Electricity Connection and Storage – Submission to the National Infrastructure Commission from the Cheshire and Warrington Local Enterprise Partnership

Cheshire and Warrington Local Enterprise Partnership

The Cheshire and Warrington Local Enterprise Partnership (LEP) is a private-sector-led partnership charged with driving the economic growth of the Cheshire and Warrington Sub Region and is one of 39 LEPs in England. Established in March 2011 it covers the three Unitary Authorities of Cheshire East, Cheshire West and Chester and Warrington, an area of approximately 871 sq. miles.

Summary

The Cheshire Warrington Local Enterprise Partnership is keen to respond to the Call for Evidence issued by the NIC, however we acknowledge that the questions posed are, on the whole, very specific and technical in nature. As such the LEP does not have the level of expertise to answer these in its own right, however the Cheshire and Warrington Sub-Region is home to a number of nationally significant energy-related companies a number of whom we have consulted with through the Cheshire Energy Hub (http://www.cheshireenergyhub.co.uk/).

One of the lead partners in the Energy Hub, EA Technology, has responded to the Call for Evidence in its own right and we have restated their response as **Appendix A.** Further information is included below in respect of the barriers to deployment of energy storage.

In terms of key points we would wish the Commission to 'take away' from the evidence submitted, these would be: -

- Continued investment in the development of energy storage capability and technology will be critical in ensuring energy security and continuity of supply. Having a reliable, affordable energy supply is crucial for many of the key industrial sectors based in Cheshire and Warrington and without out such security future investment in new products and facilities could be at risk.
- Supporting the development of SMART Grid technology will be an important element of enabling creation of a more responsive, flexible energy market.

Context

Strategically located between the Core Cities of Liverpool and Manchester and with close to a million people our Cheshire and Warrington is one of the most successful economies in the country. Generating in excess of £23 billion of GVA per year, our sub-region has a workplace GVA per head consistently above the national average and around 30% higher than any other economy in the North of England.

Based on latest 2014-2015 economic data, Cheshire & Warrington is:

- ***A major economy with a large cohort of world-leading firms****, with an annual Gross Value Added (GVA) of over £23bn, and 430,000 work-based employees. The C&W economy is equivalent in scale to cities such as Birmingham and Leeds. The sub-region's key firms include Bentley Motors, Tata, Vauxhall and Barclays, and there are distinctive sectoral specialisms in advanced, high-value engineering, energy, and professional and business services as well as growth potential in food, agri-tech and biological engineering.*

- ***A diversified and internationally-oriented economy****, with around one-fifth of employment in Cheshire and Warrington in export-intensive industries, the third highest of any LEP area across England. Cheshire and Warrington has a consistently strong record in attracting new inward investment compared to the national average, with the area offering a diverse range of investment locations for investors: in urban centres, in and around attractive market towns, and in high-quality, yet accessible, rural spaces.*

