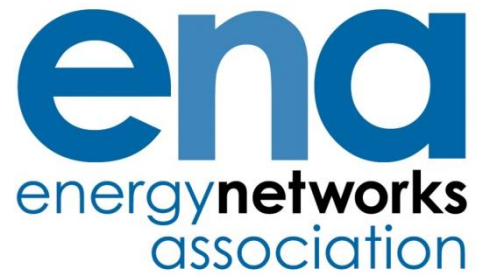


The Voice of the Networks



Open Networks Workstream 3: Product 2

Functional and System Requirements

15th May 2018

Energy Networks Association

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Functional and System Requirements

Document Control

Version	Issue Date	Author	Comments
1	07/08/2017	Open Networks Project	First Draft for comments
2	18/09/2017	Open Networks Project	Second Revision, following SG and AG comments and feedback
3	15/05/2018	Open Networks Project	Updated document following Workstream 3 definition of DSO models in SGAM tool.

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Functional and System Requirements

1. Introduction

This report is part of the ENA Open Networks Workstream 3 – Product 2: Functional and System requirements. This product aimed to define all the functional and system requirements for DSOs (independent of market models).

The requirements have been captured in a standard methodology using Use Cases. A framework has also been developed to identify the changes required within existing business activities and to score the level of changes required, dependant on the trajectory of transition.

The following activities have been undertaken within the Product 2 workgroup:

1. Requirements capture using structured method
2. Review in a Working Group
3. Revise and iterate
4. Review in a Working Group
5. Review, iterate and present to Steering Group for Approval

Following broader review of DSO functionality in Workstream 3 to build DSO models in SGAM, DSO functionality has been modified in Version 3 of this document.

2. PID Requirements and Outputs

The Product Initiation Document outlined the task with the following requirements:

Define the specific functionality / system requirements for DSOs (independent of market models).

For example, this could include:

- Development, contracting and procurement of services
- Increased visibility of demand and generation
- Increased active network management and operation
- Data sharing
- Security

We would expect requirements to be captured using a standard methodology (e.g. Use Cases) to give structure and discipline to requirements capture. For example, the NG Future Energy Scenarios could be used. Again, these would be broken into policy, technical, customer commercial and regulatory requirements. Areas that will need standards/common approaches will need to be identified, as well as where functions are interconnected.

We are likely to need to define sub-products to deliver this overall picture:

- Identified SGAM Model Inputs
- Requirements
 - Technical— Regulation
 - Commercial— Customer
- “No Regrets” functional requirements that could be progressed regardless of market model would be identified.

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- To allow realistic functional requirements to be identified, the high-level timescales and costs must be included for each requirement.

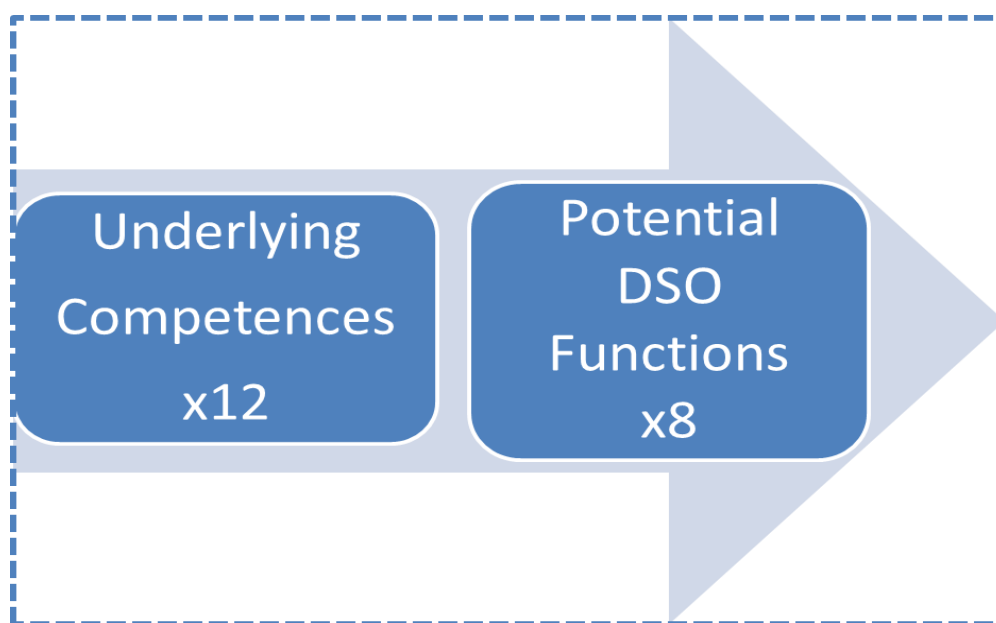
Activity	Deadline	Output
Requirements capture using structured method	June 2017	Requirements capture using structured method and presented to Steering Group for approval
Review in a Working Group		
Revise and iterate		
Review in a Working Group		
Review, iterate and present to Steering Group for Approval		
Identify what is required to populate SGAM model	June 2017	Requirements captured in format that aids transition into SGAM model

3. Approach to Product 2

3.1 Description of Methodology

The methodology used by the Product 2 team comprised a number of steps:

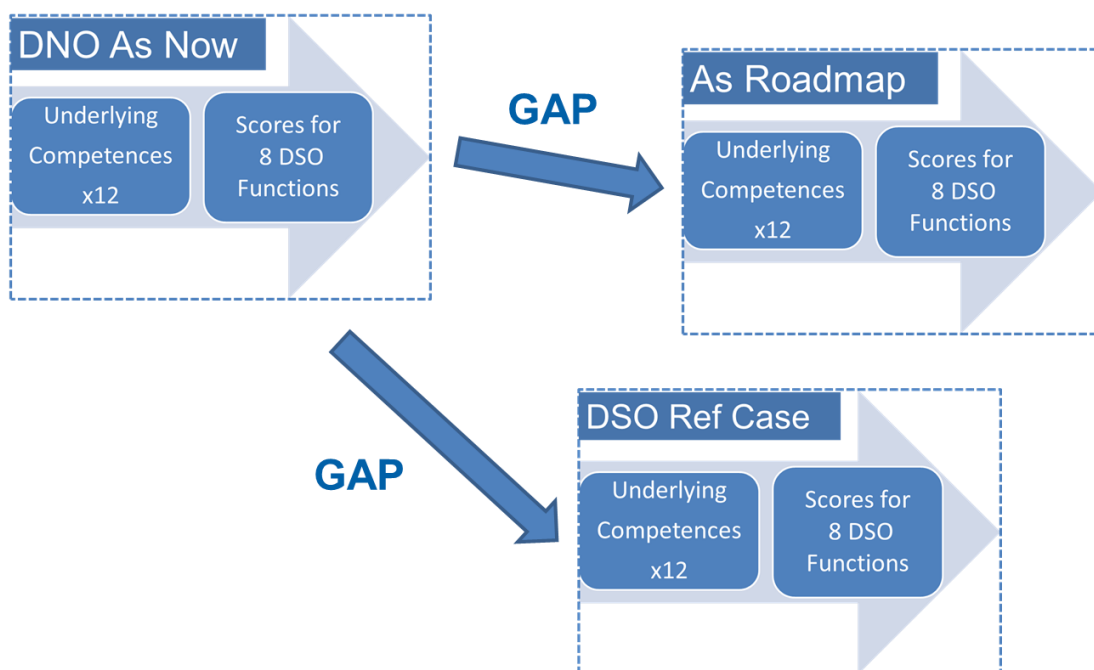
1. **Potential DSO Functions** - The team identified the main functions and activities that DSO's might carry out going forward. The range of functions and activities was deliberately broad to cover a wide range of potential DSO activities including some that might not fall to DSOs following industry debate. To some extent, this was informed by the functions already carried out by the GBSO. As the set of 8 functions took shape, it was also used as part of the Workstream 3, Product 1 DSO Definition. The 8 functions might be thought of as areas where DSOs would interact with other stakeholders to provide services to customers and consumers.
2. **Supporting DSO Competencies** – The underlying organisational skills and capabilities needed to deliver the 8 functions were then identified. These reflect more fundamental organisational requirements that will underpin delivery of the DSO functions. 12 competences were initially identified. A mapping of competences to DSO functions was created to select the relevant capabilities and skill sets to support different areas of DSO functionality.



3. **Competency Levels** – A simple scoring system for each of the 12 competences was then developed. This used scores of 1 through to 5 (lower to higher competence) to measure the level of competence in place or the level that might be needed to deliver a particular DSO functionality going forward. Descriptions for competency scores were agreed based on the complexity, depth and volume of the competency. This scoring system allows objective but simple scoring of DSO positions so as to identify what areas of DSO functionality need development.

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- Scoring of Current DNO Positions** – An initial scoring of the 8 DSO functions was carried out based on mapped competences and current DNO capability. The scoring was not carried out for each DNO but represented a collective position across the DNOs. For example, if there was evidence of a more advanced competence level in one DNO, this higher score was used. This assumes that DNO learning will be shared to enable each DNO to more quickly develop competence levels.
- Scoring of DSO Roadmap Positions** – The DSO roadmap published as part of Product 1 was then reviewed and the functional capabilities needed to follow this roadmap were assessed. The levels of competences needed to deliver the required DSO functionalities were estimated albeit this was a more subjective scoring exercise as the Roadmap is relatively high level. With a set of current scores for each DSO function and a set of scores needed to follow the roadmap, gaps can be articulated as illustrated below.



3.2 Use Case Descriptions

The Use Cases developed for Product 2 represent the development of each of the 8 DSO functions over time in line with the Product 1 Roadmap. For each function, they include a set of current scores and also the development that would be needed over the short, medium and long-term timescales used in the Roadmap.

At this stage, the Use Cases do not represent holistic views of a future state (market arrangements, operational capability, investment processes etc). However, the methodology used here could be used to assess the gaps to these more holistic views if required.

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3.3 Process & Product Timeline

The initial development of DSO functions and competences was carried out by the Product 2 team. Functions and competences were drafted by team members and peer reviewed within the team.

The draft functions, competences and methodology were presented to the wider Workstream 3 group at the regular Workstream 3 meetings and also in a more focussed teleconference. Feedback from the wider team was taken on board. The functions and competences were also shared with the Stakeholder Advisory Group on 19th July. Extensive and useful feedback on the scope of the functions and competences was gathered.

Through this process the functions were revised. Two further competences were added and four of the initially proposed competences were combined into 2 competences.

The following table presents the main activities of the project, including relevant milestones:

Task	12th June	19th June	26th June	3rd July	10th July	17th July	24th July	31st July	7th August	14th August	21st August
Workstream 3 Meetings											
1 Finalise Functional Areas	Take on F/B										
2 Finalise Competences	Take on F/B										
Use Cases for 8 Functional Areas											
3 Current State Scoring											
4 Peer Review of Current Positions		Peer Review									
5 Scoring based on Roadmap		S/M/L Scoring									
6 Peer Review S/M/L Positions			Peer Review								
7 Product 2 Dissemination Telecon											
8 Firm up Roadmap Use Cases											
9 S/H Advisory Group Meeting											
10 Update Functions & Competences											
11 SGAM Model Integration											
Report & Approval											
12 Draft Report & Circulate											
13 Finalise Report											
Potential Further Work											
Individual DNO Scoring											
Agree & Score Ref Models x3											
"No Regrets" DSO Reqt's											

Following workshops in late 2017 and early 2018 to build detailed DSO market model representations in the Smart Grid Architecture Model (SGAM), changes were agreed for 3 of the 8 DSO functions. These have been included in version 3 of this document.

3.4 Assumptions

The main assumptions in developing product 2 have been:

- DNO/DSOs will look to share best practice. Hence, the scoring of current DNO positions is based on a collective view of DNO capability.
- DNO & DSO would remain as a single licensed entity. Hence, we DSO capability will evolve and develop from current DNO organisational capability.
- DSO development will be needs driven. Hence, DNO/DSOs wouldn't invest in DSO capability if local areas had low levels of DER and there was little potential benefit.

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4. Methodology Developed

Product 2 has developed a methodology to describe the capabilities required as DNOs move towards operating a more active network as a DSO. It has also developed a framework to and score the proficiency within each of those capabilities to determine the size and scale of future change management requirements.

A simple scoring matrix can be used to compare the different transitional states and understand the business and industry impacts during these transitional pathways.

