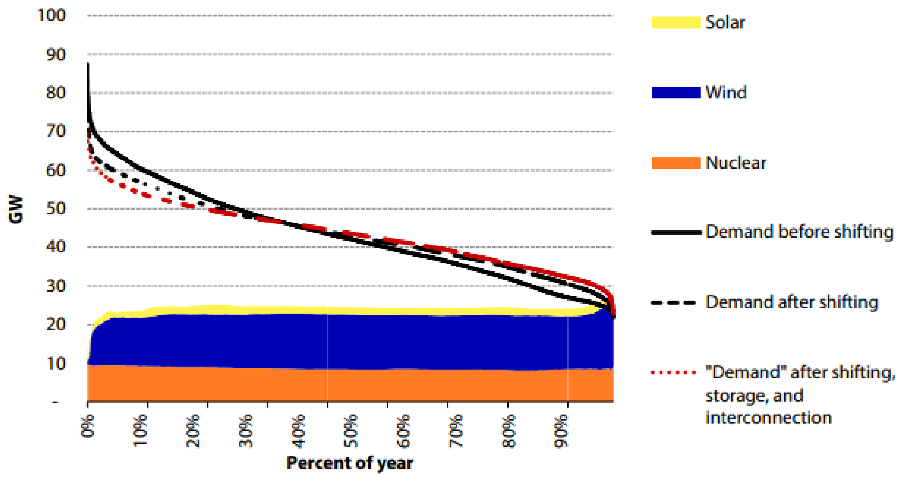
If the electrification of domestic heating is combined with significant improvements in domestic energy efficiency and demand response our housing stock could deliver thermal storage infrastructure at a scale that would significantly reduce the challenge and costs of balancing electricity supply and demand (see section 1c)

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?

➔ **To balance supply and demand in the long term whilst minimising costs to consumers the Commission should recommend reforms that are likely to correct predicted imbalances in the 2020s at the lowest costs. Responding to predictable future uncertainties – or "known unknowns" – requires an ability to understand and manage demand, integrate across infrastructure systems, build-in flexibility and preserve optionality.**

[6] https://www.iea.org/Textbase/npsum/EEMR2014SUM.pdf
[7] US Department of Energy, Solid State Lighting Research and Development Multi-Year Program Plan, 2014
[8] Transmission Planning and Regional Power Market Integration: UK Oportunities (2015), Simon Skillings and Goran Strbac, http://www.e3g.org/library/transmission-planning-and-regional-power-market-integration-uk-opportunitie
[9] Committee on Climate Change, Sectoral Scenarios for the Fifth Carbon Budget, 2015, p41, https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/

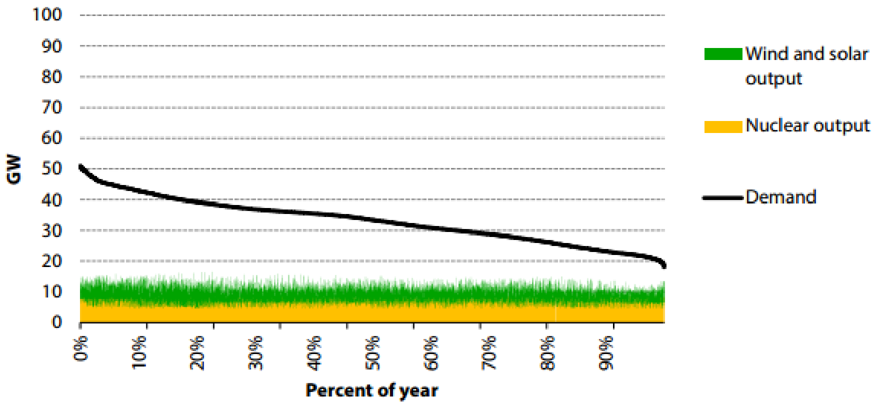
The CCC's lowest cost decarbonisation scenario through to 2030 shows interconnection, demand response and storage deployed and significantly increasing system flexibility. Figure 2 (below) shows how the deployment of flexibility infrastructure lowers peak demand during periods of reduced low-carbon output (on the left) and increasing demand at periods of high low-carbon output (on the right).