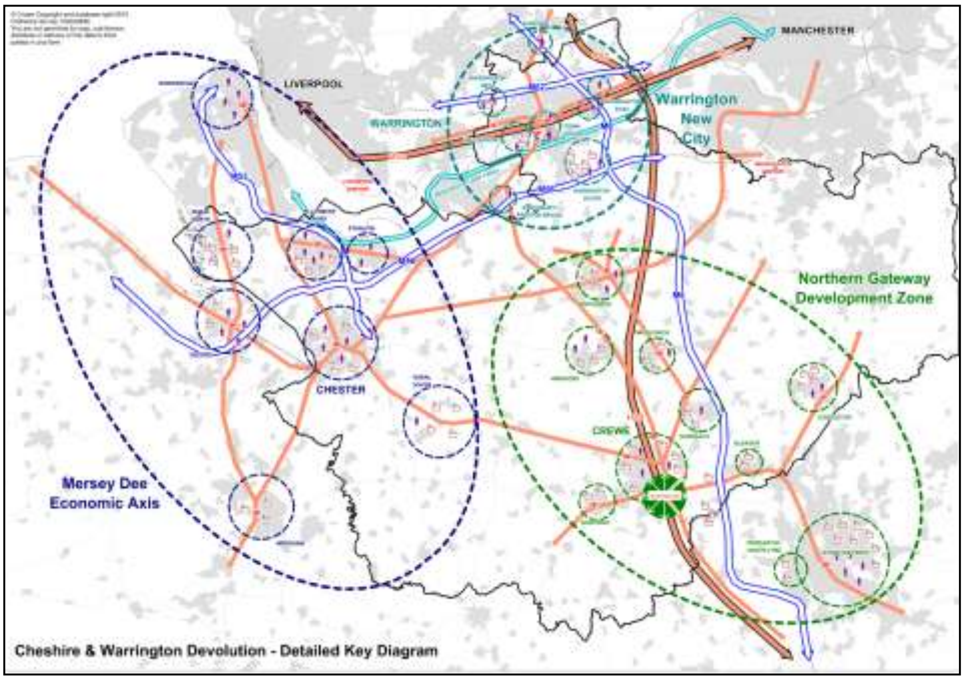
- ***A private sector-led and knowledge-rich economy****, with a high density of private sector jobs relative to its population, one of the highest outside of the capital. The area boasts a large private sector business base, with business density rates well above the national average; the business base contains a well-defined mix of high profile international companies, well-established and substantial medium-sized companies, and a dynamic and growing small business base.*

- ***A connected economy****, with long established linkages to Manchester and Liverpool and their city centres, higher education, and innovation assets, as well as strong economic links to North Staffordshire and the 'Potteries', and across the border to North Wales. Our people and businesses benefit from key strategic transport infrastructure – the West Coast Main Line, the national motorway network, the M6, M62, and M56 axis – and proximity to international transport linkages at Manchester and Liverpool airports, and the Port of Liverpool, but it is recognised that current capacity limit, resilience and journey times connecting to this key infrastructure remain poor.*

Our current Strategic Economic Plan forecasts economic growth of some £12 billion by 2030 and we are in the process of revising this to target a £50 billion economy by 2040. **We would therefore stress the importance of not restricting consideration on transport connectivity to city regions. Important as they are, our big cities are not the only source of economic growth in the UK**.

Helped by the proximity to key air and sea gateways and trade routes, Cheshire and Warrington LEP has developed three interconnected spatial proposals that will increase and accelerate growth, enhancing the sub-region's economic impact within the Northern Powerhouse and UK.

These spatial proposals are fundamentally driven by enhanced connectivity and strategic transport investment and are shown in terms of their spatial locations, and spatial interactions with surrounding Core City Regions and adjacent LEP's in the figure below.



Key Growth Areas & Existing Transport Connectivity

Northern Gateway Development Zone

The primary aim of the Northern Gateway Development Zone is to capitalise on Crewe's current and future connectivity through the arrival of HS2, delivering high speed connectivity to the Northern Powerhouse 7 years earlier than otherwise planned.

This will help maximise the benefits and growth opportunities as the "Gateway to the Northern Powerhouse", supported by productivity critical improvements in term of access to/from the HS2 hub, by all modes.

Across this area as a whole there is the potential to deliver 120,000 jobs and over 100,000 homes by 2040, with supporting, and required transport investment to consolidate early-HS2 benefits across the North.

Mersey Dee Economic Axis

C&W is building upon collaborative links with the Mersey Dee region to unlock a number of growth employment sites in Chester, Ellesmere Port, North East Wales and Wirral. These opportunities have the potential to bring forward:

- Over 700 hectares of employment land; and 1 million sift of prime city centre commercial space; and
- Deliver 54,000 new jobs and 41,000 new homes by 2040

Cheshire Energy Hub, based in Ellesmere Port is supported by a number of leading International energy systems companies based in Cheshire and Warrington including Atkins, Boulting Group, C-Tech Innovation, CNS (Capenhurst Nuclear Services), EA Technology, Electricity North West, National Nuclear laboratory, Storegy UK and Scottish Power.