System Co-ordination	
Network Operation	
Investment Planning	
Connections & Connection Rights	
System Defence and Restoration	
Service/Market Facilitation	
Service Optimisation	
Charging	
	Forecasting Regulatory Codes & Frameworks Commercial Relationships & Whole System Coordination Power System Analysis Contractual Arrangements & Dispatch Outage Planning Data Management Settlement Customer Account Management Change Management

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5. DSO Functions – High Level Descriptions

8 DSO functions have been identified and described to cover a wide range of potential DSO activities going forward. High level descriptions for these functions are in the table below.

DSO Function	Description
System Co-ordination	Operate local and regional areas and co-ordinate energy and power transfers with other networks and systems to enable whole system planning, operation and optimisation across different timescales. System Co-ordination could include local actions to support thermal, voltage and frequency management across networks including actions to minimise losses, manage constraints and provide capability.
Network Operation	Operate the electricity distribution network to maintain a safe and secure system. Ensure that network powerflows remain within limits and that the network operates within acceptable voltage limits. Ensure that the network remains secure against credible events such as circuit trips and generation loss. Identify and manage current and future risks. Coordinate and collaborate with Great Britain System Operator (GBSO) to manage potential conflicts to support whole system optimisation. Respond to customer needs.
Investment Planning	Identify capacity requirements on the distribution network and secure the most efficient means of capacity provision to customers. Co-ordinate with the GBSO and Transmission Owners to identify whole system options. These would include commercial DER options as well as distribution network investment.
Connections & Connection Rights	Provide fair and cost effective distribution network access that includes a range of connection options that meet customer requirements and system needs efficiently.
System Defence and Restoration	Enhance whole system security through the provision of local and regional flexible services. Provide system resilience to very low probability but high consequence events using risk based approaches. Provide the means to re-establish the wider synchronous area in the event of widespread disruption.
Service/Market Facilitation	Interface with the GBSO and other network operators to enable the development of distribution capacity products, the creation and operation of local network service markets and to enable DER access/participation in wider services for whole system optimisation. Facilitate local and national markets to access and settle services through auctions and other market arrangements for whole system efficiency. Ensure these arrangements are fair and transparent. Provide information and control system infrastructure to facilitate local and national markets and service provision.
Service Optimisation	Ensure system needs can be efficiently met across all timescales by identifying network requirements, understanding the limitations of network assets and providing network access for additional flexibility services from smart solutions and DER services. Ensure whole system optimisation and resilience through the optimal selection of flexibility services.
Charging	Sets Distribution Use of System prices for local network Determines Point of Connection Determines connections charges and informs of Transmission reinforcement charges (if applicable) Consideration to Exit Charging (dependent on size, variations and apportionment)

Each DSO function includes a discrete set of activities that a future DSO may be required to carry out depending on how the electricity supply industry and markets develop over the next 5-10 years. It is likely that each function would be developed over different timescales.

Each function has an associated set of activities to further define its scope. These activities and further descriptions are listed in Appendix A.

The functions have been refined to take account of feedback from the wider Workstream 3 group and from the Stakeholder Advisory Group. Further narrative on the development of each function is given below.

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5.1 System Co-ordination

“System Co-ordination” would see the DSO undertake a number of activities to support whole system planning, operation and optimisation across transmission and distribution networks. Power and energy transfers across local and regional areas would be managed to ensure adjacent networks or systems are balanced and operated efficiently.

Activities associated with “System Co-ordination” would include co-ordination with the GB System Operator, with other DSOs, iDNOs/iDSOs and with local energy systems to ensure the overall system is operated within technical and commercial limits. Local energy systems in this respect could include community energy schemes, private networks etc. Other activities falling under System Co-ordination could include cross vector energy exchanges such as the large-scale transfer of electricity to heat. The co-ordination of services to support wider network operation (e.g. voltage management) is also included in this function.

This DSO function was previously referred to as “Balancing” but has been renamed to “System Co-ordination” and more clearly drafted to clearly differentiate it from the real-time energy balancing activity carried out by the GBSO.

5.2 Network Operation

This would include activities to ensure secure and efficient real-time operation of distribution networks. These include operating within acceptable thermal, voltage and short circuit ratings and acting to ensure that the network and its connected resources remain stable. These activities are becoming more complex as levels of distribution connected generation, storage and responsive demand increase and as distribution networks become more active.

“Network Operation” activities also include the configuration and operation of distribution networks to reduce losses and to enable to efficient use of connected resources. “Network Operation” will also require DSOs to take account of equipment outages and condition through operational planning and risk management activities.

There is potential for misunderstanding between the “Network Operation” and “System Co-ordination” functions. The former covers technically based activities to ensure effective real-time operation whereas the latter focusses on interactions with other networks and systems.

5.3 Investment Planning

“Investment Planning” activities are becoming more complex as networks are developed with increasing levels of active resources. As well as the traditional investment solutions used by DNOs, alternative solutions are being developed to manage network capacity.

Alternative solutions include SMART network control based solutions such as Active Network Management (ANM) and solutions that defer or avoid investment in new network assets by utilising network and connected DER flexibility.

Going forward, an increasing element of the “Investment Planning” function could be to work with other network owners and operators to take forward efficient whole system solutions that address wider network limitations.

Functional and System Requirements

5.4 Connections and Connection Rights

The “Connections and Connection Rights” function covers activities directly related to the provision of distribution network connections and to managing ongoing access to the distribution network. Such activities include the design of connections, putting in place connection agreements with clearly defined access rights and the ongoing management of these agreements.

Increasingly, the “Connections and Connection Rights” function is also covering how DSOs manage the increasing demand for connection to some areas of distribution networks. Activities here include how to manage access to limited network capacity including mechanisms such as queue management and commercial constraint payments.

5.5 System Defence and Restoration

The “System Defence and Restoration” function recognises that distribution networks and resources can play an increasing role in overall electricity system resilience and in the re-establishment of networks following a major system incident.

Activities included in “System Defence and Restoration” are contingency planning for High Impact Low Priority events (e.g. storms), the design and operation of resilience schemes to help manage extreme frequency deviations (e.g. Low Frequency Demand Disconnection), the design and operation of “islanding” arrangements and contributing to Black Start arrangements.

DSOs can also play a role to ensure DER resilience to system disturbances (e.g. Loss of Mains Protection, Fault Ride Through capability) and the risk management of networks with high volumes of connected DER is included in this function.

5.6 Service/Market Facilitation

“Service and Market Facilitation” is a broad ranging function to define distribution network service requirements and support the market arrangements put in place to provide these and other services. Activities would include assessing the value of flexibility, the definition of new services and supporting the operation of the markets and systems needed to provide these services. DSO’s would also support the market participants through information provision.

Wider co-ordination aspects under “Service and Market Facilitation” include the mitigation of potential service conflicts and the design and implementation of service arrangements to provide efficient whole system outcomes.

5.7 Service Optimisation

“Service Optimisation” is a function to ensure that services are available to support networks and wider system operation. Activities include the procurement, selection and optimisation of services in line with capacity constraints and the facilitation of flexibility services through the smart use of networks. Activities might also include ensuring that last resort provisions are in place to support network operation in a situation where market operation has failed.

Note: This function has been updated in V3 of this document to remove reference to commercial service provision by DSOs. It replaces the “Service Provision” function in V2.

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5.8 Charging

The “Charging” function recognises a potential DSO role in setting charges for the connection and use of distribution networks. Increasingly this will require a whole system view and close interaction between network owners and operators to design and operate efficient and equitable network charging arrangements.

Functional and System Requirements

6. Competences – High Level Description & Mapping to Functions

A total of twelve functional competences have been identified and developed with scoring criteria. These scored competences enable the proficiency within the DSO functions to be assessed and gap analysis undertaken.

1. Forecasting
2. Regulatory Codes & Frameworks
3. Commercial Relationships & Whole System Pricing
4. Whole System Coordination
5. Power System Analysis
6. Contractual Arrangements & Service Compliance
7. Dispatch
8. Outage Planning
9. Data Management
10. Settlement
11. Customer Account Management
12. Change Management

Functional Competence	Description
Forecasting	Development of consistent, repeatable and auditable methodologies in operational and investment timescales for forecasting demand, generation, network power flows and the requirements for DSR & flexibility.
Regulatory Codes & Frameworks	Capability to develop existing licenses, industry codes and policies to facilitate DSO operations.
Commercial Relationships & Whole System Pricing	Understanding and defining the different commercial relationships between the parties operating in the electricity system. Ensuring operational and investment decisions are fully understood and support delivery of cost effective and economic network.
Whole System Coordination	Transmission and distribution collaboration on investment and operational decisions to better facilitate whole systems outcomes.
Power System Analysis	Capability to carry out network powerflow analysis in operational and network investment timescales to inform network security and investment decisions.
Contractual Arrangements & Service Compliance	Creation, development, administration and management of contractual arrangements to support the interactions required for DSO. Ensuring that services are provided as contracted when instructed.
Dispatch	Instructing third parties in planning and operational timescales to adjust output and then inform the market of actions being taken.
Outage Planning	Planning network outages that reduce the impact on customers accessing the network, whilst ensuring the network remains secure.
Data Management	Having suitable systems to facilitate the information and data exchanges required to plan and operate as a DSO.
Settlement	Ensuring service providers are remunerated in a timely fashion for the services provided.
Customer Account Management	A strong customer ethos drives activity across the DSO organisation.
Change Management	Adaptive and effective at implementing new learning and organisational change with sound risk management.

Functional and System Requirements

6.1 Forecasting

Development of consistent, repeatable and auditable methodologies in operational and investment timescales for forecasting demand, generation, network power flows and the requirements for DSR & flexibility.

Attributes	Scoring
<ul style="list-style-type: none"> • Long term trending info maintained. • Know masked demand/true demand. • Forecasting DER outputs for intermittent and weather dependent technology types. • Forecasting network equipment capability as weather conditions change. • Provides info to market participants. • Short-term forecasts linked to contracting requirements, resilience actions etc. • Comprehensive long term forecasts aligned with other network operators. • Real time system with operational forecasts being updated on a regular basis. 	1 Some competence through traditional activities, capabilities and in-place systems.
	2 Understand emerging forecasting needs with some tactical solutions in place to address.
	3 Broad understanding of op & inv requirements with measures in place to provide capability.
	4 Very strong in some areas but some gaps exist. Inconsistency between network operators.
	5 Fully functional forecasting capability in operational & investment time-frames. Seen as authoritative in service area.

6.2 Regulatory Codes & Frameworks

Capability to develop existing licenses, industry codes and policies to facilitate DSO operations.

Attributes	Scoring
<ul style="list-style-type: none"> • Manage incremental changes to, and industry interactions for, existing codes/frameworks. • DSO requirements are well described in codes and DSOs can interpret and deliver these. • Clear and transparent rationale for decisions. • Actively identifying issues & driving change to meet industry developments. • Expert interactions with Gov't, Regulators. 	1 Some knowledge of likely DSO requirements based on current approach.
	2 Good description of DSO accountabilities within codes and frameworks.
	3 Competent, clear understanding of req'ts and responsive to code developments.
	4 On top of DSO codes & framework req'ts. Actively identifying and driving code change.

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- | | | |
|--|---|--|
| <ul style="list-style-type: none"> • Reporting and regulatory KPIs in place. • Expert understanding and integration of international codes and policies. | 5 | Extensive capability through organisation. Authoritative, leading GB & wider debate. |
|--|---|--|

6.3 Commercial Relationships & Whole System Pricing

Understanding and defining the different commercial relationships between the parties operating in the electricity system.

Ensuring operational and investment decisions are fully understood and support delivery of cost effective and economic network.

Attributes	Scoring	
<ul style="list-style-type: none"> • Whole system cost and benefits understood including network and non-network costs. • Commercial positions across industry well understood. • Good process for options assessment. • Totex, whole life based approach. • Future optionality recognised in benefits. • Reduction in likelihood of stranded assets. • DSO business model(s) clear. Understand what models are appropriate for service area. • Ongoing review of market delivered costs against network derived services. • Ensuring balanced costs/incentives are spread across stakeholders. • Technical best deployment of services. 	1	Recognition of emerging commercial drivers including DSO opportunities. Some decisions (inv or op) take account of pricing information.
	2	Developing new commercial opportunities and relationships in some areas. Pricing of DER and other D options better understood.
	3	Commercial relationships established and strong over service area. Good availability and use of pricing information for different T & D oper & inv options.
	4	Wide range of incentives and remuneration mechanisms for DSO operation. High degree of confidence in efficiency of oper & inv options.
	5	Mature and appropriate DSO models being implemented in different areas. Full use of T & D options with full understanding of costs.

