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SPEN DSO Vision

SP ENERGY NETWORKS

SPEN DSO Vision

1 ACKNOWLEDGMENT

SP Energy Networks acknowledges the input provided by the DSO steering group in developing this Vision document.

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	Jim McOmish	Head of Distribution	SP Energy Networks
	Allan Hendry	Head of Licence and Revenue	SP Energy Networks
Advisory Members	Damon Hewlett	Grid, Regulation & Generation Policy, Energy Markets	Scottish Government

We would also like to thanks former members of the steering group Nicola Medalova representing National Grid and Gordon MacDougall representing RES. Their input was crucial to the development of this vision document.

SPEN DSO Vision

FOREWORD

As the UK builds towards a low carbon future, the nature of the electricity grid is changing - we no longer rely solely on centralised energy generation to supply all of our demand customers. We are experiencing increasing volumes of Distributed Generation and Distributed Energy Resources (DER), Smart Meters are being installed in our customers' homes and greater adoption of electric vehicles.

As network operators we need to adapt to meet these challenges whilst maintaining low cost and reliable energy distribution for our customers. In addition, as our customers increasingly become 'prosumers' (both consuming and producers of electricity), we need to facilitate a fair market for the services that they could provide to the electrical network.

If we are to facilitate the transition to a low carbon future in a cost effective way we need to maximise the potential of the existing electrical infrastructure. The evolution of the energy sector towards a smarter system will only be possible if Distribution Network Operator's (DNOs) play an active coordinating role between all market participants, facilitating the markets and services in a neutral and non-discriminatory manner. This can be achieved by extending the current role of DNOs to that of Distribution System Operators (DSOs). An effective DSO model will reduce system balancing costs, whilst enabling the flexible networks necessary to facilitate customer's use of low carbon technologies. It is my opinion that the implementation of a DSO model optimises customer engagement, minimises costs, improves customer service, manages losses and optimises investment at a local level.

The network evolution has already started, key enabling technologies are commercially available and have already been trialled on our network. These technologies have allowed customers to get connected to our network quickly - where previously they would have had to wait on significant reinforcement works in order to connect.

In transitioning from a DNO to a DSO we would plan to invest in network monitoring, control and communications which would ultimately minimise the overall costs to our customers.

All of this will occur in a context in which policy makers are promoting greater competition and creating new markets for energy balancing services. Customers will become more empowered and benefit from having access to more information and greater choice. It is essential that appropriate regulatory arrangements are implemented to enable the evolution of DNOs to become DSOs. These changes will enable the industry to better meet changing customer expectations and reduce the overall costs to customers.

This document sets out my vision for transitioning SP Energy Networks from its current DNO role to that of a DSO. We have created it in conjunction with key industry stakeholders, however the transition from a DNO towards a DSO will not happen in isolation, and will require widespread engagement from customers, policy makers and industry. To that end I welcome your views and opinions on our DSO vision, with a view to informing the current industry debate on the transition of DNOs to DSOs in the UK.

Frank Mitchell, CEO

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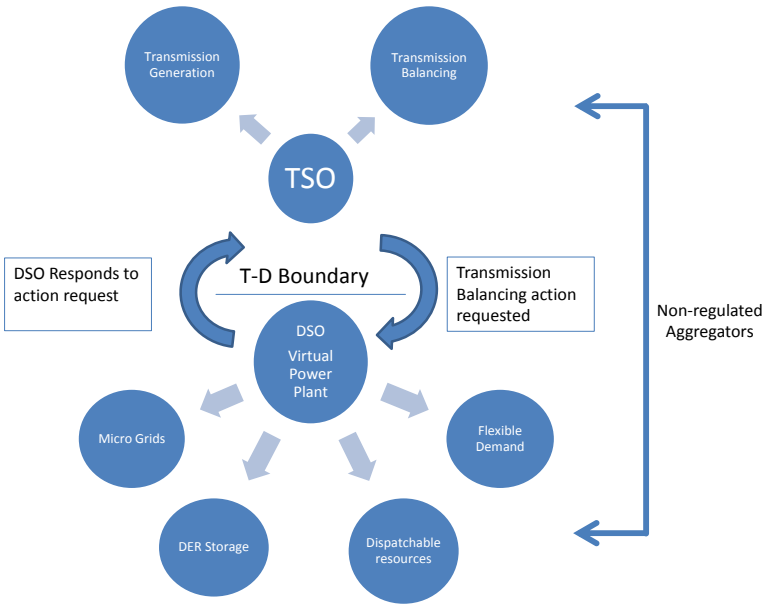
2 EXECUTIVE SUMMARY

- Our Vision is that SPEN will transition towards becoming a full DSO which will facilitate an open and inclusive balancing services market at the Transmission/Distribution interface. The DSO will also carry out local system balancing, efficiently utilising the Distribution network;
- We will continue to improve the level of customer service and manage system security in line with our current role as a DNO. We will ensure that the expansion of our role as a DSO continues to deliver value for money to our customers;
- Our DSO model will be capable of enacting system balancing actions from the SO within timescales that best meet the needs of the SO and the capabilities of the DERs connected to our network areas;
- Our transition to a DSO will be both modular and proportionate;
- We will work with BEIS, Ofgem, UK Network companies, DER providers and key stakeholders to develop and implement a fair and cost effective remuneration mechanism for all DSO services and DER providers.



The DSO will facilitate a more open balancing market, encouraging transparent and non-discriminatory access. The DSO will continue to provide system security and quality of service in distribution networks in order to serve network customers. This will be achieved through the extended use of active system management; and through the supervision, control and signalling of Distributed Energy Resources.

3 NEEDS CASE

3.1 Regulatory Focus and the Changing Landscape in the UK Energy Sector

Recognising the changing landscape in the UK energy sector both BEIS (previously DECC) and Ofgem have identified the need for network companies to evolve. A number of key publications have been referenced below which outline government views and opinion.

DECC's Smart Grid Vision and Routemap document[1] states:-

'Great Britain is already seeing the impacts of the transition to a low carbon economy. Our electricity generation mix is changing with an increasing level of renewable and other low carbon generation. At distribution system level, the increasing requests for connection of solar PV installations, onshore wind farms, and other forms of distributed generation are creating technical challenges, which have knock-on impacts for the transmission system as well.'

And also that:-

Electrical demand patterns are changing too. An emerging challenge is the increasing electrification of heat and transport, a key part of decarbonisation. Comprehensive modelling undertaken by DECC, network companies and academia illustrates clearly that electricity consumption and, in particular, peak demand (which ultimately drives the need for both generation and network capacity), has the potential to exceed anything previously designed for.

The changing generation mix is something that we have already experienced within the SP Energy Networks network areas. We have yet to witness significant penetration of electric vehicles and next generation electric heating but fully expect these to ramp up considerably if the UK carbon reduction targets are to be met. These scenarios are ultimately based on an informed view of available evidence, therefore network companies must endeavour to make 'no regrets' investments that provide the capability and flexibility to deal with range of scenarios.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

ECCC Low Carbon Networks Report - Summary[2]

The report finds that Networks face three challenges:-

1) *Accommodating new energy sources which requires connections to, and reinforcement of, the grid.*

2) *New sources of energy are variable in output and system operators must therefore employ new tools to balance supply and demand.*

3) *Networks' efforts to overcome these obstacles must not be impeded by outdated and inflexible regulation and governance.*

Networks have a number of tools to balance variable energy sources:

- *Storage technologies, (hydro to household batteries): the deployment of storage is obstructed by archaic regulation and unfair 'double-charging', both of which the Government must address urgently.*

- *Demand Side Response could empower consumers large and small to manage their energy use in line with system-wide need, but a more detailed Government strategy is needed to help this solution reach its full potential.*

- *Greater interconnection with European neighbours will improve the UK's ability to meet peak demand, though they note that Great Britain is likely to remain a net importer of electricity.*

Development of DNO to DSO

- *Network companies have generous allowances for early-stage testing of the technological solutions they need, but the UK struggles to bring these innovations into commercial reality.*
- *More and more electricity generation occurs at the regional distribution, rather than national transmission level, but Distribution Network Operators remain blind to their energy flows and passive in managing them.*
- *There must be a transition to fully-functional Distribution System Operators which balance and control their local grids.*
- *In Transmission they recommend creating an Independent System Operator (ISO).*
    - *"The Government must set out its intentions regarding an ISO, and consult on a detailed, staged plan for their implementation."*

Finally the Future Power System Architecture (FPSA) project[3] commissioned jointly by DECC (now BEIS) and Ofgem and completed by the IET and Energy Systems Catapult outlines some of the key

[2] House of Commons Energy and Climate Change committee – Low carbon infrastructure, First Report of Session 2016-17 (14th June 2016)

[3] http://www.theiet.org/sectors/energy/resources/fpsa-project.cfm?origin=reportdocs

future uses of the UK network and the challenges of realising this network. The report highlights seven key drivers of *'new or significantly extended functionality'*

These drivers have been highlighted below as they are integral to our DSO Vision:-

