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.

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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.

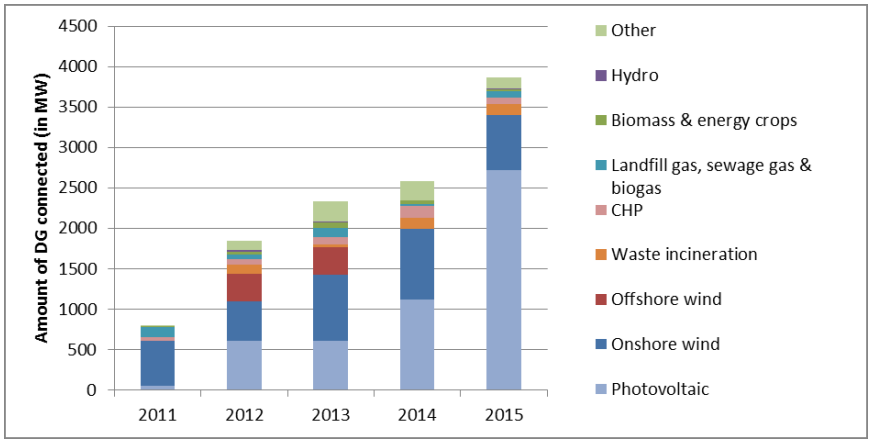

Figure 1 Increase in in intermittent, non-despatched generation connected to the UK distribution network

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

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

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 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

[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/

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.

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.

[6] http://myelectricavenue.info/

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

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.

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