6.4 Whole System Coordination

Transmission and distribution collaboration on investment and operational decisions to better facilitate whole systems outcomes.

Attributes	Scoring	
<ul style="list-style-type: none"> • Exchanging T-D data to ensure smooth system operation and efficient investment. 	1	Occasional whole system approaches with limited exchange of data.

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<ul style="list-style-type: none"> Processes in place to optimise whole system operation and investment. Skills and methodologies in place to review network decisions across the t-d boundary. Wide-scale use of D connected flexibility to mitigate T and D network issues. Simple customer interfaces encompassing T & D for system access and service provision. 	2	More frequent whole-system assessment to address problems. Can articulate benefits.
	3	Operational & Investment processes reviewed, agreed and in regular use.
	4	Well developed skill-sets in T & D organisations. Customers see good T & D alignment.
	5	Mature processes with little differentiation between T&D assets and services.

6.5 Power System Analysis

Capability to carry out network powerflow analysis in operational and network investment timescales to inform network security and investment decisions.

Attributes	Scoring
<ul style="list-style-type: none"> Watts (thermal) & VAr (Voltage) analysis. Mature management of network and user data with accurate network models in place. 	1 Some analysis capability through ongoing work and in-place systems. Limited case analysis.
<ul style="list-style-type: none"> Modelling of high & medium voltage assets. Modelling of customer assets, DER. Identify key network risks and contingencies. 	2 Developing analysis capability in key areas to support immediate challenges.
<ul style="list-style-type: none"> Carry out analysis taking a whole system perspective on security (NETS SQSS, P2 etc). 	3 Broad capability across different types of analysis. Deals with significant volumes of analysis. Includes some dynamic analysis.
<ul style="list-style-type: none"> Can deal with high volume of power system analysis work across voltages. Dynamic analysis capability (e.g. transient, generator stability etc). 	4 Very strong analysis capability in many areas and including real time. But some gaps remain.
<ul style="list-style-type: none"> Quality of Supply (harmonics, unbalance etc). Demand response to network conditions. 	5 Full analysis capability in op & inv time-frames. Recognised as expert across industry.

Functional and System Requirements

6.6 Contractual Arrangements & Service Compliance

Creation, development, administration and management of contractual arrangements to support the interactions required for DSO.

Ensuring that services are provided as contracted when instructed.

Attributes	Scoring
<ul style="list-style-type: none"> Standard conditions & terms developed and in place to manage connection & services. 	1 Traditional connection contracts in place. Some contract management competence through traditional DNO activities.
<ul style="list-style-type: none"> Managing a range of connection contracts. Range of service contracts in place to manage network requirements (duration etc). Operating qualification & tender processes. Range of incentives & compensation in place. 	2 Range of connection options in place that are well understood by customers. Have identified and specified some DSO service requirements.
<ul style="list-style-type: none"> Deals with non-compliance and non-delivery. Checks to ensure that service providers are capable of providing the contracted response. 	3 Recognise & communicate future service req'ts. Building up capability to deal with extra volume. Some monitoring of service provision.
<ul style="list-style-type: none"> Checks/monitoring to ensure that services have been delivered when called. Good understanding of contract terms across planning and operational functions. 	4 Testing of service capability ahead of operation. Dealing with greater contract volumes and types over different timeframes. Measures to address service non-provision.
<ul style="list-style-type: none"> Managing significant volumes of contracts and counter-parties. 	5 Full contract capability with skills and volume in place to manage range of DSO activities. Checks that services have been provided when called.

6.7 Dispatch

Instructing third parties in planning and operational timescales to adjust output and then inform the market of actions being taken.

Attributes	Scoring
<ul style="list-style-type: none"> Method of placing instructions in place. Could be via control engineer action or automatic. 	1 Some limited capability to instruct DER. May be via control engineer.
<ul style="list-style-type: none"> Ensuring speed of response is appropriate for the service required. 	2 Wider use of instructed DER capability.

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<ul style="list-style-type: none"> • Pre-instruction analysis for security and service interactions • Linkages to commercial systems. 	3	Wide scale use of dispatch instructions guided by security & commercial optimisation.
	4	Automated dispatch systems in place.
	5	Well developed and reliable dispatch systems in place. Co-ordinated with other systems.

6.8 Outage Planning

Planning network outages that reduce the impact on customers accessing the network, whilst ensuring the network remains secure.

Attributes	Scoring	
<ul style="list-style-type: none"> • Planning windows appropriate to outage requirements. • Use of DER and other flexibility to mitigate outage impacts. • Ongoing DSO-customer channels for outages. • Customer expectations of system access and outage management are clear. • Quantification of outage costs to customers and justification of approach. • Ensuring network unavailability impacts fall equitably on customers and network operators. 	1	Planning windows appropriate to outage requirements.
	2	Use of DER and other flexibility to mitigate outage impacts.
	3	Ongoing DSO-customer channels for outages.
	4	Customer expectations of system access and outage management are clear.
	5	Quantification of outage costs to customers and justification of approach.

6.9 Data Management

Having suitable systems to facilitate the information and data exchanges required to plan and operate as a DSO.

Attributes	Scoring	
<ul style="list-style-type: none"> • Clear data requirements for DSO operation. • Capturing data at appropriate granularity. 	1	Handling some DER and other data to support DSO investment and operations processes.

Functional and System Requirements

<ul style="list-style-type: none"> Identifying and sourcing critical 3rd party data to support effective network operation. Handling high volumes of DER data for DSO activities and to provide market information. Providing 3rd party access to meet user needs. Data available for whole system optimisation. Data available for entire distribution network. Systems sized for current & future req'ts. Making best use of smart meter data. Strong maintenance of data integrity. Monitoring & testing supports data models. 	2	Simple data models and system in use. Handling new areas of data to support markets etc.
	3	Good understanding of what data is required and what is not to support accurate decisions. Handling large-scale volumes of data.
	4	Common data management systems in place across T&D and across network operators. Large-scale data available to 3rd parties.
	5	Fully competent in managing and sharing large-scale volumes of data for DSO operation.

6.10 Settlement

Ensuring service providers are remunerated in a timely fashion for the services provided.

Attributes	Scoring	
<ul style="list-style-type: none"> Remuneration to market participants for services within agreed timescales. Sound methodologies & auditable systems. Well justified penalties where services have not been provided. Handling over or under provision of service. Ensuring market participants are returned to balanced position following DSO actions. Managing payments across multiple markets and service providers. 	1	Some experience of settling services.
	2	Principles for settling specific services in place.
	3	Local systems in place to settle specific services.
	4	Principles and systems agreed across network operators to manage and settle services.
	5	Well developed systems in place to settle a range of services across areas.

6.11 Customer Account Management

A strong customer ethos drives activity across the DSO organisation.

Attributes	Scoring
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Functional and System Requirements

<ul style="list-style-type: none"> • Strong and visible customer facing functions • Can manage a large volume of direct customer interaction • Customer needs are reflected back into DSO • Understands different customers – generators, demand side providers, local authorities, community schemes etc • Always considers interests of less active and less vocal customers • Offers flexible & tailored connection options • Offers flexible & tailored options to take services 	1	Customer management largely based on a traditional model for new connections.
	2	Increased volumes and types of customers being handled. Increased awareness of diverse customer requirements through DSO.
	3	Actively managing a diverse range of customer types.
	4	Strong customer ethos through DSO organisation. Managing high volumes of diverse customers.
	5	Strong and flexible customer focussed DSO organisations in place with the ability to handle new customer and service types.

6.12 Change Management

Adaptive and effective at implementing new learning and organisational change with sound risk management.

Attributes	Scoring	
<ul style="list-style-type: none"> • Can-do attitude across DSO • Fast innovation & development cycle • Look for and share learning across DSO organisations • Effective implementation of new learning • Innovates with a wide range of partners • Considers impacts of changes across organisation and stakeholders • Risks fully considered and mitigated 	1	Utilises established innovation routes (NIA, NIC etc) to identify and test new approaches.
	2	Any new learning to support DSO implementation is identified and implemented.
	3	Innovation cycles are accelerated and changes to support DSO are implemented quickly.
	4	Full impacts of changes are assessed and understood through the value chain with extensive stakeholder interaction.
	5	DSOs are considered to be fast learning organisations with fast innovation cycles. Learning is shared across DSO organisations.

7. Current DNO Capability including scoring

7.1 System Co-ordination

Current												
System Co-ordination	1	0	0	1		1	1		1	0	1	1
[Total score = 7]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

At present, little system co-ordination of local networks is carried out by DNOs. Most of the competences that would support the System Co-ordination function are not yet being developed or are in the early stages of development through ongoing trials. The increasing use of ANM systems is starting to provide a means to interact and manage levels of DER.

Some trials are in their early stages that will help develop System Co-ordination functionality. These include Local Energy Markets and innovation projects such as Power Potential where the DNO will be acting to manage and control local DER for voltage services. DER contracts, dispatch and settlement mechanisms will be being developed through these ongoing trials. ICT, data requirements and exchange mechanisms will also be specified.

In terms of Competences to support the System Co-ordination Function:

- **Forecasting** – Existing DNO capability provides a starting point for the forecasting capability to support System Co-ordination. Capability is improving in some areas by building on leading edge work. However, as yet, this capability is limited in operational timescales.
- **Whole System Co-ordination** – Resources on distribution networks are largely managed passively with limited consideration of whole system impacts. Through some projects and trials, more extensive whole system approaches are being considered on a local basis. These initial trials should provide a basis to develop this competence.
- **Contractual Arrangements & Service Compliance** – Existing contractual arrangements are in place with many of the participants that would be party to System Co-ordination (e.g. operation of power transfers from a local area). Some consideration of DER contracting is taking place and DSO understanding should develop quickly through the work in local areas and trials.
- **Dispatch** – There is developing capability through the implementation of ANM schemes. Ongoing projects will shortly put in place some DER dispatch for specific MW, MVar services.

Functional and System Requirements

- **Data Management** – DNOs are starting to handle increased levels of DER and network data to support operations. Communications links are being utilised to enable near real-time exchange of data in some areas. As yet, data management is not focussed towards System Co-ordination activities.
- **Customer Account Management** – DNO customer facing functions are based around traditional activities of connection, service maintenance etc. Different interactions are emerging as DER look to connect and operate more flexibly within DNO networks.
- **Change Management** – There has been extensive use of innovation mechanisms and some evidence that DNOs are implementing changes through their organisations. The sharing of learning across organisations is limited.

7.2 Network Operation

Current												
Network Operation	1	1	1	1	2	1	1	1	1		1	1
[Total score = 12]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Operation with respect to the condition of distribution assets and the management of network losses is relatively mature. However, in recent years, DNO networks have been operated on a relatively passive basis with little need to actively manage generation and other dynamic resources. This is changing with increasing levels of DER in many areas of distribution networks. Network operational capability should develop quickly through trials and the early provision of services.

- **Forecasting** – There is some DNO forecasting capability in place through traditional approaches. Through ongoing trials and early tactical solutions, there should be an increasing capability to carry out short term forecasting of operational requirements.
- **Regulatory Codes & Frameworks** – Current accountabilities for network operation are well understood and discharged by DNOs. Through ongoing projects and industry work, DNOs are starting to assess how whole system approaches might work from a regulatory perspective.
- **Commercial Relationships & Whole System Pricing** - There is increasing recognition of the commercial interfaces that will support network operation and the potential to manage network requirements through whole system services. For example, the use of DER to address transmission thermal and voltage constraints is starting to be explored

Functional and System Requirements

and DSO capability to deploy DER resources is being developed. As yet, there is little use of costs for operational decision making, for example the costs of DER curtailment or wider transmission costs.

- **Whole System Co-ordination** – This is limited for network operation. Resources on distribution networks are largely managed passively with little consideration of wider impacts. Through trials, more extensive whole system approaches are being considered on a local basis.
- **Power System Analysis** – Little distribution network analysis is taking place to support network operation other than in the operational planning phase. DNO thermal and voltage analysis uses a range of tools. Increasingly, worst case operational conditions are being identified and assessed to support network operational decisions.
- **Contractual Arrangements & Service Compliance** – There is little consideration of DER operation and limited interaction with providers to ensure that performance criteria are met.
- **Dispatch** – There is developing capability through the use of ANM schemes in places.
- **Outage Planning** – Some key outages are co-ordinated with customers and across operators.
- **Data Management** – Increasing levels of data are being sourced and managed to support operations. Communications links are being utilised to enable near real-time exchange of data with other operators in some areas. Ongoing trials will help determine key data requirements.
- **Customer Account Management** – DNO customer facing functions are based around traditional activities of connection, service maintenance etc. Different interactions are emerging as DER look to connect and operate more flexibly within DNO networks.
- **Change Management** – Innovation mechanisms are being used to develop and test network operational capability. The implementation and sharing of learning is limited.

7.3 Investment Planning

Current												
Investment Planning	2	2	2	1	2				2		1	1
[Total score = 13]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Current DNO investment planning is largely based on traditional approaches to demand security. Network investment options and reinforcement requirements for generation are well understood albeit there is no specific generation connection standard in place. At present, few whole system options are being considered. Active Network Management (ANM) options are being increasingly used to manage areas where there are increasing volumes of generation.

Functional and System Requirements

In some cases, a broader consideration of these is beginning to take place in investment timescales so that ANM schemes can be used to support both distribution and transmission networks.

Some greater co-ordination on investment planning is also emerging through regional planning work in capacity limited areas. Whole system options may also emerge to address wider transmission capacity requirements with the further development of voltage management initiatives.

- **Forecasting** – There is already some longer term forecasting capability within DNOs (e.g. MW demand forecasting for the Grid Code). Some DNOs are establishing scenario planning capability that could be linked to the GB-wide Future Energy Scenarios (FES) co-ordinated by the GBSO.
- **Regulatory Codes & Frameworks** – Current accountabilities for investment are understood and discharged by DNOs. Through ongoing trials, DNOs are starting to assess how whole system approaches might work from a regulatory perspective. The potential for distribution network and DER based options to support an extended NOA process is also starting to be explored.
- **Commercial Relationships & Whole System Pricing** – There is increasing recognition of the relationships that will be required around investment, for example, the requirements around ANM implementation. DNOs have some understanding of what investment options are likely to be available (asset and non-asset based) and where there are limitations on their networks. There is good understanding of asset costs in respect to investment decision making but less understanding, as yet, around the wider costs impacting investment decision making such as the costs to DER of curtailment, or the wider transmission system impacts of DNO investment. Early work on local markets to manage regional capacity constraints should inform this shortly.
- **Whole System Co-ordination** – Whole system approaches are limited albeit there are week 24/week 42 Grid Code data supported P2 compliance processes in place. In some trial areas (e.g. Regional Programmes, Dumfries & Galloway), a fuller review of investment options is beginning with the GBSO & TOs. These are supported by T/D data transfers and more granular modelling.
- **Power System Analysis** – Some analysis is already taking place to support investment decisions. This includes thermal and voltage analysis for new connections and wider network-wide modelling using tools such as “Transform”. There is little dynamic modelling capability in place. More extensive DNO power system analysis is taking place through Regional Programmes.
- **Data Management** – Increasing levels of data are being sourced and managed to support investment processes. In some areas and trials (e.g. Regional Programmes), key data and models to support whole systems investment assessments are being established.
- **Customer Account Management** – DNO customer facing functions are based around traditional activities of connection, service maintenance etc. Different interactions are emerging as DER look to connect and operate more flexibly within DNO networks. More flexible connection arrangements have emerged through ANM arrangements and there is some early engagement with DER to provide services.
- **Change Management** – Innovation mechanisms are being used to develop and test network options to avoid investment (e.g. Power Potential). As yet, the implementation and sharing of learning is limited.

7.4 Connections & Connection Rights

Current												
Connections & Connection Rights		3	1	1	2	2		1	2		1	2
[Total score = 17]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Whilst there are no immediate regulatory barriers impeding the development of connections and connection rights for DSO market models, there is further work required in creating consistent and transparent contractual frameworks to enable commercial management of network constraints:

- **Regulation Codes/Frameworks** – Existing regulatory codes and frameworks are well defined and comprehensive for distribution demand customers and DG customers connecting to unrestricted passive networks. These regulatory codes do not prevent active network management and are beginning to further facilitate the complex interactions which occur within active networks.
- **Commercial Relationships & Whole System Pricing** – Some work has been completed to recognise the emerging commercial drivers.
- **Whole System Co-ordination** – Exchange of customer connection or service data between the boundary limited to development of SOW process.
- **Power System Analysis** – Analysis of the power system for planning future connections is well developed using existing edge case techniques and additional edge cases are being added to standard modelling techniques where DNOs perceive them as a problem.
- **Contractual Arrangements and Service Compliance** – A range of flexible/alternative connection options are available from all DNOs. There are absolute limits of agreed supply capacity managed, but limited volumes of policing.
- **Dispatch** – Limited capability is developing through the development of ANM schemes. However, the dispatch requirements in system restoration situations could be very complex.
- **Outage Planning** – Some management of outages to limit the effect on customers
- **Data Management** – Some simple systems in place to manage customer connection agreement data for a variety of purposes.
- **Customer Account Management** – Some new customer management features emerging e.g. real time ANM updates, network capacity maps and service tenders.
- **Change Management** – A number of projects have developed connection agreement terms and brought these into BAU.

7.5 System Defence and Restoration

Current												
System Defence and Restoration	1	1	0	1	1	1	1	1	1		1	1
[Total score = 10]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management
<p>There is existing DNO capability in place to support current defence and restoration plans. DNOs already play a large part in providing whole system resilience through emergency demand management (e.g. voltage control, LFDD). In addition, current GB black start arrangements rely on active DNO participation to rebuild the network. With respect to generation resilience, DNOs are actively supporting changes to Loss of Mains protection arrangements. Ongoing codes work on this and for European Network Codes implementation should improve whole system network resilience.</p> <ul style="list-style-type: none"> • Forecasting – There is capability in place to manage potential operational risks such as storms. Ongoing trials should increase capability to forecast short term operational requirements. • Regulation Codes/Frameworks – Existing Grid and Distribution Code requirements help deliver system defence (e.g. LFDD). These need to be further developed to address changing risks. • Commercial Relationships & Whole System Pricing - There has been little work to determine how increasing DER could support defence. Some recognition of opportunities is emerging. • Whole System Co-ordination – Traditional defence and restoration approaches rely on DNO management of load (e.g. voltage management, block loading). Otherwise, distribution resources are largely managed passively with limited consideration of whole system impacts. This is starting to change with revisions to Black Start approaches, LFDD updates etc. • Power System Analysis – Some capability is in place through DNO steady state analysis but extensive understanding of demand behaviour, dynamic behaviour is not in place. A wider range of system conditions are starting to be modelled. The analysis capability to support deployment of early whole system approaches will support improved defence and restoration capabilities. • Contractual Arrangements and Service Compliance – Existing requirements (e.g. Generator G59/G83 protections) provide some resilience to extreme events. These could be extended. There is increasing awareness of DER capabilities and compliance with connection conditions. 												

Functional and System Requirements

- **Dispatch** – Limited capability is developing through the development of ANM schemes. However, the dispatch requirements in system restoration situations could be very complex.
- **Outage Planning** – There is some management of outages to prepare for bad weather etc. Priority customers would be made aware of increased risks.
- **Data Management** – Some data is in place to support defence and restoration (e.g. LFDD scheme management) and increasing information is becoming available on DER. Through trials, more real-time distribution data should become readily available.
- **Customer Account Management** – Whilst this is largely based around traditional activities (e.g. connection), strong management of customer interfaces is in place under emergency conditions.
- **Change Management** – There is some limited innovation around system defence and restoration with projects reacting to operational challenges. Proposed changes take time.

7.6 Service/Market Facilitation

Current												
Service/Market Facilitation	1	0	2	1		1		0	1	1	1	2
[Total score = 11]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

To date, the demonstration of flexibility services and the stimulation of markets to provide the service, has been accomplished through innovation projects such as CLASS, Entire, FALCON, Power Potential, Capacity to Customers and BAU tenders such as CMZs.

- **Forecasting** – Traditional systems and data allow for some forecasting for services to be completed.
- **Regulation Codes/Frameworks** – Existing codes and frameworks focus purely on a transmission or distribution solution.
- **Commercial Relationships & Whole System Pricing** – Some early services (e.g. CMZ, Entire, Power Potential, Capacity to Customers) being developed in specific areas. Some ability to consider total cost rather than just deliver new network build solutions.
- **Whole System Co-ordination** – Some joined up approaches to service procurement in specific areas of constraint.
- **Contractual Arrangements and Service Compliance** – Development of traditional contracts for specific service delivery in trial areas.
- **Outage Planning** – Services not used for mitigated outages.

Functional and System Requirements

- **Data Management** – Some traditional sources of data able to be used for market facilitation.
- **Settlement** – Few areas capable of settlement of services based on specific projects.
- **Customer Account Management** – Interaction of services limited to certain areas, but volumes beginning to rise.
- **Change Management** – Strong competences of DSO service operation beginning to emerge from projects across most DNOs.

7.7 Service Optimisation

Current												
Service Optimisation	1	1	2	1	0	1	1	2	1	1	1	2
[Total score = 14]												
	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Managing distribution constraints through commercial services has been undertaken through innovation projects and specific trials to date.

- **Forecasting** – Limited capability within network operators to forecast requirements.
- **Regulation Codes/Frameworks** – Existing code requirements to deliver cost effective and efficient networks enables a range of network and service solutions to be considered.
- **Commercial Relationships & Whole System Pricing** – Specific ANM or CMZ areas have allowed distribution DER to be used to mitigate whole system constraints.
- **Whole System Co-ordination** – Limited experience in whole system service optimisation.
- **Power System Analysis** – No tools developed for understanding service optimisation.
- **Contractual Arrangements and Service Compliance** – DNO to customer connection agreements have been amended to cover services in some areas.
- **Dispatch** – Some services are being dispatched by DNOs in specific areas.
- **Outage Planning** – Flexibility in network has traditionally been used to mitigate need for outages.
- **Data Management** – Existing data flows of DER output and network monitoring can be used to build up the service optimisation competence.
- **Settlement** – Some experience of settling services under trial projects in specific zones.
- **Customer Account Management** – Customer management mainly stemming from traditional operation.

Functional and System Requirements

- **Change Management** – Strong service related competence beginning to emerge from projects across most DNOs.

7.8 Charging

Current												
Charging	0	1	1	1		2			2	3	1	1
[Total score = 12]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

The way the networks are paid for by customers is based upon the network needs and customer requirements of centralised generators delivering energy through passive networks. For active networks with large amounts of embedded DER and active participants delivering services, then there needs to be a change in the way the capital and operational costs of the network need to be recovered.

- **Forecasting** – Few requirements for forecasting within current position.
- **Regulation Codes/Frameworks** – Work has been undertaken on the gaps and changes needed to the codes and regulation in order to facilitate DSO operations, but more is required.
- **Commercial Relationships & Whole System Pricing** – Additional charges have been introduced in specific ANM or CMZ areas to better enable new ways of interaction.
- **Whole System Co-ordination** – Charging is predominately transmission or distribution specific.
- **Contractual Arrangements and Service Compliance** – DNO to customer connection agreements have been amended to include service provision in some areas.
- **Data Management** – Large volumes of data exchanged through existing methodologies.
- **Settlement** – Existing settlement functions well defined and consistent, but further changes required to enable DSO models.
- **Customer Account Management** – Customer management mainly stemming from traditional operation.
- **Change Management** – Much of the changes have happened outside of the existing charging regimes.

8. DSO Requirements based on Roadmap Position

8.1 System Co-ordination

Long Term												
System Co-ordination	4	4	4	4		4	5		4	5	5	4
[Total score = 43]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – System Co-ordination would include extensive use of ANM for DER dispatch. Several trials and projects would have completed and more effective solutions would have emerged. The frameworks and code requirements to support System Co-ordination would be in place. The DSO Roadmap envisages some larger regions (multiple grid supply points) operating with mature DSOs in place. In these regions, DSO functionality would include the dispatch and operation of DER to satisfy local network limitations. Surplus services (MW, MVar, Frequency Response) that are available could be offered to the GBSO and to other DSO regions.