1. ***'The flexibility to meet changing but uncertain requirements*** *recognising that the form, magnitude, timing and tipping points of future power system developments are not all predictable far in advance. Changes include uptake of new technologies (e.g. domestic generation and storage, electric vehicles, heat pumps) or active consumer participation (e.g. smart tariffs, home energy automation).*
2. ***The change in mix of electricity generation*** *will require new techniques to manage system frequency, stability and reliability as intermittent renewable sources and distributed generation grow to take up a much larger share of total generation.*
3. ***The use of price signals or other incentives will enable customers to save money by becoming active participants in the power sector*** *and, in doing so, to contribute to decarbonisation while keeping system balancing costs down.*
4. ***The emergence of new participants such as smart cities, groups of technology users, aggregators and social enterprises*** *will require new modes of interaction with the power system to exploit benefits of aggregation while mitigating any risks of destabilisation.*
5. ***The active management of networks, generation, storage and demand*** *will facilitate growth of intermittent and distributed generation and new loads such as heat pumps and electric vehicles, without unnecessary network constraints or costly upgrades.*
6. ***The recovery from major outages will be far more challenging as the power system becomes more decentralised.*** *Managing prolonged outages will require sophisticated coordination to reintroduce load and to reconnect distributed generation and storage.*
7. ***The need for some coordination across energy vectors*** *(electricity, gas, biofuels, petroleum and heat networks) will become inevitable as the UK decarbonisation strategy proceeds with the electrification of heat and transport energy. '*

3.2 Network Challenges

SP Energy Networks has been at the forefront of the connection of Distributed Generation in the UK. Across our three franchise areas we have connected ~7GW of renewable generation. We have faced unique challenges within our Southern Scotland and North Wales regions where we are facilitating high levels of renewable generation. These areas are resource rich in terms of wind yield and land but they are also areas of low population density and therefore low electrical demand. A good example of this is an area of South West Scotland where peak demand is around 177MW, however through our focus and innovation we have managed to connect 310MW of Renewable energy, This surplus of generation in a sparsely populated area means that at key points of any given day wind generators are seeking to export across the Distribution Network and onto a highly constrained Transmission network. This challenge aligns closely with the second of the FPSA projects identified drivers.

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To address these issues we have focused a number of our innovation projects on alternative means of connecting DG customers to our networks. This will often lead to some form of constrained connection, but from our findings it is clear that there is additional capacity on the electrical network that can be utilised. However we require additional monitoring and control capabilities in order to release this capacity without adversely affecting our existing customers or assets.

Alongside this rollout of DG the rollout of Smart Meters will assist us in understanding customer behaviours and the demand and generation profiles on our LV networks. The challenge for us will be ensuring that the data is captured securely and the large volume of data can be translated through to network information that allows us to minimise costs to our customers whilst facilitating the transition to a Smart Grid.

SPEN Network Statistics

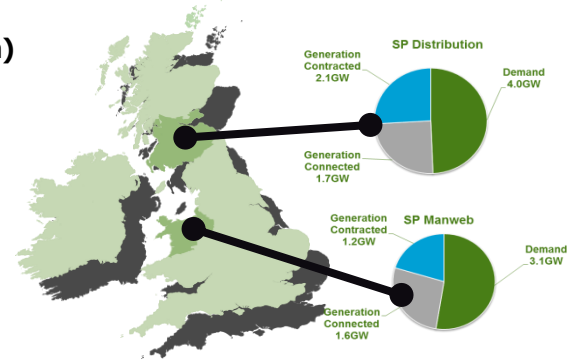
- 3.5m connected customers across our SPD and SPMW Licences
- Over the last 5 years Customer Interruptions have reduced by 14% in SP Distribution and by 24% in SP Manweb
- Over the last 5 years Customer Minutes Lost have reduced by 29% in SP Distribution and by 33% in SP Manweb
- 6.8 GW of Renewable Generation is connected to our networks three licence areas

SPEN Distribution Network Statistics (>1MW)

- Demand **7.1GW**
- Distribution DG Connected **3.3GW**
- SPT Renewables **2.7 GW**
- DG Contracted **3.3GW**

SPM Stats

- SPM System Maximum Demand (Total) - **3.1GW (System)**
- DG connected (>1MW) **1.6GW**
- Feed-In-Tariff (<1MW) – PV Connected **148MW**
- *DG Contracted 1.2GW*



SPD Stats

- SPM System Maximum Demand (Total) – **4.0GW**
- DG connected (>1MW) **1.7GW**
- Feed-In-Tariff – PV Connected **166MW**

DG contracted to connect to the Distribution network 2.1GW

3.3 Financial Context

It is critical that the transition from DNO to DSO is cost effective for UK customers, therefore we have considered the financial justification of this transition. The key financial drivers for transitioning to a DSO are outlined below:-

- Minimising the reinforcement costs associated with a Low Carbon transition
- UK System Operator Balancing Mechanism
- Facilitating the connection of Low Carbon Technologies

Minimising the reinforcement costs associated with a Low Carbon transition

DECC's Smart Grid Vision and Routemap document[4] states that the rollout of Smart Grids, will reduce the network reinforcement requirements of the electricity network by between £2.5Bn and £12Bn by 2030. It is clear that in order to realise these savings DNOs need to maximise the utilisation of the existing electrical infrastructure. Indeed DECC (now BEIS) recognised that '*the traditional distribution network operator will evolve from its current role managing a largely passive network to operating as a distribution system operator supporting local balancing and system optimisation'.*

This can be accomplished through real time monitoring and control of Distributed Energy Resources (DERs). Currently the control of DERs has been achieved through bi-lateral agreements with the SO and only with large scale generation and demand resources. In order to maximise the utilisation of the existing infrastructure, the real time monitoring and control of DERs must be more inclusive and capable of managing conflicting priorities between the SO, TOs and DNOs.

As outlined in the FPSA report the change to a low carbon future will also require DNOs to adapt to changing but uncertain requirements, further reinforcing the need for flexibility.

Balancing the system

National Grid's role in balancing the system is set out in primary legislation and regulated by the Gas and Electricity Markets Authority working through Ofgem. It is specified in detail in transmission licence conditions and a series of codes, including the Balancing and Settlement Code. Compliance with balancing requirements is included in individual generation and supply licences, and generators and suppliers may also negotiate or bid for the provision of certain types of balancing services. Where they do so, they generally receive an availability payment as well as a payment for the use of a service.

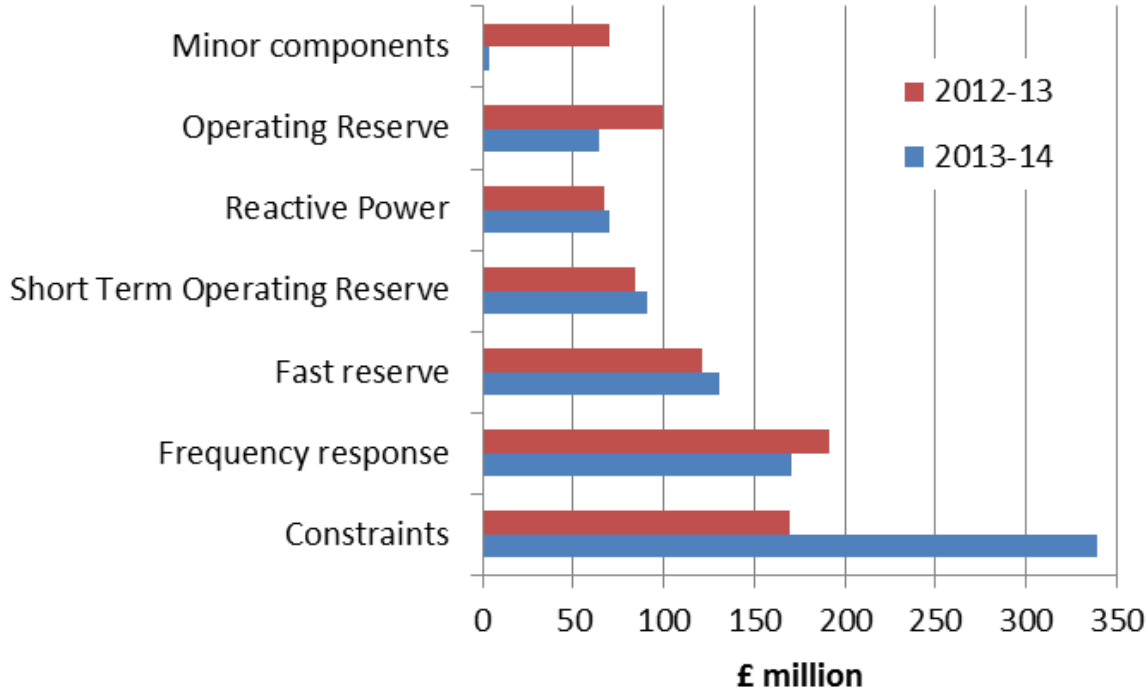
Balancing activity is based on half hour periods ('Settlement Periods'). Suppliers and generators contract with each other and provide details to National Grid of their contractual positions one hour before each settlement period. They also provide estimates of their likely actual generation and

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

demand in that period, and what they would charge or be prepared to pay for altering their level of generation or demand ('bids and offers'). National Grid can then take any balancing actions necessary using these bids and offers and a range of other services available. Further information on balancing services can be found in Appendix A - Keeping the Electricity Transmission System in Balance.

