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DNO transition to DSO

February 2020

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

1. Foreword

The UK's electricity system is undergoing a rapid period of change as distribution network customers invest in generation and alter their consumption behaviours to affect a lower carbon future.

To enable a greater volume of demand, generation and storage to be connected, our networks are becoming smarter and more active. Creating a more efficient and flexible system will benefit all customers and empower them to be at the centre of the energy revolution.

We recognise that the change from a Distribution Network Operator (DNO) to a Distribution System Operator (DSO) is essential to driving performance and efficiency from our network and to ensure it can meet the future energy demands of all our customers. The enhanced capabilities we are developing will also give our customers the freedom to access other opportunities within the developing energy system.

Since our last update, we have been developing our Flexible Power product and now have many zones where a flexible solution is helping us manage network peaks.

We have also developed our plans for data and have published our 'Digitalisation Commitments' which demonstrates how we make best use of new and existing data to manage our networks.

Our industry-leading innovation work, combined with the years of experience of operating a highly-reliable and cost-effective distribution network, makes us uniquely placed to lead the management of an increasingly smart, flexible and efficient local electricity system as energy becomes more decentralised.

We view the planning and operation of a more active regional distribution network as a natural extension of our current role. With DSOs managing the co-ordination of transmission and distribution services at a local level, it enables the National Transmission System Operator (NETSO) to concentrate on balancing the national network using un-conflicted services competitively made available.

Through the Open Networks project, we are working to ensure that our approach, as we transition to the future energy system, is coordinated with other network and system operators.

We will continue to review our proposed actions and workplan in line with views received from our customers, other stakeholders, BEIS and Ofgem.

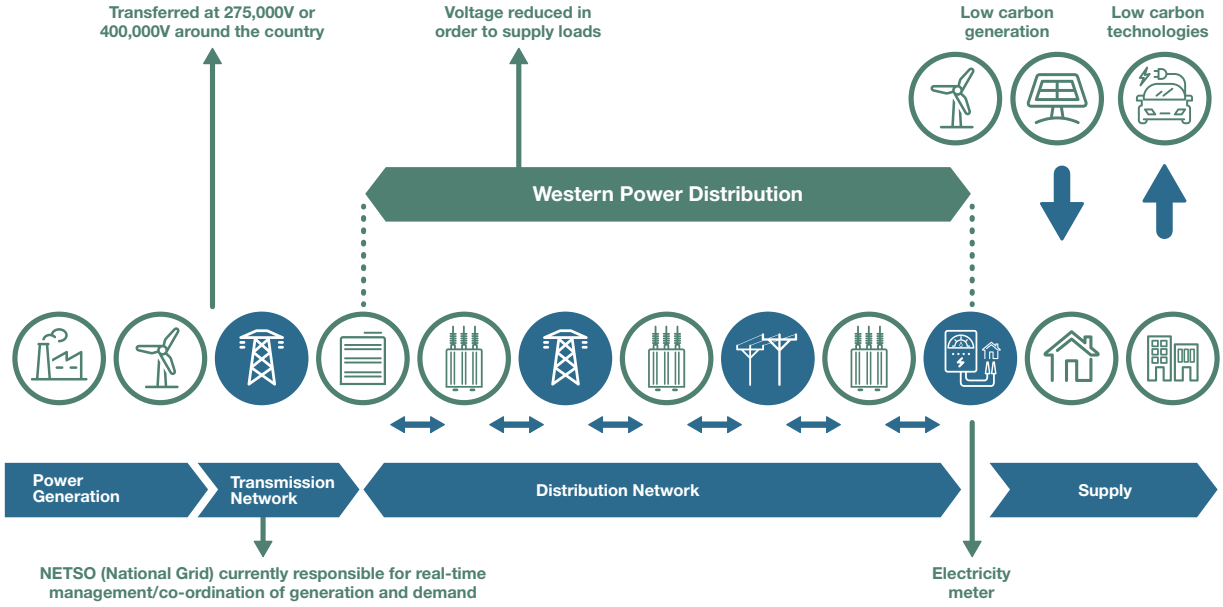
This document specifically includes updates based upon the ENA Open Networks Future Worlds document.

Phil Swift
CEO Western Power Distribution

2. Executive Summary

As WPD moves from being a Distribution Network Operator to a Distribution System Operator, it will carry out its existing functions and take on some new ones so as to:

- develop and maintain an efficient, co-ordinated and economical system of electricity distribution;
- facilitate competition in electricity supply, electricity generation and flexibility services;
- improve the resilience and security of the electricity system at a local level;
- facilitate neutral markets for more efficient whole system outcomes;
- drive competition and efficiency across all aspects of the system; and
- promote innovation, flexibility and non-network solutions.



With WPD, as a DSO, managing the co-ordination of services at a local level, the complexity and risk can be reduced for the National Electricity Transmission System Operator (NETSO), resulting in a more efficient and cost effective whole system.

As a regulated business with no interests in UK generation or supply, WPD views the facilitation of our customers into these neutral markets as a natural extension of our current role in managing the power across our distribution networks.

We are uniquely placed to ensure simple and consistent access to new markets for our active customers through maximising the utilisation of our existing electrical and communication networks. We are also able to use the flexibility inherent in our network to ensure all customers benefit; through both receiving a resilient and secure supply and through cost effective delivery.

Our investment of £125m to transition to a DSO will support the customer adoption of electric cars, low carbon heating and for further distributed generation. During ED1 we are investing £600m in reinforcing the network.

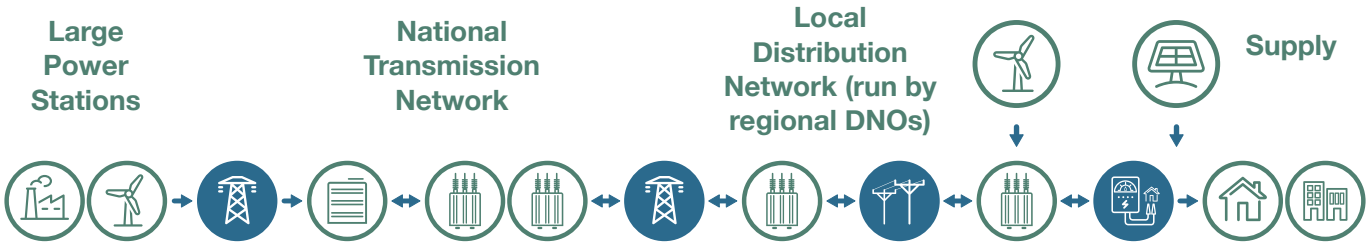
3. Contents

4. The Way Electricity is Sourced and Consumed is Changing

The energy system is changing. Many large power stations are closing as they come to the end of their lives to be replaced with smaller, and in many cases renewable, forms of electricity generation. These are often spread around the country, connected directly to the local distribution rather than national transmission electricity grid system.

Our industrial, commercial and domestic customers have also embraced government and regulatory incentives to install smaller scale generation at their own premises in the form of solar panels and other technologies.

The type of generation deployed is often intermittent in nature, making flows across the electricity network much more complex to predict.

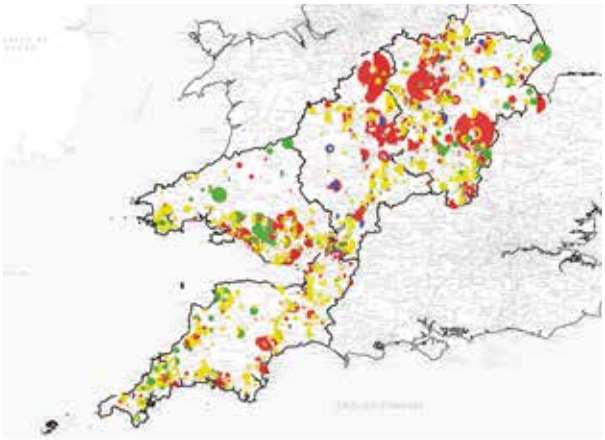


Many large power stations are closing as they come to the end of their lives.

Intermittent renewables and other forms of electricity generation are now directly connected to the local distribution network, rather than the transmission system. These types of generation deployed are often intermittent and much more complex to predict.

We also expect to see the rapid adaptation of new forms of electricity demand. Electric vehicles are quickly becoming mainstream. With a typical electric car using a similar amount of electric as an average domestic home, they have the potential to significantly alter the traditional daily energy usage profiles today's network was designed around. There are also new technologies emerging, such as battery storage and hydrogen, as well as heat pumps and electric heating that could further disrupt traditional energy use across the country.

4. The Way Electricity is Sourced and Consumed is Changing



Key

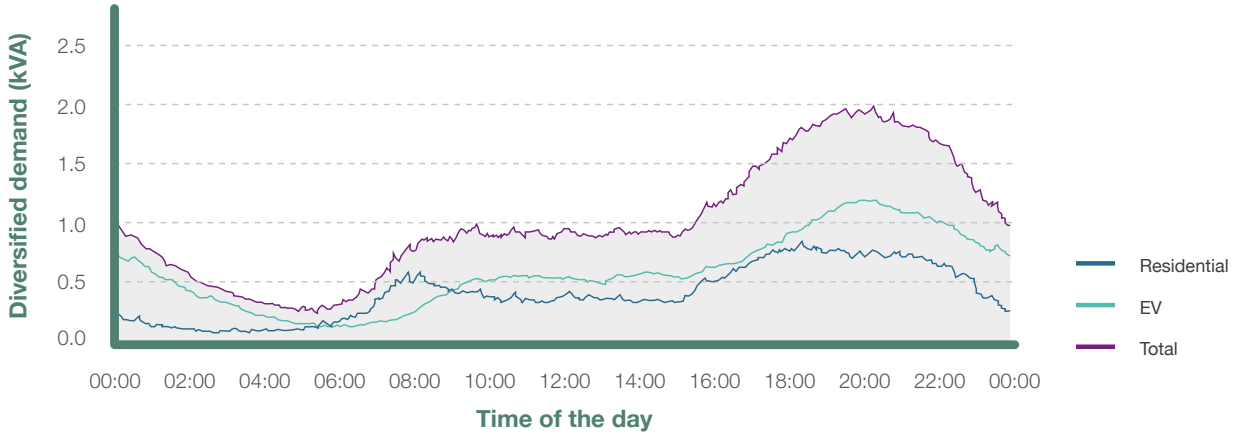
- Wind
- Solar
- Energy Storage
- Other

The map opposite shows the locations and types of generation connected and accepted connections to the networks in WPD over the past few years. Larger generators are depicted with a larger circle. The colour indicates the fuel type.

We also expect to see the rapid adoption of new forms of electricity demand. Electric vehicles are quickly becoming mainstream, with an electric vehicle becoming 'What Car of the Year in 2019'.

An electric car driving 10,900 miles a year would consume about 3,100kWh of electricity. This is the same amount as an average domestic home. They have the potential to significantly alter the traditional daily load profiles that today's system was designed around. We expect that tariff signals will help direct EV charging away from peak times.

Diversified domestic demand including EV charging

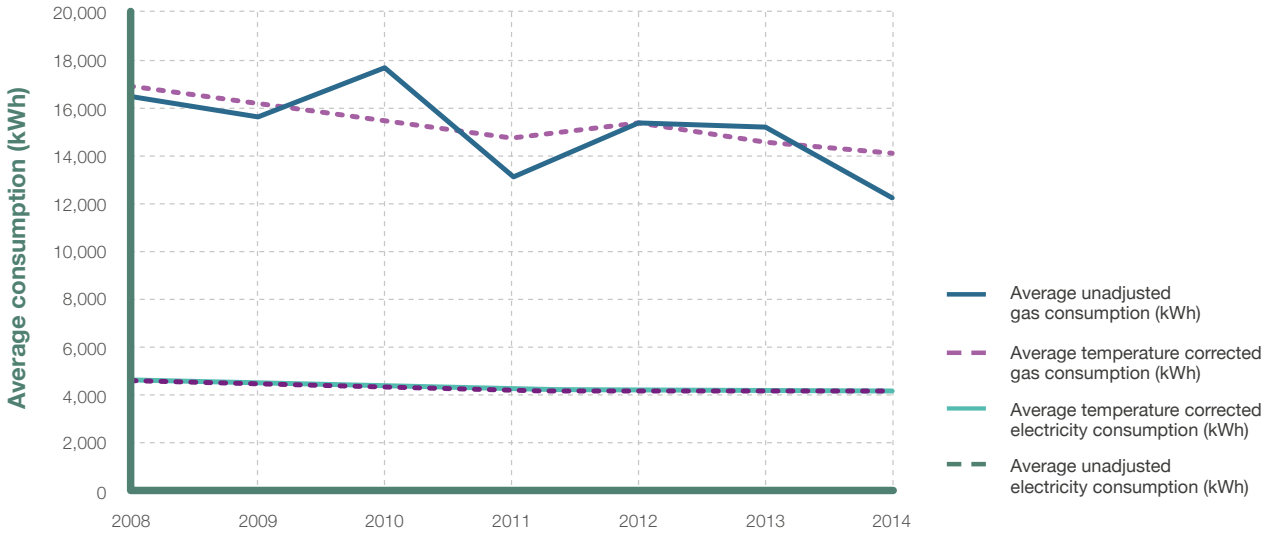


A critical element of meeting the UK's Net Zero commitments involves the decarbonisation of heat. The natural gas network delivers energy to over 80% of homes in the WPD region. An average duel-fuel customer uses about 12,500kWh of gas to heat their home and about 3,100kWh of electricity. Less than 10% of homes use electricity as the primary source of heating.

