FPSA Stakeholder Perspectives

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1 Introduction

This document is a distillation of the Future Power System Architecture (FPSA) functions as seen from the perspective of the five groups of stakeholders listed above. The document summarises: their future business opportunities and requirements; why those opportunities are important; the relevant FPSA functions; the consequences of those functions not being implemented; and some common conclusions.

This tabulation sets out the analysis at a level of detail. Five two-page summaries have also been prepared and these are available on the IET and ESC websites.

1 Perspective 1 - SO, DNO/DSO, TNO, OFTO, Large Generators, established networks equipment vendors, key consultancies, technical media

The Business Drivers	The lead party	Network Company Business Opportunities & Requirements	Why are these opportunities important?	The likely consequences of failing to take these opportunities	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
1. An effective DNO to DSO transition	DNOs	Aggregation of Demand Response for managing D-network power flow constraints and provide services to the SO	DSO roles have yet to be fully defined and their regulatory frameworks do not yet exist. However, there are consistent signals from BEIS and Ofgem that they believe this is a way forward that will bring benefit for consumers. The Smart, Flexible Energy consultation issued by BEIS and Ofgem jointly is an example of this. If additional roles and responsibilities are required from the present DNOs it can be reasonably assumed they will receive appropriate remuneration. To gain this added value and build their reputations as forward-looking businesses, it will be important for them to implement new roles in a timely way and have the capability to roll them out at scale. This can only be achieved if the necessary new power sector functionality is in place. The required functionality does not exist at present.	**Enable and execute necessary operator interventions** In the absence of new sector functionality and DNO business processes it will not be possible for DNOs to move effectively to DSO roles. New DSO functionality needs to be designed, proven and implemented in a timely way, or the opportunity will be lost as a result of actions by non-DNO parties (for example if they opt to make traditional asset or control system investments that have 20-40 year lives and so undermine the business case for new DSO services).	16.3, 7.1, 16.1,	To make available the necessary sensors, data, and commercial mechanisms. Ensure data inter-operability and open systems so that information can be analysed and shared between key parties, for example DSOs, the GBSO and energy market participants. Commercial mechanisms will require implementation of highly robust and auditable data systems.	Considering the span of new business challenges and opportunities summarised here, it is evident that: 1. **Significant additions and changes are required to the functionality** that supports today's power system and this will have consequences for the businesses that share ownership of it; 2. These changes have, in many cases, a **whole-system dimension that spans today's company and governance boundaries** 3. It is not sufficient simply to identify and agree the new functionality, it is **imperative that the sector's change processes are streamlined,** for example to enable proper representation of both existing and new parties, and to make change mechanisms **sufficiently agile to provide timely outcomes** and can respond to **continual further change and new learning**, and respond to as yet unknown customer requirements; 4. It would be **erroneous to envisage these new functionalities simply being grafted on to today's power sector model** - the changes now emerging offer not only new roles for existing parties, but also the opportunity to transfer existing roles to new parties who are positioned to provide more efficient solutions to the challenges. An example of the former is DNOs becoming DSOs, and of the latter, new system flexibility being provided by parties 'beyond the meter'.
	DNOs	Management of reactive power profiles to control D-network voltages and provide services to the SO			7.1, 9.1, 15.3		
	DNOs	Management of storage to address D-network constraints and provide services to the SO			16.3, 7.1, 16.1, 15.3,		
	DNOs	Active Network Management, including generation curtailment controls to optimise network capacity for hosting new connections			7.1, 3.2, 4.1, 12.1,		
	DNOs	Transformer/Tapchanger control (CLASS) for real and reactive power services to the SO			16.3, 9.1, 15.3,		
	DNOs	Demand/generation/storage/reactive power management by DSO out of its own area (eg including embedded IDNO and private networks)			7.1, 9.1, 15.3		
2. Improvements at the TSO-DSO interface to ensure adverse interactions are avoided	DNOs, GBSO	Gain Active Network Management benefits (e.g. constraining on/off DSR and DG, optimising EV charging) to address D-network constraints while avoiding adverse T/D interactions	Smart Grid Forum analysis (WS3 and WS7) and LCNF projects have confirmed that deployment of smart network solutions can have economic and practical advantages, such as achieving faster new connections. It will be of increasing importance that these 'new tools' are genuinely established as Business as Usual capabilities - this requires prompt and effective resolution of any TSO-DSO interface issues that are encountered.	**Form and share best view of state of system in each timescale** If these challenges are not addressed effectively, the T/D boundary will be an escalating source of risk to security of supplies. This will frustrate economic solutions and result in delays to resolving new connection queues.	5.1, 9.1, 3.3,	Investment planning and operational planning will require close co-operation. Functionality changes may need to be designed-in to the controls of automated systems.	
	DNOs, GBSO	Maximise distributed storage benefits to D-network voltage and power flow management but avoid adverse T/D interactions			9.2, 8.1,		
3. Responding to new system operational imperatives	DNOs	Distribution network cold start with high penetration of EVs, HPs, local storage etc.	The annual System Operability Framework reports, published over the last three years by National Grid, provide evidence of changes to national and local power system operating behaviours that require close attention if adverse outcomes to customers are to be avoided. The issues highlighted here as examples	**Monitor trends / emerging risks to the power system and implement mitigating actions** If the new processes and system functionality are not developed, proven in trials, and then implemented across the GB system there will be steadily rising risk to system security, cyber security, and	2.3, 9.1, 3.3, 5.2, 12.1, 13.1,	Forward thinking will be key to responding to these significant challenges in a timely way to avoid unacceptable impacts on customers. This will require new modelling and forecasting tools, new regulatory and commercial mechanisms, and the data to drive these techniques and the protocols	
	GBSO, DNOs	Develop and implement new approach to Defence Plans (Low Frequency load shedding)			5.2, 12.1, 13.1,		
	GBSO, DNOs	Develop and implement a new approach to national system Black Start			2.6, 3.3, 12.1, 13.1,		

Perspective 1

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	GBSO, DNOs	Develop a robust capability to anticipate new network operational challenges and invest accordingly	require mobilisation of thinking, increase in understanding, and proving of solutions ahead of wider roll-out and integration with existing systems. These are not issues that can be resolved simply by purchasing off-the-shelf solutions. Some of these issues are now starting to receive attention by the DNOs/NG, through the ENA. Fundamentally new power sector functionality will however be necessary to address the full range of operability challenges.	customer service. There will be a likelihood of poor investment decisions resulting in stranded assets that add needless costs to customer bills. Without new planning and investment functionality, the next regulatory resets (ED2, ET2) will be lacking in evidence and the strategic cases for informed decision making.	0.1, 5.1, 9.1, 5.2, 12.1,	and data management systems to enable secure sharing and interpretation. Design changes may be required to home energy management systems and smart devices, for example to introduce randomised starting or intelligent response to system frequency or voltage.	
	GBSO, DNOs	Ensure T & D protection reliability and coordination as periods of low fault infeed increase (especially T-system IDMT back-up)			5.2, 9.2,		
	GBSO, DNOs	Continuing attention to DG ROCOF relay maloperation risks as system inertia declines			5.2, 9.2,		
	GBSO, DNOs	Continuing attention to potential DG instability issues due to lowering system strength and impact on voltage depressions			5.2, 9.2,		
	DNOs	Resolving power quality deterioration arising from penetration of power electronic devices			2.1, 2.2, 5.2,		
	DNOs	Managing waveform quality (THD and resonance) issues due to lowering system strength			2.1, 5.2,		
	DNOs	Identify emerging cyber threats and counter these on a whole system basis			2.5, 9.2, 12.1, 13.1,		
4. Responding to changing customer expectations and behaviours	DNOs	Seamless new services from smart meters, home energy management, and new devices	Many changes are taking place in customer premises and at the 'grid edge'. The DNOs have a significant opportunity to be 'part of the solution' rather than 'part of the problem'. However mobilisation of enabling sector functionality is required if these are to made a reality in a timely way. The DNOs and TSOs may also have partnering or supporting roles in enabling third party providers to meet new customer requirements.	**Implement smart grid to maximise system security** Without interoperability and suitable standardisation, customers will be locked in to proprietary systems and ad hoc solutions. This will stifle market behaviours and competition, and is likely to result in early obsolescence and deep customer frustration, for example when new smart appliances are purchased.	15.3, 14.1,	For new services to customers to be simple and seamless, there must be co-ordination of inter-operability between devices, commercial arrangements that are not overly complex, and concepts and controls that are user-friendly and sufficiently standardised for customers to recognise and enjoy using them.	
	DNOs	Ability for customers to deploy home storage and maximise its benefit			16.2, 15.3, 14.1,		
	DNOs	Availability of 'virtual private network' services from DNOs for local market trading			15.5, 16.2, 15.3,		
	GBSO, DNOs	Large scale aggregation by third parties delivering essential services to the SO			16.3, 7.1, 6.2, 15.3, 13.1,		
	DNOs	Local market/community energy facilitator and service provider roles			15.5, 2.4, 7.1, 15.3, 14.1		
5. Taking the opportunities presented by wider societal changes	DNOs	Community Energy & Local Market developments (geographic)	Community Energy enterprises, both geographic and virtual, continue to gain interest and form part of a trend in 'energy democratisation'. There are specific opportunities for new for DNO/DSO roles as described above, but there is also the challenge of repositioning the network companies in the eyes of wider society. There opportunity for DSOs to establish themselves as the 'go to organisations' as	**Market developments** These developments are already happening; they are being promoted by government and pulled by changing customer preferences (e.g. peer to peer). If the DNOs wish to create new added-value business activities, they must put in place the necessary functionality and develop the associated technical and business skills (before their	15.5, 15.3,	The challenges here are new to network companies and will require solutions to technical, commercial and regulatory issues. Furthermore they span company boundaries and require whole-system approaches. In particular they require customer and third party engagement at significantly higher levels than in the past.	
	DNOs	Community Energy developments (virtual)			15.3, 8.1,		
	DNOs	High EV deployment clusters, including autonomous vehicles			5.2, 2.3,		

Perspective 1

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	DNOs	Integration of Smart City developments, and provision of expert facilitation roles	communities, local government, and businesses seek to establish new arrangements.	clients/customers by-pass them).	2.4, 16.2, 15.3, 16.1,		
6. Gaining benefit from Gov't & Regulatory policy developments	DNOs, GBSO	Roll out of innovation into networks for maximum customer benefit	There is uncertainty in times of change and the government and the regulator will be looking for convincing evidence that new DNO/DSO initiatives and investments will bring customer benefit. Having robust plans for developing necessary new functionality, and evidence of delivering effective outcomes, are two key elements in building confidence and demonstrating benefits to external parties.	**Manage interfaces with connected systems** As the systems of different energy vectors become more sophisticated, more complex, and more inter-connected, today's network companies will need to be well-informed and responsive, or they will be by-passed by the new parties who will find ways to circumvent them.	5.1, 3.3, 4.1, 9.2, 14.1,	For the network companies to be on the front-foot and able to bring forward innovation and deploy it in a timely way, it will be essential to be proactive, not simply responsive. This will require horizon scanning, tools and data, and a whole-systems co-ordination that shares data between network companies, customers and new third parties entering the energy sector. Regulatory barriers to (socialised) investment ahead of need will need to be resolved.	
	DNOs, GBSO	Bring forward creative new services to enhance GB system flexibility			0.1, 15.1, 15.3, 9.2, 14.1,		
	DNOs, GBSO	Robust justification where strategic 'investment ahead of need' is required			0.1, 5.1, 3.2, 9.2,		
	DNOs, GBSO	Increasing cross-vector interactions, e.g. for home heat decarbonisation			3.1, 15.4,		

2 Perspective 2 - Domestic / micro-SME customers (and/or representatives thereof), Suppliers and NTBMs the smart metering community, smart home and energy management services

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
1. Providing customers with smart energy choices	**Suppliers (large and small), NTBMs smart home and energy management service providers**	Provide smart metering and (with customer consent) in-home monitoring technologies to help energy service companies to design products and service offerings that will increase customer choice, minimise energy costs, and improve their overall energy system engagement experience.	Monitoring and sensor technologies coupled with R&D into drivers of customer behaviour will help identify customer preferences and predict their predisposition to different service offerings	Failing to identify customer energy usage trends or their appetite and needs for effective engagement with the energy system will lead to ineffective products and service offerings and failure to leverage opportunities for whole energy system optimisation	2.1, 2.2, 2.5, 12.1, 14.1, 15.1, 15.2	**Enable and execute necessary operator interventions** Given the necessary development of technology and attention to markets, domestic and SME demand, storage and micro-generation provides new opportunities for operators to secure ancillary services. **Monitor trends/emerging risks on the power system and implement mitigating actions** Given the potential scale of the impact, it will be essential to identify and counter threats to the operability of the power system arising from customer side of the meter technologies - in terms both of shocks to the system from demand step changes and cyber security. **Market developments** The provision of flexible tariffs supported by smart meters and hh settlement for profile class 1-4 as well as 5-8 customers is the first step to unlocking flexibility at the domestic and micro-SME level and rewarding customers accordingly. However, maximising the exploitation of flexibility opportunities from the customer side of the meter will require appropriate technical integration, and markets and settlements provisions, to facilitate active engagement of customers and their service providers through a full range of customer choices. **Implement smart grid to maximise system capacity** Automating customer side of the meter actions will be essential to securing the scale and speed of response required for some aspects of system operability, as	Based on need for greater flexibility to deal with an increasing dependence on weather-dependent generation, and domestic demand profile changes arising from solar PV, EVs and heat pumps, it is evident that opportunities afforded by smart metering, hh settlement, smart appliances, digital technologies, IoT etc can be exploited. The traditional 'vanilla' approach to metering, tariff design and billing for domestic and SME customers would fail to provide the necessary incentives for customers to actively engage with the energy system, as would failure to ensure open standards that permit plug-and-play interoperability. Consequences of failing to unlock this flexibility would be that: additional generation and network capacity would be required; a higher level of fossil fuelled thermal generation would need to be retained; GHG emission targets would be at risk; opportunities for new revenue streams would be missed and electricity prices would be higher. Whilst ToU tariffs and price signals are a precursor to accessing flexibility, trials have shown that they alone are unlikely to encourage customers to significantly change their energy consumption behaviour. Non-traditional business models and new approaches to energy service provision will be required which facilitate interaction with customers' energy appliances to access flexibility and reward customers accordingly. Further service offerings providing incentives for customers to engage could include provision of lifestyle services such as remote control and monitoring (e.g. via a mobile phone or tablet app) of heating, lighting, security alarms etc. Arbitrage opportunities with other energy vectors will be increasingly important to ensure opportunities for
		Provide home / SME energy efficiency services	To serve customers' needs at the optimum economic level of home energy efficiency through advice on usage behaviour and electrical appliance efficiency rating selection	Customers will vary in their willingness or ability to exploit these opportunities but most customers are likely to find one or more acceptable. Failure to exploit opportunities through not providing these options will result in underutilisation of smart metering system functionality and higher overall electricity consumption than necessary and suboptimal electricity demand profiles. This in turn will lead to higher overall system capital and operating costs of both providing security and managing GHG emissions. Ensuring data privacy and cyber-security of in-home applications which communicate with the electricity system will be essential. Failure to provide this functionality has consequences for all three elements of the trilemma.	16.1, 16.2		
		Provide home / SME energy management services	To serve customers' comfort and convenience needs through the managed (HEMS) optimisation of electrical energy usage and minimisation of waste		2.1, 2.2, 2.5, 14.1, 14.2, 16.1, 16.2		
		Provide a choice of transparent smart energy tariff options (enabled by smart metering and hh settlement) and/or other forms of contracts for flexibility with clear guidance on optimum selection criteria	To ensure customers can meet their energy needs at the lowest cost consistent with their preferred electrical energy usage patterns and appetite for flexibility		2.2, 14.1, 14.2, 15.1, 15.2, 16.1, 16.2		
		Provide a range of smart energy account management and information services including smart tariff comparison and switching through the development of 'trusted' consumer access devices.	To enable customers to manage their energy budgets and ensure they are accessing the most economic tariffs and service providers through trusted in-home applications with inbuilt cyber security provision.		2.1, 2.2, 2.5, 4.1, 14.1, 16.1, 16.2		
		Provide domestic / SME customers with opportunities for income or reduced electricity charges through their provision of flexibility services (enabled by smart metering, HEMS, smart appliances, IoT)	To enable customers to exercise their willingness to flex (or allow their service provider to flex) their energy usage to take advantage of periods of lower market prices in return for lower customer energy charges - for example flexing time of use of 'wet' goods to exploit dynamic tariffs that reflect differences in market price due to variations in output of low-carbon generation		2.1, 2.2, 2.5, 14.1, 15.1, 15.2, 16.1, 16.2		

Perspective 2

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
2. Providing energy arbitrage opportunities	**cross-vector energy companies**	Provide smart home / SME energy arbitrage management services. Provide information and education for customers to help them understand the big picture and the overall opportunities.	To permit exploitation of cross-vector energy arbitrage opportunities (for example through hybrid heat pumps and cooking appliance options and/or options from heat networks) to minimise impact on peak-time electricity demand	Failure to leverage effective energy arbitrage opportunities that would otherwise exploit latent capacity of other energy vectors (for example underutilised gas networks which are suitable for adaptation to low carbon gas options) and infrastructure to minimise electricity system capacity requirements.	2.1, 2.2, 2.5, 3.1, 4.1, 15.1, 15.2, 15.4, 16.1, 16.2,	will monitoring the effect of such actions. **Form and share best view of state of system in each time scale** Assessing and monitoring the positive and potentially negative impacts of customer side of the meter interventions will be important to assessing whole system operability, security and stability. **Manage interface with connected systems** It will be important in investment planning timescales to understand the impact on other energy vectors of energy arbitrage actions. **Provide capabilities for use in emergencies** Given the predicted lowering of system inertia arising from reduced levels of synchronous generation, new forms of real power injection or rapid demand reduction will be required. Certain domestic and micro-SME applications could be adapted to provide fast (as well as dynamic) frequency response and so assist in the stabilisation of the grid in the event of a system shock (such as a loss of a major infeed)	change of use of existing energy infrastructure are exploited where this will reduce the need for new electricity infrastructure capacity. At the domestic level, hybrid heat pumps, dual-fuel cooking and water heating facilities, and access to heat networks are likely to prove effective measures to support the cost-efficient decarbonisation of heat. There is value to all parties in gaining access to the value streams arising from cross vector arbitrage However, accessing demand-side flexibility to manipulate demand profiles carries inherent risks. One is that if not co-ordinated from a whole system perspective, changes in demand profile could lead to voltage or thermal-rating related network constraints (for example tariff price signals linked to renewable generation output). Another risk is that if not co-ordinated, demand-side interventions could create technical or commercial imbalances. A further important risk to address is that step changes in domestic demand created by mass switching of appliances (for example EV chargers) as a result of either a control signal or a tariff price change could destabilise the grid and create a serious frequency excursion and possible system shutdown. Not least of the risks to be addressed is that wide scale access to HEMS, smart appliances and customer access devices carries a heightened risk of hacking into the associated communications and data management systems. Given the potential risk to electricity system security, resilience of the communications and data systems against corruption and cyber attack will be essential. The overall conclusion is that it would be erroneous to envisage these important new opportunities and functionalities simply being grafted on
3. Providing smart options from new low carbon energy applications and resources	**smart home and energy management service providers in conjunction with vendors**	Provide smart home / SME electric space and water heating services customised to reflect day-to-day variations in weather conditions and times of home / business premises occupancy	To ensure required comfort and convenience levels are achieved at the least overall system cost and therefore energy price level, exploiting flexibility from thermal insulation and hot water storage and customising heating cycles	Failure to exploit opportunities through not providing these options will result in these new low carbon electricity applications giving rise to higher than necessary system peak demands requiring additional generation, transmission and distribution system capacity, potentially higher GHG emissions due to greater need for peaking plant, potentially reduced generation plant margins at times of exceptionally high demand (e.g. exceptionally low ambient temperatures when weather dependent generation output may be very low and electrical heating demand very high) and higher overall costs of electricity. Ultimately it might result in reduced rate and scale of take-up of low carbon technologies.	4.1, 12.1, 13.1, 15.1, 15.2, 16.1, 16.2		
	smart home and energy management service providers in conjunction with EV manufacturers and charging infrastructure providers	Provide smart flexible home / small business EV charging management services customised to reflect customer variations in driving patterns (this could include V2G applications)	To exploit opportunities to minimise EV charging at times of system peak demand and/or maximise charging at times of high output from low carbon generation		2.1, 2.2, 2.5, 12.1, 14.1, 14.2, 15.1, 15.2, 13.1, 16.1, 16.2		
	smart home and energy management service providers in conjunction with solar PV and home energy storage vendors	Provide home / SME electricity demand profile optimisation opportunities from micro-generation and micro-electrical energy storage	To maximise in-home / business property usage of self-generated electricity to minimise electricity import and hence overall electricity charges - whilst also reducing thermal loading and/or voltage rise constraints on LV networks		2.5, 4.1, 12.1, 13.1, 14,1, 14.2, 15.1, 15.2, 3.3, 16.1, 16.2		

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
4. Providing added-value services	**smart home and energy management service providers in conjunction with in-home communications technology vendors**	Provide added-value services such as: home security, smoke and fire detection, health & safety alarms & alerts, remote monitoring and control, learning thermostats, intelligent lighting, other customised AI applications, etc.	Albeit associated with wider applications than energy usage, such added-value services utilising smart energy communications infrastructure will enable service providers to differentiate themselves, increasing effective competition and encouraging customers to engage with smart energy management system offerings.	Missing the opportunity to provide such services which deliver perceived lifestyle benefits will result in a missed opportunity to encourage customer engagement with smart energy systems	2.5, 16.1, 16.2		to today's power sector model - the changes now emerging offer not only new roles for existing parties, but also the opportunity for new parties who are positioned to provide more efficient or whole system solutions to the challenges. Traditional Suppliers will need to evolve to compete with new business model companies providing energy and lifestyle services, leveraging technological advances in smart appliances, communications, energy management and smart metering systems. However, co-ordination of energy service providers actions with the wider operation and management of the whole electricity system will be essential to avoid system shocks and inefficiencies. Finally there is the opportunity for communities to exercise self-sufficiency and plan and invest to operate off-grid, either in emergency situations, or routinely.
5. Providing power system management services (ancillary services) to the GBSO and/or local DSO	**Suppliers (large and small), NTBMs smart home and energy management service providers**	Provide a power system demand diversity management service	To ensure that smart electricity management services do not result in encouraging or forcing herding behaviours (for example mass switching on changes of tariff price)	These services would complement lifestyle enhancing services through using demand flexibility and managed diversity to avoid unmanageable system shocks, reduce system balancing costs, and manage network constraints. The system services provided from portfolios of contracted flexible services with customers will need appropriate management to ensure that they do not result in conflicts - such as provision of balancing services creating a local network constraint, or delivery of network constraint management services creating a technical or commercial system imbalance.	2.1, 2.5, 4.1, 12.1, 13.1, 14.1, 15.1, 15.2, 3.3, 16.1, 16.2		
		Provide power system balancing and reserve services through portfolios of aggregated home and SME flexible demand and generation contracted services with customers	Building portfolios of aggregated home and micro-SME flexible demand contracted services with residential / SME customers will enable exploitation of demand-side flexibility to reduce system balancing costs and need for reserve services		2.1, 2.2, 2.5, 4.1, 14.1, 15.1, 15.2, 12.1, 13.1, 16.1, 16.2		
		Provide frequency response services through contracts with customers to permit controlled use of automated / autonomous flexible appliances (e.g. refrigeration and possibly EVs operating in V2G mode)	Flexible appliances - esp. 'always on' appliances such as refrigeration (subject to thermostat control) - can provide an effective dynamic and/or fast system frequency response service provided measures are taken to avoid over-compensation and potential hunting leading to system instability		2.1, 2.5, 4.1, 11.1, 12.1, 13.1, 14.1, 15.1, 15.2, 16.1, 16.2		
		Provide local power network constraint management services through localised portfolios of aggregated home and SME flexible demand and generation contracted services with customers	Provided portfolios of localised clusters of contracted flexible services from residential / micro-CHP customers can be assembled then opportunities exist to provide DSR services to DNOs to ease local network constraints		2.1, 2.5, 4.1, 12.1, 13.1, 14.1, 15.1, 15.2, 16.1, 16.2		
6. Providing energy community services	**energy community service providers**	Provide opportunities for intra-community, inter-community and peer-to-peer trading, including using aggregated flexibility for trading and arbitrage	To enable exploitation of local energy community low cost / low carbon produced (or procured) electricity by using innovative applications such as distributed ledger technology to enable community-to-community and peer-to-peer energy transactions and encourage localised balancing of electricity production, arbitrage and	Failure to make provision for inter and intra-community, or peer-peer trading arrangements, that are cost-reflective in terms of network usage (and losses) and system balancing could undermine the business case for community energy schemes, and hence put at risk opportunities for more efficient localisation of	2.1, 2.5, 6.1, 10.1, 11.2, 14.1, 14.2, 15.1, 15.2, 15.5, 3.3, 12.1, 13.1, 16.1, 16.2		

Perspective 2

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
			usage.	energy production and usage.			
		Provide an EV (virtual) energy community service	Forming communities of private and commercial EV users (possibly in conjunction with EV manufacturers and charging infrastructure service providers) will create opportunities for improved monitoring and smart charging and billing service offerings, whilst leveraging scale to secure attractive energy tariffs customised for EV users.	Failure to seize the opportunities afforded by a new EV market will be a missed business growth opportunity for service providers and a missed opportunity to encourage EV adoption	2.5, 3.3, 11.2, 14.1, 14.2, 15.1, 15.2, 15.5, 12.1, 13.1, 16.1, 16.2		
		Smart city services: ie Supporting integration of energy vectors, transport, communications and other infrastructure	A 'smart city' would optimise the utilisation of its entire infrastructure (including but not exclusively energy and transport) primarily through information technology and citizen engagement. This will help ensure an efficient, economic and coordinated overall total city management system for the benefit of citizens.	Failure to apply an integrated whole system approach to the planning, management, and operations of city infrastructure and services will lead to underutilised capacity, inefficient costs, and missed opportunities to develop an efficient, economic and coordinated city ecosystem leading to suboptimal quality and costs of services for citizens.	2.1, 2.5, 3.3, 6.1, 10.1, 11.2, 14.1, 14.2, 15.1, 15.2, 15.4, 15.5, 12.1, 13.1, 16.1, 16.2		
	energy community service providers in conjunction with private network managers	Private energy network management services	Providing integrated private multi-vector energy network management services to maximise energy production (or procurement), arbitrage, and demand side management opportunities to optimise network utilisation and overall cost of energy provision	Failing to exploit opportunities to optimise utilisation of energy networks funded by the private network community could result in either underutilised assets or premature replacement - either of which could lead to unacceptable stranded costs or pressures for costly reinforcement falling on the private network community. This could extend to over-investment in utility assets which supply the private network.	2.1, 2.5, 3.3, 6.1, 10.1, 11.2, 14.1, 14.2, 15.1, 15.2, 15.4, 15.5, 12.1, 13.1, 16.1, 16.2		
		The opportunity to provide power island services.	Enable communities to go off-grid either in emergency situations, or as more usual operating mode.	Frustrate the ability of owners of power producing assets from being self-sufficient at times of local or national energy system stress.		Enable energy self-sufficiency.	

3 Perspective 3 - Large I&C Customers, Aggregators, Energy Communities, Smart Cities/Local Authorities, DG Operators, Storage Operators, VPPs and Virtual Communities

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
1. Providing I&C customers with smart energy advice and choices	**Suppliers (large and small), NTBMs smart business and business energy management service providers - in conjunction with vendors**	Offer energy usage/ pattern monitoring technologies that will help I&C customers to identify opportunities to minimise energy costs and MD charges - including through energy storage options and selective usage of standby generation, and through alternative working patterns.	I&C customers will generally benefit from impartial expert advice on the benefits and economies of managing their energy usage patterns. As well as reducing their costs the potential exists to release network capacity and ultimately reduce system demand / peak demand.	Customers will vary in their willingness or ability to exploit these opportunities but most I&C customers are likely to find one or more acceptable. Failure to exploit opportunities through not providing these options will result in higher overall electricity consumption than necessary and suboptimal electricity demand profiles. This in turn will lead to higher than necessary system peak demands requiring additional generation, transmission and distribution system capacity, potentially higher GHG emissions due to greater need for peaking plant, potentially reduced generation plant margins - all of which ultimately leads to increased energy prices for customers. Ensuring cyber-security of BEMS which communicate with the electricity system will be essential. Failure to provide this functionality has consequences for all three elements of the trilemma.	2.2, 16.2	**Enable and execute necessary operator interventions** Given the necessary development of technology and attention to markets, I&C demand, storage and generation provides new opportunities for operators to secure ancillary services. **Monitor trends/emerging risks on the power system and implement mitigating actions** Given the potential scale of the impact, it will be essential to identify and counter threats to the operability of the power system arising from I&C customer interactions with the system (for example in providing frequency response or demand turn-up services) - in terms both of shocks to the system from demand step changes and cyber security. **Market developments** Although the I&C market is already more attuned to flexibility, there are increasing opportunities for I&C customers to participate in system balancing and ancillary service markets and rewarding customers accordingly. However, exploiting flexibility opportunities from I&C customers will require appropriate markets and settlements provisions to ensure conflicts are managed (for example commercial imbalance risks to Suppliers). **Implement smart grid to maximise system capacity** Automating I&C ancillary service offerings will be essential to securing the scale and speed of response required for some aspects	Based on need for greater flexibility to deal with an increasing dependence on weather-dependent generation, and domestic demand profile changes arising from solar PV, EVs and heat pumps, it is evident that opportunities afforded by I&C customer BEMS and communications technologies to unlock flexibility opportunities will need to be exploited. The traditional 'vanilla' approach to I&C energy service provision would fail to provide the necessary incentives for many I&C customers to actively engage with the energy system. Consequences of failing to unlock this flexibility would be that: additional generation and network capacity would be required; a higher level of fossil fuelled thermal generation would need to be retained; GHG emission targets would be at risk; and electricity prices would be higher. Whilst existing ToU and MD based energy and DUoS tariff price signals are a precursor to accessing and rewarding flexibility, experience has shown that they alone are unlikely to encourage I&C customers to significantly change their energy consumption behaviour. Non-traditional business models and new approaches to I&C customer energy service provision will be required which facilitate interaction with BEMS and industrial processes s to access flexibility and reward customers accordingly. Further service offerings providing incentives for I&C customers to engage could include provision of business process management services such as remote
		Provide business energy efficiency consultation services - including advice on how to avoid wastage through more efficient energy management (proximity detection for lighting; waste heat recovery opportunities; AI applications; power factor correction; etc.)	I&C customers will generally benefit from impartial expert advice on the opportunities for energy wastage avoidance, waste energy recovery and technologies to reduce demand without impacting production. The benefits could include reduced energy consumption and reduced DUoS MD (kVA) charges. System benefits include releasing network capacity and ultimately system demand / peak demand.		2.2, 16.2		
		Provide a choice of transparent smart energy tariff options rewarding flexibility (enabled by MD metering and existing HH settlement) and/or other forms of contracts for flexibility with clear guidance on optimum selection criteria. For larger I&C customers and EIUs this could include Triad avoidance opportunities.	To ensure I&C customers can meet their energy needs at the lowest cost consistent with their ability to manage electrical energy usage patterns and the scope for flexibility inherent in their business processes.		15.1, 16.1, 16.2		

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
		Provide a range of smart energy account management and information services including tariff comparison and advice on how to minimise connection costs (for new or extended premises) vis a vis required MPR and levels of security of supply, and subsequent DUoS charges (avoidance of red-band periods and minimising MD charges)	To enable I&C customers to manage their energy budgets by ensuring they are optimising their network connection arrangements (new or expanding businesses), accessing the most economic tariffs, and managing their energy usage patterns, to optimise connection costs, minimise their usage at peak / red band charge times and minimise MD charges.		15.1, 16.1, 16.2.	of system operability, as will monitoring the effect of such actions. **Form and share best view of state of system in each time scale** Assessing and monitoring the positive and potentially negative impacts of I&C customer interventions will be important to assessing whole system operability, security and stability. **Manage interface with connected systems** It will be important in investment planning timescales to understand the impact on other energy vectors of I&C customer energy arbitrage actions. **Provide capabilities for use in emergencies** Given the predicted lowering of system inertia arising from reduced levels of synchronous generation, new forms of real power injection or rapid demand reduction will be required. Certain I&C applications, such as energy storage and standby generation (or DRUPS) could be adapted to provide fast (as well as dynamic) frequency response and so assist in the stabilisation of the grid in the event of a system shock (such as a loss of a major infeed).	control and monitoring of space and water heating, lighting, security alarms, emissions alarms etc. Arbitrage opportunities with other energy vectors will be increasingly important to ensure opportunities for change of use of existing energy infrastructure are exploited where this will reduce the need for new electricity infrastructure capacity. At the I&C customer level, industrial dual fuel processes, conversion to other energy vectors for selected processes, waste heat recovery processes, peak lopping options (including through energy storage and standby generation) to avoid Triads, and access to heat networks are likely to prove effective measures to support the cost-efficient decarbonisation of I&C processes. However, accessing I&C demand-side flexibility to manipulate demand profiles carries inherent risks. One is that if not co-ordinated from a whole system perspective, changes in demand profile could lead to voltage or thermal-rating related network constraints (for example tariff price signals linked to renewable generation output). Another risk is that if not co-ordinated, I&C demand-side interventions could create technical or commercial imbalances. A further important risk to address is that step changes in I&C customer demand created by mass switching of appliances (for example industrial scale refrigeration) by a VPP operator could destabilise the grid and create a serious frequency excursion and possible system shutdown. Not least of the risks to be addressed is that wide scale external access to BEMS through telecommunications systems carries a heightened risk of hacking into the associated communications and data management systems. Given the potential risk to electricity system security, resilience of the communications and data systems against corruption and cyber attack
2. Advising I&C customers on energy arbitrage and/or change of fuel opportunities	**Suppliers (large and small), NTBMs smart business and business energy management service providers - in conjunction with vendors**	Provide advice on energy arbitrage opportunities and/or conversion to alternative energy sources - such as more efficient and lower carbon electric industrial heat technologies and energy storage options.	Exploiting cross-vector energy arbitrage opportunities (e.g. equipment or processes with dual fuelling capability) or opportunities to permanently switch fuel sources for processes where modern alternatives provide cheaper and/or better quality products or business services can reduce the customer's energy bills, improve product quality or the working environment (and hence productivity).	Failure to leverage effective energy arbitrage opportunities that could exploit latent capacity of other energy vectors (for example underutilised gas networks which are suitable for adaptation to low carbon gas options) and infrastructure to minimise electricity system capacity requirements could result in higher costs of energy usage and infrastructure provision.	3.1, 15.4, 16.2.		
3. Providing added-value services		Provide added-value services such as: business premises security, smoke and fire detection, health & safety alarms & alerts, remote monitoring and control, intelligent lighting, other customised AI applications, etc.	Albeit associated with wider applications than energy usage, such added-value services utilising smart energy communications infrastructure will enable service providers to differentiate themselves with I&C customers.	Missing the opportunity to provide such services which deliver business management benefits will result in a missed opportunity to encourage I&C customer engagement with smart energy systems.	16.2		
4. Providing power system management services (ancillary services) to the GBSO and/or	**Suppliers (large and small), Aggregators, NTBMs and business energy**	Provide power system balancing and reserve services through DSR, standby generation / DRUPS (diesel rotary uninterruptable power supplies), energy storage,	I&C customers might have the potential to offer a range of system balancing services through demand turn down / turn up capabilities and use of standby generation in return for contracted availability and utilisation payments	Failing to provide these services would miss the opportunity to complement the above services through using demand flexibility and automated managed automatically through BEMS or through 3rd parties communicating	2.5, 3.3, 4.1, 12.1, 13.1, 14.1, 15.1, 16.1.		

Perspective 3

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
local DSO	**management service providers**		- brokered for example by an Aggregator	through BEMS to avoid unmanageable system shocks, reduce system balancing costs, and manage network constraints. The system services provided from portfolios of contracted flexible services with I&C customers will need appropriate management to ensure that they do not result in conflicts - such as provision of balancing services creating a local network constraint, or delivery of network constraint management services creating a technical or commercial system imbalance.			will be essential. The overall conclusion is that it would be erroneous to envisage these important new opportunities and functionalities simply being grafted on to today's power sector model - the changes now emerging offer not only new roles for existing parties, but also the opportunity for new parties who are positioned to provide more efficient or whole system solutions to the challenges. Traditional Suppliers will need to evolve to compete with new business model companies, Aggregators, and VPP operators, providing energy and I&C process services, leveraging technological advances in BEMS, communications and smart AI systems. However, co-ordination of I&C customer energy service providers' actions with the wider operation and management of the whole electricity system will be essential to avoid system shocks and inefficiencies.
		Provide frequency response services through automated demand reduction or real power injection capability	Frequency response will become an increasingly valuable service to the SO as synchronous generation continues to be displaced. Response needs to be either continuous (dynamic) or fast (in response to a high rate of fall of frequency) and therefore automatic. Capability will therefore depend on the I&C customer's electrical equipment and its processes. Electrical energy storage could be an option for dynamic frequency response and standby generation, or DRUPS, could be an option for fast frequency response.		2.1, 2.5, 4.1, 11.1, 12.1, 13.1, 14.1, 15.1, 15.2, 16.1, 16.2.		
		Provide contracted local power network constraint management services in exchange for availability and utilisation payments through an ability to respond to DSR calls - e.g. by turning down non-essential load, shifting demand to a later period, or running standby generation.	If I&C customers can provide DSR services to DNOs (e.g. post fault) in return for contracted availability and utilisation payments then this could allow DNOs to ease local network constraints / maintain required levels of supply security and avoid or defer network investment.		2.1, 2.5, 4.1, 11.1, 12.1, 13.1, 14.1, 15.1, 15.2, 16.1, 16.2.		

Perspective 3

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
5. Exploiting real and virtual I&C energy community opportunities	**VPP Operators, Aggregators, business energy community service providers**	Provide opportunities to I&C customers for intra-community, inter-community and peer-to-peer trading (e.g. in CBDs and business parks)	To enable exploitation of local energy community low cost / low carbon produced (or procured) electricity by using innovative applications such as distributed ledgers to enable community-to-community and peer-to-peer energy transactions and encourage localised balancing of electricity production and usage.	Failure to make provision for inter and intra-community, or peer-peer trading arrangements, that are cost-reflective in terms of network usage (and losses) and system balancing could undermine the business case for community energy schemes, and hence put at risk opportunities for more efficient localisation of energy production and usage.	2.5, 6.1, 10.1, 11.2, 12.1, 13.1, 14.1, 14.2, 15.1, 15.4, 15.5, 16.1, 16.2.		
		Provide opportunities to I&C customers to participate in virtual communities - enabling aggregated portfolios of flexible demand and generation (e.g. industrial refrigeration, commercial air-cooling, standby and peak-lopping generation, waste-to-heat recovery, etc.) VPP operators could provide the overall aggregation service and use the scale and flexibility of the portfolio to secure competitive prices for services.	The I&C sector has a major influence on electricity consumption and demand shape, but is also well placed to flex net demand from the power system (and inject real or reactive power) to provide system balancing, frequency response and reserve services in return for new revenue streams. Peer-to-peer trading of energy between I&C customers (as opposed to selling services to the SO) is a further opportunity.	Failure to exploit this capability would be to miss an important opportunity to reduce the cost of system balancing and frequency management and potentially lead to inefficient investment in conventional system balancing and reserve measures such as central generation.	2.5, 6.1, 10.1, 11.2, 13.1, 14.1, 14.2, 15.4, 15.5.		
		Provide an I&C and public EV charging (virtual) energy community service	Forming communities of commercial EV users (possibly in conjunction with commercial EV manufacturers and charging infrastructure service providers) will create opportunities for improved monitoring and smart charging and billing service offerings, whilst leveraging scale to secure attractive energy tariffs customised for I&C customers with fleets of EVs - including public transport fleets. Public EV charging infrastructure providers could also benefit from this service.	Failure to seize the opportunities afforded by an emerging market targeted at I&C EV fleet owners will be a missed business growth opportunity for service providers and a missed opportunity to encourage commercial EV adoption - with overall consequences for decarbonisation of transport objectives.	6.1, 10.1, 11.2, 12.1, 13.1, 14.1, 14.2, 15.1, 15.4, 15.5, 16.1, 16.2.		

Perspective 3

The Business Drivers	The lead party	Service Provider Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
	VPP Operators, Aggregators, business energy community service providers in conjunction with private network managers	Private I&C energy network management services	Providing integrated private I&C multi-vector energy network management services to maximise energy production (or procurement), arbitrage, and demand side management opportunities to optimise network utilisation and overall cost of energy provision	Failing to exploit opportunities to optimise utilisation of energy networks funded by the I&C private network community could result in either underutilised assets or premature replacement - either of which could lead to unacceptable stranded costs or pressures for costly reinforcement falling on the I&C private network community.	3.3, 6.1, 10.1, 11.2, 14.1, 14.2, 15.1, 15.4, 12.1, 13.1, 16.1, 16.2.		

4 Perspective 4 – Policy Makers, Academia, and Research Councils (though power sector academia will probably be interested in all templates), non-technical media

Policy or Other Driver	Interested Party	Policy Objective	The Contribution of the Power Sector	The likely consequences of failing to provide these power sector contributions	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these new power system functions are needed?	Common Conclusions
Decarbonisation of Society	**BEIS** **Committee for Climate Change** **Ofgem**	Contribute to the decarbonisation of society by taking action in areas including the production of electricity, home heating, and road transport. In support of this, accommodate low or zero carbon electricity sources in great numbers on the distribution network, facilitate EV charging, and develop opportunities for cross-vector energy optimisation.	Enable a much more flexible electricity system, capable of connecting and integrating the operation of renewable electricity sources. Harnessing a smart demand side, incorporating storage and intelligent systems 'beyond the meter', to create the additional flexibility necessary for maintaining secure and cost-effective electricity system operation as these changes take place.	The amount of renewable and low/zero carbon generation possible to connect to the distribution system will be limited. It is likely to be necessary to extend the operation of existing, or even create new, fossil fuelled traditional transmission connected synchronous generators to provide the flexibility and stand-by roles needed to ensure secure national system operation as the proportion of non-controllable generation increases and as system characteristics change (lower inertia and reducing system strength).	0.1; 1.1; 2.1; 3.1; 3.2; 3.3; 4.1; 5.1; 5.2; 6.1; 7.1; 8.1; 8.2; 9.1; 9.2; 10.1; 11.1; 11.2; 12.1; 14.1; 14.2; 15.4.	**Market developments** The challenges here are new to network companies and will require solutions to technical, commercial and regulatory issues. Furthermore, they span company boundaries and require whole-system approaches. In particular they require customer and third party engagement at significantly higher levels than in the past. Demand side flexibility will require new modelling and forecasting tools, new regulatory and commercial mechanisms, and the data to drive these techniques and the protocols and data management systems to enable secure information sharing and interpretation. The provision of flexible tariffs supported by smart meters and half-hour settlement for profile class 1-4 as well as 5-8 customers is key to unlocking flexibility at the domestic and micro-SME level and rewarding customers accordingly. However, exploiting flexibility opportunities from the customer side of the meter will require appropriate markets and settlements provisions to facilitate active engagement of customers and their service providers through a full range of customer choices at a more local level. **Implement smart grid to maximise system capacity** Automating customer side of the meter actions will be essential to securing the scale and speed of response required for some aspects of system operability, as will monitoring the effect of such actions. Design changes may be required to home energy management systems and smart devices, for example to introduce randomised starting or intelligent response to system frequency or voltage. For new services to customers to be simple and seamless, there must be co-ordination of inter-operability between devices, commercial arrangements that are not overly complex, and concepts and controls that are user-friendly and sufficiently standardised for	Based on need for greater flexibility to deal with an increasing dependence on weather-dependent generation, and domestic demand profile changes arising from solar PV, EVs and heat pumps, it is evident that opportunities afforded by smart metering, hh settlement, smart appliances, digital technologies, IoT etc. will need to be exploited. The traditional 'vanilla' approach to metering, tariff design and billing for domestic and SME customers would fail to provide the necessary incentives for customers to actively engage with the energy system. Consequences of failing to unlock this flexibility would be that: additional generation and network capacity would be required; a higher level of fossil fuelled thermal generation would need to be retained; GHG emission targets would be at risk; and electricity prices would be higher. Whilst ToU tariffs and price signals are a precursor to accessing flexibility, trials have shown that they alone are unlikely to encourage customers to significantly change their energy consumption behaviour. Non-traditional business models and new approaches to energy service provision will be required which facilitate interaction with customers' energy appliances to access flexibility and reward customers accordingly. Further service offerings providing incentives for customers to engage could include provision of lifestyle services such as remote control and monitoring (e.g. via a mobile phone or tablet app) of heating, lighting, security alarms etc.

Policy or Other Driver	Interested Party	Policy Objective	The Contribution of the Power Sector	The likely consequences of failing to provide these power sector contributions	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these new power system functions are needed?	Common Conclusions
	Environmental Lobbyists					customers to recognise and enjoy using them. **Enable and execute necessary operator interventions** To make available the necessary sensors, data, and commercial mechanisms. Ensure data inter-operability and open systems so that information can be analysed and shared between key parties, for example DSOs, the GBSO and energy market participants. Commercial mechanisms will require implementation of highly robust and auditable data systems Given the necessary development of technology and attention to markets, domestic and SME demand, storage and micro-generation provides new opportunities for operators to secure ancillary services. Investment planning and operational planning will require close co-operation. Functionality changes may need to be designed-in to the controls of automated systems. **Manage interface with connected systems** It will be important in investment planning timescales to understand the impact on other energy vectors of energy arbitrage actions.	Arbitrage opportunities with other energy vectors will be increasingly important to ensure opportunities for change of use of existing energy infrastructure are exploited where this will reduce the need for new electricity infrastructure capacity. At the domestic level, hybrid heat pumps, dual-fuel cooking and water heating facilities, and access to heat networks are likely to prove effective measures to support the cost-efficient decarbonisation of heat. However, accessing demand-side flexibility to manipulate demand profiles carries inherent risks. One is that if not co-ordinated from a whole system perspective, changes in demand profile could lead to voltage or thermal-rating related network constraints (for example tariff price signals linked to renewable generation output). Another risk is that if not co-ordinated, demand-side interventions could create technical or commercial imbalances. A further important risk to address is that step changes in domestic demand created by mass switching of appliances (for example EV chargers) as a result of either a control signal or a tariff price change could destabilise the grid and create a serious frequency excursion and possible system shutdown. Not least of the risks to be addressed is that wide scale access to HEMS, smart appliances and customer access devices carries a heightened risk of hacking into the associated communications and data management systems. Given the potential risk to electricity system security, resilience of the communications and data systems against corruption and cyber attack will be essential. The overall conclusion is that it would be erroneous to envisage these important new opportunities and functionalities simply being grafted on to today's power sector model - the changes now emerging offer not only new roles for existing parties, but also the opportunity for new parties who are positioned to provide more efficient or whole system solutions to the challenges. Traditional Suppliers will need to evolve to compete with new business model companies providing energy and lifestyle services, leveraging technological advances in smart appliances, communications, energy management and smart metering systems. However, co-ordination of energy service providers' actions with the wider operation and management of the whole electricity
	DfT	Promote a high penetration of EV and hybrid vehicles, fully using their inherent flexibility to minimise electricity system (generation and network) investment.	Facilitate smart charging of EVs, including V2G applications to promote convenience and minimise overall cost of EV refuelling arrangements. EVs can be integrated as part of the overall smart home, making use of their charging flexibility and potential storage capabilities.	Additional peak generation will be needed if refuelling is unconstrained. Substantial network reinforcement and investment will be inevitable to cope with the new system peaks arising from inflexible refuelling behaviour. Unconstrained charging in EV clusters will result in network overloading and voltage limits being exceeded.		**Market developments** The challenges here are new to network companies and will require solutions to technical, commercial and regulatory issues. Furthermore they span company boundaries and require whole-system approaches. In particular they require customer and third party engagement at significantly higher levels than in the past. EV flexibility will require new modelling and forecasting tools, new regulatory and commercial mechanisms, and the data to drive these techniques and the protocols and data management systems to enable secure sharing and interpretation. The provision of flexible tariffs is key to unlocking EV flexibility and rewarding customers accordingly. This will require appropriate markets and settlements provisions to facilitate active engagement of EV customers and their service providers. **Implement smart grid to maximise system capacity** Automating EV charging will be essential to securing the scale and speed of response required for some aspects of system operability, as will monitoring the effect of such actions as customer choices influence EV penetrations and locations. Design changes may be required to EV charging systems, for example to introduce randomised starting or intelligent response to system frequency or voltage. For EV services to customers to be simple and seamless, there must be co-ordination of inter-operability between devices, commercial arrangements that are not overly complex, and concepts and controls that are user-friendly and sufficiently standardised for	

Policy or Other Driver	Interested Party	Policy Objective	The Contribution of the Power Sector	The likely consequences of failing to provide these power sector contributions	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these new power system functions are needed?	Common Conclusions
						customers to recognise and enjoy using them. **Enable and execute necessary operator interventions** To make available the necessary sensors, data, and commercial mechanisms. Ensure data inter-operability and open systems so that information can be analysed and shared between key parties, for example DSOs, the GBSO and energy market participants. Commercial mechanisms will require implementation of highly robust and auditable data systems Investment planning and operational planning will require close co-operation. Functionality changes may need to be designed-in to the controls of EV charging systems. **Manage interface with connected systems** It will be important in investment planning timescales to understand the impact on other energy vectors of energy arbitrage actions.	system will be essential to avoid system shocks and inefficiencies.
Affordability	**BEIS**	Decarbonise the production of electricity, and accommodate low or zero carbon electricity sources and new demands in greater numbers on the distribution network and ensure that this is done at minimum costs to customers. This is key to both minimising costs to the fuel poor, and also assisting industry to be more competitive internationally. Importantly, this requires a significant increase of engagement with customers. It must be attractive and seamless, with high standards of service quality. Perspective 5 expands on some of these aspects.	Take full advantage of the facilities provided by smart metering and (with customer consent) in-home monitoring and automation technologies. A co-ordinated approach here will assist energy service companies to design products and service offerings that will increase customer choice, minimise energy costs, and improve their overall energy system engagement experience.	Decarbonisation without flexibility will lead to higher overall generation and network costs. It is likely to be necessary to retain existing, or even create new, fossil fuelled traditional transmission connected synchronous machines to maintain secure system operation.	0.1; 1.1; 3.1; 8.1; 8.2; 9.2; 11.1; 11.2; 14.1; 14.2; 15.1; 15.2;15.3; 15.4; 15.5; 16.1; 16.2; 16.3.	**Market developments** The challenges here are new to network companies and will require solutions to technical, commercial and regulatory issues. Furthermore, they span company boundaries and require whole-system approaches. In particular they require customer and third party engagement at significantly higher levels than in the past. Demand side flexibility will require new modelling and forecasting tools, new regulatory and commercial mechanisms, and the data to drive these techniques and the protocols and data management systems to enable secure sharing and interpretation. The provision of flexible tariffs supported by smart meters and half hour settlement for profile class 1-4 as well as 5-8 customers is key to unlocking flexibility at the domestic and micro-SME level and rewarding customers accordingly. However, exploiting flexibility opportunities from the customer side of the meter will require appropriate markets and settlements provisions to facilitate active engagement of customers and their service providers through a full range of customer choices.	

Perspective 4

Policy or Other Driver	Interested Party	Policy Objective	The Contribution of the Power Sector	The likely consequences of failing to provide these power sector contributions	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these new power system functions are needed?	Common Conclusions
	Ofgem **Consumer Champions (Citizens Advice etc)**	Offer energy usage/ pattern monitoring technologies that will help I&C customers to identify opportunities to minimise energy costs and Maximum Demand charges - including through energy storage options and selective usage of standby generation, and through alternative working patterns.				**Implement smart grid to maximise system capacity** Automating customer side of the meter actions will be essential to securing the scale and speed of response required for some aspects of system operability, as will monitoring the effect of such actions. Design changes may be required to home energy management systems and smart devices, for example to introduce randomised starting or intelligent response to system frequency or voltage. For new services to customers to be simple and seamless, there must be co-ordination of inter-operability between devices, commercial arrangements that are not overly complex, and concepts and controls that are user-friendly and sufficiently standardised for customers to recognise and enjoy using them. **Enable and execute necessary operator interventions** To make available the necessary sensors, data, and commercial mechanisms. Ensure data inter-operability and open systems so that information can be analysed and shared between key parties, for example DSOs, the GBSO and energy market participants. Commercial mechanisms will require implementation of highly robust and auditable data systems Given the necessary development of technology and attention to markets, domestic and SME demand, storage and micro-generation provides new opportunities for operators to secure ancillary services. Investment planning and operational planning will require close co-operation. Functionality changes may need to be designed-in to the controls of automated systems. **Manage interface with connected systems** It will be important in investment planning timescales to understand the impact on other energy vectors of energy arbitrage actions.	

Perspective 4

Policy or Other Driver	Interested Party	Policy Objective	The Contribution of the Power Sector	The likely consequences of failing to provide these power sector contributions	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these new power system functions are needed?	Common Conclusions
Security of Supplies	**BEIS** **Ofgem** **Consumer Champions (Citizens Advice etc.)**	Ensure that decarbonising the production of electricity, and accommodating low or zero carbon electricity sources in great numbers on the distribution network does not erode supply quality to customers and to wider system security of supply. Accommodate safely high numbers of smart and active systems that help customers to manage their energy usage and be rewarded for providing increased system flexibility.	Ensure that customers' smart energy systems play an effective and reliable contributory part in managing the system and do not act in a way that destabilizes the system resulting in loss of supplies. Ensure that when emergencies occur, customers' smart systems act in a manner that aids recovery and does not frustrate it.	Uncoordinated or unconstrained actions by customers' smart systems could destabilise the system and lead to widespread loss of supplies or even a total blackout. In the event of a severe system emergency, including a black start, recovery would be hampered or even significantly delayed by the uncoordinated actions of millions of smart devices. The importance of increasing system flexibility is being widely recognised, but sources of flexibility must be soundly designed if they are not to be a new source of risk (and consumer frustration). New power sector functionality is of particular importance here and must 'stay ahead' of the deployment of new sources of flexibility.	0.1; 2.1; 2.2; 2.3; 2.4; 2.5; 2.6; 3.1; 3.2; 5.1; 5.2; 6.1; 7.1; 8.1; 8.2; 9.2; 11.1; 11.2; 12.1; 13.1; 14.1; 16.3.	**Form and share best view of state of system in each time scale** Assessing and monitoring the positive and potentially negative impacts of customer side of the meter interventions will be important to assessing whole system operability, security and stability. **Monitor trends/emerging risks on the power system and implement mitigating actions** Given the potential scale of the impact, it will be essential to identify and counter threats to the operability of the power system arising from customer side of the meter technologies - in terms both of shocks to the system from demand step changes and cyber security. **Provide capabilities for use in emergencies** Given the predicted lowering of system inertia arising from reduced levels of synchronous generation, new forms of real power injection or rapid demand reduction will be required. Certain I&C applications, such as energy storage and standby generation (or DRUPS) could be adapted to provide fast (as well as dynamic) frequency response and so assist in the stabilisation of the grid in the event of a system shock (such as a loss of a major infeed). Some domestic applications (especially high power (EVs, heat pumps) or always on (e.g. fridges) devices) can also be adapted in the same way. Recovering from a serious incident could be impossible unless smart devices recognise the condition and moderate their behaviour accordingly. Unconstrained "smart" behaviour under emergency conditions is likely to delay or prevent normal services being resumed.	

5 Perspective 5 - Vendors new to the Supply Chain including grid edge products, data and communications systems and service providers, and white goods manufacturers

The Business Drivers	The lead party	New Supply Chain Vendors - Business Opportunities & Requirements	Why are these services important?	The likely consequences of failing to provide these services	Which of the 35 new power system functions are critical to have in place?	What are the main reasons these functions are needed?	Common Conclusions
1. To sell new products and services for use by residential and small C&I energy users	**New third party vendors who are established but not in the energy sector, and new SMEs/ Entrepreneurs/ start ups**	There is potentially a large market across domestic and small commercial and industrial customers, which can be enabled through access to sensors and data, application of automation and intelligent systems, provision of new smart white goods and other devices including electric vehicle charging, and by creating a relationship with customers of trust and willing engagement.	The vendor companies can make money on a sustained basis Greater energy efficiency. Making available the best deals and prices for energy including those in Fuel Poverty. Creating a more flexible energy system on the consumer side. Enabling clean energy uptake, locally and nationally. Meeting national policy goals for decarbonisation and air quality. Encouraging new vendors is important for bringing forward creativity, customer choice, and promoting competition. There is export potential and job creation across all these areas as the principles are applicable in many markets internationally.	At an overall level, the consequences of failing to make available the necessary new power system functions will be a shortfall in new vendors operating successfully at the grid edge, a lack of innovative new services being offered to customers (that may be seen operating elsewhere in the world), or a stuttering deployment of new services that lacks the quality and responsiveness to satisfy customers and wider stakeholders (such as investors in SME companies, community energy managers, and smart city developers).	0.1, 2.1, 2.2, 2.5, 6.1, 14.2, 16.2, 14.1,	These new power sector functions are key enablers for establishing a vibrant community of vendors at the grid edge. The main reasons for this are as follows: i) they enable access for information and the ability for the exchange (with permission) of customers' data, ii) they provide an environment where new vendors can identify opportunities, design, develop and deploy their products and services, iii) they set the context for services that create new power system flexibility, including the role of aggregators, iv) provide a growing and healthy sector of the energy economy that attracts and supports investment, and v) they provide the requisites needed for 'right first time' high quality to services to customers and the ability for these to be responsive to developments and create a base of highly satisfied and engaged customers. The alternative to providing excellent and continually improving services to customers is to compete on price alone - in a market place where customers can simply switch elsewhere, this is a 'race to the bottom' that businesses are wise to avoid.	There is **evident opportunity for new products and services** to be provided at the grid edge, both by new and by established vendors. These products and services can potentially add to power **system flexibility**, facilitate **community energy** and **smart city** developments, and bring to domestic customers and small business and industrial customers **a range of new and attractive opportunities**. These developments offer the **creation of new jobs** and **export opportunities** given the international interest in similar developments. None of this is achievable under today's sector arrangements, which **lack clarity of accountabilities for issues that span ownership boundaries,** make no provision for reasonable **access to data in open formats,** and cannot **provide the agility to respond to change** in ways that will result in great new customer offerings and establish new levels of engagement with a **customer base that has high expectations** for reliable, attractive, and responsive new applications, interfaced by (eg) smart phone devices. Furthermore, both customers and wider stakeholders will expect **high standards of data privacy and cyber security** which is an end-to-end system challenge that's problematic to address under today's segmented ownership structure
		Vendors new to the supply chain require insight and access to capabilities for developing, proving and marketing their products, such as access to customer and power system data, which may be derived from smart meters or through other sensing devices, and communicated through smart meter channels or by other means.					
		Interaction with customers needs to be of high quality and probably primarily through mobile devices such as smart phones. Vendors require access to data in standardised (open system) formats so that applications work smoothly and entirely reliably for the customer from day 1, and upgrade paths can be implemented seamlessly.	Home energy management is not a priority for most people, but experience shows that customers will use 'spare moments' at their convenience for this if Apps are easy and satisfying to use. For some customers a gaming style will appeal, with perhaps financial or other rewards, or simply creating a sense of 'beating the system'.				
		New opportunities may be created through data disaggregation, for example fingerprinting techniques to enable analysis of appliances types that are contributing to total energy use, or by finer granularity of time of use. Disaggregation may require data provision at a finer granularity than provided for, say, simple cost-tracking or billing.	Data disaggregation can inform and delight energy users, for example by revealing the reasons for higher usage costs, or identifying an appliance that is not operating correctly, or pointing to a change in household use patterns. This kind of diagnosis can be automated and avoid calls to a help desk that are time-consuming for an energy or service provider. Provision of such information is likely to build				

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			trust (although recognizing there is an ever-present need to recognize the inherent distrust in some customers).				
		For some new services and products to be successful the developer may require access to expert advice from those who manage the wider technical, commercial or regulatory context (including expertise across energy vectors). In the technical area this may be an understanding the local network, its feeding and protection arrangements, parameters such as loop impedances, or detailed requirements of system frequency control.	The power system and its commercial and regulatory frameworks have developed over many years and, for legitimate reasons, have aspects that are complex and subject to evolving change. If 'designed in from the start' these aspects can be accommodated efficiently by vendors and so achieve good outcomes for all parties. However, this requires timely access to expert advice and to insights regarding changing trends or new requirements.				
2. To sell new products and services for use by Community Energy groups, both geographic and virtual	**New third party vendors who are established but not in the energy sector, and new SMEs/ Entrepreneurs/ start ups**	There is increasing interest in Community Energy that includes local markets, peer-to-peer trading, and provision of trading platforms, for example to consolidate and sell system services. These arrangements might appear simple in principle to the user (and indeed need to) but have many subtleties that will require the development of new technical and market services.	To respond to and take advantage of the trend towards 'energy democratisation', new products and services will need to be developed. It is possible that novel trading mechanisms will be best facilitated using new techniques such as Distributed Ledger (Block Chain) designs. There is an emerging international view that it will be important to understand and gain practical experience with these designs as a key enabler for both financial transactions and emerging M2M 'Internet of Things' applications.	The absence of the necessary new power systems functions will not only be adverse for the new vendors operating at the grid edge, but will have consequential impact for those wanting to develop Community Energy enterprises, Smart Cities and other Internet of Things services.	0.1, 6.1, 14.2, 15.5, 5.1, 16.2,		

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		Virtual Community Energy groups might include the owners of a particular make of Electric Vehicle, or a business that has electrical loads at several locations. For the benefit of all parties, new products and services will be needed that meet the requirements of the virtual community owner and the requirements/constraints of the network owners, perhaps necessitating data exchange at diverse locations (eg to more than one DSO and to the GBSO). There are business opportunities here for all parties (eg providing flexibility services; diversity of risk through many-to-many services) but there is 'devil in the detail' that requires clarity in regard to accountabilities, co-ordination, and standards such as Open Data protocols.					
3. To retain residential and small C&I customers by delighting them with the service they receive and its ongoing enhancements	**New (and established) providers of products and services**	Both new vendors and established vendors have a common requirement to excel in the service they deliver to customers. This way trust is built, the customer is more likely to remain in a long-term relationship, and any problems get resolved quickly and without reputation damage (even creating reputation enhancement). This can only be achieved with 'right first time' new products and services, and with an agile response to bringing forward enhancements and new capabilities.	This approach can be observed operating effectively in the mobile phone sector. However the ability to deliver such quality and responsiveness puts a hugely challenging obligation on the vendors, the established sector players, and the gate-keepers of its change mechanisms. The long-established sector governance arrangements cannot possibly deliver what is needed to enable vendors to thrive in this competitive environment where consumers now rightly have high expectations for quality and responsiveness.	Providing services to homes, individual consumers and small businesses is a demanding customer base to work with, as expectations are set high for top quality interfaces (eg smart phone Apps), ease of set up, reliability of service and excellent responsiveness to any problems and to upgrades. If this cannot be delivered because of the unavailability of power sector functionality, goodwill will be lost at the start and the reputational damage may create a barrier hard to overcome for all the players.	0.1, 16.2,		

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4. To sell new products and services that are created at the grid edge, but whose market is with remote parties such as the DNO/DSO and GBSO, or Community Energy enterprises	**Providers of aggregation and flexibility management services**	Aggregation services have strong potential to enhance power system flexibility by means of upward and downward demand management, optimisation and management of home and community scale storage, and the integration of Distributed Generation (e.g. PV) with fixed storage devices or EVs offering V2G services. Development and delivery of these services will require many of the features described earlier in this schedule with the addition of forecasting tools (which include for cross vector effects), many of which will be entirely new and require large data analytics, machine learning, and the integration of multiple data sources.	The need to increase system flexibility is widely recognised, but the required development of new forecasting and modelling tools is at a very early stage. For many years, forecasting has been possible using 'top down' techniques (e.g. for system demand), but once demand shifting 'fills troughs and trims peaks' the predictability of 'load curves' will be lost. New techniques need to be developed using 'bottom up' methodologies and modern data analytics. Such developments will be an enabler for many aspects of an efficient and secure future energy system.	Aggregators are key to marshalling resources across large numbers of parties and converting them to a reliable and valuable service. Absence or delayed deployment of the necessary power sector functionality is potentially a serious brake, resulting in poor deployment rates of new flexibility services or poor operating experience as regards reliable and responsive service delivery.	0.1, 2.5, 6.1, 14.2, 5.1, 7.1, 16.1, 16.2, 3.2, 8.1, 9.2, 12.1,		
5. Create markets for new products that either integrate services across energy vectors (e.g. electricity, gas, heat), or integrate energy with other consumer services (e.g. e-health, home security, transport, or child/elderly care)	**New third party vendors who are established but not in the energy sector, and new SMEs/ entrepreneurs/ start ups**	New opportunities for attractive services to customers can be anticipated through techniques such as data aggregation at individual customer level, combining for example demand usage, weather data, and home occupancy patterns. This might enable flexibility services to be predicted and implemented automatically, at no inconvenience to the customer and with suitable financial or other reward. To achieve this requires a significant span of data to be accessible, perhaps using cloud-based systems combined with machine learning. Extension to other consumer services such as e-health, home security, or the monitoring of an elderly person living alone is a further step that can be anticipated. Such services would require consumer consent. It is likely that cloud based systems will be an economic choice, but work will be needed in good time to satisfy all parties in regard to data privacy and cyber security, especially where points of access for data span ownership boundaries.	It is reasonable to anticipate that there could be many new services that customers would find attractive, making use of energy data, power system data and a wide range of 'external' sources. However, this presents a data analytics and data structuring task of a scale new to the power sector. The development of algorithmic techniques, agreement on Open Data protocols, assurance of data privacy, and full confidence in cyber security are all necessary enablers. These challenges will require co-ordination between the various data owners and unambiguous accountability for managing whole-system aspects such as end to end data security. Furthermore, there must be accountability for ensuring that automated action cannot jeopardise power system security arising from multiple simultaneous actions, for example in response to a common market price signal or other 'herd behaviour' such as a response to a severe weather warning.	Cross-vector approaches are a key element to the government's energy pathways. This is reflected in the establishment of significant new bodies such as the Energy Systems Catapult and mechanisms such as the Renewable Heat Incentive. However this is only the first step to potentially much wider interactions in other aspects of life in the 'intelligent home'. New power sector functionality is one of the critical path enablers for achieving these ambitious, but potentially very attractive, new approaches to energy customers and to wider society.	0.1, 2.5, 6.1, 14.2, 15.5, 5.1, 7.1, 16.2, 3.1, 15.4,		