(Figure 2. Contribution of wind and solar to meeting demand in hypothetical 2030 scenario (reaching 100gCO2/kWh) with system flexibility deployed[10])

The CCC's findings demonstrate the timeliness of the Commissions emphasis on the system flexibility that interconnection and storage are capable of providing. They also highlight the challenge of delivering a balanced system in 2030 that does not exceed 100gCO2/kWh. Recent policy changes have removed all public investment in carbon capture and storage (CCS) development and deployment creating a very significant barrier to lowest cost balancing which the Commission should address in its recommendations to Government. The Department of Energy and Climate Change and the CCC conclude that a major deployment of carbon capture and storage (CCS) technology in the first half of the 2020s will drive down costs by reducing the requirement for low-carbon new generation.

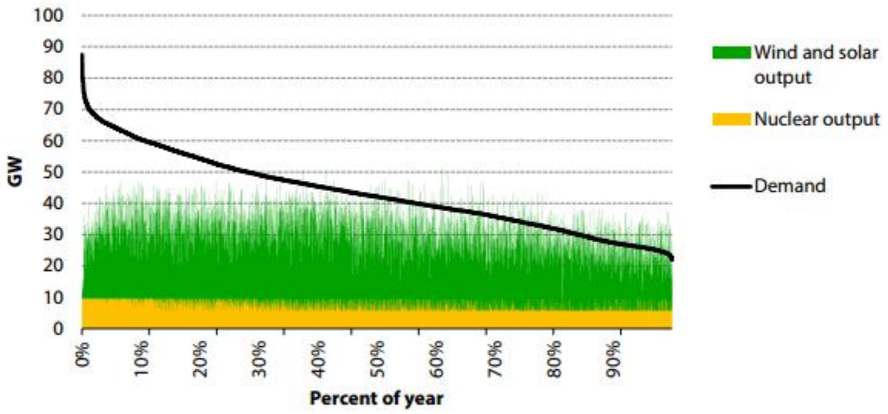
➔ The Commission should draw on the expertise of the CCC and the Department of Energy and Climate Change to ensure that it is addressing current and future balancing challenges rather than those that have already passed. Figure 3 below shows the gap between current demand and low-carbon output – in 2014 demand was always higher than the combined output of wind, nuclear and solar.



(Figure 3. The combined output of wind nuclear and solar compared to hourly demand data in 2014. CCC calculations based on Gridwatch (2015) Elexon BM Report data for 2014 and Aurora Energy Researh, EOS Data Analytics Platform (2015) data[11])

Ignoring changes to the UK energy system predicted in the Government's own scenarios, and specified in its legally binding Carbon Budgets, in order to simplify decision making today results in a high risk of policy failure; policy designed to address the balancing challenge of today will fail to address the very different challenges of the 2020s. Figure 4 (below) shows that with the higher deployment of wind and solar through the 2020s, the combined low-carbon output (including nuclear) will often exceed demand.

[10] Committee on Climate Change estimates based on Imperial College London modeling (2015)
[11] Committee on Climate Change, Sectoral Scenarios for the Fifth Carbon Budget, 2015, p65, https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/



(Figure 4. The combined output of wind nuclear and solar compared to hourly demand data in hypothetical 2030 scenario reaching 100 gCO2/kWh, Imperial College London modelling (2015))[12]

(a) Is there a need for an independent system operator (SO)? How could the incentives faced by the SO be set to minimise long-run balancing costs?

An independent systems operator (SO) and reforms to deliver resilient electricity market should be immediate infrastructure priority for the Commission.

The system operator has two key roles: firstly to ensure the least cost and secure operation of the system through design and implementation of a balancing mechanism and contingency measures and secondly to act as the delivery body responsible for central procurement of resources (e.g. low carbon technologies, capacity or flexibility resources, ancillary services to ensure compliance with statutory system operation targets).