For the UK to achieve binding Climate Change targets most homes and businesses will need to switch to renewable forms of energy for their heating. In some cases this may be biomass, hydrogen or the development of district heating networks. Heat pumps and electric heating also have the potential to place additional electricity demand on the distribution network, although many homes would need improved insulation before they are suitable for a heat pump system.

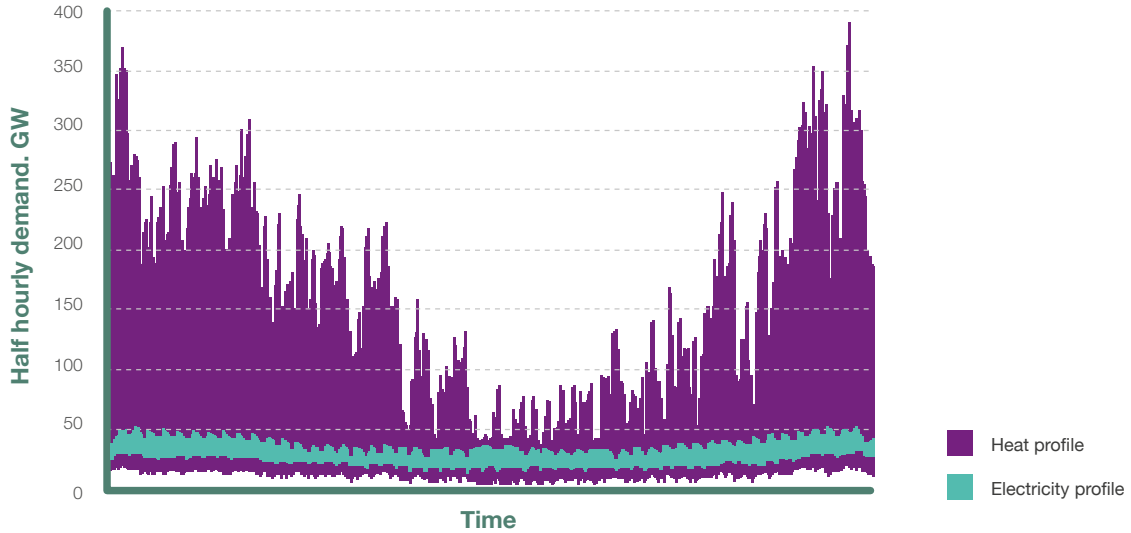
There is a natural seasonality to heating demand, but even in the summer months, electricity consumption could double if all gas systems were to be replaced with direct electrical heating systems for hot water.

Average domestic gas and electricity consumption in the UK



There are also new technologies emerging which could further disrupt traditional patterns of energy use across the country. For example, battery technologies of various sizes or new energy products such as hydrogen.

Half hourly heat and electricity demand profiles over 12 months period (from 1 January to 31 December '16)



4. The Way Electricity is Sourced and Consumed is Changing

As a consequence of these changes in how customers consume and produce electricity, DNOs have a greater need to forecast and actively manage energy flows across the network at all voltage levels.

The national electricity transmission system has traditionally had this level of active management at higher voltages coordinated by the Transmission System Operator, National Grid.

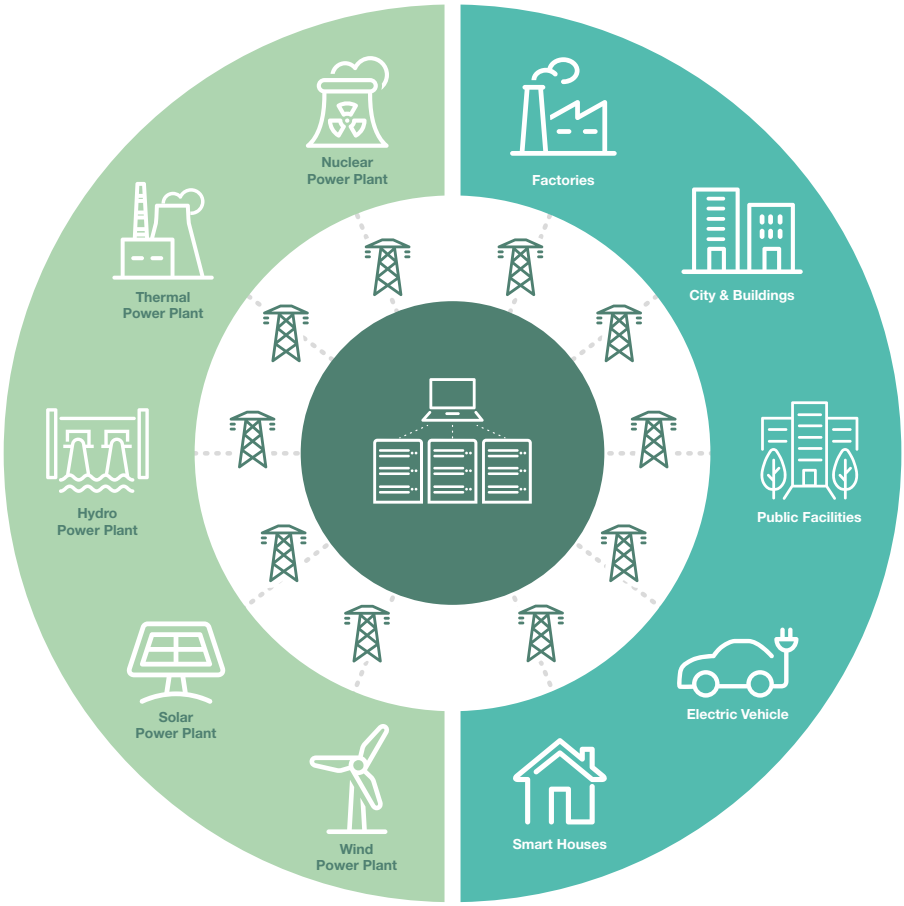
The principles of how a DNO can do this at a distribution level therefore have some foundation.

This shift in DNO roles and responsibilities will require a transition to a DSO.

The DSO will flex and manipulate the DNO network with sufficient capacity which blends more active energy management with targeted DNO infrastructure upgrades.

The technology underpinning the DSO network will be seamless and transparent to customers.

Importantly it will provide a platform for energy suppliers and other parties to deliver new and improved services to customers, at an acceptable cost.



WPD will provide a network with sufficient capacity which blends more active energy management with targeted infrastructure upgrades.

A changing energy network

To accommodate these changes whilst still operating as a passive DNO would require very substantial investments in grid infrastructure, which would be underutilised much of the time. Continued construction, maintenance and operation of passive distribution networks is no longer going to deliver the best outcomes for UK energy bill payers.

To ensure a cost-effective, efficient operation of the network, there is now a greater need to forecast and actively manage energy flows across the network. This will require DNOs to have better visibility of what is happening on the network and shift in the roles and responsibilities of DNOs - Distribution System Operations.

5. Electricity Networks Need to Adapt to Changing Use

Customers are using energy for new purposes with different patterns of consumption.

Transmission connected, centralised synchronous generation is being displaced by multiple small installations of intermittent asynchronous generation on the distribution voltages. The rate of adoption into distribution businesses is challenging the traditional design of networks, allowing security and capacity to increase, whilst keeping costs low. These drivers for system transformation are all operating simultaneously up and down the voltages, across multiple geographic areas, resulting in a rapid and unpredictable rate of change.

We have a track record in this area of accepting and connecting distribution level generation. Across the four WPD licence areas, we have re-engineered networks that were traditionally designed for 14GW of demand, to be able to accept a total of 21GW of embedded generation.

In order to facilitate the transition to a low carbon energy system, electricity networks will need to increase their role in supplying the energy needs of the UK. The electrification of heating and transport will see levels of electricity consumption rise and the networks are already responding to this, investing in core assets to ensure capacity is made available. During the period 2015-2023, WPD is spending over £7.1bn on managing and developing the network, £172m of which is specifically targeted at reinforcement to support low carbon technologies (LCTs). A further £50m is targeted at deploying smart grid technologies to further accommodate LCTs on our network.

However, the uncertain location, timing and uptake of this transition will mean that networks will need to quickly respond to the adapting needs of customers. Increasing the agility of the networks and their ability to deliver flexibility will be the key mechanism by which the energy system can deliver the changes in a timely, efficient and economic manner. Whilst the networks can deliver some flexibility, this will be supplemented by customers providing further flexibility, through the use of a range of technical and commercial mechanisms and contracts, developed by TSOs, DSOs and other market participants to achieve a secure, low cost electricity system.

Developing local energy markets and providing all customers within those geographic regions with the ability to participate will allow new entrants to balance the system and provide new signals to customers and energy system stakeholders on which generation and consumption behaviours are most harmonious to the networks.

As a DSO, WPD will co-ordinate the operation and interaction of the energy supply and demands of customers and assets on a localised basis, reducing the need to transmit energy over long distances and minimising the variability and volatility impacts on the NETSO.

21GW

Across the four WPD licence areas, we have re-engineered networks that were traditionally designed for 14GW of demand, to be able to accept a total of 21GW of embedded generation.

What our customers think

Developing the capability to leverage and coordinate customer provided flexibility, as well as maximising the flexibility inherently within the network will be an important part of operating a more active distribution system.

There was a clear consensus across our consultation responses that the DSO must be a neutral market facilitator and that by doing so, the flexibility will be delivered by whichever party is best placed to offer the required services at a competitive rate.

Our customers also felt that markets were likely to be able to provide sufficient flexibility at a competitive price in all circumstances and that DSO investment to provide their own non-network flexibility was not necessary.

How we are responding

WPD will not invest in its own non-network flexibility where it can be delivered more cost effectively through the market.

6. A Changing Role for WPD

WPD recognises the need to transition to a DSO mode of operation to support changing energy uses by customers and a more dynamic operation of networks. We think DNOs are well placed to become DSOs although there are steps we need to take to build the required capabilities.

Additional measurement equipment and data analytical solutions will first be deployed to those areas which have the most significant changes to their traditional use, or where we forecast a strong uptake of LCTs (such as electric cars, solar panels or heat pumps).

The additional equipment will allow us to optimise the network topology and create capacity in the network to accommodate changing use.

Innovative technological and commercial solutions will enable us to continue to provide an efficient, coordinated and economic network for current and future customers. It will allow us to best accommodate emerging system needs, be coordinated with neighbouring DSOs and interface better with the national transmission network.

Transitioning from a network based on passive operation enabled inherently through its design, into one in which demand and generation is balanced locally by a mixture of enhanced sensing with active technical and commercial mechanisms, is often called a smart grid. It will require significant change in our current role, but will facilitate a smarter energy system which can flexibly meet the needs of our users.

WPD has a large research and innovation programme to test new solutions before deploying them across the wider business. Since 2005 our Future Networks Programme has continually developed better ways of delivering network capacity and providing an improved service to customers.

We have developed significant competence in a number of key areas which fall under the umbrella of DSO operations:

- Our alternative connections suite has developed four additional options for customers seeking to connect to the grid (Timed, Soft-Intertrip, ANM and Export Limited). These are particularly useful in areas of constraint (where the connection cannot be accommodated without network reinforcement). The alternative connections suite combines both contractual and technical approaches. These methods of connection vary in cost and complexity and enable the solution to be tailored to the individual requirements of the customer. We have been able to develop these solutions within WPD to enable our internal systems to manage transmission level constraints and provide efficient, economic and timely access for customers.

- Our FALCON, SYNC and ENTIRE projects have demonstrated our ability to forecast, manage and dispatch both demand and generation turn up/turn down services and have been designed to do so in conjunction with National Grid, allowing customers full access to a number of markets providing revenue streams, whilst also minimising any risk of operating conflicting services.

- Several innovation projects have developed the new remote control, monitoring and telecommunications equipment we need to have a more detailed view of how assets are used. This ensures we get the best value from them, whilst avoiding a potential for them to become overloaded or unreliable.

- We also continue to test innovative equipment to be used on the electricity infrastructure itself. These include devices such as battery storage and power electronic based equipment (for example Flexible Power Links, Flexible AC Transmission systems and Fault Current Limiters).

Through implementation of our DSO strategy, WPD will ensure that our network, and our business, is embedded with the capability to deliver all the emerging system requirements our customers have, both now and in the future. By taking strategic decisions now, we can incrementally deliver this capability whilst maintaining enough flexibility that will equally enable a number of uptake scenarios without the risk of leaving assets stranded.

This transition will build on our Innovation Programme which is already delivering results for the benefit of our customers.

WPD has a large Research and Innovation programme that tests new solutions before deploying them across our regions. We have developed significant competence in a number of key areas which will help enable our transition to a DSO.