There are two types of balancing actions. Energy imbalance actions address overall mis-matches between generation and demand at a national level across the settlement period as a whole. System imbalance actions tackle local or regional constraints in the capacity of the transmission network, or short-term variations between demand and supply within a settlement period. Constraint actions can result in compensation ('constraint payments') for generators which lie behind a constraint barrier.

Cost of individual balancing services



Source: National Grid MBSS reports for March 2013 and March 2014
Total cost of running the UK's Ancillary Service was ~£1bn in 2014/2015

The total cost of delivering Ancillary Services in the UK is wrapped up within the Balancing Services Use of System (BSUoS) charges. BSUoS charges are split into two components:

1) **Internal costs**: National Grid's costs of running the UK's ancillary services including balancing staff, accommodation and IT systems which are covered by its regulatory settlement

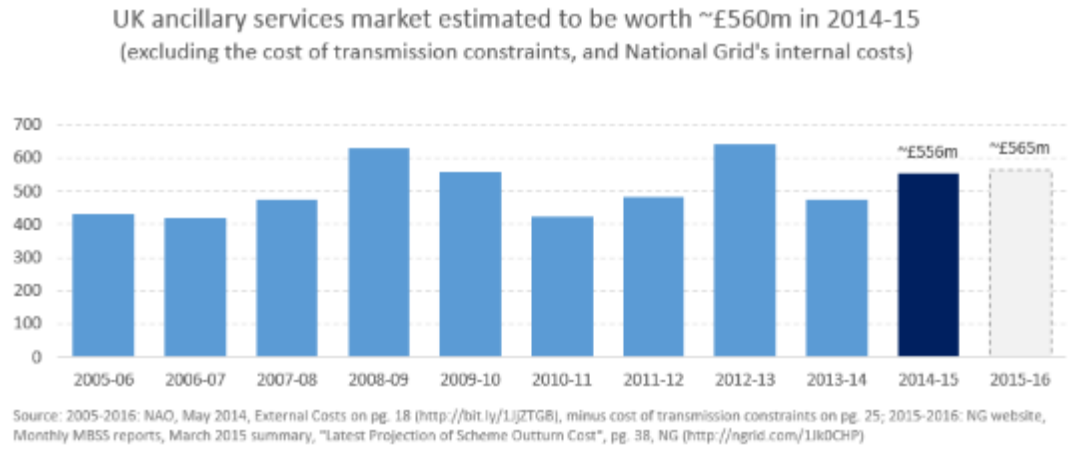
2) **External costs**: charges from generators and / or consumers for ancillary services

Balancing Services Use of System (BSUoS) charges were almost £1bn in 2014/2015 (£989m), down slightly from £1,002m in 2013/2014. This represents £1.88/MWh for each MWh generated.

External UK ancillary service market valued at ~£560m in 2014/2015

The external market size for ancillary services in the UK can be considered as the sum total of all external BBUoS charges, which are mainly provided by third parties other than National Grid. Excluding transmission constraints, the total external costs of running the ancillary service market in 2014/2015 were ~£560m.

Over the past 10 years, external ancillary service costs (excluding transmission constraints) have grown at ~1% per year from ~£430m in 2005-06. Extrapolating from National Grid's March 2015 forecast suggests this cost will rise slightly to ~£570m in 2015-2016.



The services that make up the ~£560m of external costs include:

- Fast Reserve
- Short Term Operating Reserve (STOR)
- Frequency response
    - Mandatory Frequency Response
    - Commercial frequency response, including: Firm Frequency response (FFR) and Frequency Control by Demand Management

- Reactive power
- Footroom
- BM Start-up
- Operating Reserve
- Other minor components, including: Fast Start and Black Start

It is envisioned that by transitioning to a DSO we will facilitate additional organisations to act in this balancing market, opening up competition and reduce the cost implications of balancing actions for UK customers.

Facilitating the connection of Low Carbon Technologies
Traditional approaches to network design have involved modelling worst case scenarios of minimum demand, maximum generation when assessing the impact of DG developers seeking to connect to the network. Our Accelerating Renewable Connections (ARC)[5] and Flexible Networks[6] innovation projects we have demonstrated that this approach does not maximise the utilisation of our existing assets. Through real time monitoring and control of the network we have been able to connect DG customers at a lower cost and/or significantly earlier than traditional reinforcement would allow.

As an example of the benefits of adopting Active Network Management, during our ARC project at Berwick GSP, 3 customers have achieved access to the distribution network behind a transmission constrained boundary through the deployment of ANM, whilst avoiding the need for wider network reinforcement through the creation of an enduring 'non-firm' Statement of Works process avoiding £12 million in transmission reinforcements.

The rollout of flexible methods of connection is being undertaken by all of the UK DNOs, however under the current balancing mechanism it is possible for Distribution ANM schemes to work against SO actions undertaken through bi-lateral agreements with the SO. To address this issue either the SO requires greater visibility and control of the Distribution network or a DSO must be empowered to issue actions to DERs directly connected to the Distribution network.

The Active Network Management (ANM) and flexible connection techniques explored in these projects will form the basis for the technical requirements for the transition towards a DSO model.

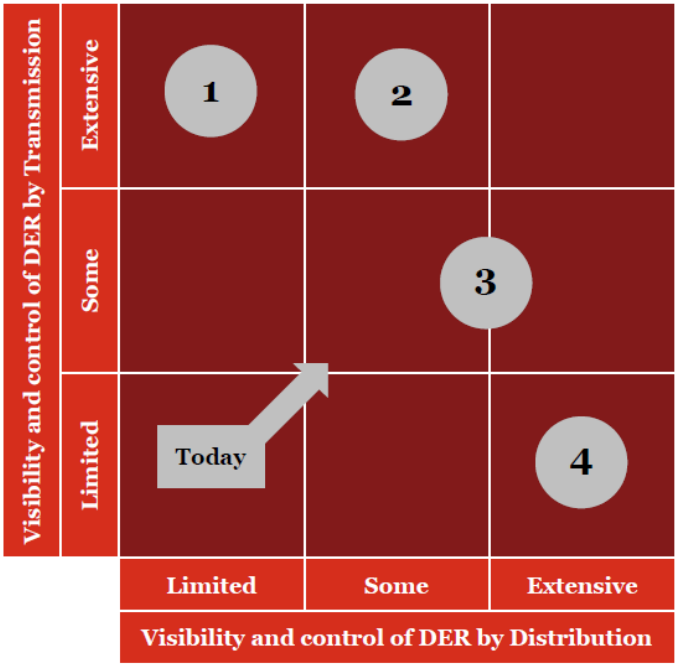
[5] http://www.spenergynetworks.co.uk/pages/arc_accelerating_renewable_connections.asp
[6] http://www.spenergynetworks.co.uk/pages/flexible_networks_for_a_low_carbon_future.asp

4 OUR DSO VISION

4.1 Potential DSO Models

There are a number of interpretations of the roles and responsibilities of a DSO in the UK. These DSO models can be broadly categorised based on the extent to which the SO (or future Independent SO) or the DSO is responsible for system balancing services and the extent to which the DSO is responsible for facilitating an ancillary services market.

The diagram below outlines a high level view of the DSO model options focused on the technical control and utilisation of DER.



These models can be interpreted as follows:-

1 – Total TSO
2 – DSO DER manager
3 – Transmission support
4 – Total DSO

The total TSO model involves the existing TSO (or independent SO) extending their existing management of DER resources to include all DER assets connected at the distribution level. This would require a significant extension of the capabilities of the SO particularly in terms of system

monitoring and control. However the existing commercial and licence arrangements would require less revision in order to be extended to additional DERs.

Under the DSO DER manager model the TSO would retain primary control over network balancing services but also contract services from DSOs. An example of this type of service would be the current arrangements for ENWL's CLASS project[7], which involves ENWL providing ancillary services to National Grid as the SO.

The transmission support model is an extension of the DSO DER manager model with DSOs also carrying out the aggregation and management of some DERs.

The two central models both result in the risk that there is an overlap and/or conflict of control boundaries for DERs.

The Total DSO model involves the DNOs extending their role to manage all DER resources below the Transmission/Distribution boundary. The DSO would then respond to instructions by the SO and manage the DERs to best meet these instructions. This would also require the DSO to facilitate an ancillary services market for DERs.