It is necessary for the Commission to decide three things: the preferred nature of ownership, the requirement for unbundling and the method of incentivisation for the system operator. The current structure of transmission system operation is a legacy from the early days of liberalisation when there was concern that secure operation of the system required a detailed understanding of the network infrastructure and its maintenance schedules. However, it is now clear that this concern was misplaced and independent system operation has proved viable not only in many overseas markets but also in Scotland (for more information see Annex 1).

Independent system operators have become a standard feature of electricity markets around the world. The increase in complexity of market operation and the need to ensure resources (generation, network and demand) are employed optimally suggest that the time is right to establish a GB ISO, with an eye toward regional integration of system operation. Apart from ensuring that generation, network and demand resources are treated on a level playing field, an ISO can work closely with neighbouring system operators to ensure resources are used efficiently across a larger geographical area. This could be the first step towards creating a regional SO charged with the efficient operation of the market at a regional level.

(b) Is there a need to further reform the "balancing market" and which market participants are responsible for imbalances?

➔ **Transformational benefits can be obtained through increasing the availablility of low cost balancing resources. The Committee should focus on the challenge of maximising the availability of flexible demand resources and ensure the interconnection of markets allows the full sharing of balancing resources between countries.**

Market reforms over the past 25 years have been based on the presumption that the most efficient outcomes are achieved by allocating imbalance costs where possible and leaving the move to organised trading as late as possible. The 'balancing market' actually comprises three elements:

- Future imbalances resolved through bi-lateral trading
- Future imbalances resolved through organised trading
- Current imbalances resolved through contingency actions

Imbalances arise for both energy and system reasons. Energy imbalances involve those that can be predicted ahead of time and actions that can be taken to restore balance and those that can't be predicted where contingencies need to be put in place to allow recovery. System issues involve locational constraints that are relatively constant and those that cannot be predicted and require various services to maintain system integrity.

The two key choices facing market designers involve the extent to which the costs of imbalance should be allocated between market participants and the point at which organised trading takes over from bi-lateral trading (see Annex 2). Renewable intermittency generally

[12] *ibid*

arises through changes in weather conditions and, therefore, is predictable several hours in advance. Experience in other markets with high levels of variable renewable generation has demonstrated that future output is most easily predicted on a system wide basis, rather than by individual operators, as the impact of weather systems moving across a country can be forecast. This suggests that the system operator is best placed to manage the risk of renewable intermittency since they will have earlier warning of imbalance and access to a wider range of remedies. This would need to be achieved by moving to organised trading several hours ahead of real time.

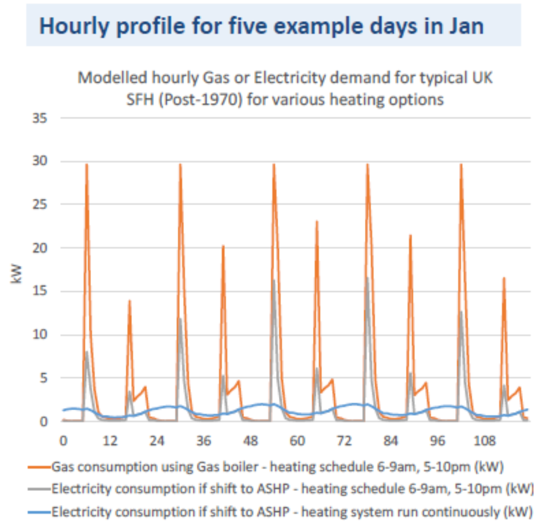
Balancing market design is an extremely complicated issue that has remained contentious despite several decades of attention from regulators and trading experts. It is broadly accepted that the costs of imbalance arising for energy reasons should be allocated to those parties out of balance. However, there are a number of important questions that remain to be resolved:

1. Is the calculation of imbalance cost appropriate in terms of predictability and magnitude?
2. Could imbalances arising for system reasons (long term constraints, reserve costs) be allocated?
3. Is it more efficient to allow intermittent renewables to resolve imbalances through organised trading several hours ahead of real time?