We have developed a suite of 'Alternative Connections' options for customers to connect to the grid in areas where capacity is constricted.

Our projects have demonstrated our ability to forecast, manage and dispatch both demand and generation 'turn up/turn down' services.

Several innovation projects have developed the new remote control, monitoring and telecommunications equipment we need to have a more detailed view of how assets are used.

We also continue to test innovative equipment to be used on electricity infrastructure itself, including battery storage, vehicle-to grid technology, and power electronic based equipment.

123MW

In 2018, we contracted with customers to provide 123MW of flexibility.

What our customers think

There was significant support from our consultation responses in agreeing that a move to DSO operations will be required to meet the future needs of WPD's customers. All our contributors either agreed or strongly agreed that this would be an essential role to be undertaken.

Industrial and commercial customers are already beginning to provide flexibility and this is expected to ramp up in scale in the very near future. Domestic customers are also likely to be able to participate as they invest in smart technologies within the home, albeit on a longer time horizon.

How flexibility should be accessed and commercially managed received varying views. There was general agreement that flexibility should be accessed through multiple market routes, with customers free to participate via their own chosen procurer or intermediary, however this needs to be a simple, transparent and reversible process.

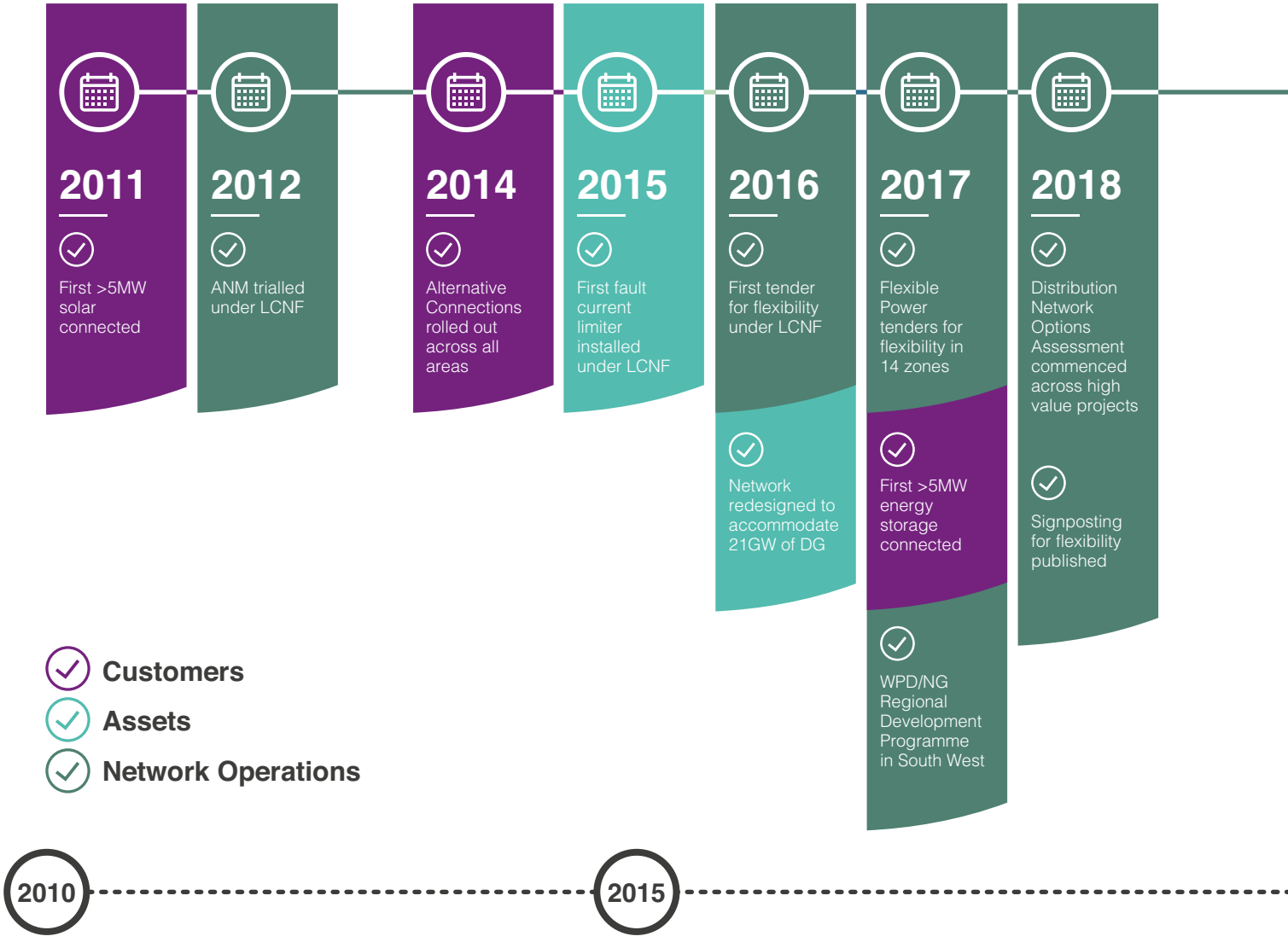
How we are responding

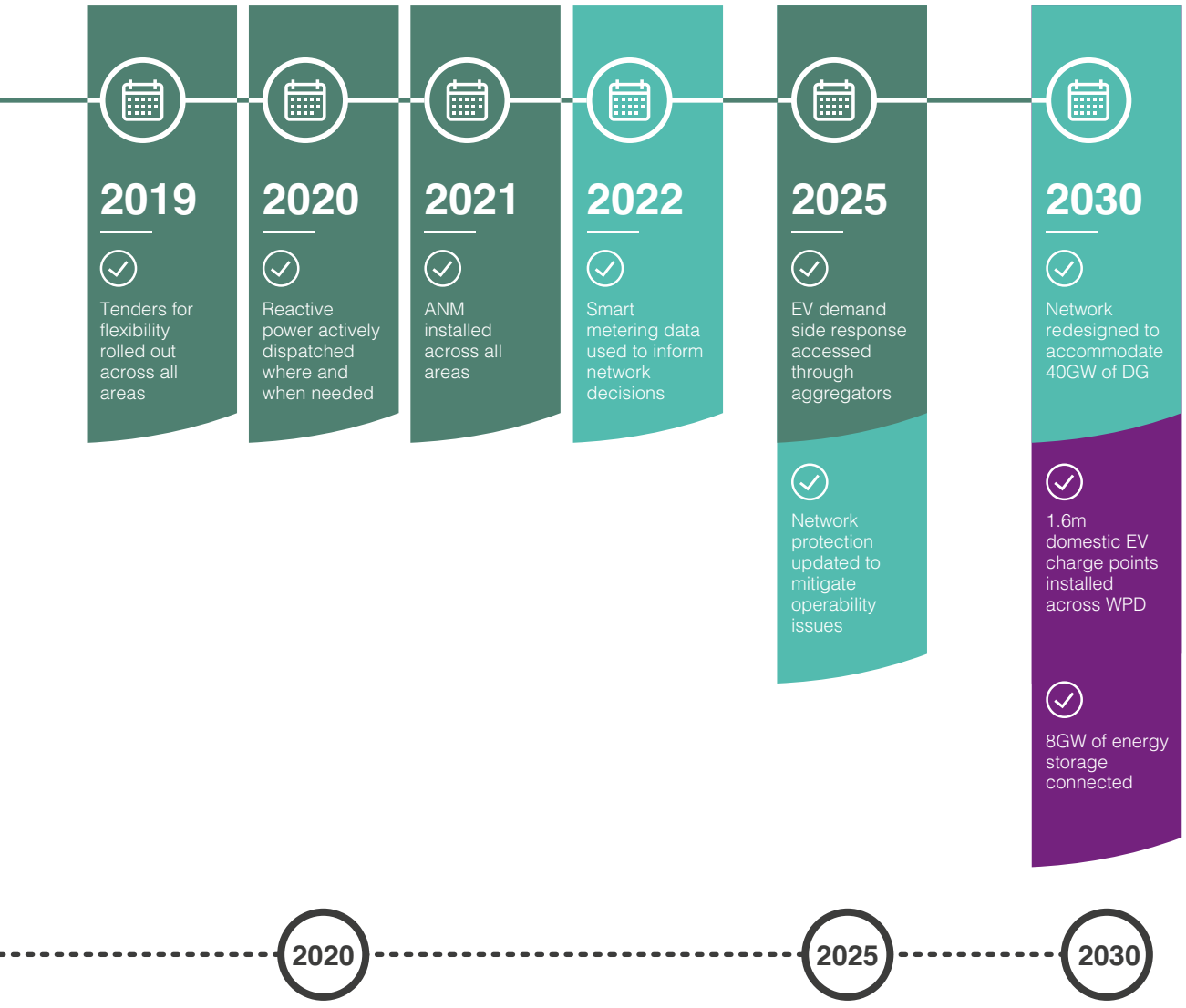
WPD understands the importance of the visibility of its actions as we move towards being a DSO, and strongly believes our customers should be at the heart of the transition. We will continue to consult on our priorities and demonstrate progress through our stakeholder events.

We will also begin to put in place enablers which will stimulate the creation of flexibility within distribution networks:

- We will ensure we are leading the roll out of DSO operations across all our regions.
- As the amount of domestic installed capacity increases, WPD will use aggregators or large virtual power plant operators to access flexibility from domestic customers, allowing the market to guide the development of solutions.
- WPD will use a mixture of tenders and market based arrangements to fulfil its flexibility requirements.

7. Longer Term Vision




2019
Tenders for flexibility rolled out across all areas
2020
Reactive power actively dispatched where and when needed
2021
ANM installed across all areas
2022
Smart metering data used to inform network decisions
2025
EV demand side response accessed through aggregators
Network protection updated to mitigate operability issues
2030
Network redesigned to accommodate 40GW of DG
1.6m domestic EV charge points installed across WPD
8GW of energy storage connected
2020
2025
2030

8. Our DSO Transition Programme

More intermittent and less predictable use of the electricity distribution system is inevitable as customers substitute carbon based fuel sources (oil and gas) with cleaner electricity.

Traditional DNO operations would require very substantial investments in passive grid infrastructure, which would be underutilised much of the time. Continued construction, maintenance and operation of passive distribution networks is no longer going to deliver the best outcomes for UK electricity bill payers.

DNOs therefore need to transition to becoming DSOs in order to operate and maintain efficient, economic and co-ordinated networks. WPD plans to be at the forefront of this transformation.

We will roll-out DSO competences using a top-down approach, ensuring the 132kV, 66kV and 33kV networks are targeted first, prioritising those areas which will benefit most. This enables the rest of the network to be incrementally upgraded as the customer need dictates.

We will protect the integrity and safety of lower voltage networks through a combination of advanced modelling, additional visibility and conventional reinforcement. We will maximise the use of smart meter data, apply additional network sensing where relevant and implement simple control schemes. We aim to develop wider flexibility for the use of import/export capping as an alternative to conventional solutions only reinforcing the networks when these solutions cannot deliver what is required.

Our DSO Transition Programme

Through implementation of our DSO Transition Programme, WPD will build on our Future Networks Programme and invest £125 million by 2023 to ensure that our network, and our business, has the capacity to deliver all the emerging system requirements our customers have, both now and in the future. We will roll-out DSO competencies using a top-down approach, prioritising those networks and areas which will benefit most from intervention. This enables the rest of the network to be incrementally upgraded as the customer need dictates, without the risk of leaving assets stranded. Our strategy will focus on enhancing and developing key competences in three core business areas:

Assets

Investment in technology to ensure networks operate at high performance levels.

Roll out of Active Network Management across entire network by 2021, with expanded connections options available for customers allowing them to get quicker and cheaper access to the network.

Telecommunications readiness and strategic investment in fibre networks will deliver more visibility and controllability.

Customers

Propositions for DSR services will be developed for specific customer group, prioritised in regions and customer segments as the need arises.

Creation of a localised visibility platform that will demonstrate where there is congestion or capacity on the network, informing localised tariffs and supporting the development of a Local Energy Market.

Alternative connection products will be extended to all WPD areas and extended to include demand and storage connections.

Network operations

Invest in technology to give us unprecedented visibility and monitoring of the network. Use complex data analytic tools to forecast requirements and ensure the network is proactively managed.

Upgrade business areas to facilitate flexibility services such as demand side response.

Continue work to develop and update regional energy scenarios that will establish future network needs and inform strategic investment in the network.

Data analysis

WPD's DSO Transition Programme will focus on enhancing and developing key competences in the three core areas identified in our business plan that guide the existing delivery of the network – Assets, Customers and Network Operations. Data analysis underpins all our core areas.

23,000

Over the past five years, our automation programme has upgraded over 23,000 strategic network switching points.

Traditional DNO operations would require very substantial investments in passive grid infrastructure, which would be underutilised much of the time.

Assets

WPD has always invested in technology to ensure our networks operate at high performance levels. Over the past five years, our automation programme has upgraded over 23,000 strategic network switching points to be remotely operated, enhancing the security and resilience of our network.

Substation technology and the supporting infrastructure will be primarily deployed on our EHV network, ensuring that our 132kV, 66kV and 33kV assets benefit from this visibility, before increasing it at lower voltage levels.

