Department of Electronic and Electrical Engineering
Bath BA2 7AY · United Kingdom
Telephone 01225 386330
Facsimile 01225 386305 Department Office
01225 386062 Direct
Email f.li@bath.ac.uk

A response to the BEIS/Ofgem consultation on "A smart flexible energy system"

This submission is made by Professors Furong Li and David Tolley at the Department of Electronic and Electrical Engineering, University of Bath. The Department has been closely involved with a number of issues concerning the development and evolution of the electricity supply arrangement in the UK and has advised Ofgem and other parties within the industry on a variety of policy matters, particularly those associated with network charges, Grid Codes and community energy.

1. Introduction

The BEIS/Ofgem consultation on a smart flexible energy system addresses the fundamental prospective shift in the nature of electricity supply in Great Britain. The future electricity grid will faces unprecedented complexity and uncertainty. The rapidly falling cost of low carbon technologies (such as PV, EVs, battery storage, and heat pumps) and their connection to the periphery of the grid is causing businesses and homes, which historically have been passive energy consumers to become energy "prosumers". That is they can store, convert and/or generate energy, thus enabling them to be active actors in the market. Each actor will make independent decisions in pursuit of their own 'selfish' or 'altruistic' goals.

These emerging trends will make conventional centralised control, dispatch and scheduling tools, market structures, organisations and procedures no longer fit for purpose. The rise of prosumers, where the distinction between the energy buyer and seller merges, is far beyond the capability of the current market and system operation framework [Hardy, Ofgem 2015]. This consultation starts to address the complex problem of how strategic direction can be given to creating a system that can resolve economically the future technologies that will condition the way we produce, distribute and consume electricity.

2. Our Concerns on the Current Vision for a Smart Energy System

Whilst this initiative is to be applauded, we are concerned with the broad vision that has been set out for a smart energy system. The key objective seems to be to mobilise flexibility so that it can ***respond*** to system balancing and ancillary services across the whole system. This runs the risk of creating an overly complicated system with energy products that very few people can understand, as the financial sector experienced pre-2008.

3. An Alternative Vision for a Smart Energy System

Our suggested alternative vision is to organise flexibility so as to ***reduce*** substantially the need for system balancing and services across all levels by largely removing ***uncertainties*** thus creating a win-win situation for major players. Conventional plants would run at their best efficiency whilst the intermittency of renewable generation would be largely taken up by flexible customers. Consumers would then pay less for their energy consumption. Critically, this will reduce the communication between TSO/DSO, and SOs and aggregators. By reducing the need for system balancing and services, particularly at the transmission level, the ***complexity*** of the system operation can be significantly ***simplified***.

If the value from flexibility is very substantial then more passive consumers will see an incentive to become active so allowing more uncertainties to be soaked up. This approach would ultimately lead to a reduction in the need for a highly reliable supply from the central system; much like the BT infrastructure of today that largely serves passive customers.

4. Key Elements of this Alternative Vision

This alternative vision requires a fundamental rethink of our market structure and a deeper understanding of the capability of flexibility so as to inform the market design. The key objective would be to consider how flexibility may change the need for future system services and balancing.

4.1 Key Element 1: *Multi-tiered markets to reducing system balancing and services*

Our current market design does not lend itself to realise this vision. In our energy market we mix renewable generation with traditional generation, causing significant inefficiencies for fossil and nuclear generation without any compensation. Consumers are left to pay for the increased inefficiency. Furthermore, in the face of diminishing flexible generation, nuclear generation plant is required to provide flexibility to cope with the intermittency of wind or solar energy by dumping heat that has already been produced. This adds a further layer of inefficiency to the functioning of the electricity supply system.

An ideal situation would be for there to be a two or more tiers to the market. A base-tier of the market would be similar to that which exists today and would offer near 100% firm supplies at prices that reflect the cost of conventional fossil generation. A second tier to the market would trade a mix of renewable and controllable generation and link the lowest priced energy to customers that could cope with greatest supply interruption (or supply intermittency).

Figure 1 below shows a multi-tiered market structure where multiple markets exist to trade different commodities, from a highly reliable supply (near 100%) to a highly unreliable supply (at say 40%). Multiple market equilibriums would be established for each band of reliability where consumers would either accept the lower reliability of the supply at a lower price, or contract for a more reliable supply at a higher price.

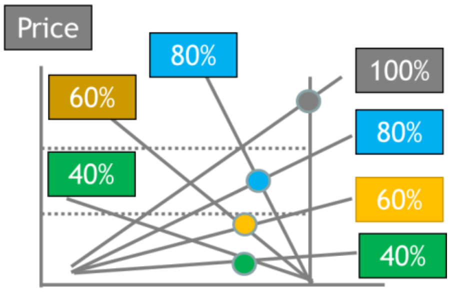

Figure 1. Supply/Demand Curves for a Multi-tiered market - Extend the Traditional Energy Market from Price and Quantity to Quality. [F. Li, "Incentives for local production and demand flexibility to support community energy", New Market Models for Community Energy, January 2015].

Multi-tiered markets essentially create a secondary market for intermittent generation to directly interact with, and trade with flexibility. This leaves the base tier of the market free to pursue the best efficiency for conventional plant and minimises the costs of system balancing through flexibility.

4.2 Key Element 2: *Open up distributed supply systems to local consumers in order to reduce system balancing and services*

The scope for flexibility at the distribution level is very substantial and has the potential to dominate the whole-system flexibility value. By considering how to develop flexibility for the whole system without first fully understanding the potential for flexibility at the distribution level, and the impact this would have at the transmission level, we risk making a leap forward that is unnecessary.

Opening up a distributed energy supply would both reduce costs for the energy consumer as well as reducing the connection cost for low carbon technologies, such as storage and distributed generation. This would have the merit of accelerating the uptake of these technologies.

The current approach has three key shortcomings that create delay in the uptake of low carbon technology and increase customer bills. These are:

i. Distributed generation cannot distribute energy locally. Instead it has to be routed through a central supply which allows uncertainties to accumulate until a critical point is reached that requires expensive connection costs of upgrading the network, and delay to the technology uptake. This can be the case for generation, storage and demand.
ii. Intermittent distributed generation will add further uncertainty to the local system which in turn increases the need for system flexibility.
iii. Local communities cannot at present access directly the local production of energy but must work through a central supplier.

A flexible distributed supply system would allow distributed generation to provide cheaper energy to local communities by removing the network upgrading cost, and reducing the need for reserve in the local system. This value alone could be very substantially for the flexibility provider. The cost to the system operator would be of a lower order, especially if the uncertainty is largely removed at the local level or in the renewable tiers of the market.

4.2 Key Element 3: *Obtain a better understanding of the nature of flexibility so as to reduce the need for system balancing and services*

Flexibility is a very complicated commodity and requires a deep understanding to inform its capability, value and market design. It needs a sophisticated ICT capability. Flexibility from CHP plant is vastly different to that inherent in storage or DSR. For example, flexibility of a storage system is dependent on the sophistication of its management system and will be time-dependent. That is if the storage is discharged in one time period then its flexibility will be affected in the immediate successive periods. CHP on the other hand can provide sustained flexibility so long as the gas supply is available. For a system with diverse mixes of low carbon technologies, the aggregated flexibility is likely to be both complex and highly dynamic. This requires a careful description so as to inform the inherent value, market design, and communication requirements.

5. Our Conclusions

Our belief is that this consultation moves too rapidly to address some of the more peripheral matters without first addressing the core issues of the ICT revolution in the industry. The focus on storage and aggregators seems premature when the features of the "smart" evolution do not appear to have been fully considered. We believe it would have been more helpful for this consultation to set out a number of possible visions, and their likely implications for market structure, market design and market players. The vision as set out by the paper is of incremental change to the present industry structure that extends the transmission market arrangements to distribution, and allows flexibility to apply across at the whole system. This is the status quo with yet more sticking plaster. The radical approach we favour would be to create a platform that allows flexibility to interact directly with uncertainty at the local level, thus removing much of the need for system balancing and services.

The distribution system has a relatively low legacy of change in its current arrangement. It is therefore an ideal place to think outside the box and test a radical value proposition for flexibility. This is a once in a generation opportunity to introduce a highly innovative and efficient market arrangement. Trials at the distribution level will also inform change that might be necessary at the transmission level. If we pass up this opportunity, and rely only on the provision of flexibility on a whole system basis, we will be saddled with an inefficient and complicated system for obtaining the flexibility needed to cater for the intermittency of the renewable generation connecting to the system.

We envisage a multi-tiered market developing that can link the uncertainty of output from some producers with the innate flexibility of some loads, or other flexible generation and storage. This can occur initially at a local level through a distribution system made up of many efficient sub-systems that are loosely connected. This in turn should reduce system complexity and lessen the need for system balancing and whole system flexibility services.

A key step in developing this approach is to obtain a deeper understanding of the nature and capability of the flexibility that could exist in all parts of a future electricity supply market that can fully utilise the capability offered by developments in ICT.

A response to some of the questions posed in the consultation

Although we would have wished to have seen a broader consultation we have offered some views below to the questions that have been posed.

Storage (Questions 1 – 5)

In response to questions 1 and 2 we largely agree with the policy and regulatory barriers that have been identified. A concern we have here is that there is no distinction between the different storage technologies since their operating characteristics can be very different, as exemplified by the performance of lithium-ion batteries and supercapacitors.

Furthermore storage management strategies will have influence on whether the storage can support or be detrimental to the system, as they will directly impact on the time, speed and frequency of charging and discharging. If there is no understanding of the control strategy that a storage device will adopt, then storage should be treated as demand since it may draw current from the system at the time of system peak.

The lack of classification for storage in terms of its technology and management strategy will make it difficult to create a universal policy and regulatory framework. It would help if a logical storage classification was first developed that described the relevant charging framework, connection requirements, and protocols for use of the system. This might call for the establishment of storage management standards.

Question 3 concerns the network charges that should be borne by storage. If a storage facility is managed to operate within the limit of the existing network, it should not incur the costs of any future network. Furthermore if a storage facility can mitigate the consequences of the system peak for the network then it should be rewarded for deferring network reinforcement.

Flexible connection agreements would help a specific storage facility to operate according to its characteristics within the limit of the existing network. A flexible arrangement could also modify the secure limit of an existing system if the storage can utilise the spare capacity of the system when the system is intact. This is illustrated in a recent paper[1].

The definitions of a storage facility cited in the consultation embrace both the actual storage medium and the equipment needed to convert and re-convert the electricity to a storable form. Perhaps the definition should also make clear that the energy stored will not be used on the same site, since otherwise storage could become a device for avoiding taxes and imposts that would otherwise fall on the final consumption of electricity.

Aggregators (Questions 7 – 10)

At present Aggregators are effectively agents of the SO. They are unlicensed and usually undertake their activities in a contractual relationship with the SO. The SO uses these agents as a source of ancillary services which are an alternative to actions in the Balancing Mechanism. As such neither route is an effective market place because there is only one buyer of the flexible action.

The introduction of information technology into the market equation offers the prospect of many providers of flexibility and many users who might employ the flexibility for their own purposes. Flexibility users could be network owners (to reduce capital investment), system operators (to

[1] R. Li, Z. Zhang, F. Li, P. Ahokangas, "A Shared Network Access Business Model for Distribution Networks", IEEE Transaction on Power Systems, accepted 2017.

manage constraints and system security), generators (to manage imbalances), or other consumers and suppliers (to manage demand). However, the challenge here is to devise a market arrangement that can allow these exchanges to occur. Amending Licence Condition C.16 would be a stop-gap.

What is needed is access to a platform where flexibility can be traded. We envisage as a minimum a two-tier arrangement where on the first tier energy would be traded in half hourly blocks, as at present, whilst on the second tier flexibility can be traded. This is a complicated notion because there is no generic definition of flexibility which in the context of electricity supply has many different attributes and is likely to be facility specific. Research is needed to identify how flexibility can be described in a homogenous fashion, and how it might then be exchanged between providers and users. Regulation of this arrangement would need to be through a Code of Practice to ensure the system remained secure and stable.

The areas of consideration raised in paragraph 40 may be of immediate interest in the context of the current duties and obligations of the SO, but they will tend to lose their relevance if this concept is adopted and the system becomes more “smart”.

System value pricing (Questions 11 -14)

Flexibility is a difficult concept in electricity supply because it manifests itself in so many directions. The manner in which ancillary services are described illustrates this with ancillary service provision tending to be linked to specific technologies or plants with specific attributes. The consequence (as paragraph 3.1.3.(b) recognises) is that auctions for the services as currently described become at best a two-horse race, and once contracted the provider is precluded from other possible revenue streams.

If “flexibility” could be defined in more generic terms and the market arranged on a two or more tier basis, where the value of flexibility in whatever guise it was needed could be recognised, then the particular attributes of a particular generating plant, or storage device, or customer’s demand could be put to more effective use. The information flows and platform to enable this need to be researched, devised, developed and implemented.

Smart tariffs (Questions 15 – 18)

In our view it is essential that with the smart meter roll out all customer demand is settled on a half-hourly basis. We therefore fully support the sentiment expressed in paragraph 3.2.7. Without this, and if profiling is retained there will be a perverse incentive on suppliers not to offer time of use tariffs that can influence customer behaviour either directly or through the use of innovative application technologies. Indeed we would suggest that the advent of half-hourly settlement should be accompanied by a mandate on suppliers to offer customers, if requested, direct access to wholesale energy or local energy prices, which in turn would encourage the offering of realistic time-of-use tariffs designed for a customer’s needs.

Innovation in customer applications that could exploit the price flexibility is blocked by the lack of any financial consequence of the application. This block would be removed if smart tariffs were on offer to all customers. Whilst a minority of customers apparently still shy away from the prospect of “smart” tariffs, this might simply be through a lack of understanding as to how they could benefit from them, if they so choose. For many electricity is a “utility” and they will use it as they wish with scant regard for its immediate cost, but this should not preclude them from the financial consequence of its use when they find it useful.

Smart distribution tariffs (Questions 19 – 21, and 22 – 24)

The Licence Condition mantra that distribution tariffs should reflect costs and facilitate competition has always been a somewhat woolly requirement. The reality is that distribution tariffs are an allocation methodology for recovering revenue that has been determined elsewhere by the RIIO price regulation process. The charging methodology tries to use this revenue allocation process to also introduce pricing signals that may influence more efficient future investment in the networks. The algorithms for this are generally crude. The advent of a smart system where information technology can be deployed to make the operation and investment of the system even more efficient need to be addressed but without losing sight of the fact that the long-lived investment in the networks needs to be sustained if the infrastructure is to remain secure.

The use of a geographic feature in transmission pricing and the employment of LRIC pricing in EHV distribution charges from almost a decade ago are useful features in network charging, but the growth of distributed generation and the prospects for energy storage makes this an area where further development could now be appropriate.

A lacuna in the present charging arrangements is any link between sophisticated control of the network and the requirement for future investment. Securing the operation of a passive system is likely to require massive network investment. But the operation of a "smart" network offers an ability to accommodate much higher flows within the existing system. Network charges should also reflect the ability of the SO to address congestions and constraints by calling on flexibility through ToU network charges so as to alleviate stress in the network in the appropriate time periods.[2,3]

There could be other unrecognised elements in network charges. The value that customers obtain from having access to a stand-by supply was recognised by the Energy Act 1983 but there are other features which are not considered as providing value to a party connected to a distribution (or transmission) network. Examples include access to a constant voltage source with a stable frequency, the ability to choose supplies from multiple suppliers, and for small distributed generators the ability to spill energy to a system that is for all practical purposes infinite. It may now be appropriate to consider how transmission and distribution charges could be aligned to remove disparities between them and provide more effective pricing signals for the connected party.

Time-of-use pricing in distribution charges would seem an obvious step forward once smart meters are universally installed. In the meantime this would appear another area that would benefit from some fundamental research of the type undertaken by Ofgem in 2005 that led to the introduction of locational signals in distribution pricing.

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[2] Z. Li, F. Li, Y. Yuan, "Transmission Use of System Charges Based on Trade-offs between Short-run Operation Cost and Long-run Investment Cost", IEEE Transactions on Power Systems, 28 (1), pp. 559-561, 2013.
[3] J. Li, C. Gu, R. Bhakar and F. Li, "Transmission use of system charging for differentiating long-term impacts from various generation technologies," *Journal of Power and Energy Systems*, vol. 2, no. 2, pp. 11-19, June 2016.