➔ **Above all, it is important to realise that any benefits that may, or may not, be achievable through addressing these questions of detailed market design are likely to be small in comparison to the benefits that can be obtained through increasing the available of low cost balancing resources. In particular, it is important to maximise availability of flexible demand resources and ensure the interconnection of markets allows the full sharing of balancing resources between countries.**

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

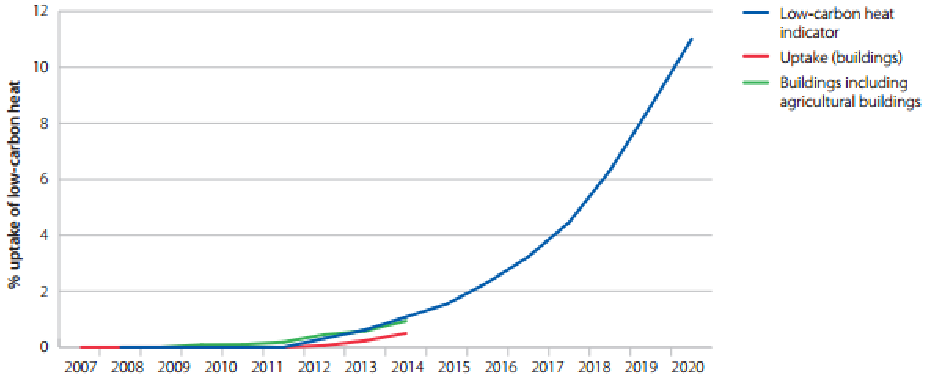
The potential for consumers to respond to price signals and adjust demand is currently unknown but may be a very significant and cost-effective alternative to achieving system balance through supply side measures. A transformational impact on system balancing could be achieved by combining the electrification of heat with domestic energy efficiency (see Figure 5).



(Figure 5. Element Energy for CCC – Research on district heating and local approaches to heat decarbonisation[13])

➔ **The high likelihood of policy failure on heat electrification poses a significant risk to lowest cost systems balancing. The Committee should recommend the delivery of domestic energy efficiency and heat electrification as an infrastructure priority.**

[13] Element Energy for CCC – Research on district heating and local approaches to heat decarbonisation https://www.theccc.org.uk/publication/element-energy-for-ccc-research-on-district-heating-and-local-approaches-to-heat-decarbonisation/



(Figure 6. Uptake of Low Carbon Heat in Buildings from DECC 2014 energy consumption statistics, CCC calculations)[14]

The current market is based on the presumption that consumer engagement should be driven by price and price alone. Whilst there is likely to be a proportion of consumers, particularly those that are large or sophisticated, that will respond to price, many will not. Experience in the supplier switching market suggests that the majority of customers will not engage, despite low levels of effort required and benefits that are far greater than are likely through offering demand flexibility.

A lack of consumer engagement might be acceptable if it was simply a matter of failure to switch supplier since potential impacts on resource efficiency are limited. However, the provision of demand flexibility has real and material potential benefits for overall resource costs that could significantly reduce prices to all consumers. Moreover, widespread engagement in the energy market is an essential prerequisite for the decarbonisation of heat since this will involve significant changes to individual premises.

➔ **The Infrastructure Commission should initiate a fundamental review of the issue of consumer engagement in the context of maximising the potential for demand flexibility and the decarbonisation of heat. In the meantime, momentum must be maintained in promoting market access for those consumers who are prepared to respond to a simple economic incentive.**

2. What are the barriers to the deployment of energy storage capacity?

(a) 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?

At present, energy storage does not provide the most efficient means to help balance the energy system when compared to demand side response, interconnection or generation. Energy storage systems are currently technically immature but have the potential for significant cost reductions over the coming years and decades.

Driving forward these technical developments requires new and additional R&D investment but also a programme of deployment to deliver 'learning by doing'. This, in turn, might require system operators, both at transmission and distribution level, to take a long term perspective on the potential benefits for cost efficiencies. These considerations must therefore be included within the relevant regulatory and incentivisation frameworks.

(b) 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.)

➔ **Transformational opportunities for energy storage can be delivered as part of the electrification of heating (see section 1c) and transport.**

The Commission should include in their next inquiry specific questions to establish a more detailed understanding of the energy storage possibilities from the mass distribution of battery storage through electric vehicles. The effect of zero emissions vehicles on the system balancing challenge will largely be determined by whether or not Government can encourage strategic investment decisions that ensure an orderly transition. With a large disruption to the light vehicle market now considered likely[15], failure to intervene could undermine other interventions to improve energy balancing.