Active Network Management (ANM) will be rolled out across a number of zones as identified in our innovation strategy, through to full availability across our entire network by 2021. We now offer connection options to demand customers, storage operators and those using a lower level of system capacity. This enables customers to accept some curtailment to connections to get quicker and cheaper access to the network, ahead of any required reinforcement.

As the network requires more visibility and controllability, a robust, secure and high speed communications network will be essential to core operations. WPD is strategically investing in fibre networks at critical locations and is identifying a set of modern technologies (and service providers) to ensure we can provide resilient communication connections to customers.

Customers

Enhanced visibility will give us the data, not only for us to manage our network to the highest levels, but also to enable us to give the best information to customers, providing leading indicators on where distribution network capacity is plentiful and where further support from flexibility services is required. By making this information available, WPD will contribute to the neutral facilitation of regional markets for the deployment of third party owned flexibility services.

WPD is also committed to providing level playing field access to all customers within our region so they can participate in energy markets at both the transmission and distribution levels.

Through forecasting using internal data sets, WPD will be able to provide instantaneous and predicted constraint levels for Distributed Energy Resources (DER) within operational timescales. This will allow the levels of constraint to be used when dispatching flexibility services and ensure the network is managed to maximise capacity, minimising constraints.

8. Our DSO Transition Programme

Network Operations

Between 2015 – 2023, to enhance our network performance, we will be investing in technology to give us increased visibility of the network.

This visibility will cover real and reactive power, for both import (demand) and export (generation) connections. As well as ensuring the power flows on the network are monitored with high granularity, our systems will allow the energy distribution patterns to be recorded and traced.

By viewing energy flows on a temporal basis, we can forecast requirements and ensure the network is pro-actively managed in an optimum way.

Complex data analytical tools will be deployed to allow us to visualise and interrogate the data. We will share the results of this enhance visibility with customers, their energy suppliers and the NETSO.

Conventional reinforcement will still be needed where the future loads on the network require sustained increase in capacity. However, for short periods of time or for uncertain conditions, non-network solutions, such as demand side response or other flexibility services, may solve the issues for a lower total cost. WPD will be upgrading areas of the business to facilitate the dispatch and settlement of flexibility services.

What our customers think

Our four point plan (Page 30) set out the two focus areas of smarter EHV and safe and secure LV networks. The extent to which our stakeholders agreed with these objectives varied considerably. There was agreement that EHV and sub transmission networks will be most heavily influenced by changes within the energy system and that these should be prioritised for smart rollout. However, others were concerned that the focus on EHV assets should not come at the detriment of HV and LV networks.

Some respondents strongly preferred a more passive approach to LV networks, stating that conventional reinforcement will definitely be required to achieve the long-term energy requirements, whereas other respondents disagreed with this approach, explaining that smart intervention on LV networks could provide significant benefits in ensuring capacity was available despite uncertain levels of LCT uptake.

One consistent message from our customers was that there is a clear preference to expect the penetration of smart technologies to percolate through the whole network and not be voltage dependant.

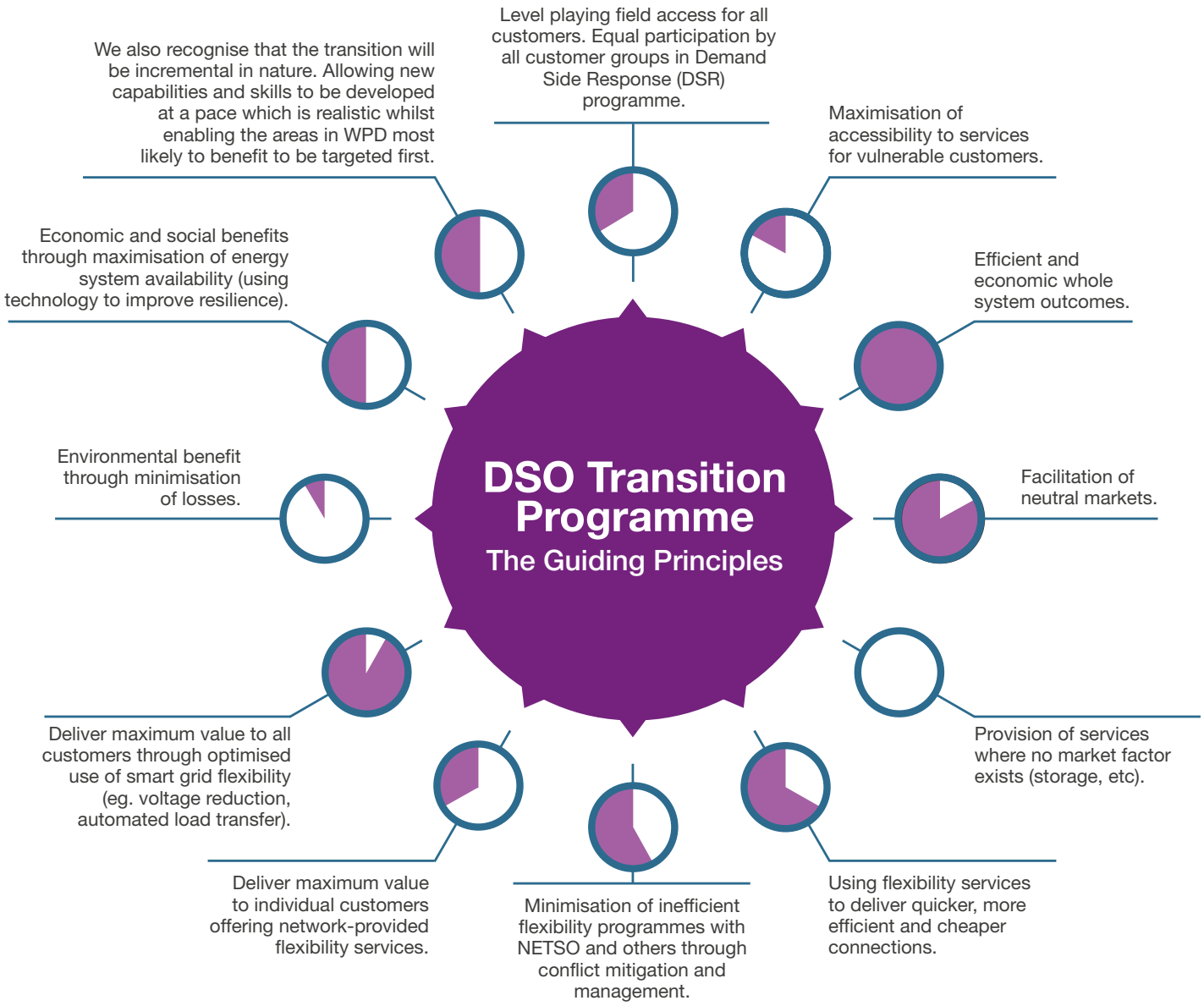
How we are responding

WPD agrees with our stakeholders that the previous explanation within the focus areas of smarter EHV and safe and secure LV networks could be interpreted as too simplistic. It is important that all customers are provided the opportunity to participate within a more active system and that the implementation of smart technology should be driven by the economics of it as a solution, rather than a limitation of system design.

With this in mind, we have altered the description of our approach within those two focus areas and can now commit to the following:

- We will focus rollout of smart interventions on our EHV networks and prioritise co-ordinated approaches to flexibility which also benefit lower voltage networks.
- We will implement smart interventions on lower voltage networks where the highest impact of LCTs is predicted and where the benefits can be co-ordinated across all voltage levels.

9. DSO Transition Principles



Fuller circle designates higher priority.

9. DSO Transition Principles

What our customers think

In our consultation we asked for comments on and help with the prioritisation of our DSO guiding principles. There was broad consensus between our stakeholders that the DSO should primarily focus on enabling efficient whole system outcomes and there was a strong preference for the DSO to co-ordinate with the NETSO to achieve this.

Our stakeholders valued delivering value for all customers through utilisation of flexibility and facilitation of this by creating neutral markets. Additionally, our stakeholders expect us to use this flexibility to provide quicker, more efficient connections.

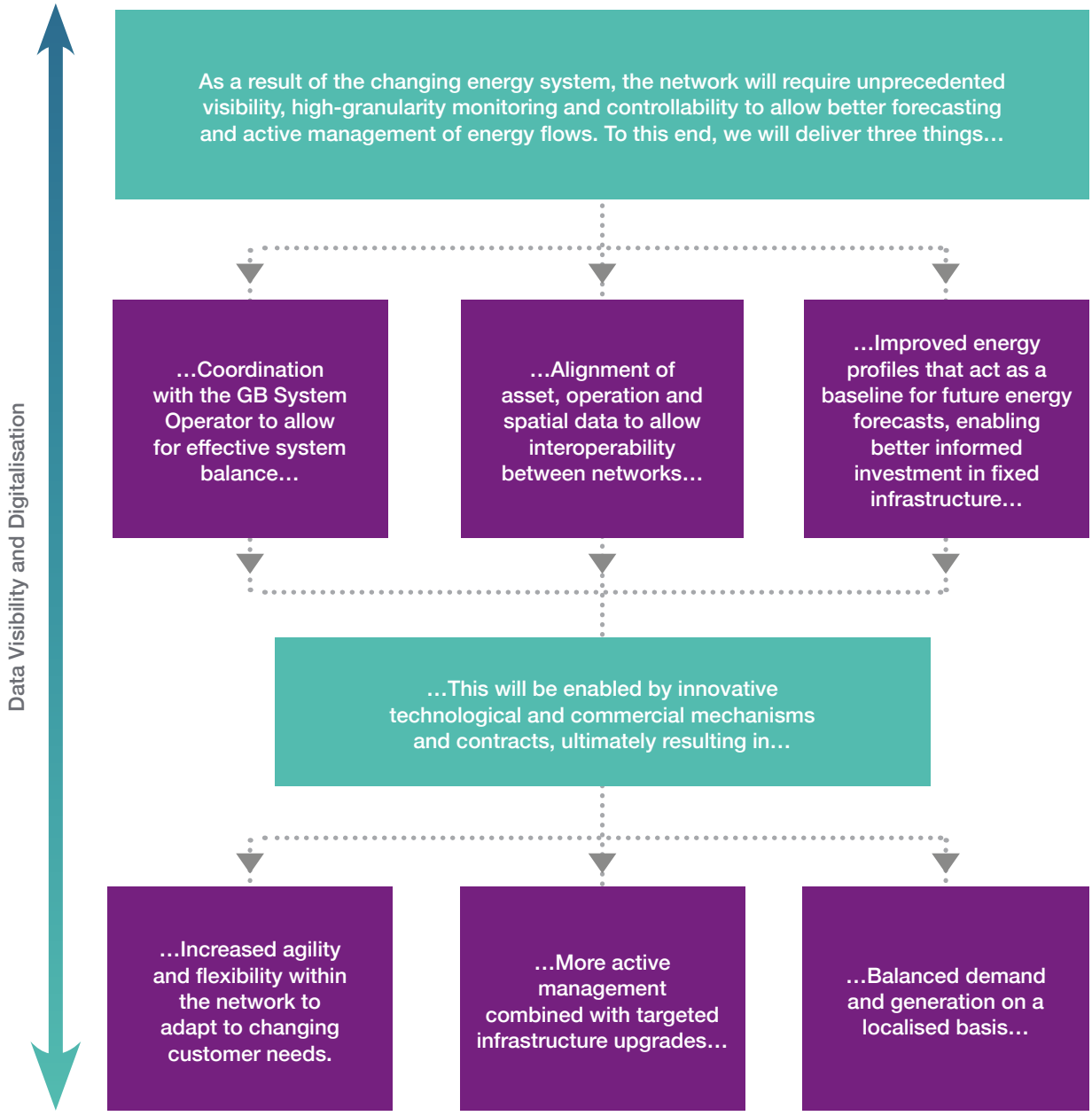
The responses also showed a preference for the creation of efficient markets and benefits that pass through to all customers above the creation of a level playing field or mechanisms that directly benefit individuals. Provision of services where no market actor is present was universally scored with a lower importance, suggesting our stakeholders are confident that, given the right conditions, markets will deliver the required flexibility.

How we are responding

The feedback received from our consultation work has allowed us to prioritise some of our principles and narrow the focus of delivery towards those deemed most important by our stakeholders. Through our ongoing stakeholder engagement activities, we will continually seek feedback that these remain a priority into the future and assess whether any additional principles may need to be considered.

- WPD will work closely with the NETSO to ensure we are delivering efficient whole system outcomes as we move towards becoming a DSO.
- We will ensure that neutral markets are developed to make these opportunities available to all customers and that all customers benefit from the efficiency savings.
- WPD will not invest in smart grid flexibility services where the market can do so more economically.

What does the transition to a distribution system operator look like?



We believe that, because the majority of services that will enable the network to be more flexible will be connected at a distribution level, it would be most appropriate for regional DSOs to have full operational responsibility for managing constraints on the regional transmission network within limits set by the GB System Operator – allowing whole system planning on a regional basis.