In order to inform our views on what we deem to be the most efficient and optimal model and the basis for this vision document we have created an internal DSO steering group, which has also been informed by key industry stakeholders. These models have been reviewed by our DSO Steering Group and our initial findings are that the Total DSO model would be most appropriate solution in the UK. A number of the benefits for this solution are highlighted below:-

- Local control would be best placed to meet local customer service requirements
- Scalable architecture (horizontally and vertically)
- Responsibilities of DSO align with asset ownership boundary
- DNO carrying out DSO role would be best placed to balance manage new requirements alongside existing customer and stakeholder priorities
- No resource contention
- Can compare relative DSO performance and reward appropriately
- No ambiguity of control
- Could drive different approaches and innovation across DSOs
- Can be locally responsive with locally specific solutions
- Potential for innovative localised customer propositions from local suppliers
- Can be piloted in an area or a community

However rolling out of this model would also result in a number of significant challenges:-

[7] http://www.enwl.co.uk/class

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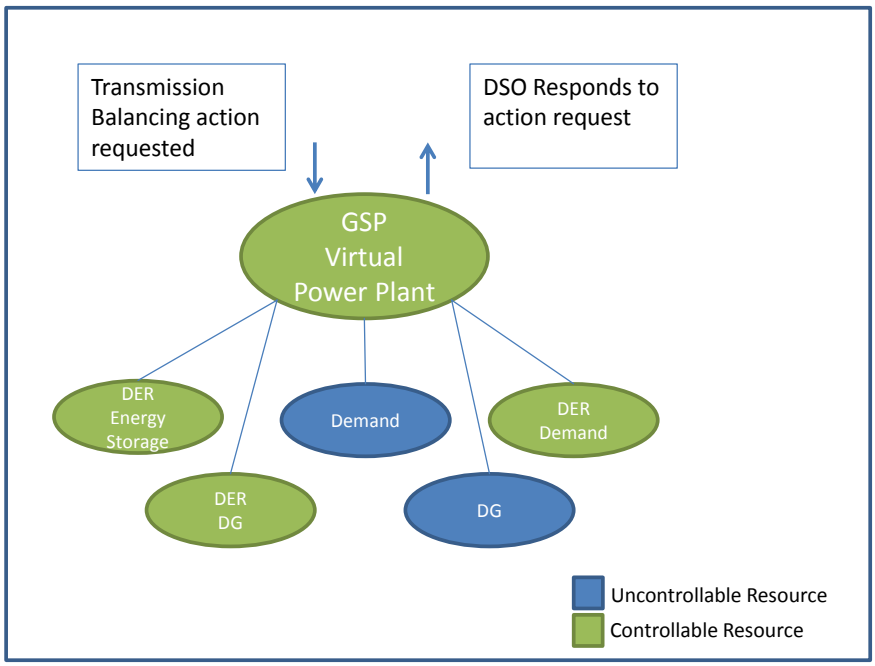
- Regulation will be required to standardise approach across DSOs, so that national customers and retailers can operate fairly across the UK
- Most significant commercial and regulatory change required of the DSO models discussed
- DNOs would need to adapt their roles to market facilitators on a real time basis

4.2 Our DSO Vision

Our Vision is that SPEN will transition towards becoming a full DSO which will facilitate an open and inclusive balancing services market at the Transmission/Distribution interface. The DSO will also carry out local system balancing, efficiently utilising the Distribution network

These DERs will be aggregated into Virtual Power Plant (VPP) or Virtual Balancing Mechanism Units (VBMUs) which will interface with the SO, to act on balancing instructions. This aggregation will require the DSO to facilitate a market and as such a mechanism will need to be developed to remunerate DERs for the services they provide and/or provide pricing signals for DERs without direct control (e.g. groupings of domestic electric vehicle charging points) to react to system requirements.

We believe that this approach will be critical to ensure that the market is prepared for the emergence of new participants.



Interaction between DSO, TO and DERs

In addition the DSO will balance the local distribution network, making effective use of the existing Distribution network and where practical matching local generation with local demand. The increased information on the system utilisation will also act as an investment driver identifying where additional network reinforcement is required.

We will continue to improve the level of customer service and manage system security in line with our current role as a DNO. We will ensure that the expansion of our role as a DSO continues to deliver value for money to our customers.

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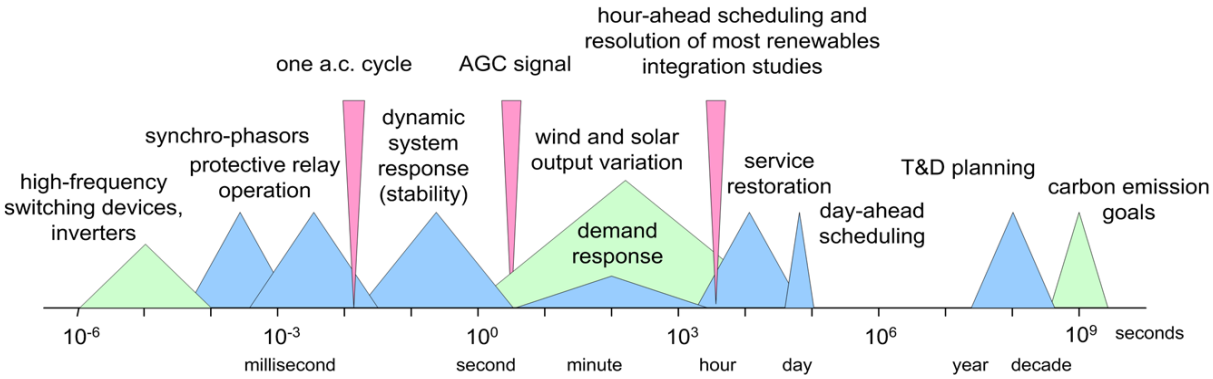
In moving to our new role as a DSO we must also balance our existing commitments to customers and the regulatory and licence commitments we have as a UK DNO.

A critical element of this will be maintaining system security on an increasingly decentralised network. With the closure of large scale thermal plant and an increasing volume of intermittent generation being connected to the network, the DSO will need to carry out a co-ordination role to ensure that UK customers continue to experience the high level of system security currently provided by the UK electricity network

Our DSO model will be capable of enacting system balancing actions from the SO within timescales that best meet the needs of the SO and the capabilities of the DERs connected to our network areas.

Critical to realising our DSO vision will be a communication infrastructure that provides a seamless interface between the TSO, our control facilities and the DER resources that we will aggregate. This will allow us to provide balancing services within an acceptable timeframe for the TSO. This will also need to be balanced against the capabilities of the DERs connected to our networks.



Jeffrey D. Taft, PhD
Chief Architect for Electric Grid Transformation
Pacific Northwest National Laboratory
24 June 2015

We will work with BEIS, Ofgem, UK Network companies, DER providers and key stakeholders to develop and implement a fair and cost effective remuneration mechanism for all DSO services and DER providers.

The DSO role will require policy makers, industry and key stakeholders to develop remuneration mechanism(s) for DSO services. Research, modelling and trials will need to be carried out in order to ensure that the remuneration methodology is indeed in the best interests of UK customers. Any remuneration mechanism must also factor in the long term low carbon goals of UK Government.

Our transition to a DSO will be both modular and proportionate.

- In terms of a modular approach, we will identify those network areas that most urgently require real time monitoring and control to address current issues.
- In terms of proportionality not all network and geographic areas will require the full range of integration and DSO services, this may be due to a lack of foreseeable network constraints. We will install sufficient network monitoring capabilities to monitor the requirements of these areas.

We believe that the correct way to transition towards a DSO is to develop the monitoring and control capabilities across our existing networks, focusing on our current network challenges. This is also the first stage in rolling out active network management in those network areas. These are no regrets actions, required to facilitate a smart grid network[8] and a major stepping stone towards the technical requirements for DSO enabled network areas. This modular approach will also allow us to test the operation of a DSO model in a controlled manner, allowing learning to be applied to future DSO enabling works.

4.3 Technically

Our vision is that we will create VPPs or virtual balancing mechanism units (VBMUs) at the interface between our own networks and the Transmission network(s). This approach will be modular based on the network requirements and connected DERs in the downstream network. In order to achieve this we will install sufficient monitoring and control equipment to facilitate real time network balancing. We believe that with careful technical consideration the initial rollout of monitoring and control equipment is a 'no regrets' investment as this will be required irrespective of the level of network control required within any particular network area. Each VPP interfacing with the transmission SO may also be supported by smaller cells of VPP on our Distribution networks.

Active Network Management (ANM) will be the cornerstone of our transition to a DSO. The ANM and flexible networks elements of the DSO transition have already been trialled on our network and the technology is largely proven. However we believe that there are two key areas of development required to facilitate a full transition to a DSO.

- Standardisation of solutions and the interface with communication networks to enable innovation.
  By developing more standardised solutions across the suppliers of ANM technologies more widespread adoption of ANM technology will be made possible, both for DSOs and DER developers. This will also have the effect of reducing the implementation cost for these solutions, driving further efficiency.

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf

- More advanced optimisation tools, software and data management methods.
  The existing optimisation tools for ANM schemes function for relatively simple schemes. A fully functioning DSO will required a more complex network of DERs to be managed and will also require a number of axis of optimisation e.g. Commercial, fault level, frequency.

To support our transition to a DSO we have also created a SPEN Smart Grid Steering Group, subordinate group to our SPEN DSO Steering Group. This group will address the detailed technical and commercial challenges in transitioning to a DSO. This group will also work with industry and key stakeholders to seek commonality in the technical specifications and policies required to enable DSO activities.

Communications network and data protocols

We will review the requirements of our communication network to ensure that we have suitable infrastructure in place to respond to action requests from the UK SO and also to manage the real time balancing of the network below each VPP. In addition with industry we will develop common data architectures that will allow a range of DERs/DSOs and the SO to communicate without different interface requirements across the UK. This is one of the long term objectives of our innovation strategy as evidenced with our Inspire NIC bid[9].

The introduction of common data models and an increase in the number of channels, which may impact of the electrical network, data security will be at the heart of our transition to a DSO.

Trial areas

It is our intentions to trail two geographic areas as DSO enabled network areas within the RIIO ED1 price review. These areas have been identified to address existing network challenges and would be an ideal demonstration of real time energy balancing within a geographic area.

SP Distribution Licence area

- Dumfries and Galloway
  The Dumfries and Galloway network area is rich in natural resources but has relatively low demand requirements, with the large volumes of DG now connected to the network Dumfries and Galloway is now a net exporter of energy. There is currently 190MW of demand with 340MW DG connected and a further 660MW contracted to connect to the network

  Our RIIO T1 plans included a solution to facilitate the full scale of contracted generation (both Transmission and Distribution) within the Dumfries and Galloway network, the UK System Operator has since determined that this is not the most cost effective option. We will therefore be seeking to facilitate the connection of contracted generation through the

[9] https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-year-four-screening-submission-inspire-scottish-power-distribution

deployment of innovative solutions ultimately developing Dumfries and Galloway into a DSO enabled network.

SP Manweb Licence area

- North and Mid Wales
  The North and Mid Wales network area includes a wide range of urban and rural environments with a significant penetration of distributed generation. There is currently 800MW of demand with 800MW DG connected and a further 700MW contracted to connect to the network. In order to facilitate the future deployment if generation in the area we will seek to utilise innovative solutions including active network management, enhanced thermal ratings, battery storage and Direct Current (DC) cable solutions[10]. The network also operates meshed (heavily interconnected) and will allow us to demonstrate novel ANM solutions on this type of network architecture.

This transition will start by installing the required network monitoring and control equipment to understand the real time balancing capabilities of the network. This will then be extended to active control of the network, ultimately leading to commercial trials of a working DSO model.

4.4 Commercially

Our DSO model will provide a commercial and technical framework allowing Distributed Energy Resources to participate in the UK balancing services market. This will be achieved by understanding the real time requirements of the UK SO and the real time capabilities of DERs within the DSO enabled network areas and agreeing commercial terms act on that market. Ultimately we believe this will be achieved through a real time service tender process facilitated by communications, automated services and commercial terms. Our goal is to facilitate an open market where participants can choose to contract directly with national grid, utilise the service of aggregators and other third parties or contract with the DSO.

The DSO would be able to draw on a range of services, including:-

- Controllable generation
- Storage
- Demand Side Response (DSR)

The DSO is then able to use these to:-

- reduce network reinforcement
- provide flexibility
- offer balancing services
- provide ancillary services

[10] http://www.spenergynetworks.co.uk/pages/angle_dc.asp

- encourage demand to match generation

The DSO can aggregate services to operate as a Virtual Power Plant or Virtual Balancing Mechanism Unit. A Virtual Power Plant (VPP) comprises a portfolio of DER which can offer services to the system operator. A VPP aggregates the capacity of diverse DER resources and offers these as a single, combined service.

The DSO will register, for example, GSPs as a Virtual Balancing Mechanism Units (VBMUs) or enrol in ancillary services and will contract with the NETSO to provide a range of system services. The DSO will recruit participants (generators, consumers, energy storage developers and aggregators) for services which they will then dispatch and instruct in order to deliver the response required by the NETSO. In doing so, the DSO will ensure that technical network constraints on the local network can be kept within operational limits.

Where there are existing Balancing Mechanism participants beneath a GSP which is DSO enabled a solution will be required to prevent conflict between SO actions and DSO actions. This can either be achieved by contracting with the DSO or by ensuring that sufficient information is shared between the existing vendor, the SO and the DSO. These potential conflicts can currently occur between distribution ANM schemes and SO actions. E.g. The SO sends a turn down request to a transmission contracted generator connected to the distribution network, the local ANM scheme identifies the real time headroom availability created and makes that headroom available to distribution connected generators, effectively circumventing the SO action.

As well as helping to support the market, the DSO will also have to consider distribution network constraints and the opportunities for using commercial innovations such as demand side response (DSR) in order to reduce the requirement for network reinforcement. The DSO would also require closer interactions with the NETSO, such as a responsibility to assist with balancing at a national level and providing ancillary services such as reserve, frequency response, and voltage and reactive power management.

The DSO will deliver more local balancing markets through community schemes, bi-lateral contracts (otherwise known as virtual private wire) and energy storage. The DSO would become the local market facilitator and would meter and settle the services as contracted, it should form part of an overall totex arrangement as, although the aim is to maximise utilisation of assets, the possibility that ‘the right answer’ is some new assets should not be excluded

The commercial methods to be developed by the DSO and required by the NETSO will be:

- Turn down services
- Turn up services
- Frequency response
- Reactive power management
- Outage management (which may be physically delivered as turn down or turn up services)

- Virtual private wire
- Local balancing to a dynamic TEC

To deliver the proposed model a range of new commercial contracts will be required both between the NETSO and the DSO, and also between the DSO and local participants. We believe that this approach is most consistent with the industry and market structure within the UK and we do not believe that this will have any detrimental effect on existing market operation. We believe that any effect will be positive, through the enabling of additional competition, which will reduce the overall costs borne by customers. Key to this will be answering the following questions;

(a) what contracts will be available to each type of DER provider and identifying which parties would be best placed to manage potentially complex contracts, and

(b) reviewing existing contractual mechanisms to identify different services which might be rationalised, e.g. in respect of timing of tendering and contract award, and the potential for linkages between offers.

4.5 SPEN DSO Model

The DSO will need to develop new relationships with the customers connected to the distribution network with a view to understanding their needs and how they can potentially participate in a 'smarter network' operation. In some cases, this could result in working directly with sites and service providers including aggregators to reduce energy consumption, modify behaviour and optimise the efficiency of the network operation. By pragmatically doing this across the full supply chain from the overall system operation, through transmission, distribution and finally connected customers it is expected that the DSO will have a greater positive impact than if a single stakeholder were to attempt to implement unilateral changes.

Several models have been put forward by the industry and stakeholders, including:

- Deep TSO
- Independent SO
- DSO

Some stakeholders may be attracted to the idea of a single National System Operator (NSO), which can be clearly identified and held responsible for any problems across the transmission and distribution networks. However it is our view that this would be impractical, uneconomic and would not adequately address and resolve local network constraints, which would result in additional reinforcement of the distribution and transmission networks as network constraints become more challenging to manage effectively. Furthermore, the complexity and scale of the communications, control systems, data handling and processing requirements would make the development of a single, integrated monitoring and control system, i.e. a merged EMS/DMS, highly challenging to deliver".

The cost of balancing the electricity system would continue to rise if the SO continues to operate within an environment where it has limited visibility and rising uncertainty over GSP load profiles coupled with insufficient resources under its influence to deliver the required balancing and ancillary services.

Certain aspects of system operation will effectively be devolved to the DSO which controls assets connected at distribution voltage levels to assist in overall system operation. The DSO, with unique understanding of the local network and access to the distributed customers, is no longer merely an asset management organisation but one that operates as a neutral market facilitator ensuring that a much larger base of customers and resources can participate in a wider market.

Balancing and Ancillary Services

Balancing Service	**Deep TSO**	**Independent SO**	**DSO**
Firm Frequency Response (FFR)	√	√	√
Enhanced Frequency Response	√	√	√
FFR Bridging Contract	√	√	
Frequency Control Demand Management (FCDM)	√	√	
Reactive Power	√	√	√
Fast Start	√	√	
Black Start	√	√	
Fast Reserve	√	√	
Short Term Operating Reserve (STOR)	√	√	
STOR Runway	√	√	
BM Start-up	√	√	
System to Generator Operational Intertripping Schemes	√	√	
Commercial Intertrip Service	√	√	
Ancillary Contracts to manage System Issues	√	√	
Maximum Generation Service	√	√	
Local balancing to a dynamic TEC			√
Virtual Balancing Mechanism Unit (VBMU)			√
Ancillary Services Aggregator (ASA)			√
Demand Side Response (DSR)	**Deep TSO**	**Independent SO**	**DSO**
Demand Turn Up	√	√	√
Load Turn Up	√	√	√
Demand Side Balancing Reserve (DSBR)	√	√	√
Direct contracting for DSR with I&C customers	√	√	√
DSR with SME customers	?	?	√
DSR with domestic customers			?
Local auctions for DSR services at network ‘hot-spots’			√
Active Network Management (ANM)			√
Virtual Power Plant (VPP)			√
Micro-Grid			
Virtual private wire			√
Local Market Facilitator			√

5 TRANSITIONING TO A DSO

5.1 What Needs to Change

In this section we discuss some of the key changes required to enable our transition towards a DSO. These can broadly be categorised into:-

- Key enabling technologies
- Key commercial changes
- Key policy changes

These changes will also need to be developed and agreed with a wide range of stakeholders to ensure that the DSO model is compatible with all UK networks and provides a consistent approach for demand and generation customers.

5.2 Key Enabling Technologies

Technology will be a vital component in facilitating the development of the DSO model to enable the interoperability and visibility of actions between DSO, generation units, demand side response providers and the SO. The DSO smart grid model of the future will look very different from the network of today. Power will be generated from multiple sources, flow in multiple directions and will offer consumers greater flexibility and choice. However with greater integration of intermittent renewable generation and demand this will create voltage and power quality issues and will impact the ability to adequately protect against system events.

Distributed Energy Resource (DER), Demand Response (DR) and Energy Storage (ES) mechanisms will introduce new variables and complexities into the traditional passive distribution network. These variables will require a more dynamic and flexible solution, not only with respect to its operation but also investment decisions over an extended period of time. The DSO will have to manage an increasingly congested playing field with market drivers leading to potential conflicts with network availability or capabilities. The DSO will have to ensure reliability during times of peak load, whilst balancing local production and demand and accommodating new intermittent DER. As the flows of power become more complicated the ability to become more flexible will be essential.

Although enabling architecture may be complex in nature to address these issues, they will ultimately be born from the need to solve simple problems which will have to be addressed in any case to facilitate the Smart Grid. These include:-

- Enhanced Monitoring
- Improved modelling and Prediction tools
- Control and Automation of Assets
- Communication and Distribution Management System(s) (DMS)
- Cyber Security and Data Protection

Enhanced Monitoring

An increasingly complex distribution network will require higher levels of monitoring beyond the current substation boundaries. Data will need to be collected at key network locations and at a higher frequency and granularity, both in relations to real time system operations and longer term network planning. Current practices of real time monitoring must expand beyond the substation to strategic locations, service providers and DER installations. The ability to control the network, take actions and react to wider system events through the use of enhanced monitoring solutions will aid our ability to detect issues directly impacting network performance, system stability and ensure we maintain a safe and reliable network. New sensors, communication equipment and information technologies promise to improve efficiency, reliability and power quality of the distribution system, improve the quality of service and enabling increased DER penetration and improved customer choice.

Enhanced modelling capabilities will include:-

- Wide area monitoring at all voltage levels
- Increased penetration and scope of Intelligent Electronic Devices (IED)
- Real time state estimation
- Load flow analysis
- Power quality monitoring

Improved modelling and Prediction tools

Enhanced monitoring will lead to improved understanding and data capture from an increasingly dynamic and complex distribution network. As network understanding increases so will the need for more sophisticated network planning tools. These tools will offer SPEN the ability to forecast with improved accuracy, leading to improved network planning and development decisions. With tools and real time data detecting transient issues and market changes, development decisions and local solutions can be adopted to increase grid resilience. Moreover software tools will enable services and solutions to be managed autonomously without human intervention, predicting solutions and actions based on network information in near real time. Sophisticated analysis tools will support flexibility by enabling adaptability to changing business and system requirements.

Key enabling predictive solutions will facilitate,

- Improved Network modelling leading to real time network solutions
- DER forecasting and control
- Network capabilities for dynamic running arrangements
- Improved network flexibility

Control and Automation of Assets

Although improved monitoring and modelling tools will enable the network to be controlled and optimised with confidence, the ability to take actions will still be dependent on controllable assets. Network Controllable Points (NCPs) will be standard practise and will be essential for day to day network running. These controllable points will expand beyond the current operation of circuit breakers and voltage tap-changers, to power electronics and the control of active network management solutions in near real time based either on market drivers or network optimisation.

The DSO smart grid will require advancements in automation to enable legacy assets to be controlled and operating within their operating limitations. This will lead to the requirement for advancements in protection and fault detection solutions and increased monitoring and understand for assets coming towards end of life. Highly reconfigurable protection will be essential to ensure appropriate protective settings based on circuit configuration and fault level contributions.

Advanced networks automation and control capabilities will include

- Voltage / power flow optimisation
- Active System Management
- Automatic control in real time to optimise network performance
- Control of load / demand
- Fault control / Fault level management
- Highly configurable or Dynamic Protection

Communication and Distribution Management System (DMS)

Ultimately the monitoring, modelling and control of assets will not be possible without an integrated IT solution and faster more reliable communication. Significant expansion of automation and monitoring will drive the need for additional bandwidth with expanded coverage. Wireless solutions with near real time monitoring and control will be required to operate and control service solutions based on market drivers. The DSO smart grid network will connect network assets, DER, customers and third parties service providers. It will require a common infrastructure to enable device to device communication across the network.

Communication capabilities will include;

- Interaction of wired and wireless communication platforms
- Prioritisation of service solution or coverage
- Automation distribution control
- Increase cyber security solution
- Increased reach of communication solution for rural and underground assets
- Centralised or Decentralised network intelligence?

With greater visibility and control of the distribution system the requirement for a sophisticated distribution management system (DMS) that can handle and fully integrate a wide variety of system

tasks will become essential. The integration of new sensors, communication and advanced information technology will accelerate the role the DSO can perform and its capabilities. Traditionally computing infrastructure has been centrally controlled and very much limited to the control room activities however as field devices become more intelligent many will have the ability to provide autonomous network solutions.

Computing infrastructure technology requirements and capabilities will include;

- High availability
- Monitoring and health checks
- Increase functionality between service and third party providers
- Increase data processing
- 'Big Data'

Additional management capabilities will include,

- Black start and islanding running arrangement
- Information exchange between DSO, SO and third party service providers
- Firm and un-firm connection agreements
- Real time voltage and power quality control

Cyber Security and Data Protection

The transition to a full DSO model will result in a significant increase in communication links between the UK system operator, network operators and 3rd parties it is essential that cyber security is fully risk assessed and mitigating actions put in place to ensure overall system security. In addition the types of data being transferred between parties need to be understood to understand the Data Privacy implications. These challenges have been at the forefront of the Smart Meter rollout in in the UK and it seems pragmatic to follow a similar process to minimise the risk to UK customers.

5.3 Key Commercial Arrangements

DNO/DSO Remuneration

The concept of DNOs being recompensed for ancillary services has been effectively trialled in ENWL's CLASS project. Through control of existing assets ENWL have explored the provision of the following services:-

- DSBR (Demand Side Balancing Reserve)
- FR (Frequency Response)
- FFR (Firm Frequency Response)
- FCDM (Frequency Control by Demand Management)
- STOR (Short Term Operating Reserve), and
- Reactive Power Services.

Ofgem have provided confirmation on the regulatory treatment[11]. The associated costs and revenues can be reported in the Valued Added Services' category of Directly Remunerated Services. This approach could be extended to additional services, however this could only be achieved through working with Ofgem and NG in its capacity as the UK SO.

Whilst this may be a suitable interim solution for the RIIO ED1 period a more comprehensive charging mechanism for ancillary services will be required for RIIO ED2 and as DNOs transition towards becoming DSOs.

Neutral facilitators of an ancillary services market

In our DSO vision we see ourselves as neutral facilitators of an ancillary services market. To achieve this goal we need a transparent and fair mechanism to remunerate DER providers, when they are called upon to provide ancillary services. Clear contractual arrangements will need to be provided to DER providers on how they will be dispatched and how they are prioritised. This will be crucial to ensure DER providers have all available information when they seek to secure financeability for their projects.

Given the increased volume of DERs we expect to be available to DSOs, we believe that the dispatch and remuneration process will need to be heavily automated through optimisation software and automated payment services. To date ANM schemes have focused heavily on automating networks based on electrical system requirements, this technology will need to adapt to balance both system and commercial demands.

Influencing the behaviour of uncontrolled DER assets

In addition to those DERs that will have direct contractual arrangements for the provision ancillary services, there will be generation and demand resources that have no such arrangements in place that may still assist in overall network balancing e.g. domestic storage, domestic EV charging. The extent to which a DSO has control over these resources, either through pricing signals or other non-direct means must be determined. This must be decided in conjunction with key stakeholders, reviewing the implications on:-

- Customer behaviour
- Energy pricing
- Decarbonisation of heat and transport
- Regulatory implications of DSO/DNO powers

[11] https://www.ofgem.gov.uk/publications-and-updates/direction-distribution-network-voltage-control-services-nget-so-residual-balancing

5.4 Key Policy Changes

Changes to the roles and responsibilities of existing DNOs

If DNOs are to transition towards expanded roles as DSOs then a review of our existing capabilities under the Distribution licence will be required. The licence will need to be modified to capture the remuneration process for DSOs and to capture any additional obligations that this expansion of our activities might entail. Under our current Distribution licence we can provide direct services to the SO[12], however our ability to act on this market or to procure services for subsequent re-sale to the SO are limited[13]. If we are to act as a balancing agent this will need to be addressed.

Ownership of DER resources

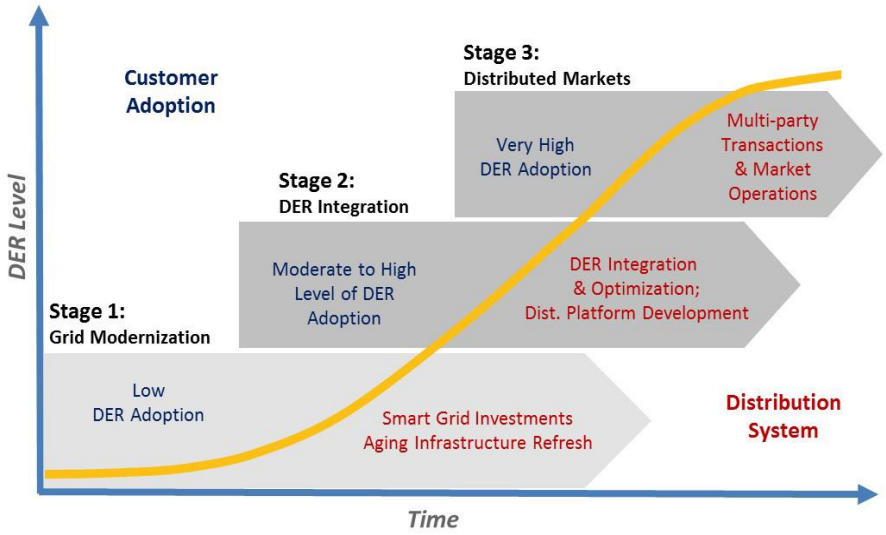
Whether or not DSOs will be able to own and operate DER resources will need to be decided. If it is deemed appropriate and cost effective it may be in UK customer's best interests for DSOs to own DERs, however specific guidance will be required on which types of asset can be owned. This decision is perhaps most prevalent when discussing energy storage assets, which may provide benefits to customers through the deferral of traditional reinforcement. We believe that in the main appropriate commercial signals will facilitate this need, however there may be cases where there is insufficient incentive for developers to connect DER resources where they are needed. In these situations the most cost effective solution may be for DNO/DSOs to own DERs.

[12] https://www.ofgem.gov.uk/system/files/docs/2016/04/dno_voltage_control_drs8_direction.pdf - Classification of Directly Remunerated services as a result of ENWL's CLASS project

[13] https://epr.ofgem.gov.uk//Content/Documents/Electricity%20Distribution%20Consolidated%20Standard%20Licence%20Conditions%20-%20Current%20Version.pdf – Distribution licence Condition 29.6-29.10

6 ROADMAP TO REALISING OUR DSO VISION

The DSO vision will not be achieved over the short term rather an evolutionary change will be required as increased understanding, technology advancements and commercial arrangements are developed to solve local issues on the distribution network. This process has already commenced through the development and use of smart technologies and in particular the use of active network management as a method to control generation and demand. The development of a DSO will be fundamentally driven by the requirement of the local distribution network to solve particular issues. The adoption of DER across the network is uneven with certain areas with significant adoptions and other areas with none. This patchwork of adoption is currently driven by policy, current network limitations and local external factors. The readiness of the networks to become a DSO can be classified into a three stage evolutionary framework.



Berkele Lab: Distribution Systems in a high distributed energy resource future (Oct 2015)

Stage 1: Low Level of DER adoption

- Smart Grid Integration driven by policy requirements and regulatory stretch
- Greater control and utilisation of legacy assets
- Improved communication and integrated IT solution

Stage 2: Moderate DER adoption

- Unconventional approach to network planning and control becoming the new norm
- Wide Area Monitoring
- Decentralised network intelligence
- Predictive Modelling
- Big Data Processing
- Integration IT solution

Stage 3: High Level of DER requiring new commercial frameworks

- Conventional approach to network planning and control no longer an option
- Real Time Network Configuration
- Active System Management
- Dynamic Protection
- TSO - DSO Interface and control
- Local Balancing systems

6.1 Short Term

The network is predominantly in stage 1 where levels of DER adoption is low and can be accommodated within the existing distribution system without material changes to infrastructure or operations. Network modernisation is driven by regulated policy decisions with smart technology solutions becoming more prevalent as legacy assets are managed with higher utilisation and flexibility.

In the short term localised areas of the distribution network will be approaching stage 2 as levels of DER and powers flows becoming unmanageable within current commercial or regulatory frameworks.

Key priorities in the short term – 1-2 years

- Rollout and extend the use of active network management as a solution to manage network constraints. Introduction of ANM working group to accelerate into Business as Usual (BaU)
- Network DSO classification to priorities areas which are likely to benefit from a DSO model
- Expand network monitoring to future proof legacy assets
- Modelling and investigation into ancillary services market and identifying cost effective solutions
- Identifying policy changes required to facilitate a transition to DSO

6.2 Medium Term (DSO trials)

As DER adoption levels become material and reach a threshold levels, new control, planning and enhanced functionality will be required to ensure safe and reliable distribution. Managing power flows and engaging with new service providers will become essential.

Over the medium term significant network areas will progress into stage 2 where levels of DER adoption will require alternative solutions to ensure network stability and reliability. This threshold based on DER adoption experience in the U.S. and elsewhere, appears to be when levels reach beyond about 5 percent of distribution grid peak loading system-wide[14].

Furthermore with increased level of DERs this will provide an opportunity to leverage their value for distribution efficiencies, to support reliable operations or as an alternative to traditional reinforcement. This greater level of interaction between DER, service providers and distribution activities will require increased corporation with the TSO to ensure reliable operation of the integrated grid.

Key priorities medium term – 3-7 years

- Trial DSO areas in both SP Distribution and SP Manweb network areas
- Development of network roadmap to DSO for all distribution areas
- Commercial arrangements in place with NG and DER providers within DSO trial areas
- Policy changes implemented to facilitate DSO actions

6.3 Long Term (Full transition to DSO)

The final stage to DSO it the transition to stage 3, where high level of DER and increased customer awareness lead to a distribution level energy balancing market. This conceptual stage will go beyond service providers solving network solutions to the trading and management of energy between multiple parties.

The long term strategy for SPEN will be to transition to this stage, with a modular DSO model approach based on a network priority basis, proportionate to network and customer requirements. Giving the regulatory changes and high penetration of DER adoption required for this stage, the long term objective will likely involve the trial modular approach across a geographic region. It is also likely to involve the trial across areas without significant levels of DERs which may want to proactively explore potential efficiency gains and local resilience benefits of such markets.

The long term approach for SPEN will likely involve;

- Full or modular implementation of DSO model
- Development of DSO development strategy for network areas with limited network service provisions

[14] Berkele Lab: Distribution Systems in a high distributed energy resource future (Oct 2015)

SPEN DSO Vision

	SPEN Activities			
	Immediate <1 year	Short (1 - 2 years)	Medium (3 - 7 years)	Long (8+ years
SPEN Roadmap	• Creation of DSO Vision Document • Alligning business requirments	• Rollout and extend the use of active network management as a solution to manage network constraints. Introduction of ANM working group to accelerate into Business as Usual (BaU) • Network DSO classification to priorities areas which are likely to benefit from a DSO model • Expand network monitoring to future proof legacy assets • Modelling and investigation into ancillary services market and identifying cost effective solutions • Identifying policy changes required to facilitate a transition to DSO	• Trial DSO areas in both SP Distribution and SP Manweb network areas • Development of network roadmap to DSO for all distribution areas • Commercial arrangements in place with NG and DER providers within DSO trial areas • Policy changes implemented to facilitate DSO actions	• Full or modular implementation of DSO model • Development of DSO development strategy for network areas with limited network service provisions
Key Enablers	• SPEN DSO Steeri ng Group	• Wide area monitoring • Improved modelling and Prediction tools • Greater Control of assets • Communication & IT • DER forecasting and control • Network capabilities for dynamic running arrangements • Prioritisation of service solution or coverage • Increase cyber security solution	• Increased penetration and scope of Intelligent Electronic Devices (IED) • Load flow analysis • Power quality monitoring • Improved Network modelling leading to real time network solutions • Improved network flexibility • Network capabilities for dynamic running arrangements • Fault control / Fault level management • Increased reach of communication solution for rural and underground assets • Interaction of wired and wireless communication platforms • Increase functionality between service and third party providers • Increase data processing for Big Data • Black start & islanding running arrangement	• Real time state estimation • Active System Management • Automatic control in Real time to optimise network performance • Control of load / demand • Highly configurable or dynamic protection
DSO Evolution		• Smart Grid Integration driven by policy requirements and regulatory stretch • Greater control and utilisation of legacy assets • Improved communication and integrated IT solution	• Unconventional approach to network planning and control becoming the new norm • Wide Area Monitoring • Decentralised network intelligence • Predictive Modelling • Big Data Processing • Integration IT solution	• Conventional approach to network planning and control no longer an option • Real Time Network Configuration • Active System Management • Dynamic Protection • TSO - DSO Interface and control • Local Balancing systems

APPENDIX A - KEEPING THE ELECTRICITY TRANSMISSION SYSTEM IN BALANCE

National Grid's role in balancing the system is set out in primary legislation and regulated by the Gas and Electricity Markets Authority working through Ofgem. It is specified in detail in transmission licence conditions and a series of codes, including the Balancing and Settlement Code. Compliance with balancing requirements is included in individual generation and supply licences, and generators and suppliers may also negotiate or bid for the provision of certain types of balancing services. Where they do so, they generally receive an availability payment as well as a payment for the use of a service.

National Grid procures Balancing Services in order to balance demand and supply and to ensure the security and quality of electricity supply across the GB Transmission System. In accordance with the Transmission Licence, National Grid is required to establish and publish statements and guidelines on Balancing Services.

Frequency Response
System frequency is a continuously changing variable that is determined and controlled by the second-by-second (real time) balance between system demand and total generation.

Reserve
National Grid need to access to sources of extra power in the form of either generation or demand reduction, to be able to deal with unforeseen demand increase and/or generation unavailability.

System Security
National Grid has the obligation of ensuring the security and quality of electricity supply across the GB Transmission System.

Trading
In meeting forecast energy requirements at minimum cost National Grid trade energy related products forward in time (i.e. in advance of the Balancing Mechanism).

Reactive
The requirement for reactive power is primarily driven by the interaction of real power flows on the transmission system with the complex impedances of the various elements that make up the network together with the demand at the lower voltage system interfaces.

Settlements
The settlements team is responsible for calculating and initiating payments to ancillary service providers.

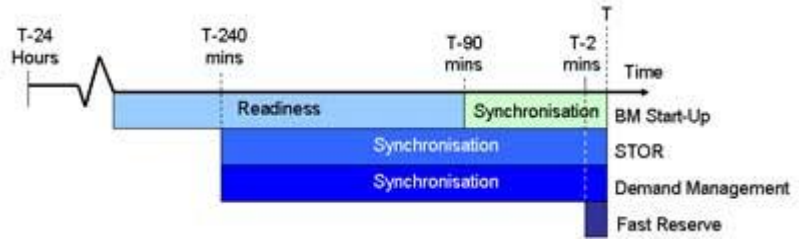
Demand Side Response
Ancillary services are a suite of specialist services and markets provided by the system operator to facilitate and support the continuous flow of electricity and ensure demand matches supply and

balance supply and demand in the final hour before settlement. The purpose of ancillary services is to provide support across the whole of the electricity system to ensure that the system remains stable at all times.

Many of the UK's ancillary services are being developed into commercial products by a new entrants looking to deploy technologies such as energy storage and demand response.

What are Reserve Services?

National Grid requires access to sources of extra power in the form of either generation or demand reduction, to be able to deal with unforeseen demand increase and/or unavailability of generation. These additional power sources available to National Grid are referred to as Reserve and comprise synchronised and non-synchronised sources. Different sources require different timescales in order to be ready to deliver the services. In this section Reserve Services are listed on an increasing timescale of getting in the state of readiness as illustrated below.



Fast Reserve

Fast Reserve provides the rapid and reliable delivery of active power through an increased output from generation or a reduction in consumption from demand sources, following receipt of an electronic despatch instruction from National Grid.

Short Term Operating Reserve

Short Term Operating Reserve (STOR) is a service for the provision of additional active power from generation and/or demand reduction.

BM Start-up

The BM Start-up Service gives National Grid on-the-day access to additional generation BMUs that would not otherwise have run, and which could not be made available in Balancing Mechanism timescales.

STOR Runway

STOR Runway is a contracting opportunity for Demand Side Providers to support the growth of new volume in to the STOR market.

Enhanced Optional STOR

This service is where National Grid has a requirement for provision of a volume of an Enhanced Optional STOR Service from non-BM Providers on a trial basis for this winter.

Demand Turn Up

Demand Turn Up has been developed to allow demand side providers to increase demand (either through shifting consumption or reducing embedded generation) as an economic solution to managing excess renewable generation when demand is low

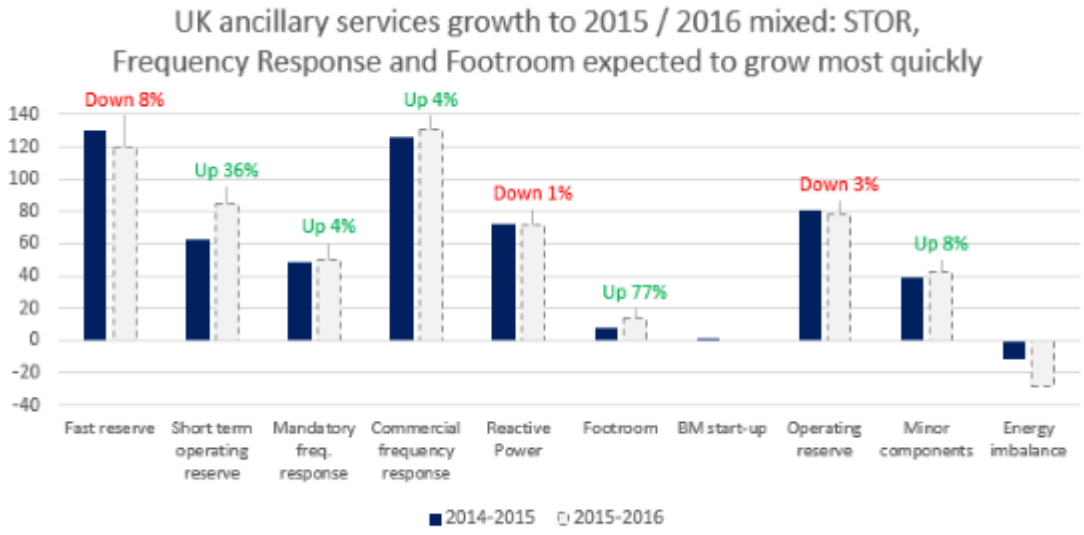
The table below provides an overview of the market size for each ancillary service in 2014 / 2015, in both £m and GW. Fast Reserve, STOR and Frequency Response services cost a combined £366m, or 65% of all external ancillary service costs (excluding transmission constraints). The majority of capacity is allocated against fast reserve, although STOR and commercial frequency response are also significant.
Revenue per year per MW varies across the main commercial services varies from £25k-£35k per year for Footroom to £50k-£55k per year for commercial frequency response.

	Market size 2014/15 (£m)	Market size in 2014/15 GW (5)	Minimum generator load	Revenue / year (£/MW)	Mandatory service	Generators	Loads
Total	**556**						
Fast Reserve	130	~3	50MW	£40k to £50k	✗	✓	✓
STOR	62	~2	3MW (1)	£25k to £45k	✗	✓	✓
Commercial freq. resp.	126	~2.5	10MW for FFR (3) 3MW for FCDM (4)	£50k to £55k	✗	✓	✓
Mandatory freq. resp.	48	N/A	Generators >100MW (National Grid area)	Varies; covers costs	✓	✓	✗
Reactive power	72	N/A	Generators >50MW	Varies; covers costs	✓	✓	✗
Footroom	8	~0.3	N/A	£25k to £35k (2)	✗	✓	✓
Others	109						

(1) STOR runway is a route for smaller providers to participate with less than 3MW of capacity
(2) Flexitricity estimates that Footroom can generate revenues of £15k to £35k per year per MW
(3) Firm frequency response.
(4) Frequency control by demand management.
(5) Market size divided by estimated revenue / year per MW.

Outlook

The highest growth services are STOR, Frequency Response and Footroom. In 2014/2015, STOR cost £62m, frequency response cost £174m and Footroom cost £7.5m. However, other services such as Fast Reserve and Reactive Power are both forecast to fall in value.



Source: NG website, Monthly MBSS reports, March 2015 summary, "Latest Projection of Scheme Outturn Cost", pg. 38, NG (http://ngrid.com/1JkOCHP)

National Grid's figures do not provide an outlook for the growth in generation / load capacity for the STOR, Frequency Response and Footroom markets. If capacity fails to grow in line with total costs, holders of existing STOR, Frequency Response and Footroom capacity may benefit from a significant boost to their revenues.

Assuming no change to capacity, this could move revenue per MW per year for STOR up to ~£35k-£60k, for Commercial Frequency Response up to ~£50k-£60k and Footroom up to ~£40k-£60k. However, the dynamics of these markets are likely to be difficult to predict. This area of ancillary services has drawn significant recent competitive interest from an increasing number of Smart Grid providers including Flexitricity, KiWi Power, Endeco Technologies, EnerNOC, Open Energi and generation and storage providers like UK Power Reserve, GreenFrog, Stor Generation and RES Group. The National Audit Office (NAO) advised DECC (now BEIS) that a wide range of factors might impact on UK balancing activity over the next decade, and their impact on the costs of balancing is unclear due to the extra complexity and uncertainty involved in the operation of the system.