The levelised cost of solar PV has fallen by 78% since 2009 and is increasingly cost competitive with fossil fuels[16]. Solar generation in the UK has grown from under 1GW in 2010 to 5GW by end of 2014. The new tariff for domestic-scale solar of 4.39p/kwh means it now makes sense for

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[14] Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament: Summary and recommendations https://www.theccc.org.uk/publication/reducing-emissions-and-preparing-for-climate-change-2015-progress-report-to-parliament/ p80
[15] http://www.goldmansachs.com/our-thinking/pages/new-energy-landscape-folder/report-the-low-carbon-economy/report.pdf
[16] http://www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf

household to store what they generate in a battery at home rather than export it for the low tariff. Current trends in distributed generation will be reinforced by the proliferation of newly available battery storage systems for homes and large-scale commercial business, such as the Tesla Powerwall.

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

The UK is currently under-connected with its neighbours and significantly greater levels of interconnection would be in the interests of consumers. The current wholesale price of electricity in the GB market is double the price of the German and Nordic electricity markets. Greater interconnection should lead to greater price convergence, including lower costs for GB consumers.

UK interconnection capacity represented only 6% of installed generation capacity in 2014. This puts the UK 21st out of 28 member states. In October 2014 the European Council agreed a target for countries to achieve 15% interconnection capacity by 2030. This target helps to provide forward certainty for the industry as well as adding a political focus on moving investment forward. The 15% target should be seen as an appropriate minimum level of interconnection capacity for the UK to achieve by 2030, with further interconnection capacity developed if needed.

➔ **Interconnection is a strategic system resource. It plays four key functions to support the interests of UK consumers:**

- First, greater interconnection between GB and European markets can enable optimal use of existing generation assets, meaning the most efficient plant are used first – lowering costs to consumers
- Second, interconnection across European markets can enable new generation (and/or demand) to be sited in the most optimal locations – for example for wind power to be located in the windiest regions and solar PV to be located in the locations with the most solar irradiation.
- Third, interconnection can act as a flexibility resource, to facilitate the integration of variable renewable generation.
- Fourth, interconnection can support energy security across asset replacement cycles – meaning the UK can import power when margins are low (as at present) and have the potential to become an electricity exporter in the future.

(a) 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?

The Cap and Floor regime is an improvement on the merchant-only model but remains deeply suboptimal from a system perspective. While there is a strong pipeline of interconnectors planned over the next 7 years, the current regime alone is unlikely to lead to an optimal level of interconnection for British consumers. There are three core reasons for this:

- The Cap and Floor model – like the merchant model – relies primarily on congestion rents based on price differentials to fund new investment. However, as interconnection approach the optimal level from a system point of view, price differentials will fall and may not be sufficient to support new investment.
- As the only model of its type in the EU, the Cap and Floor adds regulatory complexity to projects and additional barriers when connecting with other countries (who tend to operate more straightforward regulated investment models).
- Unlike onshore transmission, there is currently no 'system architect' for interconnection, meaning interconnection development tends to be fragmented and incremental. Owners of existing interconnection built under a merchant model have a perverse incentive to avoid new interconnection development.

A new, more forward-looking perspective is needed. Transformational cost reduction and security improvements are available through a regional system architect empowered to make anticipatory investments. In any future with a greater level of interconnection significantly less infrastructure is needed to deliver a secure, balanced and low-carbon energy system.

The 2020s will see the continuing convergence of investment in building efficiency, electricity and gas infrastructure, and the beginning of the integration of electricity and transport systems. It will be impossible to make a credible case for future energy investment without a clear assessment of the impact of regulation and public investment on future demand. This must include assessment of international power resources as the UK grid will be increasingly balanced at European scale, drawing on Norwegian hydroelectric, Irish wind and Spanish solar power[17].