10. Flexibility Services

Electricity networks require generation and consumption to be balanced in real time. Even as energy storage solutions become more common the rate and times which they are charged and discharged will need careful coordination.

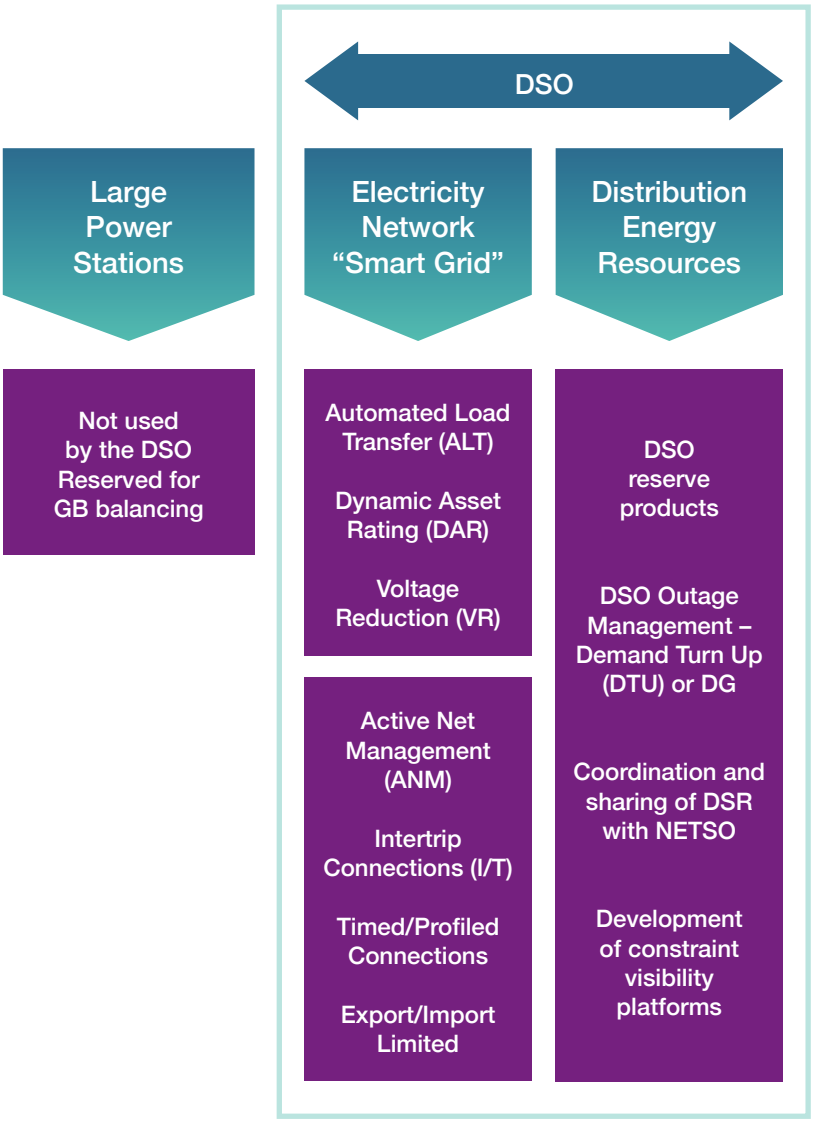
Flexibility products and programmes are used by the System Operator to balance the overall GB electricity system. Traditionally this came from contracts with larger power stations to turn up or down their output, or the large hydro-electric schemes in Wales and Scotland.

As the generation mix has changed, with much more of it directly connected to the distribution networks their NETSO flexibility products have become more complex. These have allowed participation by smaller DNO connected generation and demand customers. However the actions have been done in a manner which is uncoordinated with DNOs. As DNOs transition to DSOs such actions will be inefficient and will likely lead to unexpected outcomes.

As a DSO, WPD will have our own flexibility and reserve products, for customers to offer their services in return for payment. We will also deploy a range of smart grid technical solutions which will automatically control customer equipment with Alternative Connections and reconfigure the network configuration. NETSO flexibility services will need to be changed to accommodate the increased complexity and dynamic nature of a DSO system.

DSO Flexibility Services

Electricity System Flexibility can come from three sources:



Flexibility services can help system operators run more efficiently through controlling power and energy flows across network infrastructure.

10.1 Flexibility Programmes

10.1.1 NETSO System Flexibility

Flexibility is the ability of a power system to maintain stability in the face of swings in supply or demand. Traditionally, flexibility was provided in power systems almost entirely by controlling the supply side at large power stations.

The GB system has seen increasing shares of intermittent renewable generation requiring additional flexibility to maintain system reliability as the variations in supply and demand grew to levels far beyond what was originally conceived.

This has led to the introduction of additional flexibility programmes by the National Electricity Transmission system operator (NETSO – run by National Grid) for short term reserve and fast acting frequency response services.

As larger power stations continue to close and electricity generation becomes much more distributed much more flexibility will be needed across the whole system. This "flexibility gap" will need to be covered by new flexibility options, much of which will be facilitated by a DSO.

10.1.2 Smart Grid Flexibility

Research and Innovation projects have developed a range of new solutions which are changing traditionally passive networks into ones which are much more active.

These solutions fall into two categories:

Smart Grid Network Solutions

Smart Grid Alternative Connection Solutions

Smart Grid Network Solutions

We have identified four types of smart grid network solution:

- **Automated Load Transfer (ALT)** – Unlike the NETSO, DSO programmes do not need to be balancing energy volumes. Rather they manage power capacity in discrete network zones. Where one section of a network is at capacity, another may have spare. Therefore automated load transfer schemes allow a DSO to move power around to solve constraints.

- **Dynamic Asset Rating (DAR)** – A number of innovation projects have explored how environmental conditions can affect the physical capacity of network components. For example under windy and cool conditions an overhead line can have its rating increased. A number of projects have also investigated the impact on asset health from deliberate (but controlled) overload of cables and transformers. DAR can therefore be used as a source of DSO flexibility.

- **Voltage reduction (VR)** – By slightly manipulating the voltage at which electricity is delivered to customers it has been shown that demand can be increased or decreased. WPD's policy is to operate the system voltage as low as possible as it minimises customer bills **(www.westernpowerinnovation.co.uk/Projects/Closed-Projects/Voltage-Reduction-Analysis.aspx).** However for much of a year there is still sufficient headroom and footroom to use voltage control as a form of demand response for DSO flexibility.

- **Power Electronic Equipment** – Network devices from the Flexible AC Transmission System (FACTS) family have the ability to be dynamically controlled and rapidly adjust system voltage through the injection or absorption of reactive power. Similarly devices such as Flexible Power Links can be used as sources of flexibility, delivering either real or reactive power flexibility.

As larger power stations continue to close and electricity generation becomes distributed, much more flexibility will be needed across the whole system.

10. Flexibility Services

Smart Grid Alternative Connection Solutions

Alternative connections have become common place for WPD's distributed generation customers who want to connect to the distribution system than is possible with a conventional infrastructure solution.

Our innovative solutions allow customers to connect their distributed generation at reduced cost, with quicker timescales but will contain some form of curtailment to avoid expensive reinforcement costs.

There are four variants:

- **ANM – Active Network Management**
  This solution is the most complex and used mainly with larger new connections and primarily generation. Customer control equipment is installed into a WPD control solution which allows for full dynamic control of the network, generation and demand.

- **Soft Intertrip**
  Some networks are constrained due to a single upstream asset requiring reinforcement, or a single limit being infringed under certain conditions. This solution has an on-site soft intertrip Remote Terminal Unit which provides two normally open contacts for the customer's control system to monitor; Stage 1 and Stage 2. When both sets are open, the connection will be free of constraints. The levels of curtailment corresponding to the operation of the Stage 1 and Stage 2 contacts are defined at the planning stage.

- **Timed**
  This solution is a simple timer-based device that monitors the connection agreement with the customer, which will include some form of curtailment based on times of day. The customer's connection agreement will include an operating schedule which will define the times and levels of capacity available to them. The solution is supplied by the customer's equipment and does not require any additional investment from WPD to implement.

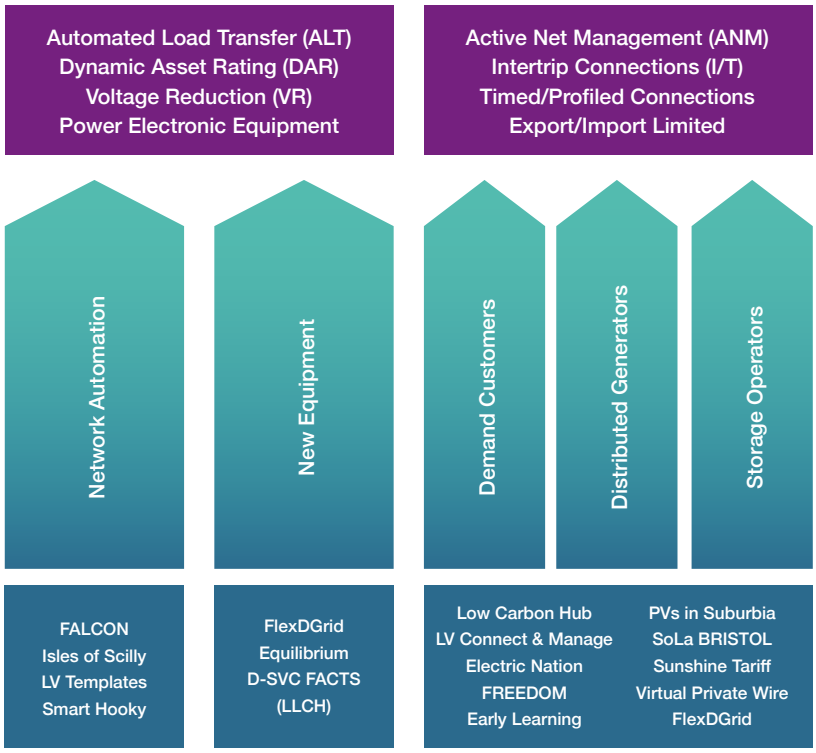
- **Export limited**
  This type of connection enables customers to cap their import from or export to the distribution grid. This often allows customers to connect renewable generation or storage beyond their meter whilst protecting the distribution network. Measurement and control equipment is used to automatically adjust the customer equipment to ensure they comply with their connection agreement.

DSO Flexibility Services (Smart Grid)

DSO Flexibility from the Electricity Network and Connections:

Electricity Network "Smart Grid"

- We are technology agnostic
- Security and resilience are critical
- High availability and fail safe
- Alternative connections are customer led
- Rollout is prioritised by need
- Plan to exploit Smart Meter data
- Our Future Networks Programme is delivering insight and will allow for a rapid roll out to BAU.



10. Flexibility Services

10.1.3 Flexibility from Customer's Distributed Energy Resources

The DSO will develop flexibility products which customers with controllable demand or generation will be able to provide services against. These are likely to be reserve services for real power or voltage control (rather than fast acting products such as frequency response – which remains the responsibility of the GB System Operator).

The smart grid flexibility solutions described in the previous section will be mostly used in operational timescales. Customer Distributed Energy Resource (DER) flexibility services will be taken in investment decision timescales to reduce, defer or negate conventional build. Identifying, contracting and operating such non-network solutions are at the centre of the DSO transition. WPD originally launched five Constraint Managed Zones (CMZs) which deployed non-network solutions. Our Flexible Power product (**www.flexiblepower.co.uk**) is aimed to offer simplicity and certainty to customers with flexible DER wishing to offer a service. Unlike the NETSO reserve products, Flexible Power will offer locational products that can deliver improved reliability to the DSO.

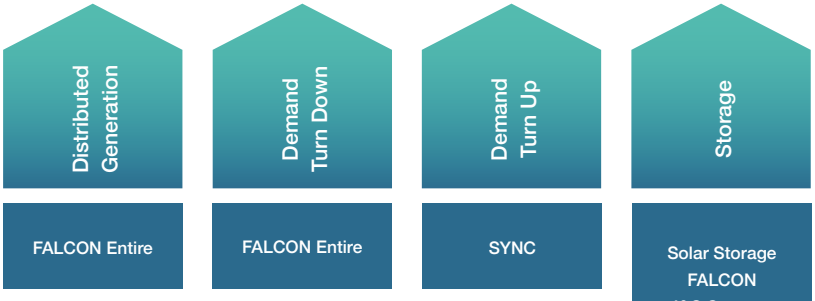
Since the start with five CMZs, we have extended our Flexible Power footprint. Our 2020 procurement plan includes 175 substations across 42 CMZs.

DSO Flexibility Services (DSR)

DSO Flexibility from Distributed Energy Resources:

Flexible Power
By Western Power Distribution

- We are technology agnostic
- DSO flexibility products have different technical requirements to the NETSO
- DSR is a market provided service
- Products designed to secure supplies at the lowest possible whole system cost
- Our Future Networks Programme is delivering insight and will allow for a rapid rollout to BAU.



Flexible Power allows customers to contract directly with WPD or via an established NETSO aggregator. It is also designed to accommodate future local energy markets such as our joint trial with Centrica in Cornwall (**www.centrica.com/cornwall**).

What our customers think

Most respondents agreed that WPD's alternative connections, which enable customers to get quicker, more efficient connections through alternative network access arrangements, have stimulated the connection of DG, but that there is little appetite or incentive for existing connections to transfer to alternative connection terms or participate in capacity sharing arrangements.

There was also agreement that once a wider range of market mechanisms are developed by the DSOs, then the market will adequately deliver the required flexibility without further stimulation from the DSOs.

10.2 DSO Market Models

10.2.1 Facilitation of Neutral Markets

The increased number and capacity of distributed energy resources connected to the electricity system is leading to an increase in the level of active management of demand and generation seen on the distribution network. This changing system is driving an increase in the interactions between the transmission and distribution networks and there is a growing need for parties to move away from the current market model.

Moving away from traditional roles will allow new markets to be created and accessed by a wider number of participants, helping both existing and new market participants to support network and system operation.

WPD strongly believes that customer connected flexibility and distribution network smart grid flexibility can help alleviate both transmission and distribution constraints and contribute to releasing additional capacity on both the transmission and distribution networks. There is significant value for both active and passive customers connected to the electricity network in maximising the usage of these flexibility sources where it is effective and economic to do so.

In order to economically achieve this, the greatest number of participants must be able to provide services across a number of market procurers.

Achieving this cost effectively, there must be limited conflict between various procurers of flexibility and network capacity must be sufficient to facilitate the services provided by market participants.

WPD believes there are four key principles to achieving this:

1. Facilitating accessibility to markets
Customers will expect level playing field access to a wide range of revenue streams and DSOs will have a key role in facilitating neutral markets. Multiple paths to market could ensure competition remains, but must not lead to conflict or complexity. Customers will expect the complexity to be designed out by Industry. Ultimately, the efficiency of the route to market will be reflected in the commercial revenues passed through to participants. Distribution network operators will increase their usage of non-build solutions, creating new markets for new and existing participants.

2. Increased T-D Co-ordination
Clear coordination processes and common methodologies for procurement and dispatch of services will aid efficient local/system wide usage of resources. Principles of access and rights for access will also need to be considered from a whole system viewpoint. Increased information exchange across the transmission and distribution interface will enable conflicts to be managed on an operation timescale. Evolving the existing roles and responsibilities to have a more co-ordinated approach to system resilience, which can take advantage of new forms of flexibility on the system.

3. Product/Service Convergence
At a design stage of the products and services which utilise flexibility across both transmission and distribution system requirements will reduce the likelihood and impact of any market conflict. Co-ordination across market procurers to define consistent methodologies and principles will help support level playing field access. Providing information to customers on the prerequisites or service delivery will enable them to assess the suitability of connection types and ensure they can benefit from potential revenue streams. Convergence of services and connection types will aid the simplification of customer offerings and improve the customer experience.

4. Signposting for services
DSOs will publish more information on the availability of capacity across their networks for power delivery. They will also publish information to assess ability of the network to transmit power and understand the utilisation of assets. Proactive information publishing will provide leading signals on where to connect to maximise system efficiency and charging methodologies will be changed to provide lagging indicators to reduce network congestion. This visibility of the existing and future network will help markets deliver the services required. DSOs will further stimulate markets by the signposting of markets for non-build solutions, opening new revenue streams for participants.

How we are responding

DSOs will have an important role in providing information to markets to develop the capability of flexibility in areas where it will be required. Provision of this information will also be critical in ensuring the flexibility is used efficiently across the system.

- WPD will signpost its flexibility needs ahead of following a technologyagnostic procurement process.
- WPD will co-ordinate with the NETSO, suppliers and other procurers of flexibility to avoid market conflicts.

10. Flexibility Services

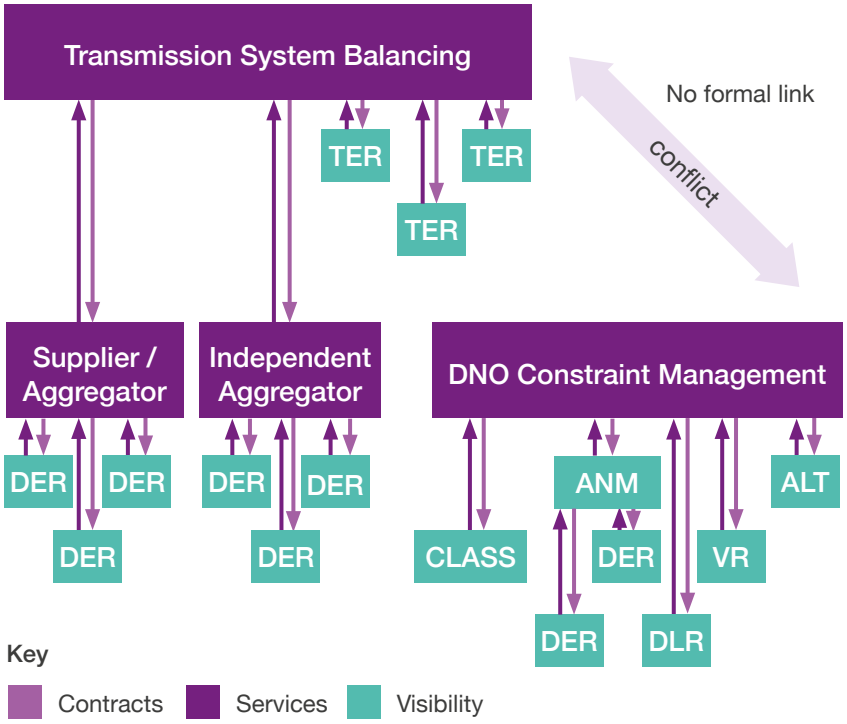
10.2.2 Current Market Model

The existing market model for procuring services to resolve transmission issues has no direct link with DNO constraint management. This has no effect when solely transmission connected energy resources are utilised, or when the distribution network capacity is assumed to be infinite.

However, as Distribution Network Operators are increasingly actively managing the network, curtailment due to constraints can cause conflicts and reduce in the effectiveness of services delivered. As the number and level of constraints increase, the likelihood and consequence of the conflicts will become more apparent.

Unmanaged conflicts between services will result in a more inefficient whole system outcome.

Current Market Model



10.2.3 Future Model

The ENA Open Networks project has developed future models into rounded future worlds. We support World B as a future model.

World B: Coordinated DSO-ESO Procurement and Dispatch

The impact of World B on;

Getting connected and commercial arrangements
All Customers wishing to connect to distribution networks will discuss their development with their local DSO (or IDSO), as in World A. Where this causes potential issues across the transmission - distribution interface the DSO will discuss with the ESO and submit a 'Transmission Impact Assessment' (or similar) request to ensure coordinated development of networks. Developers wishing to connect to transmission networks would speak to the ESO who would develop a connection offer in collaboration with the host TO. World B has not seen significant change to charging and access arrangements (these having taken place in World C).

Flexibility market arrangements
In this World, there could be a central ancillary services market for flexibility resources connected at the transmission and distribution networks providing services to the ESO and some DSOs similar to the current Balancing Market. The ESO will procure services for both national needs and also regional transmission requirements. Additionally there could be coordinated regional and local markets for flexibility resources connected to the distribution networks facilitated by the host DSO. The ESO and DSOs will work together to ensure efficient procurement and dispatch decisions are made across these markets to optimise procurement in a transparent manner and manage any conflict of service provision.

System coordination and operation

System coordination and operation interfaces will remain similar to today with DSO and ESO control rooms working together to ensure security of supply and asset safety. It is recognised that the future will have an increased number of active participants connected to distribution networks. This will increase the requirement for coordination between SOs whose processes will need to evolve to manage increased uncertainty in system flows and demands. Emergency restoration processes will also need to evolve recognising the increased number of options through the availability of Black Start DER.

Network design and development

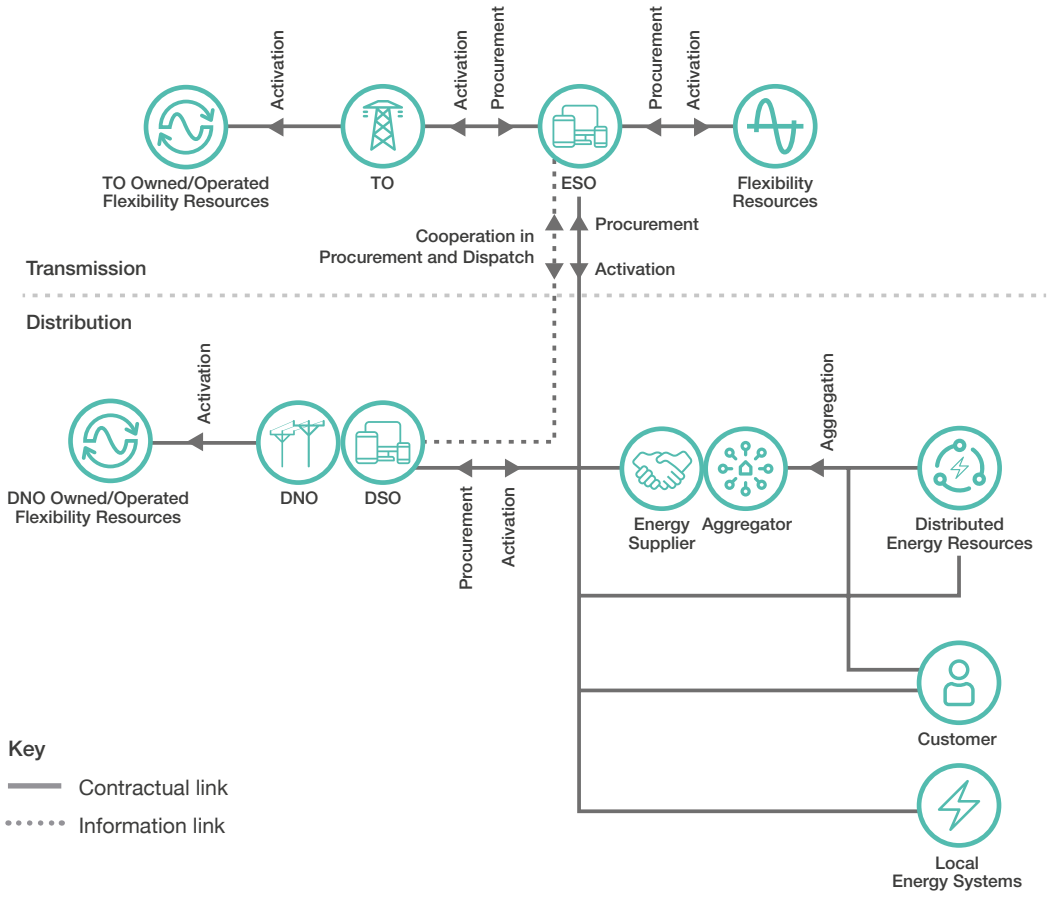
Technical and commercial discussions between SOs will continue to be held similar to existing processes to ensure overall efficient network development. There will be an increased need for overall coordination of network and non-network solutions to meet future system needs.

SOs would continue to have responsibility for the strategic design of their responsible networks. In the case of the ESO, this would require discussions with the TO on detailed development requirements. A transparent process would exist to look at solutions to transmission needs from non-network and distribution options.

In this World, flexibility resources can provide services to multiple SOs and are able to stack revenues from these differing SOs. It is recognised that, on occasion, the needs of different SOs will conflict and it will be the joint responsibility of these SOs to coordinate service procurement and dispatch activities. This will be done in a transparent manner which creates the most efficient outcome for the end consumer.

The illustration below shows the flexibility market arrangements for this World.

World B - Coordinated DSO - ESO Procurement & Dispatch - Flexibility market arrangements



11. The Plan for DSO

This section sets out the enabling functions and the actions we suggest are necessary to support WPD's transition to a DSO. The following table is extracted from the WPD Innovation Strategy and shows the building blocks on which new DSO capabilities could be tested and built. The building blocks are grouped into five workstreams.

A. Data Integrity
A DSO required accurate and granular information on asset capability (design ratings and health/condition), how they are connected (or could be) and their actual operation (both real time and historic).

B. Market Integration
A DSO acts as a platform facilitator for customers, suppliers, aggregators and other participants to offer or receive services. Sharing information on network capability in multiple timeframes will enable businesses to offer customers innovative energy services. Data sharing between Transmission and Distribution is critical to ensuring the whole system is optimised in the interests of customers.

C. IT Systems
A DSO will need enhanced functionality, greater data storage and in some areas new IT systems. These systems will be used by the DSO internally and to support the other workstreams.

D. Customer Propositions
As customers adopt low carbon technologies or generate power more locally, the range of connection types for homes, businesses and generators is set to increase to meet customer needs. A DSO will also facilitate flexibility markets and make use of flexibility as an alternative to conventional network construction.

E. Equipment
Advances in ICT are enabling the creation of smart grids, the foundation of many DSO new functions. A new generation of sensors, control equipment and telecommunications will be used to support market integration and the new customer propositions.

DSO Transition Programme				
Data Integrity	**Market Integration**	**IT Systems**	**Customer Propositions**	**Equipment**
Alignment of Data – Common Information Model	WPD regional energy scenarios	Power System Modelling	DSR products by customer segment	Telecommunications readiness
Energy and Utilisation Data – MWh not MW	WPD Operability Framework	Energy Management and Forecasting	DSM tariff structure	Transducers and measurement equipment
Network Connectivity	DSR Shared Service (link to NETSO)	Time Series Data Storage and Visualisation	Alternative Connection Agreements	Settlement and metering data for Network Operations
	Visibility Platform (link to aggregators / suppliers)	Asset Management Systems	Managed Connection Agreements	Managed Connection Interface Devices
	Network Charging Methodology	Settlement and Billing		Active Network Management Technology
Organisational Change / New Functions				

A number of WPD innovation projects which test the capabilities and demonstrate processes are already helping us to develop these DSO functions. Further testing is ongoing within WPD and we are also collaborating with the other DNOs through the ENA to share learning.

The pace of change will require WPD to transition to a DSO model over the next few years. The rollout of DSO solutions will be coordinated through an over-arching DSO Transition Programme, with project delivery and business change led by the BAU line managers. We think this is the best way to ensure DSO functions are introduced incrementally and with sufficient flexibility to adapt to changing external circumstances.

We have estimated that the one off set up cost for our DSO Transition Programme is approximately £75m. This is comparable to similarly sized business transformation programmes in other industries. Many of the solutions, in addition to the implementation cost, will also have ongoing operational costs associated with them. For example additional IT systems and new teams within the business. We estimate that the total cost once we factor into the cost of recurring items such as licences and additional employees within our current business plan period (to 2023) will be of the order of £100-£125m.

We have constructed a high level workplan, timescale and budget for the five DSO transition workstreams and projects as detailed here.

More detailed information on the work related to these workstreams we have already done or are now testing can be found in Appendices A to E.

Data Integrity	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Alignment of Data – Common Information Model									5
Energy and Utilisation Data – MWh not MW									5
Network Connectivity									10

Market Integration	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
WPD regional energy scenarios									0.5
WPD Operability Framework									0.5
DSR Shared Service (link to NETSO)									2
Visibility Platform (link to aggregators / suppliers)									5
Network Charging Methodology									2

IT Systems	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Power System Modelling									2
Energy Management and Forecasting									10
Time Series Data Storage and Visualisation									2
LV Connectivity / GIS									5
Settlement and Billing									2

Customer Propositions	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Power System Modelling									1
DSM tariff structure									1
Alternative Connection Agreements									2
Managed Connection Agreements									1

Equipment	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Telecommunications readiness									5
Transducers and measurement equipment									5
Settlement and metering data for Network Operations									5
Managed Connection Interface Devices									2
Active Network Management Technology									2

Key: Testing Rollout

11. The Plan for DSO

A DSO four-point plan

1

Expand the existing roll out and application of smart network solutions to the higher voltage networks, prioritising areas which are the most likely to benefit.

From this we will optimise investment decisions, deliver greater network flexibility and maximise customer connection choice (flexible connections for demand, generation and storage).

The prioritisation will also be influenced by the amount of benefits endowed to the lower voltage networks.

2

Contract with customers and aggregators for non-network solutions.

Co-ordinate with other parts of the industry by helping to establish visibility platforms for suppliers, aggregators and customers.

This will include the requirement to raise the awareness of DSR and to help customers to value stack where appropriate.

3

Co-ordinate with GB at the T/D interface.

Share data and forecasts in multiple time horizons. Maintain overall system security. Consider whole system issues and propose solutions.

Secure additional flexibility through prosumer awareness – actively support Power Responsive. No exclusivity in DSO flexibility contracts.

4

Protect the integrity and safety of lower voltage networks.

We will maximise the use of smart meter data, apply additional network sensing where relevant and implement simple control schemes. We aim to develop wider flexibility for the use of import/export capping as an alternative to conventional solutions only reinforcing the networks when these solutions cannot deliver what is required.

We will accelerate the deployment of smart technology on networks where high penetrations of LCTs are anticipated and where whole system benefits are greatest.

Data Visibility and Digitalisation

12. What this means for our Customers

For large energy users	• Price signals for electricity network usage may be derived from more market based mechanisms rather than forward-looking charges, as at present. • The difference in costs between network charges at high and low periods may drive large energy users to flatten out their energy consumption or shift their consumption in time. • There will be clear routes to directly benefit from altering consumption patterns. • Flexibility is valued as a service and the response created by demand turn up or down may be valuable. • Users may be drawn to different areas due to more beneficial network access charges. • Access to NETSO stacking.
For distributed energy users	• The ability to bid for transmission balancing services is available to more market participants. • Secondary trading markets for distribution network capacity may be created, allowing customers to trade their network access peer to peer. • Flexibility is valued as a service and the response created by generation turn up or down may be valuable. • Certain areas of the network will become unattractive for new build generation, particularly if the existing generation is increasing distribution network costs. • Access to NETSO stacking.
For smart technology providers	• Networks will be seeking non-traditional alternatives that are able to provide new capacity or maintain existing equipment quicker and more economically than the traditional reinforcement or network build solutions. • Communications between parts of the energy infrastructure will become more critical than ever before. • Data will drive decisions and have an increased importance.
For vulnerable customers	• The number and length of interruptions will continue to decrease, providing customers with an even higher reliability supply. • Smart metering will allow customers to see their usage in real time. • Structured tariffs will incentivise off-peak usage. • The definition of off-peak usage will vary depending on the make-up of adjacent network load. • There will be greater roles for social landlords in helping vulnerable customers to participate. • Access to NETSO stacking.
For local communities	• Stronger locational signals for distribution network charges may result in demand or generation being attracted to a specific location due to the complementary nature of the existing customers connected to the network. • Local communities may be able to structure new markets and provide local investment opportunities in new assets, resources or services. • Access to NETSO stacking.

13. Glossary

ANM – Active Network Management
Using flexible network customers autonomously and in real-time to increase the utilisation of network assets without breaching operational limits, thereby reducing the need for reinforcement, speeding up connections and reducing costs.

CMZ – Constraint Managed Zone
A designated area of network which employs commercial techniques to manage electrical constraints.

DER – Distributed Energy Resources
Smaller power sources embedded in the distribution network that can be aggregated to provide the power to meet demand.

DNO – Distribution Network Operator
The person or legal entity owning or operating a passive system used for the distribution of electricity between the transmission network and to the points of delivery to customers.

DSO – Distribution System Operator
The person or legal entity owning or operating an active system used for the distribution of electricity between the transmission network and to the points of delivery to customers.

DSR – Demand Side Response
A commercial service allowing customers to be rewarded for shifting their consumption to help manage constraints on the network.

ED1
The eight year price control review period between 2015 and 2023 which sets the outputs for distribution network operators.

EHV – Extra High Voltage
Distribution networks operating at 33kV, 66kV and 132kV.

Flexibility Services
Using on-network or customer owned equipment to control power and energy flows across network infrastructure, leading to more efficient and cost effective outcomes.

NETSO – National Electricity System Operator
The person or legal entity operating and balancing the national electricity transmission system in Great Britain.

HV – High Voltage
Distribution networks operating at 6.6kV and 11kV.

LV – Low Voltage
Distribution networks operating and 1000V and under.

RIIO
Ofgem's framework for setting price controls for network companies using the RIIO (Revenue = Incentives+Innovation+Outputs) performance based model.

Smart grid
Transitioning from a network based on passive operation enabled inherently through its design, into one in which demand and generation is balanced locally by a mixture of enhanced sensing with active technical and commercial mechanisms.

Appendix A

Data Integrity Workstream

WPD's asset, operational and spatial data systems are not easily aligned or manipulated today. A DSO will require consistent access to asset types, locations, ratings, historical usage and connectivity for many new functions. The data will also need to be exchanged with third parties such as the NETSO and suppliers/ aggregators. Interoperability and use of international standards would be beneficial and may be necessitated through future codes and standards.

A1 – Alignment of Data Common Information Model

WPD, like all DNOs, has traditionally held static data about its assets.

In common with other DNOs, WPD systems comprise three core business applications for asset management

1. A Graphical Information System (GIS)
2. An Asset Database
3. A Network Management System.

Traditionally these systems hold different data within them. Tailored to each system's purpose. For example, an asset database holds static technical data about equipment once built; a mapping systems show where assets are located or details of proposed new infrastructure; and a Network Management System contains real time information for the higher voltage equipment which can change second by second.

Data is held in within each system and is mostly in proprietary formats dictated by the software application. There is limited common indexing between the systems. This makes it difficult to compile a full set of data for sharing with third parties.

Our Common Information Model DSO Transition project has taken the Integrated Network Model (INM) approach developed under LCNF Project FALCON to align 11kV network data in our systems.

It uses a combination of rules, automated machine learning and human data cleansing. The data is then validated and converted into the Common Information Model IEC standard.

The project is progressing well with the WPD South West licence area due for completion in Q1 2020. The remaining three license areas will be complete by the end of 2020.

The CIM dataset will be used within WPD as a "single version of the truth" for network planning and modelling.

The project will also develop the business process and technical solution for openly publishing the data, whilst ensuring appropriate commercial and privacy restrictions are in place.

Further phases will see the CIM dataset extended to other voltage levels.

Project Case Study

- LCNF Project FALCON demonstrated automated data harmonisation on an 11kV network. A new NIA project has demonstrated this at 132kV and 33kV for the network in Cornwall.
- NIA Project Common Information Model.

Innovation Project	CIM
Budget	£0.751
Spend to date	£0.017
Project completion	Nov-17
Close down report	Feb-18

Data Integrity	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Alignment of Data – Common Information Model									5
Energy and Utilisation Data – MWh not MW									5
Network Connectivity									10

Appendix A

A2 – MWH not MW

Traditional distribution network design relies on creating a network that is sized for the largest credible peak demand it is likely to see. As long as the peaks are accurately recorded, that is sufficient to ensure that a passive network is operating within its technical limits.

DNOs have traditionally not needed a highly granular view of historical loadings on assets, however a DSO need to have much more complete, granular and accurate data to support DSO functions which seek to increase utilisation and more dynamically control distributed energy resources. It is particularly important, when you understand the utilisation of assets, to be able to know when in time the loading occurs. Improved energy profiles are therefore needed as a baseline for future energy forecasts and will be the foundation of justifying any future investment in fixed infrastructure.

WPD's flexibility analysis which uses scenario forecasting to predict future load flows and flexibility needs has required us to develop data improvement, cleansing and extrapolation techniques. A time series data error identification and improvement programme is also underway to enrich the underlying measurement data.

Project Case Study

- First phase NIA Time Series Data project completed. This identified the improvement works needed.
- Second phase NIA project determined future requirements and prototype visualise methods for the data.

Project	Time Series Data
Budget	£0.164
Spend to date	£0.158
Project completion	Feb-17
Close down report	May-17

An assessment was carried out of our current time series data though the NIA Data Analytics project. Steps are already being taken to upgrade WPD's substation telemetry systems to provide enhanced visibility. Further work is planned to identify the functionality needed in future telemetry systems and where measurement equipment will need to be fitted. The data is critical to support DSO planners and forms the foundation for our future flexibility requirements.

A3 – Connectivity

Network connectivity is well documented for higher voltage networks but can differ between DNO core systems depending on whether they show the designed (normal) running arrangement or the actual status.

Low Voltage networks have traditionally operated in passive mode and in most cases were designed with sufficient capacity to last for their lifetime. However as local networks become more active, LV connectivity will also be needed for modelling purposes.

Through the Electric Nation project we have tested automated methods of inferring LV connectivity.

The solution developed will be used in the Network Assessment Tool (NAT) system being rolled out to our LV planners. During the rest of ED1 we intend to roll out a programme of improving and cleansing this inferred LV connectivity. The improved data will be imported into WPD's Electric Office GIS application.

It will also be made available externally in line with our Open Data and Digitalisation commitments.

Appendix B

Market Integration Workstream

B1 – WPD regional energy scenarios

Future network investment needs to be considered and justified against a set of energy scenarios. WPD regional scenarios are now 'business as usual'. We have also developed joint scenarios with National Grid and other DNOs. This action is complete.

B2 – WPD Operability Framework

National Grid's "System Operability Framework" (SOF) focuses almost exclusively on an assessment of transmission issues (with limited consideration of future concerns at distribution level that could impact transmission). We are using the WPD energy scenarios to develop a distribution focused version of the SOF (D-SOF) to highlight future issues and inform market participants of future restrictions or to highlight a need for ancillary services.

B3 – DSR Shared Services

The NETSO is increasingly reliant on commercial arrangements with customers with flexible Distributed Energy Resources (often via aggregators) to provide a system balancing function. Most of these customers are connected to the distribution rather than transmission network. The NETSO currently assumes distribution networks are passive with sufficient capacity that any action they take (within a customer connection envelope) will have the desired consequence.

DNO networks are becoming much more active (and large parts of distribution networks already have active management of Distributed Generation) meaning that NETSO actions may not have the desired effect at the transmission level. For example, the NETSO may request a customer with a standby generator to run to make up for a shortfall in national generation. However a DNO active network management system may automatically sense the local network is at capacity and automatically reduce the output of another generator in line with their connection terms.