For the DSO Roadmap case, the market models being used in different DSO regions would be relatively consistent. Large volumes of data would be handled in operational timescales and the DSO would interact with the GBSO and other DSOs to enable wider system co-ordination and energy balancing. Data would be managed with a “Whole System” perspective. DSOs would provide frameworks for, and interact with, smart city and community initiatives. Whilst System Co-ordination activities would not yet be mature, they would be comprehensive and leading edge when compared internationally.

In terms of Competences to support the System Co-ordination Function:

- **Forecasting** - MW and MVar forecasting capability for demand and DER would be very well developed in DSO co-ordination areas. Short term planning forecasts would be very strong.
- **Regulatory Codes & Frameworks** - Consistent frameworks would be in place across different areas. However, codes and frameworks would still be developing given the relative immaturity of DSO models. Governance would be strong.
- **Commercial Relationships & Whole System Pricing** - Decisions would be based on a good understanding of a broad range of options for which pricing information would be available.

Functional and System Requirements

- **Whole System Co-Ordination** – Well developed processes and skill-sets would be in place to enable the optimal use of services across T-D boundaries and between DSOs. Services derived from network assets might also be used. Processes would not yet be mature or fully consistent.
- **Contractual Arrangements & Service Compliance** – A wide range of contracts would be used to support System Co-ordination. Contract volumes would depend on the number of areas operating with DSOs but are likely to be high. DSOs would be ensuring that service requirements are clear and that services are being provided as requested with measures in place to address any shortfall or non-provision of services.
- **Dispatch** – ANM systems would be widely used. Services would be dispatched to satisfy a range of factors. Dispatch processes would be automated and co-ordinated with GBSO systems.
- **Data Management** – Large scale volumes of data would be handled in real-time via enterprise systems. Data would be shared across organisations.
- **Settlement** – Systems would be in place to settle a wide range of services taking account of interactions with different areas.
- **Customer Account Management** – There would be excellent understanding of the different customers, service providers and local energy parties that the DSO would deal with. The volume of diverse and active customers would be high. Connection and service requirements would be tailored to customer needs.
- **Change Management** – There would be excellent sharing of learning within DSOs and across DSO organisations. DSOs would work closely with other stakeholders, develop new approaches with them and implement these quickly. The risk of changes and the impacts on wider parties would be weighed up carefully by DSOs as a matter of course.

Range of “System Co-ordination” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 4 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Geography** - DSOs and the need for System Co-ordination may be focussed in areas with high levels of DER penetration with more traditional models persisting in other areas. Alternatively, DSOs may be placed extensively across current DNO regions and service areas.
2. **Volume, Complexity and Interaction with Local Energy Arrangements** – Such arrangements could include local energy markets, community energy schemes, peer to peer arrangements, smart city schemes etc. In the mid 2020's the numbers and complexity of local energy arrangements may still be very limited or, alternatively, they may be in place in most Grid Supply Point networks. This represents one variable that will affect DSO System Co-ordination. Additionally, the degree of DSO participation and interaction with these local arrangements is unclear. DSOs might take a very active role in their operation or it may be the case that DSOs interact with these arrangements in narrow and well defined ways.

Functional and System Requirements

3. **Cross Vector Energy Exchange** – In long term timescales, there could be very well developed interfaces with other energy vectors (transport, heat) and the development, co-ordination and resolution of these interfaces could be a substantive DSO role. Alternatively, cross vector energy exchanges may still be very limited in scope and volume.
4. **Service Co-ordination for Other System Operators** – If DSOs are co-ordinating services in their service areas, it may be that surplus capability can be made available to other system operators. The extent to which the DSO looks to optimise positions across system operators will impact the shape of this function.

8.2 Network Operation

Long Term												
Network Operation	5	4	4	4	4	4	4	4	4	4	4	4
[Total score = 45]												
	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – In the longer term (+8 years), there is likely to have been a wide roll-out of DSO network operational capability in areas of high DER penetration. The reference case envisages separately licensed DSOs operating regionally. These would have regional forecasting capability and they would be procuring and dispatching a suite of services within these regions to manage constraints and provide services to the GBSO. A standard commercial operating model would be in place within a well-defined commercial and regulatory framework. The DSOs would interface widely and would be providing market information via enterprise systems.

- **Forecasting** – A strong regional forecasting capability would be in place to support network operation and the effective deployment of a range of services. Short term forecasting of operational requirements would be rolled out in areas where there would be value and significant capability is likely to be in place in DSO organisations.
- **Regulatory Codes & Frameworks** – The requirements for DSO operation and the supporting regulatory and codes framework would be progressed and more clear ahead of RIIO-D2. DSOs would understand their positions in the wider market and would be to the fore in managing further code requirements and updates.
- **Commercial Relationships & Whole System Pricing** - DSOs would be working within defined commercial models. Whole system value opportunities would be clear and DSOs would be developing these. The commercial relationships with DER, aggregators and other parties would be maturing and new relationships emerging. The costs and benefits

Functional and System Requirements

of different operational options and services would be understood albeit new options would still be emerging.

- **Whole System Co-ordination** – There would be effective interfaces between DSOs and the GBSO. Information would be shared and services optimised. Whole system network operational processes would be in place with clear T & D accountabilities.
- **Power System Analysis**– The analysis capability would have developed significantly and DSOs would have a deep understanding of their network operation. There would be widespread real-time thermal and voltage analysis in DSO areas and some dynamic analysis capability would be in place. Some gaps in analysis capability might remain where these are less frequently required.
- **Contractual Arrangements & Service Compliance** – Reliable services would be in place with monitoring and measures to handle service non-compliance.
- **Dispatch** – DSOs would be dispatching services in their regions using well defined protocols and systems. There would be some level of co-ordination with the GBSO and other systems.
- **Outage Planning** –There would be active management of network and DER outages across DSO operating areas.
- **Data Management** – Systems would be in place to manage large-scale volumes of data for network operational activities. Key areas of data would be well understood. Excellent information would be available to control engineers. Information would be provided on a regular basis to market participants.
- **Customer Account Management** – DSOs would have a strong customer awareness and ethos with good understanding of the different customers, service providers and local energy parties they deal with. The volume of diverse and active customers would be high.
- **Change Management** – There would be excellent sharing of learning within and across DSOs. DSOs would work closely with other stakeholders, develop new operational approaches and implement these quickly. The risk of changes and the impacts on wider parties would be weighed up carefully by DSOs as a matter of course.

Range of “Network Operation” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 3 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Geography** - DSOs and the need for Network Operation may be focussed in areas with high levels of DER penetration with more traditional models persisting in other areas. Alternatively, DSOs may be placed extensively across current DNO regions and service areas.
2. **Volume, Complexity and Interaction with Local Energy Arrangements** – Such arrangements could include local energy markets, community energy schemes, peer to peer arrangements, smart city schemes etc. In the mid 2020’s the numbers and complexity of local energy arrangements may still be very limited or, alternatively, they may be in place in most Grid Supply Point networks. This represents one variable

Functional and System Requirements

that will affect DSO Network Operation in that DSOs may be actively operating some or many of these arrangements.

3. **DER Volumes and Robustness** – Network operation is likely to be more complex if DER levels are higher, if DER is not visible and controllable and if DER is highly vulnerable to system disturbances including those that occur in other networks. Alternatively, if DER is visible to network operators, is robustly connected and is controllable, network operation should be more straightforward.

8.3 Investment Planning

Long Term												
Investment Planning	4	4	5	5	4				4		4	4
[Total score = 34]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management
<p>Reference Case 1 (DSO Roadmap case) – Regional whole system investment planning would be well established with relatively mature data management and analysis processes in place across many DSO service areas. There would be strong alignment between the TSO and DSO planning assumptions and data. The RIIO D2 and T2 review and associated incentive arrangements would support whole system investment.</p> <ul style="list-style-type: none"> • Forecasting – There would be a good understanding of the information needed to support investment decisions and capability would be in place. This would include a much stronger forecasting capability in investment timescales including demand and local generation and an understanding of key timeframes. Local investment scenarios would be aligned with wider GB investment scenarios. • Regulatory Codes & Frameworks – Defined processes would be in place to support whole system investment and a more comprehensive regulatory framework would be in place to support and remunerate whole system investment. Accountabilities across DNOs, DSOs, TOs and the GBSO would be clear with respect to investment. These would be developing quickly to support the RIIO-D2 and T2 processes. • Commercial Relationships & Whole System Pricing – There would be a good understanding of the commercial positions of the different parties offering investment options. DSO value would be more clear and explicit and key commercial relationships would be established. Incentives would be in place to support DSO participation in wider investment processes. There would be broad understanding of assets and services costs for T and D options. 												

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- **Whole System Co-ordination** – Regional planning processes would be in place. Whole system investment options would be the norm in most areas with processes and skillsets in place to support these. The wider industry would see little differentiation between T & D processes.
- **Power System Analysis** – Enhanced analysis capability would be established in DSOs including power system analysis for investment. There would be joined up T & D analysis to support investment decisions. Network analysis would be broader in scope than now with greater volumes of studies carried out.
- **Data Management** – T and D data requirements would be well understood and systems would be in place to support investment assessment. Significant volumes of investment planning data would be used and managed through systems. DSOs would have a clear picture of DER and DER capability in their areas.
- **Customer Account Management** – DSOs would have a strong customer awareness and ethos with good understanding of the different customers, service providers and local energy parties they deal with. The volume of diverse and active customers would be high. Options to provide services would be available to customers.
- **Change Management** – There would be excellent sharing of learning within and across DSOs. DSOs would work closely with other stakeholders, develop new investment approaches and implement these quickly. The risk of changes and the impacts on wider parties would be weighed up carefully by DSOs as a matter of course.

Range of “Investment Planning” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 4 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Geography** - DSOs and the need for more extensive whole system and non-traditional approaches to Investment Planning functionality may be focussed in areas with high levels of DER penetration with traditional models of investment persisting in other areas. Alternatively, updated investment models may be in place across all service areas.
2. **Levels of DER Engagement** – There may be insufficient value to engage smaller DER in service options to avoid or defer investment. Alternatively, low cost aggregation and control mechanisms (requiring little direct DER involvement) may lead to large scale use of DER.
3. **Extent of Whole System Optioneering** – Whole System investment optioneering may be of value in only a limited number of cases, for example where the TO’s are carrying out boundary reinforcement. For most T & D investment (e.g. lower voltages), it may be the case there is no value in enacting a whole system approach.
4. **DSO Involvement in Transmission Network Option Assessment (NOA) Process** – There may be value in DSOs co-ordinating DER options to provide smart

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transmission network capacity. The degree of involvement could be limited to a few cases only or to multiple transmission boundaries. Also, it is not clear if regulatory considerations will limit DSOs from providing options based on the utilisation of DNO network assets to increase transmission capacity.

8.4 Connections & Connection Rights

Long Term												
Connections & Connection Rights		5	5	4	3	5		4	3		5	4
[Total score = 38]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – With established service markets allowing other options to conventional reinforcement to be exercised, commercial and connection agreements are well designed and defined to enable cost effective whole system approaches.

- **Regulation Codes/Frameworks** – Frameworks and codes have been developed in line with key principles identified earlier on in the transition. Clear direction from Government has established the foundations for how the energy system will be developed.
- **Commercial Relationships & Whole System Pricing** – Models of network operation running in areas are defined by the network and amount of competition in the vicinity, delivering best value for consumers.
- **Whole System Co-ordination** – Good alignment through well designed agreements allows market conflict to be limited without undue complexity.
- **Power System Analysis** – Analysis required for commercial arrangements is good enough to deliver accurate results across a long enough time period, without requiring significant granularity or detail.
- **Contractual Arrangements and Service Compliance** – A range of service contracts and connection contracts are in place to facilitate connections and accessibility to markets.
- **Outage Planning** – Connection arrangements enable effective management of the outages required for network operations. Outages are managed with the least disruption to customers.
- **Data Management** – Standardisation of connection terms has reduced the need for bespoke agreements, enabling bulk management of contracts without undue complexity.
- **Customer Account Management** – Customers would be highly engaged in network operations and DSOs would be strongly customer focused and able to adapt processes to handle new customer requirements.

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- **Change Management** – Strong focus on collaboration between network operators enables quick implementation. Whole system impacts are considered before changes are implemented.

Range of “Connections & Connection Rights” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 2 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Active Participation Volumes** – If large numbers of connections become active participants and are frequently altering their proposed windows and modes of operation, the management of the information required within the connection agreements may be a much more significant task.
2. **Facilitating an equitable system** – Contracts would provide an equal distribution of risk and reward across all parties in the energy system.

8.5 System Defence and Restoration

Long Term												
System Defence and Restoration	4	3	3	4	3	3	3	3	3	3	4	3
[Total score = 36]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – With DSOs and regional planning approaches in place in several areas, whole system defence and restoration plans would be developing to minimise the risk of widespread black out. DSOs would be engaging with DER to ensure local network resilience and would have some capability to recover local areas post event.

- **Forecasting** – A strong regional forecasting capability would be in place to support network operation. This would support improved resilience capability.

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- **Regulation Codes/Frameworks** – Enhanced requirements for DSOs to improve resilience would be emerging. Some initial consideration of regulatory requirements is likely ahead of RIIO-D2.
- **Commercial Relationships & Whole System Pricing** - Commercial opportunities and relationships around System Defence and Restoration would be emerging. There would be good understanding of DER value for resilience support and high value options would be in place.
- **Whole System Co-ordination** – There would be tactical development of whole system capability around defence and restoration. Wider network operational processes will support this. New DSO skills and more effective interfaces with the GBSO would support improved capability.
- **Power System Analysis** – This would be more mature. More widespread thermal and voltage analysis in DSO areas will support improved defence and restoration capabilities.
- **Contractual Arrangements and Service Compliance** – Contracts would be being put in place to recognise DSO roles and the support that DER can provide. Monitoring and measures to handle service non-compliance would be in place.
- **Dispatch** – There would be a broader capability to dispatch resources with active DSO areas. DSOs would be dispatching services within their region using well defined protocols and systems. There would be some level of co-ordination with the GBSO and with other DSOs that would support improved system defence and restoration capability.
- **Outage Planning** – In this timescale, there would be increased interaction with customers to manage outages and an understanding of critical local contingencies and steps to mitigate.
- **Data Management** – There should be improvements to the active management of defence and restoration schemes. Improved DER information on resilience and real-time distribution data should be readily available. Improved data and improved transfers between network operators would support system defence and restoration capability.
- **Customer Account Management** – DSOs would have a strong customer ethos and a good understanding of the different customers, service providers and local energy parties they deal with. This would include customer resilience and potential impacts through disturbances.
- **Change Management** – Learning would be shared within and across DSOs. DSOs would work closely with other stakeholders, develop new operational approaches and implement these quickly. Risks and impacts on wider parties would be weighed up by DSOs as a matter of course.

Range of “System Defence and Restoration” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 2 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Geography** - DSOs and the need for more extensive whole system and non-traditional approaches to System Defence and Restoration functionality may be focussed in areas with high levels of DER penetration with traditional approaches persisting in other areas. Alternatively, updated approaches may be in place across all service areas.

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2. **Opportunities for Islanded Arrangements** – There may be largescale opportunities to island areas in the event of system disturbances. Alternatively, these opportunities may be few.

8.6 Service/Market Facilitation

Long Term												
Service/Market Facilitation	5	4	5	4		5		4	3	5	4	4
[Total score = 43]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – Requirements signposting and service procurement is now a core functionality of the DSO. Missing markets stimulated to help enable a more cost effective energy system. Delivery through services considered on a par with traditional reinforcement, where commercially viable.

- **Forecasting** – Significant competence in understanding system service requirements across a number of timescales.
- **Regulation Codes/Frameworks** – Service and market facilitation at the heart of regulatory regime.
- **Commercial Relationships & Whole System Pricing** – Mature markets and pricing models have enabled development of the energy system to be enhanced through the procurement of services.
- **Whole System Co-ordination** – Good alignment across T & D, including well thought out service design has reduced conflict.
- **Contractual Arrangements and Service Compliance** – A range of services are managed to support the interactions required for full DSO operations.
- **Outage Planning** – Services used to mitigate outages and planned around maximising accessibility to markets.
- **Data Management** – Good understanding of what data is required and by whom.
- **Settlement** – Systems in place to settle multiple services across multiple providers.
- **Customer Account Management** – Customer interaction is strongest in areas where service delivery is key to enhancing the network.
- **Change Management** – Market drives majority of changes within the value chain and DSOs are quick to implement changes to enable further service delivery models.

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Range of “Service/Market Facilitation” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 4 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Geography** – The development of markets will be focussed in areas with high levels of DER penetration with traditional approaches persisting in other areas. Alternatively, updated approaches may be in place across all service areas.
2. **Volume, Complexity and Interaction with Local Energy Arrangements** – Such arrangements could include local energy markets, community energy schemes, peer to peer arrangements, smart city schemes etc. In the mid 2020’s the numbers and complexity of local energy arrangements may still be very limited or, alternatively, they may in place in most Grid Supply Point networks.
3. **Level of Active Participation** – In some areas of networks, there may be limited amount of customers pursuing active participation so there may be a reduction in the level of market functionality required.
4. **Capability of Passive Networks** – Networks that do not have any distribution network constraints will have a limited requirement for services. Networks without constraints will also be more able to accommodate transmission response services, which are required to operate with a high availability.

8.7 Service Optimisation

Long Term												
Service Optimisation	3	3	5	5	4	5	5	4	3	5	3	4

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<p>[Total score = 49]</p>	<p>Forecasting</p>	<p>Regulatory Codes/Frameworks</p>	<p>Commercial Relationships & Whole System Pricing</p>	<p>Whole System Co-ordination</p>	<p>Power System Analysis</p>	<p>Contractual Arrangements & Service Compliance</p>	<p>Dispatch</p>	<p>Outage Planning</p>	<p>Data Management</p>	<p>Settlement</p>	<p>Customer Account Management</p>	<p>Change Management</p>
<p>Reference Case 1 (DSO Roadmap case) – DSOs are using available services in a co-ordinated manner to manage their own risks and contribute to resilience on a whole system basis.</p> <ul style="list-style-type: none"> • Forecasting – Some inconsistency between network operators exists around ability to define and manage service requirements. Broad understanding of requirements. • Regulation Codes/Frameworks – Clear guidance within codes and frameworks as to the management and optimisation of services. • Commercial Relationships & Whole System Pricing – A fully development market allows investment in building network flexibility where this is appropriate and procuring it where the market can deliver it most competitively. • Whole System Co-ordination – DSO service requirements are well aligned with TSO requirements. TSO requirements are supplied outside of constrained distribution areas. • Power Systems Analysis – Ability for network flexibility and DER services to address network constraints is analysed and well understood across a number of time frames. • Contractual Arrangements and Service Compliance – Significant ability in co-ordinating services across networks and ensuring service provision is compliant. • Dispatch – Reliable dispatch systems in place to run a co-ordinated network. • Outage Planning – Services used to mitigate outages and outages planned around maximising accessibility to markets. • Data Management – Good understanding of what data is required and by whom. • Settlement – Systems in place to settle multiple services across multiple providers. • Customer Account Management – Volume of customer management will be proportional to amount of services required on a network. • Change Management – DSOs rapidly respond to changes in the markets in order to maximise the value and ensure system is secure. 												

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Range of “Service Optimisation” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 2 of these are outlined below and should be considered in the construction of DSO reference models.

1. **Competitiveness** – In areas of greater competition within the service market, the requirement for network operators to invest in additional network flexibility will be reduced.
2. **Geography** – There may be certain parts of networks which are less attractive for external investment and require additional network operator owned flexibility to be provided.

8.8 Charging

Long Term												
Charging	3	5	5	5		5			4	5	4	4
[Total score = 40]	Forecasting	Regulatory Codes/Frameworks	Commercial Relationships & Whole System Pricing	Whole System Co-ordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Reference Case 1 (DSO Roadmap case) – Charging methodologies have been updated to fully reflect DSO operations. Balance of costs equitably and fairly split across all customers connected to the network.

- **Forecasting** – Little volatility in charging should require only broad forecasting for charging.
- **Regulation Codes/Frameworks** – Principles outlined in the regulation enables well defined frameworks to be created.
- **Commercial Relationships & Whole System Pricing** – Pricing and commercial models are mature and well aligned to customer & network requirements.

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- **Whole System Co-ordination** – Mature levels of co-ordination across transmission and distribution networks allow charging to be levied fairly.
- **Contractual Arrangements and Service Compliance** – Contracts and services are integrated with the charging methodologies and enable costs to be well understood.
- **Data Management** – Volumes of data exchanged between parties to enable charging activities.
- **Settlement** – Systems in place to settle charging for entire system.
- **Customer Account Management** – Management of customers through existing channels.
- **Change Management** – Full impacts of alterations to the various charging methodologies well understood and assessed before implementation.

Range of “Charging” Functionality

There are several dimensions that would affect the shape of this function in long term timescales (long term equates to RIIO-ED2 timescales, around 7 years from now). 2 of these dimensions are outlined below and should be considered in the construction of DSO reference models.

1. **Variability of Power Flows** – Areas of network which have significant power swings and large amounts of intermittency may require different charging regimes.
2. **Activity of local energy markets** – The presence and activity of local energy markets may influence the charging revenues in particular areas.

9. Potential Further Product 2 Work

The DSO function and competence framework developed under Product 2 could be further utilised to support DSO development. Areas of work that were identified through the work but not yet progressed are listed below. Some of these areas may be further explored as part of the smart grid architecture modelling (SGAM) to be carried out under Products 3 and 4 but further work using the function and competence framework may also be useful.

- **DNO Self Assessment** – The initial scoring carried out and detailed in this report is based on best practice across the GB DNOs. A more extensive scoring of DSO functional competence across each of the DNOs using the framework would achieve a more accurate current position. It would also help us to understand differences between DNOs and examples of best practice that to share across DNOs.
- **Ongoing Work to Improve DSO Functions and Competences** - Many projects are already ongoing to improve DNO capability in specific areas relating to DSO development. These include projects funded under the mechanisms Ofgem have put in place (NIA, NIC). If relevant projects are identified and reviewed, their value in developing DSO capability could be captured and better understood.
- **Further Stakeholder Review** – The feedback provided by the Stakeholder Advisory Group has been very valuable in developing the DSO function and competence framework. It is the only external feedback received to date. Further stakeholder feedback on DSO requirements and on current DNO capability across functions and competences would be useful. Some information might be drawn from recent and ongoing stakeholder surveys. However, more focussed sessions with specific stakeholders would be useful.
- **DSO Reference Models** – The Use Cases presented in this report are based on the DSO Roadmap recently published as part of Product 1. If a small number of DSO models can be described, the functional requirements for these could be mapped against the DSO function and competence framework and the gaps to current DNO capability identified.
- **“No Regrets” DSO Development** – It is likely that many elements of DSO functions and the underpinning competences could be developed with little likelihood of regret. For example, if there are elements common to many different DSO reference models, these could be taken forward.
- **More Focussed Development and Innovation Work** - To help build the requirements for future DSO functionality, projects could be scoped to address gaps where work is not already underway.

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10. Conclusions

Product 2 has produced a framework based on eight potential DSO functions. These functions cover a likely range of activities that future GB DSOs may need to carry out depending on the further growth of DER, the need to access flexible resources and regulatory frameworks and incentives.

The functions are System Co-ordination, Network Operation, Investment Planning, Connection & Connection Rights, System Defence & Restoration, Service/Market Facilitation, Service Optimisation and Charging. The extent to which these may be required by DSOs will vary on a regional or market basis. For example, DSOs seem likely to be carrying out increased activities around System Co-ordination and Service/Market Facilitation but there may be less requirement to develop further System Defence & Restoration functionality.

The maturity of each function can be measured by relating underlying competences to the delivery of each function. Twelve competences have been identified and mapped to each function. The level of each competence (measured from 1 to 5) allows a simple means to compare current DNO capability with future required DSO capability. Depending on future DSO models, a gap analysis for each DSO function and competence can help us to understand how and where DSO organisations need to be developed.

The gap between current DNO functionality and the DSO functionality envisaged through the Product 1 DSO roadmap is summarised below.

System Co-ordination	3	4	4	3		3	4		3	5	4	3
Network Operation	4	3	3	3	2	3	3	3	3		3	3
Investment Planning	2	2	3	4	2				2		3	3
Connections & Connection Rights		2	4	3	1	3		3	1		4	2
System Defence and Restoration	3	2	3	3	2	2	2	2	2		3	2
Service/Market Facilitation	4	4	3	3		4		4	2	4	3	2
Service Optimisation	2	2	3	4	4	4	4	2	2	4	2	2
Charging	3	4	4	4		3			2	2	3	3
	Forecasting	Regulatory Codes & Frameworks	Commercial Relationships & Whole System Pricing	Whole System Coordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Functional and System Requirements

In developing the framework of DSO functions and underlying competences, feedback has been provided by members of the Open Networks Workstream 3 group and by the Stakeholder Advisory Panel. As this has led to the revision of functions and the inclusion of additional competences, it is likely that further review of the framework will lead to further refinement. Some ideas to achieve this are included in section 9 of this report.

At this stage, further work to better understand the gaps and the early requirements for DSO development should be guided by likely DSO reference models. The work reported done here will provide an input to the SGAM modelling to be carried out as part of Workstream 3 Products 3 and 4. As this SGAM work is progressed and as DSO reference models become more clear, there will be value in applying the framework of DSO functions developed here to better understand requirements and to establish further actions to achieve DSO.

Appendix A – DSO Functions (Version 7 - Includes changes identified through the assessment of DSO market models)

No.	DSO Functions	Description	Activities	Description
1	System Co-ordination	Operate local and regional areas and co-ordinate energy and power transfers with other networks and systems to enable whole system planning, operation and optimisation across different timescales. System Co-ordination could include local actions to support thermal, voltage and frequency management across networks including actions to minimise losses, manage constraints and provide capability.	Co-ordination with GB System Operator	Managing MW and Mvar demand and generation within a local network area and managing exchanges to and from the GB transmission system within agreed technical and commercial limits.
			Co-ordination with other DSOs and Distribution Networks (including IDSOs)	Managing MW and Mvar demand and generation within a local network area and managing exchanges to and from other distribution networks within agreed technical and commercial limits. These distribution networks will include networks operated by the same DSO, other DSOs, DNOs and Independent DNOs.
			Co-ordination with local energy systems including industrial networks, community schemes, smart cities etc.	Managing MW and Mvar demand and generation within a local network area and managing the interfaces to local energy systems and arrangements within agreed technical and commercial limits. These local energy systems and arrangements might include community energy arrangements, smart city arrangements as well as the private networks used to supply industrial complexes.
			Co-ordination of networks to enable cross vector energy exchanges.	Managing the distribution network so that cross-vector energy exchanges are facilitated where these are acceptable technically and commercially.
			Co-ordination of local network services.	Contributing to the management of other networks and wider systems (e.g. transmission voltage management, overall frequency management) through the facilitation and co-ordination of local network services provided by DER.

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No.	DSO Functions	Description	Activities	Description
2	Network Operation	<p>Operate the electricity distribution network to maintain a safe and secure system. Ensure that network powerflows remain within limits and that the network operates within acceptable voltage limits. Ensure that the network remains secure against credible events such as circuit trips and generation loss. Identify and manage current and future risks.</p> <p>Coordinate and collaborate with Great Britain System Operator (GBSO) to manage potential conflicts to support whole system optimisation. Respond to customer needs.</p>	Operate network within thermal ratings.	Use network asset rating and powerflow information and operate local distribution network assets within ratings.
			Operate network within voltage limits.	Model network powerflows and operate distribution network assets within secure voltage limits.
			Operate network to maintain dynamic stability.	Operate distribution networks such that the network and its connected resources (e.g. generators) remain stable for secured faults.
			Operate network within fault level limits	Model network infeeds and contingencies to ensure that equipment and connected resources remain within short circuit ratings and within protection limits.
			Operate network to meet other power quality criteria.	Review and monitor potential for other power quality problems including harmonics and unbalance and operate network to avoid these.
			Operate network taking account of ongoing asset condition.	Monitor the condition of assets and adjust operation on the basis of latest condition.
			Operate network to minimise losses.	Model network powerflows to ensure that losses on distribution network are minimised.
			Enable network outages to provide access to assets and resources.	Forward planning and ongoing operation to ensure that network security is maintained during network outages and outages of key DER.
			Optimised use of assets and dispatch of services	Utilise available resources in the most efficient way to operate within network limits.

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No.	DSO Functions	Description	Activities	Description
3	Investment Planning	<p>Identify capacity requirements on the distribution network and secure the most efficient means of capacity provision to customers.</p> <p>Co-ordinate with the GBSO and Transmission Owners to identify whole system options. These would include commercial DER options as well as distribution network investment.</p>	Traditional investment planning	Offering connections and upgrades for new customers and for load growth based on the provision of network asset based solutions.
			Whole system planning	Coordinate with the GB System Operator and Transmission Owners to determine the most efficient options for whole system optimisation.
			Non-traditional investment planning	Providing alternative solutions to traditional asset based investment including ANM systems to manage areas of constraint, DER contracts and despatch etc.
			Security of supply (D&G)	Ensuring security of supply and network resilience is maintained in accordance with regulatory planning and design codes.
4	Connections & Connection Rights	<p>Provide fair and cost effective distribution network access that includes a range of connection options that meet customer requirements and system needs efficiently.</p>	Connection agreements	Providing connections for customers with defined terms and conditions for network access. Defining the roles and responsibilities for each party involved in the connection.
			Connection access rights/principles/information	Agreeing how capacity constraints on the transmission and distribution networks that affect all customers will be managed by network operators and how this information will be disseminated.
			Queue management/priorities	Managing clear, consistent and non-discriminatory arrangements for how customers waiting for new capacity will be treated.
			Commercial arrangements for constraints	The mechanisms for managing network constraints through commercial means.

No.	DSO Functions	Description	Activities	Description
5	System Defence & Restoration	<p>Enhance whole system security through the provision of local and regional flexible services. Provide system resilience to very low probability but high consequence events using risk based approaches. Provide the means to re-establish the wider synchronous area in the event of widespread disruption.</p>	Loss of Mains & other Protection Arrangements	Ensuring the design and implementation of DER connection arrangements that have adequate resilience to network disturbances. This includes the specification of connection interface protection arrangements (including Loss of Mains) and compliance testing.
			Network Contingency Planning for High Impact Low Probability (HILP) Events	Forward planning to ensure network has the capability to remain resilient against high consequence events such as extreme weather.
			Resilience (Voltage Reduction, LFDD, HFGD)	Providing whole system network resilience and defence through the design and implementation of mechanisms including Voltage Reduction, Low Frequency Demand Disconnection (LFDD) and High Frequency Generation Disconnection (HFGD).
			Resilience (Islanding)	Providing local and whole system network resilience and defence through the design and implementation of islanding mechanisms to enable local areas of network to remain in service in the event of a wider system incident.
			Black Start	Enabling whole system network re-establishment following a major system incident through the staged energisation of local networks. This could include the block loading of larger generators as part of wider Black Start plans.

Functional and System Requirements

No.	DSO Functions	Description	Activities	Description
6	Services / Market Facilitation	<p>Interface with the GBSO and other network operators to enable the development of distribution capacity products, the creation and operation of local network service markets and to enable DER access/participation in wider services for whole system optimisation.</p> <p>Facilitate local and national markets to access and settle services through auctions and other market arrangements for whole system efficiency. Ensure these arrangements are fair and transparent.</p> <p>Provide information and control system infrastructure to facilitate local and national markets and service provision.</p>	<p>Define distribution network service requirements including scope, timescale and locational aspects.</p> <p>Assess value and facilitate services to utilise flexibility sources to support distribution network operation.</p> <p>Facilitate the operation of Distributed Energy Resource Management systems (DERMs) and Local Energy Markets (LEMs) that are transparent.</p> <p>Interaction with aggregators and other non-traditional actors.</p> <p>Support the implementation of non-traditional market models for local energy supply.</p> <p>Service conflict mitigation/resolution.</p> <p>T-D co-ordination for transparent and consistent whole system outcomes</p>	<p>Establish the principles behind the planning, contracting and despatch of services to support distribution network operation. Sign post requirements for services through information provision. Define service requirements including scope, location, timescales and technology aspects.</p> <p>Assess the value of flexibility for distribution network operation and sign post requirements. Facilitate services and markets to provide flexibility.</p> <p>Put in place the infrastructure / platforms that enable network operators to access the technical capability of DER and to commercially optimise and settle payments for DER services.</p> <p>Enable the operation of new market roles (e.g. aggregators) within the GB energy systems. This may include commercial and regulation requirements and the provision of information/data exchange.</p> <p>Enable the operation of non-traditional business models within the GB energy systems (e.g. local energy markets, peer to peer trading). This may include commercial and regulation requirements and the provision of information/data exchange. Provide information to enable settlement of these markets.</p> <p>Identify, manage and mitigate service conflicts (e.g. GBSO and DSO use of resources). Enable sharing of services where feasible.</p> <p>Enable a more co-ordinated approach to the operation of services and markets and enable consistent whole system outcomes through enhanced Transmission and Distribution visibility, co-ordination and control.</p>

Functional and System Requirements

No.	DSO Functions	Description	Activities	Description
7	Service Optimisation	Ensure system needs can be efficiently met across all timescales by identifying network requirements, understanding the limitations of network assets and providing network access for additional flexibility services from smart solutions and DER services. Ensure whole system optimisation and resilience through the optimal selection of flexibility services.	Smartgrid network flexibility	Enable flexibility services through novel utilisation of existing network components.
			Service access management	How services will be selected and managed by network operators depending on capacity constraints. Includes prioritisation methodologies (e.g. LIFO, technical best, economic best).
			Service selection	Transparency of decisions and actions when choosing the optimal selection of flexibility services. May include a framework/rules/criteria.
			T-D co-ordination	How issues and solutions on both T & D are co-ordinated to enable efficient whole system outcomes.
			Conditions/process of market failure	Identifying when last resort provisions should be enacted.
			Regulation & competition frameworks	Identifying the rules for managing and remunerating last resort service provision. Putting in place methodologies to ensure that these continue to be efficient against other solutions.
8	Charging	Sets Distribution Use of System prices for local network Determines Point of Connection Determines connections charges and informs of Transmission reinforcement charges (if applicable) Consideration to Exit Charging (dependent on size, variations and apportionment)	Distribution Use of System Charges	Sets Distribution Use of System prices for local network
			Determines Point of Connection	Designs incremental capacity increases on the network
			Determines Whole system reinforcement charges	Reflecting transmission charges and distribution costs in whole system charges.
			Exit Charging (dependent on size, variations and apportionment)	Management of transmission costs at the GSP

Appendix B – DSO Competences (Version 6)

Competence	Description	Attributes Include	Scoring
1) Forecasting	Development of consistent, repeatable and auditable methodologies in operational and investment timescales for forecasting demand, generation, network power flows and the requirements for DSR & flexibility.	<ul style="list-style-type: none"> - Long term trending info maintained. - Know masked demand/true demand. - Forecasting DER outputs for intermittent and weather dependent technology types. - Forecasting network equipment capability as weather conditions change. - Provides info to market participants. - Short-term forecasts linked to contracting requirements, resilience actions etc. - Comprehensive long term forecasts aligned with other network operators. - Real time system with operational forecasts being updated on a regular basis. 	<ol style="list-style-type: none"> 1) Some competence through traditional activities, capabilities and in-place systems. 2) Understand emerging forecasting needs with some tactical solutions in place to address. 3) Broad understanding of op & inv requirements with measures in place to provide capability. 4) Very strong in some areas but some gaps exist. Inconsistency between network operators. 5) Fully functional forecasting capability in operational & investment time-frames. Seen as authoritative in service area.
2) Regulatory Codes & Frameworks	Capability to develop existing licenses, industry codes and policies to facilitate DSO operations.	<ul style="list-style-type: none"> - Manage incremental changes to, and industry interactions for, existing codes/frameworks. - DSO requirements are well described in codes and DSOs can interpret and deliver these. - Clear and transparent rationale for decisions. - Actively identifying issues & driving change to meet industry developments. - Expert interactions with Gov't, Regulators. - Reporting and regulatory KPIs in place. - Expert understanding and integration of international codes and policies. 	<ol style="list-style-type: none"> 1) Some knowledge of likely DSO requirements based on current approach. 2) Good description of DSO accountabilities within codes and frameworks. 3) Competent, clear understanding of req'ts and responsive to code developments. 4) On top of DSO codes & framework req'ts. Actively identifying and driving code change. 5) Extensive capability through organisation. Authoritative, leading GB & wider debate.

Competence	Description	Attributes Include	Scoring
<p>3) Commercial Relationships & Whole System Pricing</p>	<p>Understanding and defining the different commercial relationships between the parties operating in the electricity system.</p> <p>Ensuring operational and investment decisions are fully understood and support delivery of cost effective and economic network.</p>	<ul style="list-style-type: none"> - Whole system cost and benefits understood including network and non-network costs. - Commercial positions across industry well understood. - Good process for options assessment. - Totex, whole life based approach. - Future optionality recognised in benefits. - Reduction in likelihood of stranded assets. - DSO business model(s) clear. Understand what models are appropriate for service area. - Ongoing review of market delivered costs against network derived services. - Ensuring balanced costs/incentives are spread across stakeholders. - Technical best deployment of services. 	<ol style="list-style-type: none"> 1) Recognition of emerging commercial drivers including DSO opportunities. Some decisions (inv or op) take account of pricing information. 2) Developing new commercial opportunities and relationships in some areas. Pricing of DER and other D options better understood. 3) Commercial relationships established and strong over service area. Good availability and use of pricing information for different T & D oper & inv options. 4) Wide range of incentives and remuneration mechanisms for DSO operation. High degree of confidence in efficiency of oper & inv options. 5) Mature and appropriate DSO models being implemented in different areas. Full use of T & D options with full understanding of costs.
<p>4) Whole System Coordination</p>	<p>Transmission and distribution collaboration on investment and operational decisions to better facilitate whole systems outcomes.</p>	<ul style="list-style-type: none"> - Exchanging T-D data to ensure smooth system operation and efficient investment. - Processes in place to optimise whole system operation and investment. - Skills and methodologies in place to review network decisions across the t-d boundary. - Wide-scale use of D connected flexibility to mitigate T and D network issues. - Simple customer interfaces encompassing T & D for system access and service provision. 	<ol style="list-style-type: none"> 1) Occasional whole system approaches with limited exchange of data. 2) More frequent whole-system assessment to address problems. Can articulate benefits. 3) Operational & Investment processes reviewed, agreed and in regular use. 4) Well developed skill-sets in T & D organisations. Customers see good T & D alignment. 5) Mature processes with little differentiation between T&D assets and services.

Competence	Description	Attributes Include	Scoring
<p>5) Power System Analysis</p>	<p>Capability to carry out network powerflow analysis in operational and network investment timescales to inform network security and investment decisions.</p>	<ul style="list-style-type: none"> - Watts (thermal) & VAr (Voltage) analysis. - Mature management of network and user data with accurate network models in place. - Modelling of high & medium voltage assets. - Modelling of customer assets, DER. - Identify key network risks and contingencies. - Carry out analysis taking a whole system perspective on security (NETS SQSS, P2 etc). - Can deal with high volume of power system analysis work across voltages. - Dynamic analysis capability (e.g. transient, generator stability etc). - Quality of Supply (harmonics, unbalance etc). - Demand response to network conditions. 	<ol style="list-style-type: none"> 1) Some analysis capability through ongoing work and in-place systems. Limited case analysis. 2) Developing analysis capability in key areas to support immediate challenges. 3) Broad capability across different types of analysis. Deals with significant volumes of analysis. Includes some dynamic analysis. 4) Very strong analysis capability in many areas and including real time. But some gaps remain. 5) Full analysis capability in op & inv time-frames. Recognised as expert across industry.
<p>6) Contractual Arrangements & Service Compliance</p>	<p>Creation, development, administration and management of contractual arrangements to support the interactions required for DSO.</p> <p>Ensuring that services are provided as contracted when instructed.</p>	<ul style="list-style-type: none"> - Standard conditions & terms developed and in place to manage connection & services. - Managing a range of connection contracts. - Range of service contracts in place to manage network requirements (duration etc). - Operating qualification & tender processes. - Range of incentives & compensation in place. - Deals with non-compliance and non-delivery. - Checks to ensure that service providers are capable of providing the contracted response. - Checks/monitoring to ensure that services have been delivered when called. - Good understanding of contract terms across planning and operational functions. - Managing significant volumes of contracts and counter-parties. 	<ol style="list-style-type: none"> 1) Traditional connection contracts in place. Some contract management competence through traditional DNO activities. 2) Range of connection options in place that are well understood by customers. Have identified and specified some DSO service requirements. 3) Recognise & communicate future service req'ts. Building up capability to deal with extra volume. Some monitoring of service provision. 4) Testing of service capability ahead of operation. Dealing with greater contract volumes and types over different timeframes. Measures to address service non-provision. 5) Full contract capability with skills and volume in place to manage range of DSO activities. Checks that services have been provided when called.

Competence	Description	Attributes Include	Scoring
7) Dispatch	Instructing third parties in planning and operational timescales to adjust output and then inform the market of actions being taken.	<ul style="list-style-type: none"> - Method of placing instructions in place. Could be via control engineer action or automatic. - Ensuring speed of response is appropriate for the service required. - Pre-instruction analysis for security and service interactions - Linkages to commercial systems. 	<ol style="list-style-type: none"> 1) Some limited capability to instruct DER. May be via control engineer. 2) Wider use of instructed DER capability. 3) Wide scale use of dispatch instructions guided by security & commercial optimisation. 4) Automated dispatch systems in place. 5) Well developed and reliable dispatch systems in place. Co-ordinated with other systems.
8) Pricing	Incorporated into Competence 3		
9) Outage Planning	Planning network outages that reduce the impact on customers accessing the network, whilst ensuring the network remains secure.	<ul style="list-style-type: none"> - Planning windows appropriate to outage requirements. - Use of DER and other flexibility to mitigate outage impacts. - Ongoing DSO-customer channels for outages. - Customer expectations of system access and outage management are clear. - Quantification of outage costs to customers and justification of approach. - Ensuring network unavailability impacts fall equitably on customers and network operators. 	<ol style="list-style-type: none"> 1) Some outages managed to limit impacts on larger customers. 2) Regular interactions with customers to minimise and explain outage impacts. 3) Principles and methodology developed and in place to manage wider outage plan. 4) Can demonstrate active outage management across stakeholders to minimise impacts. 5) Fully optimised outage management drawing on DER and other flexibility.

Competence	Description	Attributes Include	Scoring
10) Data Management	Having suitable systems to facilitate the information and data exchanges required to plan and operate as a DSO.	<ul style="list-style-type: none"> - Clear data requirements for DSO operation. - Capturing data at appropriate granularity. - Identifying and sourcing critical 3rd party data to support effective network operation. - Handling high volumes of DER data for DSO activities and to provide market information. - Providing 3rd party access to meet user needs. - Data available for whole system optimisation. - Data available for entire distribution network. - Systems sized for current & future req'ts. - Making best use of smart meter data. - Strong maintenance of data integrity. - Monitoring & testing supports data models. 	<ol style="list-style-type: none"> 1) Handling some DER and other data to support DSO investment and operations processes. 2) Simple data models and system in use. Handling new areas of data to support markets etc. 3) Good understanding of what data is required and what is not to support accurate decisions. Handling large-scale volumes of data. 4) Common data management systems in place across T&D and across network operators. Large-scale data available to 3rd parties. 5) Fully competent in managing and sharing large-scale volumes of data for DSO operation.
11) Settlement	Ensuring service providers are remunerated in a timely fashion for the services provided.	<ul style="list-style-type: none"> - Remuneration to market participants for services within agreed timescales. - Sound methodologies & auditable systems. - Well justified penalties where services have not been provided. - Handling over or under provision of service. - Ensuring market participants are returned to balanced position following DSO actions. - Managing payments across multiple markets and service providers. 	<ol style="list-style-type: none"> 1) Some experience of settling services. 2) Principles for settling specific services in place. 3) Local systems in place to settle specific services. 4) Principles and systems agreed across network operators to manage and settle services. 5) Well developed systems in place to settle a range of services across areas.
12) Contract & Service Compliance	Incorporated into Competence 6		

Competence	Description	Attributes Include	Scoring
<p>NEW –</p> <p>Customer Account Management</p>	<p>A strong customer ethos drives activity across the DSO organisation.</p>	<ul style="list-style-type: none"> - Strong and visible customer facing functions - Can manage a large volume of direct customer interaction - Customer needs are reflected back into DSO - Understands different customers – generators, demand side providers, local authorities, community schemes etc - Always considers interests of less active and less vocal customers - Offers flexible & tailored connection options - Offers flexible & tailored options to take services 	<ol style="list-style-type: none"> 1) Customer management largely based on a traditional model for new connections. 2) Increased volumes and types of customers being handled. Increased awareness of diverse customer requirements through DSO. 3) Actively managing a diverse range of customer types. 4) Strong customer ethos through DSO organisation. Managing high volumes of diverse customers. 5) Strong and flexible customer focussed DSO organisations in place with the ability to handle new customer and service types.
<p>NEW –</p> <p>Change Management</p>	<p>Adaptive and effective at implementing new learning and organisational change with sound risk management.</p>	<ul style="list-style-type: none"> - Can-do attitude across DSO - Fast innovation & development cycle - Look for and share learning across DSO organisations - Effective implementation of new learning - Innovates with a wide range of partners - Considers impacts of changes across organisation and stakeholders - Risks fully considered and mitigated 	<ol style="list-style-type: none"> 1) Utilises established innovation routes (NIA, NIC etc) to identify and test new approaches. 2) Any new learning to support DSO implementation is identified and implemented. 3) Innovation cycles are accelerated and changes to support DSO are implemented quickly. 4) Full impacts of changes are assessed and understood through the value chain with extensive stakeholder interaction. 5) DSOs are considered to be fast learning organisations with fast innovation cycles. Learning is shared across DSO organisations.

Appendix C – Initial Scoring

System Co-ordination	1	0	0	1		1	1		1	0	1	1
Network Operation	1	1	1	1	2	1	1	1	1		1	1
Investment Planning	2	2	2	1	2				2		1	1
Connections & Connection Rights		3	1	1	2	2		1	2		1	2
System Defence and Restoration	1	1	0	1	1	1	1	1	1		1	1
Service/Market Facilitation	1	0	2	1		1		0	1	1	1	2
Service Optimisation	1	1	2	1	0	1	1	2	1	1	1	2
Charging	0	1	1	1		2			2	3	1	1
	Forecasting	Regulatory Codes & Frameworks	Commercial Relationships & Whole System Pricing	Whole System Coordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Appendix D – Roadmap Scoring

System Co-ordination	4	4	4	4		4	5		4	5	5	4
Network Operation	5	4	4	4	4	4	4	4	4		4	4
Investment Planning	4	4	5	5	4				4		4	4
Connections & Connection Rights		5	5	4	3	2		4	3		5	4
System Defence and Restoration	4	3	3	4	3	3	3	3	3		4	3
Service/Market Facilitation	5	4	5	4		5		4	3	5	4	4
Service Optimisation	3	3	5	5	4	5	5	4	3	5	3	4
Charging	3	4	5	5		5			4	5	4	4
	Forecasting	Regulatory Codes & Frameworks	Commercial Relationships & Whole System Pricing	Whole System Coordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management

Appendix E – Transitional Scoring

System Co-ordination	3	4	4	3		3	4		3	5	4	3
Network Operation	4	3	3	3	2	3	3	3	3		3	3
Investment Planning	2	2	3	4	2				2		3	3
Connections & Connection Rights		2	4	3	1	3		3	1		4	2
System Defence and Restoration	3	2	3	3	2	2	2	2	2		3	2
Service/Market Facilitation	4	4	3	3		4		4	2	4	3	2
Service Optimisation	2	2	3	4	4	4	4	2	2	4	2	2
Charging	3	4	4	4		3			2	2	3	3
	Forecasting	Regulatory Codes & Frameworks	Commercial Relationships & Whole System Pricing	Whole System Coordination	Power System Analysis	Contractual Arrangements & Service Compliance	Dispatch	Outage Planning	Data Management	Settlement	Customer Account Management	Change Management