As more physical interconnectors are built, the costs to UK consumers of ignoring the opportunities to share resources with European neighbours will become too large to ignore[18]. It is expected that investment in onshore, offshore and cross-border transmission capacity will reach £23bn–£50bn by 2030, which is considerably greater than the entire current Regulated Asset Value of existing GB transmission assets (< £13bn)[19].

[17] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/68816/216-2050-pathways-analysis-report.pdf
[18] http://www.e3g.org/docs/E3G_Electricity_Market_Reform-_Unfinished_Business_Simon_Skillings_120515.pdf
[19] Transmission planning and regional power market integration: The opportunities for UK Energy Policy (*Simon Skillings and Goran Strbac*) H:\ECF market integration paper - draft (2).docx

Any improvements in the network planning process therefore have the potential to deliver considerable savings in the cost of the network infrastructure as well as significantly reducing the costs of a major offshore wind deployment program. Moreover, more integrated operation of the power system with neighbouring countries has the potential to deliver further savings:

- More co-ordinated and strategic grid planning across onshore, offshore and cross-border regimes could save between £1.5bn and £10bn in the period out to 2030,
- Whilst sharing of system balancing resources with neighbouring countries can save a further £3bn each year by creating a more flexible system that has the effect of 'firming' the output from variable renewables and reducing the need for investment in low carbon generation capacity.

(b) 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?

Interconnection faces specific barriers and challenges that are not faced by other balancing technologies. It is cross-border by nature, which means dealing with multiple jurisdictions and plays multiple roles in the energy system beyond system balancing alone.

Realising the benefits from more coordinated and strategic grid planning and interconnector system balancing requires the Commission to deliver institutional, political and regulatory reform. Institutional reform can be achieved by establishing an Independent System Operator (SO) as the institution responsible for coordinating network development requirements and evaluating the implications and opportunities of market integration.

The Commission should make a clear recommendation to Government to ensure that the Internal Energy Market reform process currently being undertaken by the EU Commission focuses on two key issues of significant potential benefit to the UK:

➔ Firstly, a system of financial transmission rights trading should be introduced, since this will enable the UK to fund renewable energy projects in other countries and directly benefit from the energy produced.

➔ Secondly, a mechanism for the inter-state trading of flexibility products and corresponding allocation of interconnection capacity, since this will create a more flexible power system and reduce the quantity of low carbon generation that is required to meet decarbonisation targets[20].

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 National Infrastructure Commission can significantly improve energy infrastructure delivery by adapting best practice examples from UK and EU cities, international cities and other EU member states.

Responding to predictable future uncertainties – or "known unknowns" - requires an ability to understand and manage demand, integrate across infrastructure systems, build-in flexibility and preserve optionality. Taking advantage of digital smart technologies and the opportunities of convergence of infrastructure systems requires careful integration at the local level of consumer markets, physical systems and planning choices. Pioneering approaches to managing integrated infrastructure can be seen in New York and Berlin in electricity systems and to an extent in London on managing climate adaptation.

Under the Covenant of Mayors – a political movement of mayors that has proved to be one of the most successful instruments of EU energy policy – some 6500 cities have made climate commitments to 2020, and have produced over 4600 city/regional delivery plans, known as Sustainable Energy Action Plans (SEAPs). Many of the commitments in these SEAPs are more ambitious than the EU and national climate and energy targets: signatories have committed to an overall average of 28% GHG emission reduction by 2020 compared to the EU target of 20%3, and have just endorsed an at least 40% CO2 emission reduction target by 2030.

The Smart Cities Forum has defined additional capacities that cities would need to deliver modern infrastructure projects, particularly the need to improve capacity for project development and innovative finance. Moving to a fully devolved system will require stronger delivery support institutions to work with cities, including financial support from the Green Investment Bank.

The Investment Plan for Europe ("Juncker Plan"), which includes the creation of the European Fund for Strategic Investments (EFSI), is supporting increased investment in low carbon projects but the volume of projects coming through is currently low. A significant barrier at the city level has been that energy efficiency financing counts as debt in cities' budgets, and that many EU cities have strict debt rules in line with the national and EU frameworks. Cities are reluctant to increase their level of debts, creating additional uncertainty for energy efficiency investment. As an example, Paris had to look for alternative financing tools for its energy efficiency retrofitting in schools because traditional finance tools such as Energy Performance Contracting (EPC) required public authorities to list the payment as debt in its books.