It is therefore critical that DSO and NETSO actions are coordinated. There are several activities as a result of Smart Grid Forum Workstream 6 (WS6) and activity under the ENA's DSO Project (formally the Shared Services Group). For example, WPD is planning to establish secure links between DSO and NETSO systems to give visibility of real time conditions. We are also carrying out further trailing of coordinated NETSO/DSO services under NIA funded projects, such as SYNC and ENTIRE.

Project Case Study

- Regen SW have been assisting WPD in the production of regional scenarios.
- Scenarios for all licence areas have been delivered and stakeholder engagement complete. Network analysis complete. Shaping sub transmission documents published and webinar carried out.
- Work continues on a rolling programme of six monthly publications.

Project Case Study

- ENA Open Networks Project is now managing the DNO to DSO programme.
- Shared service trailing (DSO to customers via SO model) completed in SYNC and FALCON.

Project	Project SYNC
Budget	£0.864
Spend to date	£0.130
Project completion	Mar-18
Close down report	Jun-18

Market Integration	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
WPD regional energy scenarios									0.5
WPD Operability Framework									0.5
DSR Shared Service (link to NETSO)									2
Visibility Platform (link to aggregators / suppliers)									5
Network Charging Methodology									2

Appendix B

B4 – Visibility Platform

The Smart Grid Forum (Workstream 6) recognised the need for suppliers and communities to have visibility of distribution network congestion or when spare capacity is available. Development of more granular locational network pricing and half hourly settlement may in the future support the development of time of use tariffs by suppliers for their customers. WPD plans to develop a “plug” for a future energy market platform (with “sockets”) to provide visibility, warn of critical peak price periods and take offers of DSR service from other market participants.

A joint trial of such a platform is underway with Centrica under a European Regional Development Fund (ERDF) funded Local Energy Market project. Under NIA funding we plan to trial the development of a DSO “plug and sockets” arrangement. B5 – Charging Methodology Network charging arrangements may need more fundamental review beyond Ofgem’s current target charging review in order to support locational and time of use pricing. The social implications from any change to current cost sharing between all customers need to be carefully evaluated and tested before changes are made.

We will work with Ofgem and BEIS to commission a discussion paper and design trials around this topic. Large scale changes to charging rules are likely to be beyond the ED1 period.

Project Case Study

- Project ENTIRE tested a DSO contracted service to be shared by the NETSO.
- WPD is fully supportive of the National Grid Power Responsive initiative.

Project	ENTIRE
Budget	£1.565
Spend to date	£0.126
Project completion	Jun-19
Close down report	Sep-19

Appendix C

IT Systems

The transition to a DSO will require enhanced or additional IT systems. DSO requirements will feed into WPD's IT strategy. The following areas have been identified as those requiring attention.

C1 – Power System Modelling

Power system analysis and modelling capability will need to be enhanced for distribution network planners. Modelling of larger areas and transmission equivalents will be necessary under steady state, transient and under future energy scenarios. Functionality such as "self-serve" connection studies may also need to be supported. LV planning tools will also need to be developed to support network design for Low Carbon Technologies.

Through our innovation projects we have developed experience of various commercial off the shelf software systems. We have also begun to consider the power system modelling capabilities we will need in our real time network management systems. Our projects have also developed specific design tools for low carbon technology connections and for advanced network planning.

This area of the DSO transition programme will see us scale up and standardise our planning and modelling systems. They will make use of the Common Information Model dataset created under the data integrity Workstream.

C2 – Energy Management and Forecasting

Energy management, forecasting, Distributed Energy Resource despatch and settlement functions will require new functionality and systems.

Prototype systems for forecasting were built as a part of the FALCON Project (addressing Winter demand peaks). these are being adapted and reused on subsequent innovation projects.

Our EFFS Network Innovation Competition (NIC) project is developing a forecasting algorithms that is compliant with the ENA's Open Networks project requirements. It has been agreed by all GB DNOs and will form the basis for how DSR systems determine how much flexibility to arm or despatch in operational timescales. We think it is important that the methodology for producing these requirements is transparent, consistent and fair.

Project Case Study

- LV Templates developed a classification tool for LCT hotspot identification.
- CarConnect Electric Nation will developed an EV planning tool.

Innovation Project	CarConnect
Budget	£5.802
Spend to date	£0.929
Project completion	Oct-19
Close down report	Jan-20

Project Case Study

- Equilibrium has developed an enhanced planning tool for EHV networks.
- ANM has developed DCAT for constraint analysis.

Innovation Project	Equilibrium
Budget	£13.1
Spend to date	£2.5
Project completion	Jun-19
Close down report	Sep-19

IT Systems	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Power System Modelling									2
Energy Management and Forecasting									10
Time Series Data Storage and Visualisation									2
LV Connectivity / GIS									5
Settlement and Billing									2

Appendix C

C3 – Time Series Data Stores

A traditional DNO has a relatively basic use of historical time series data. Data volumes will increase as additional smart grid sensors are deployed meaning current systems are unlikely to be fit for purpose. Network planners will need much more accurate profiles for investment planning purposes and to design automated network control schemes. New ways of visualising the data will also be required as planners and energy managers need to quickly and simply assess network conditions and determine what corrective actions are necessary. We have established a time series data store within our operational network model. This item is completed.

C4 – Network Connectivity Systems

LV connectivity data created under the Data Integrity Workstream will need to be stored and maintained. Existing systems will be suitable for holding the connectivity data which will be able to be import/exported using the Common Information Model format.

In addition to the EFFS algorithm and forecasting system, additional functionality is to be developed in our core Network Management System. Termed a Future Network Viewer (FNV) the system will show a graphical representation of the WPD network. It will also take into account planned outages and predicted weather conditions.

C5 – Settlement and Billing

After the recommendations of the Significant Code Review are finalised, DUoS billing systems may need re-development to support locational or time of use pricing. This may also be reflected in any further enhancements needed to connection and use of system charges associated with Distributed Generation and Storage.

As part of WPD's Flexible Power, new systems to cater for settlement/payments associated with local energy markets and flexibility products have been developed and are now in place to undertake those processes as business as usual. This includes DSO services run through Flexible Power and other third party marketplaces, such as Cornwall Local Energy Market (LEM).

Flexible Power is the only UK DSO system which enables full electronic declaration, acceptance, dispatch, monitoring, verification and settlement of flexibility services.

Project Case Study

- Data Analytics project highlighted limitations of current systems.
- The TSD Phase 2 project has developed functional requirements for a new system.

Project	Time Series Data Tools
Budget	£0.096
Spend to date	£0.043
Project completion	May-17
Close down report	Aug-17

Appendix D

Customer Propositions

D1 – DSR products by customer segment

WPD has developed propositions for DSR services for specific customer groups, prioritised in regions and customer segments as the need arises. All customers can now participate in WPD's DSR schemes, with larger customers contracting via aggregators or directly depending on their wishes. Domestic and community sectors will generally contract on a wholesale basis through suppliers or other intermediaries.

Project Case Study

- Project Sync tested the concept of demand turn up at times of peak solar generation output.
- Customer revenue stacking is enabled through contracting with the NETSO for services.

Project	Project SYNC
Budget	£0.864
Spend to date	£0.130
Project completion	Mar-18
Close down report	Jun-18

Project Case Study

- Project ENTIRE tested the concept of demand turn up down or DG dispatch at times of winter demand peak.
- Customer revenue stacking is enabled through contracting with customers directly.

Project	ENTIRE
Budget	£1.565
Spend to date	£0.126
Project completion	Jun-19
Close down report	Sep-19

Customer Propositions	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Power System Modelling									1
DSM tariff structure									1
Alternative Connection Agreements									2
Managed Connection Agreements									1

Appendix D

D2 – DSM Tariffs

There is currently no opportunity for non half hourly metered customers (homes and small businesses) to access the DSR services. Locational DNO price signals through network charges may provide an incentive for customers to change consumption (in a similar way to Economy 7).

There may also be other factors which influence customer behaviour, for example knowing the source and carbon content of electricity. The foundation for this service is a fully implemented smart metering solution with an engaged customer base. Our Sola BRISTOL LCNF project tested domestic tariffs on a small scale. The “plug and socket” Local Energy Market project will further test time of use tariffs with customers in Cornwall.

Our NIA Sunshine Tariff has proven tariffs have little interest from domestic consumers with existing load types. Therefore we propose to delay plans to extensively test or propose substantial changes to charging methodologies in support of DSM tariffs until sufficient quantities of Electric Vehicles and electric heating systems are deployed.

D3 – Alternative Connections

Customers wanting a new connection for Distributed Generation already have the option of taking an alternative rather than standard connection. Timed, soft intertrip, export limited, and ANM variants have proven popular with customers.

D4 – Managed (Import/Export Limited) Connections

Customers have shown significant interest in connections where the consumption or export can be controlled under certain conditions or according to an agreed profile. A DER constraint panel has been developed and is now installed with all larger DG connections. Further development of variable export/import connections is planned.

Under the NIA Connect & Manage project we are developing a smart interface point for domestic customers. This will give customer the ability to take larger amounts of power from the network when circumstances allow. It will also allow us to protect assets from overload under exceptional circumstances when we would have the ability to turn down customer equipment such as chargers for electric cars.

Appendix E

Equipment

E1 – Telecoms readiness

Telecommunication links will be required for the collection of time series data from the control of Distributed Energy Resources (DER). Requirements for faster acting control to curtail or despatch DER are also likely. Such complex and automated schemes are likely to need higher performance telecoms. Electrical protection telecommunications requirements will increase as more complexity leads to additional intertrip and unit protection schemes.

Several Innovation projects and other ongoing research have assessed the suitability of emerging telecoms solutions to meet the above needs. WPD's NIA project Nexus is carrying out a global review of smart grid functional requirements to identify trends. The work led to trials of privately owned LTE networks. These trials have given us confidence to include LTE solutions in our future business plan and to engage with Ofcom over the provision of radio spectrum.

E2 – Transducers and measurement

Traditional networks only had sufficient telemetry and metering to enable an assessment of capacity and ensure the system was not overloaded. For a DSO much more granularity of actual energy flows is needed. Many measurement points will need to be recommissioned to provide this additional insight. In addition it is likely that additional measurement points at critical nodes will be needed to run network models and assess capacity issues. Retrofitting conventional CT/VT can be problematic and costly as we discovered on the Low Carbon Hub. Access to telemetry from other organisations (e.g. National Grid or customers) will increasingly be via Ethernet based protocols.

During the remainder of ED1 we will focus on the following priority areas:

- Installation of additional telemetry at distribution substations with high concentrations of LCTs (or where forecast).
- Improvement in the accuracy of data returned from strategic substations on the 132kV and 33kV networks.
- Integration of control systems via ICCP and data sharing with ESO at boundary points.
- Installation of additional telemetry or metering at sites with distributed generations.

E3 – Settlement and Metering Data

Significant volumes of intermittent generation and new emerging flexibility services are requiring additional and new types of metering to primarily measure energy volumes for planning and settlement purposes. There may also be an opportunity to use aggregated advanced and smart meter data for pseudo network measurements as these become prolific.

WPD's Flexible Power has developed a method of establishing demand base lines prior to turn down or turn up demand side response calls. This will be improved internally through 2020 and be fed into the Open Network programme for later in the year.

Work to create more advanced insight into network conditions from smart meter data will be postponed until sufficient devices are installed and national infrastructure is operational.

Project Case Study

- The Nexus project is developing requirements and standards for telecommunications networks which are suitable for DSO applications.

Project	Nexus
Budget	£0.274
Spend to date	£0.125
Project completion	Mar-17
Close down report	Jun-17

Equipment	2016	2017	2018	2019	2020	2021	2022	2023	Cost (£m)
Telecommunications readiness									5
Transducers and measurement equipment									5
Settlement and metering data for Network Operations									5
Managed Connection Interface Devices									2
Active Network Management Technology									2

Appendix E

E4 – Managed Connection Interface

A new type of technology is used to support the managed connections described under the Customer Propositions Workstream. Our Alternative Connections for distributed generation already require the installation of an innovative constraint panel which now incorporates a standard hardware solution that can support multiple software solutions. From NIA Connect and Manage, we've developed an LV solution for EV charging. This item is complete.

E5 – Active Network Management

Active Network Management systems are a new class of equipment which automatically adjust generation, storage or demand on a segment of network. The systems have been deployed in several UK DNOs as well as overseas. The systems need to be saleable and have an ability to interact with one another. Increasingly the areas are becoming more complex with a higher number of customers in the scheme. In addition there is a need to interact more and more with National Grid.

We therefore see a need to further refine the equipment we use to ensure it can cater for future requirements. We plan to do this by working with supply chain partners to influence their R&D and product development plans.

We will work with them to help test new products to ensure they are reliable, secure and cost effective.

Western Power Distribution (East Midlands) plc, No2366923
Western Power Distribution (West Midlands) plc, No3600574
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Western Power Distribution (South Wales) plc, No2366985

Registered in England and Wales
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

www.westernpower.co.uk

@wpduk