Thornton Science Park includes The University of Chester’s Faculty of Science and Engineering which is fast developing into a major energy-focussed research and innovation hub including development of a Smart Grid systems demonstrator.

There are strong social and economic links in to North Wales and the next generation of nuclear power station at Anglesey Energy Island.

Warrington New City

Warrington’s connectivity will be reinforced in the future as it sits at the intersection of HS2/ West Coast Mainline and TransNorth Networks.

The Town’s strategic position is at the heart of the M6, M56 and M62, benefitting from significant growth potential at Port of Liverpool and the string of ports along the Manchester Ship Canal.

Warrington New City, and associated development proposals is anticipated to deliver 26,000 new homes, and 55,000 jobs; with additional transport infrastructure to enhance strategic connectivity, enhance resilience of key Pan-Northern and Trans-European networks, and unlock capacity constraints preventing local growth.

Warrington is home to one of Europe’s most significant clusters of nuclear-related companies including NNL (National Nuclear Laboratories), AMEC Foster Wheeler and Rolls Royce Nuclear, providing engineering and consultancy services and research and development activity.

Responses to Specific Questions Raised by the Commission

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Electricity interconnection and storage

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?

- What role can changes to the market framework play to incentivise this outcome:
    - 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?
    - Is there a need to further reform the "balancing market" and which market participants are responsible for imbalances?
- To what extent can demand-side management measures and embedded generation be used to increase the flexibility of the electricity system?

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

Cheshire is location for the UK's largest onshore gas storage facility, one of a number of such assets which utilise the vast salt caverns found under the sub-region. Strategically it allows security of supply in case there are disruptions to production, transport or supply. These could be due to commercial reasons (e.g. somebody else has paid a higher price for the gas), political reasons or an outage. Gas storage is also important in balancing seasonal variations in consumption where the winter demand is greater than the summer usage. It can also cover peak demands such as weekday evenings. It can also enhance the effectiveness of gas transport and production, where it can be stored locally to where it is being used.

However there are limited areas where the geology is suitable for underground gas storage and as such this means that such facilities could be located a significant distance away from where demand for the gas actually is.

In addition to possible financial barriers, there are also Technology barriers to energy storage to consider. Market failures preventing investment in energy storage are mainly centred on the cost to develop technologies alternative to existing storage capacity. The dominant technology is pumped hydroelectric, with around 99% of installed capacity. The possibility to expand this capacity further is limited, and is in any case not suited for flexible deployment to reinforce the grid in an effective and cost-neutral manner. A further limitation is its slow response time. The dominance of pumped-hydro is due to its low cost, typically 100 €/kWh, which is a proven target that any new storage technology must approach to be commercially viable. The next most widely deployed storage technology is compressed air (CAES). CAES is also cost effective, but again limited by the availability of suitable locations and is typically deployed at a scale of 100s of MW.

The remaining electricity storage technologies are based on electrochemical systems. Sodium-sulphur (NaS), lithium ion and lead-acid batteries are the major contributors to current capacity. NaS systems are exclusively produced in Japan and the ability of European companies to enter this market is limited by the extensive IP protecting this technology. Lithium ion batteries remain expensive, and due to their high power density, are most suited to smaller scale applications such as electric vehicles and portable devices. Long term, the use of lead-acid batteries will be limited by the supply of lead and its perceived negative environmental implications. Other technologies, including flow batteries, are mainly at the development scale and unproven, with prohibitively high capital costs (>€1000/kW).

Whilst many energy storage technologies remain within the realms of academic research, aside from Li-ion, the number of industrial organisations involved in deploying these technologies remains relatively low. The lack of financial incentives in the way that feed-in tariffs benefited the renewable generation market, and a lack of understanding of how storage should be integrated into existing distribution networks are clear barriers to wide-scale deployment of electricity storage. Investing in these areas will help raise awareness of the capabilities of new and existing storage technologies, and create interest and investment for wide-scale deployment.

The most likely scenario for future energy storage is likely to be a combination of many technologies, with solid state batteries and supercapacitors being widely used for short-term energy "power-hungry" domestic applications (<10's kWh). For longer term energy requirements (100's kWh – MWh), redox flow batteries (RFB's) have the flexibility to decouple power from energy, and therefore capacity can be scaled up without the need for additional battery hardware, significantly reducing costs when compared to other battery technologies.

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

- Is there a case for building interconnection out to a greater capacity or more rapidly than the current 'cap and floor' regime would allow beyond 2020? If so, why do you think the current arrangements are not sufficient to incentivise this investment?
- 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?

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?

APPENDIX A – EA Technology Submission provided to NIC.

Electricity interconnection and storage

The following response has been provided under the National Infrastructure Commission's call for evidence, published 13 November 2015.

EA Technology has a strong heritage working with the owners and operators of energy networks to increase their reliability or make them more cost-effective. We have a rich technical knowledge base and are passionate about using this to deliver economic benefits to our customers, and the customers they ultimately serve. We have pioneered world-leading developments ranging from intelligent investment planning software, to electrical energy storage, through to running large scale projects on electric vehicles.

We therefore focus these responses on the **electricity interconnection and storage** consultation on how changes to existing market frameworks, increased interconnection and new technologies in demand-side management and energy storage can better balance supply and demand.

For more details please contact: [email address redacted]

Changes to the electricity market to ensure that supply and demand are balanced

Domestic energy consumers – representing approximately 40% of UK consumption[1] – are not currently exposed to half-hourly balancing costs. There is currently therefore little or no incentive for individual customers to modify their demand to reduce these costs. The reasons for this lack of exposure include:

- legislation enacted to simplify tariffs means that electricity supply companies cannot easily offer variable half-hourly tariffs (i.e. political constraint);
- the market demand for variable half-hourly tariffs is still to emerge (i.e. economic constraint), although fixed-time tariffs such as Economy 7 remain popular and account for 25% of domestic consumption; and
- the smart meters necessary for half-hourly billing are not yet widely deployed in the UK (i.e. technical constraint).

For non-domestic energy consumers – representing approximately 60% of UK consumption – the situation is different as approximately 70% of demand is half-hourly metered. Therefore 42% of UK electricity consumption is potentially exposed to half-hourly balancing costs and could therefore be incentivised via tariffs to ensure supply and demand are balanced. In practice, consumers do not like the variability that this entails and so they will generally look for a tariff arrangement that limits their exposure to this variability.

The result of this is that electricity consumers in the UK currently have very little incentive to ensure that supply and demand are balanced, even if it were beneficial for them to do so. As a result, balancing costs will inexorably rise (in the absence of any other controlling factors). This situation represents a market failure.

[1] https://www.gov.uk/government/collections/sub-national-electricity-consumption-data

The need for an independent System Operator

The above market failure can be addressed in a number of ways. The debate is often framed in terms of a dilemma between the two following choices:

1. should consumers and generators be exposed to balancing costs (thereby applying free market mechanisms to keep balancing costs down), or
2. should the task of minimising balancing costs be entrusted to an independent System Operator (thereby limiting the exposure of consumers and generators to balancing costs)?

EA Technology does not have a strong preference for either option.

We believe that Option 1 would, ultimately, produce the best outcome (i.e. the lowest costs to consumers, over the long term). However, all the political, economic and technical constraints described above would need to be addressed beforehand in order for this market to function. Furthermore, the current half-hourly market (on which all electricity trading is based) may ultimately be much to slow to reflect the real-time nature of balancing costs, especially as the generation mix becomes ever more intermittent (see Figure 1). Moving to real-time electricity trading would be a massive, unprecedented undertaking and not a decision to be taken lightly.

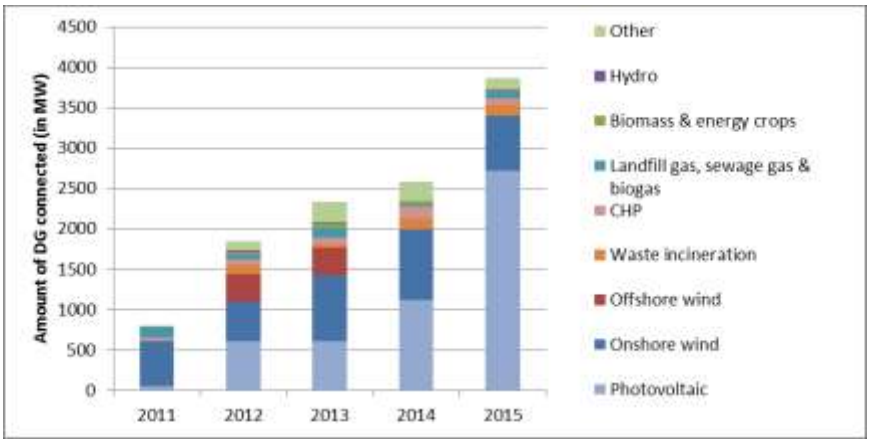

Figure 1 Increase in in intermittent, non-despatched generation connected to the UK distribution network

Option 2 represents a more pragmatic approach, in that an independent System Operator would undoubtedly drive incremental reductions in balancing costs over a realistic timeframe. Our concern is that this approach will not, ultimately, produce the best outcome. The System Operator may have only limited authority over the real-time behaviour of generators (especially distributed generation) and will have little or no control over consumer behaviour (unless the political, economic and technical constraints are addressed, as above). Therefore, rather than influencing generator and consumer behaviour to minimise balancing requirements, the System Operator is likely to respond to balancing issues through costly infrastructure investments and changes to operational procedure – over timescales measured in years. This is very different from being driven solely by a desire to reduce balancing costs. In this light, it is hard to conceive of an appropriate set of financial incentives for the System Operator that would – somewhat perversely – need to offer greater rewards as its services are needed less and less.

Interconnection versus balancing

On a small highly islanded electricity network, balancing is a real-time, technical imperative. Without balancing, the lights go out. Instantly.[2] Keeping the lights on can result in very high balancing costs.

On a heavily interconnected network (with the necessary robust transmission infrastructure)[3], balancing costs are less of an issue. Generators generate, consumers consume and the market takes care of the energy pricing. Local system operators manage power flows as best they can, but can (generally) fall back on the backbone transmission system as needed. This results in very low balancing costs.

There is therefore an opportunity to reduce balancing costs by increasing interconnection.

A market opportunity

EA Technology believes there is a strong case for using market mechanisms to minimise balancing costs to consumers over the long term.

However, EA Technology does not believe that an electricity market based around half-hourly energy prices is the right market mechanism to reduce balancing costs. Even with significant reform and investment, it is hard to imagine how variations in half-hourly pricing can achieve the desired outcome; if energy consumers are exposed to sudden price spikes, the outcome is likely to be anger and dissatisfaction directed at "those in charge" rather than any meaningful change in behaviour.

On the other hand, consumers are more likely to change their behaviour if offered a direct reward for any change they make. If inflexible generators (and network operators) are exposed to significant balancing costs, they may well be willing to pay consumers directly to help them reduce these costs. If this were a direct payment – outside of any half-hourly trading mechanism – then this would immediately address the three constraints identified above:

- there would be no change to domestic energy tariff arrangements between consumer and supplier;
- demand would be created by the offer of a payment to those able to change behaviour to address balancing costs; and finally
- the implementation of this market framework would not necessitate smart meters.

We believe that a new 'direct balancing market' mechanism that exposes market participants in the following way would produce the desired outcome:

1. System Operator sets the balancing price for a specified period
2. Flexible generators adjust their output during this period to minimise balancing charge
3. Inflexible generators either pay the remainder or pay flexible consumers to help minimise it
4. Flexible consumers modify their demand in return for payment from inflexible generators
5. Consumers who choose to remain inflexible do not benefit from such payments

Only those consumers participating in balancing activities need to have a measuring device or other mechanism to confirm participation. This would offer far more opportunity for innovation over what can be achieved using a typical domestic smart meter e.g. use of smartphones to provide monitoring and/or evidence of behaviour in return for payment. Furthermore, because there would be an active market in influencing behaviour to minimise balancing costs, together with a clear financial advantage for flexible generation over inflexible generation, any dependence on the independent System

[2] http://www.independent.com.mt/articles/2014-01-09/news/widespread-power-cut-3641016320/
[3] http://www.entsoe.eu

Operator to manage these costs is reduced. The System Operator merely needs to set the balancing cost and let the market take care of the rest.

The effectiveness of Demand Side Management

Demand Side Management is sometimes referred to as demand side response. This alternative term recognises that demand isn't something that can easily be "managed". However, it may be possible to shift useful amounts of demand using appropriate signals and incentives, at the same time as ensuring that customers retain overall control over their electricity consumption.[4]

The understandable concern about this more voluntary approach is that it may be ineffective: what if consumers are unwilling (or unable) to shift demand in response to these signals? Won't this lead to significant imbalance?

Such concern is well-founded. There is relatively little deferrable load currently in consumer premises: other than cooling and heating, most existing load (such as lighting and cooking) cannot be deferred for long. However, this rather pessimistic outlook ignores the fact that there are very significant changes occurring (and about to occur) in electricity usage patterns. The most significant changes include:

- The connection of photovoltaic (solar) generation to domestic premises (3kW-10kW+)
- The use of heat pumps for heating (3kW-15kW+)
- The charging of electric vehicles (3kW-10kW+)

These new electrical loads all share some interesting characteristics:

- They are all significant – often much bigger than existing domestic loads
- They are all becoming increasingly commonplace
- They are all controllable and/or deferrable to some degree

The Transform Model® developed by EA Technology has shown that demand will change significantly moving forward with the electrification of heat and transport and the proliferation of small scale generation (and potentially, small scale storage). Furthermore, recent work by National Grid with Element Energy[5] has indicated that, by 2030, the contribution of such deferrable loads could provide over 80% of GB's requirements. This is because loads such as electric vehicles are plugged in for an average of 8 hours per day, but only require 3 hours to draw charge, meaning the window within this load can be managed is significant.

The opportunity is there for these new loads to play a significant and increasing role in minimising balancing costs. The technology is already available: EA Technology / SSEPD's My Electric Avenue electric vehicle project[6] has shown beyond doubt how its Esprit managed electric vehicle charging can deliver significant shifting of electric vehicle loads without detriment to the customer experience. What is currently missing is any market mechanism to enable adoption of such technology. This is the opportunity currently available to the UK and we urge the National Infrastructure Commission to play a key role in realising this outcome.

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[4] Koliou, E.; Eid, C.; Hakvoort, R.A., "Development of Demand Side Response in liberalized electricity markets: Policies for effective market design in Europe," in European Energy Market (EEM), 2013 10th International Conference on the , vol., no., pp.1-8, 27-31 May 2013
doi: 10.1109/EEM.2013.6607403

[5] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Technology-reports/

[6] http://myelectricavenue.info/

Barriers to deployment of energy storage

The existing energy market and balancing regime considers “generation” (with one set of rules) and “demand” (with another set of rules). Storage technology is unique, in that it can be both generation and load. Distributed storage is often able to switch from one mode to another in a very short space of time – yet this is not recognised by the traditional market. The developing UK Balancing Services market (especially STOR[7]) provides one model to address this limitation, but unfortunately the minimum generator size (3MW) is prohibitively large and the frequency of balancing requests (~70 p.a.) much to infrequent to encourage commercial deployment of storage technologies.

Storage operators therefore need to operate two supply contracts – one for demand, one for generation – with limited opportunity to optimise between them: even if the electricity supply contract recognises that the storage unit can reduce its demand to zero at any time, it will not be able to recognise that it could also become a generator (i.e. negative load) at times of high demand. Likewise for the generation contract, which will not be able to recognise that the storage unit could become a load (i.e. negative generation) at times of excess generation. Both of these capabilities would enable storage to contribute effectively to balancing services, but cannot be achieved through conventional energy trading mechanisms. As a result, the positive contribution that storage can make to balancing at all voltage levels cannot currently be recognised.

There is another aspect of storage that is often overlooked: such technologies often make use of heat energy (e.g. phase-change heat pumps, compressed air storage). Unlike electricity, heat is extremely difficult to transport over long distances and so for these storage technologies to be cost effective, they must be in a geographically suitable location. The economically ideal location for storage would contain a synergistic mix of local heat and electricity demand that can be balanced off using the storage unit. Heat energy is not regulated and can be traded locally; unfortunately the same is not true for electrical energy. If storage operators want to make use of the local electricity grid, they can only do so by trading through the energy market – which, as described above, does not recognise the contribution that storage can make to balancing services.

EA Technology believes that two changes to the existing market would enable greater uptake of storage capacity:

1. The enabling of “Storage” connection agreements and tariffs, instead of requiring storage operators to hold both “Generation” and “Supply” contracts.
2. The enabling of electricity to be traded directly between third parties over the local electricity network (via contract with the local electricity network operator), without requiring participation in the national electricity market.

It is realised that the above proposals would represent a radical shift away from the national half-hourly trading regime and we recognise that such market freedom may be somewhat risky of adopted on a large scale. However, we think there is a case for trialling these freedoms with small scale storage units. Not only would this remove a significant barrier to the uptake of storage, but also the behaviour of these smaller units could be closely observed with a view to further relaxing national trading arrangements as more is learned about the contribution that storage can make to balancing.

Such wider uptake should also drive down the price of storage technology – an issue that must be addressed if storage is ever to make a significant contribution to balancing service.

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[7] http://www.thinkinggrids.com/ancillary-services/stor-provides-short-term-generation-support-and-cost-62m-in-2014-2015

Appropriate level of electricity interconnection

As described above, increased interconnection leads to reduced dependence on balancing services. In EA Technology's view, the economic case for increased interconnection should always be weighed up against the economic case for reducing the requirement for such interconnection through demand side response. The optimum mix of interconnection and demand side response will change and develop continually. We believe this mix should be determined though market mechanisms wherever possible.

The 'cap and floor' regime provides a useful mechanism to encourage the building of interconnection. Our primary concern is that such market "distortions" might encourage building of interconnection when it is not needed (if the floor is set too high) or discourage the connection of necessary interconnection (if the cap is set too low). There does not appear to be any reflection in this mechanism that the actual need for interconnection may change over time. Given the significant changes expected in electrical demand patterns that is expected over the lifetime of these 'cap and floor' contracts, we think there is a high risk of an eventual mismatch between the level of required interconnection and the level that is actually built.

The ideal approach would be to expose interconnection, demand side response and storage to the same market drivers – given that they all contribute to the same outcome i.e. a balanced system. We would encourage further discussion and analysis on whether the 'direct balancing market' proposed earlier in this response could be usefully extended to interconnection providers as well.

International best practice

An example of allowing consumers to participate in the market via a mechanism other than through smart metering tariffs is that provided by Powershop in New Zealand.[8] This is a model whereby customers have the option of purchasing different 'packs' of electricity units at different prices in advance of using them. In this way, customers can purchase units at a saving compared to the standard tariff. The interface is accessible via an app on the customer's phone or tablet, putting them in control of their energy purchase, and allowing them to monitor their consumption. This model is soon to be brought to the UK via partnership with RWE npower[9].

[8] http://www.powershop.co.nz/
[9] http://www.npowermediacentre.com/r/5298/rwe_npower_and_meridian_energy_limited_enter_into