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[20] Transmission planning and regional power market integration: The opportunities for UK Energy Policy (*Simon Skillings and Goran Strbac*) H:\ECF market integration paper - draft (2).docx

- ➔ Re-classifying energy efficiency expenditure as infrastructure capital spending could help overcome these barriers**.** Designating energy efficiency as an infrastructure priority and ensuring that public subsidies and financial support mechanisms in favour of energy efficiency are counted as capital spending, would give greater security and certainty to energy efficiency schemes. The Scottish Government has made home energy efficiency insulation an infrastructure priority.

Progress on deploying these innovations is accelerating as new forms of electricity market governance are pioneered across the world, led by sub-national jurisdictions such as New York[21] where the state Public Service Commission has launched one of the most extensive electricity market reform efforts in the world.

- ➔ This could provide valuable insights for the UK. Under New York's Renewing the Energy Vision (REV) new technologies including demand management, energy efficiency, distributed generation and storage are to be used as key tools in the planning and operation of an interconnected modernized power grid. The reform effort underway involves changes to the role of distribution utilities in enabling market-based deployment of distributed energy resources as well as to the current regulatory, tariff, and market designs and incentive structures to better align utility interests with achieving policy objectives. In particular, the NY Public Service Commission (PSC) has recognised the greater role that distributed energy resources can play in system balancing.

Annex 1 – Independent System Operator

The important advantage of independent system operation is that it ensures that all resources are treated equitably and there is no preference, explicit or implicit, for approaches that improve returns for the transmission (and interconnections) business. This is important and can be introduced through well-enforced business separation or full ownership unbundling.

It is also extremely important that the system operator is effectively incentivised, to ensure lowest costs to consumers (current and future). Equitable treatment of resources is only part of this challenge since it is also necessary to have a clear time-horizon over which costs are minimised. In particular, certain resources, such as those on the demand side or storage (see below) may be technologically immature and require some short term support to deliver long run efficiency.

Developing a sufficiently robust financial incentive for a for-profit system operation business is likely to be extremely complicated (the existing system operator incentivisation mechanism already suffers from complexity and lack of transparency). In most international energy markets, the preferred structure is, therefore, for a Government-owned independent system operator operating under statutory mandate.

A Government-owned independent system operator is the preferred way forward in the UK. Apart from the advantaged described above relating to the efficient procurement and dispatch of resources, it would also present the opportunity to rationalise resources currently residing in Government and Ofgem that are involved in resource procurement and market surveillance.

Annex 2 – allocating costs for energy imbalances

Market reforms over the past 25 years have been based on the presumption that the most efficient outcomes are achieved by allocating imbalance costs where possible and leaving the move to organised trading as late as possible.

The process of cost allocation for energy imbalances involves a number of subjective judgements. Firstly, the cost has to be calculated and this depends on the pricing algorithm adopted in the organised trading mechanism and the extent to which the costs of contingency reserves are included. Secondly, imbalances will often arise through some combination of energy and system reasons that cannot be separated.

The pricing algorithm adopted within the organised trading mechanism is not only important in defining the magnitude of the costs to be allocated but its predictability is also critical in determining the efficiency of the forward trading market. This latter point is particularly relevant for demand response where actions often need to be taken ahead of real time to prepare for reduced consumption. This requirement will diminish as more automation is introduced and a response can be delivered to a price signal almost immediately.

Currently, there is no attempt to allocate the costs of imbalance that arise through system reasons. However, long term locational constraints could be represented effectively through locational marginal pricing and a system of financial transmission rights and this approach is adopted in some international markets. Also, the costs of contingency reserves arise through unexpected loss of power plant (or rapid changes in demand driven, for example, by TV schedules) and the costs are particularly high as a result of power plants with high unit capacity (e.g. nuclear).

[21] See New York's Reforming the Energy Vision at http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument