WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Network Headroom Report

Methodology Document

Introduction

This document outlines the methodology used by Western Power Distribution to produce the Network Headroom Report. An opportunity to respond on the Network Headroom Report is available on the WPD website. The publication of the Network Headroom Report is to be used to consult with stakeholders on the format and detail to be presented in the Network Development Plan (NDP) in 2022.

Network Development Plan

The Clean Energy Package (CEP) (EU Directive 2019/944[1]) comprises European legislation for a unified energy strategy for delivering the Paris agreement. This has now been implemented in GB law. As part of the Clean Energy Package, Ofgem have introduced licence changes, namely SLC 25B which relates to the publication of a NDP, the first publication due in 2022. The scope of the NDP includes:

a) parts of the distribution system most suited to new connections;
b) where reinforcement of the Distribution System may be required
c) sufficient information for secure and efficient operation, coordination development and interoperability of interconnected systems;
d) a reasonable number of future scenarios;
e) non-frequency ancillary flexibility services requirements.

Through the Open Networks project (Workstream 1B Product 5), Western Power Distribution and other electricity networks have developed a form of statement for the Network Development Plan. The objective is to define the common high-level Distribution Network Operator (DNO) end to end process for delivering the NDP licence requirements in the context of planning network investments and other reporting. The latest form of statement for the Network Development Plan is available here. The form of statement describes three constituent parts for the Network Development Plan, as outlined in Figure 1 below.

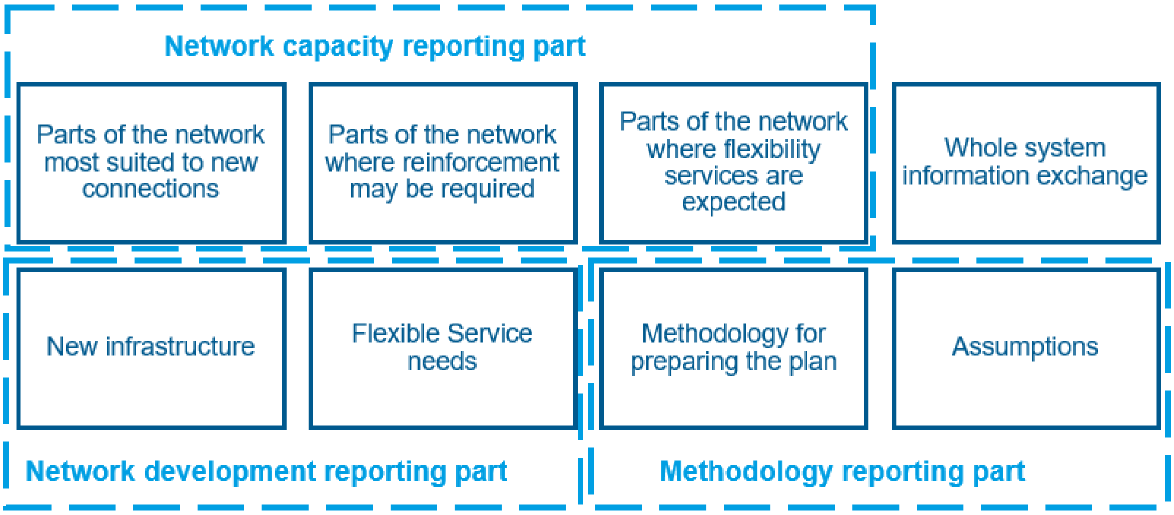


Figure 1: Outline of three parts of the Network Development Plan (taken from the NDP form of statement)

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN

Network Headroom Report

Prior to awareness of the updated Electricity Distribution Standard Licence Conditions, electricity networks shaped a Standardised Network Capacity/Headroom Report in 2020. This was delivered through the Open Networks project (Workstream 1B Product 5) and builds on the work already undertaken to standardise and align the Distribution Future Energy Scenarios (DFES) methodology and reporting format among electricity networks.

The NDP encompasses reporting on network capacity and therefore the previous learning and outputs identified for the Standardised Network Capacity/Headroom Report were useful in the development of the NDP form of statement. All DNOs committed to the discretionary publication of a Network Headroom Report in 2021 with the objective of gathering stakeholder feedback to help refine the NDP form of statement and on the understanding that it would be consumed within the NDP going forward.

As a result, the network capacity reporting aspects of the NDP form of statement have been developed building on the Standardised Network Capacity/Headroom Report, covered by this document. This one-off document aims to allow stakeholders feedback on the information provided and its value in decision making.

Western Power Distribution investment planning document structure

The Network Development Plan and component Network Headroom Report are both part of a wider suite of processes which Distribution System Operators will be undertaking from 2022 to plan the distribution network in a more proactive manner, as outlined in Figure 2.

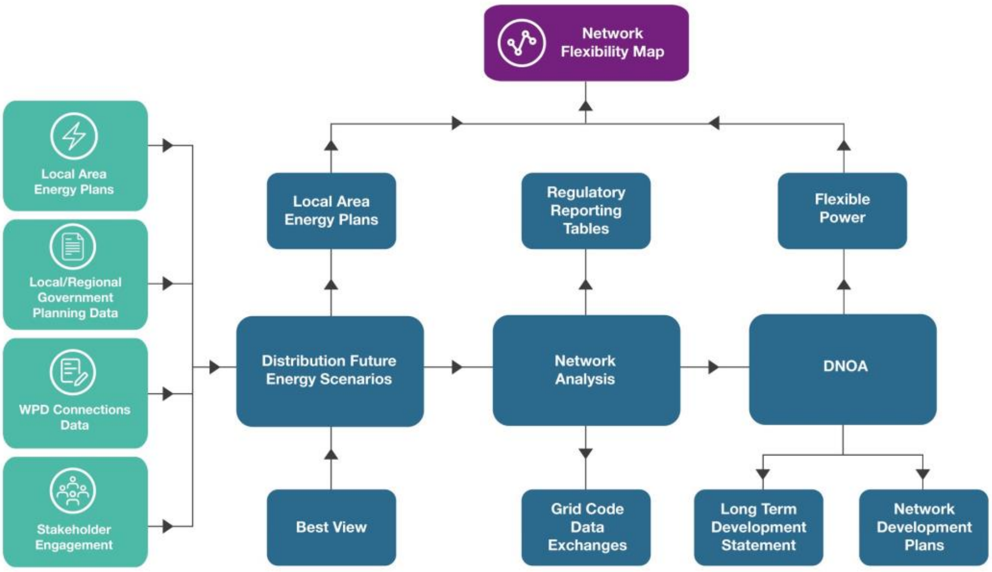
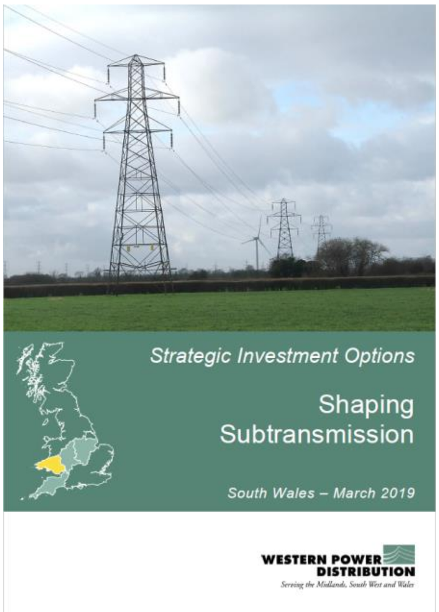


Figure 2: Diagram of end to end WPD investment planning process.



In previous years, WPD published a series of Shaping Subtransmission reports. These overlaid the DFES projections onto a network model of the 132 kV and 66 kV networks and identified potential network constraints over the medium term outlook. As part of these studies, WPD developed analysis tools and techniques to enable automated analysis of distribution networks. The Network Development Plan has formalised this network impact assessment for all DNOs to undertake on a periodic basis. The Network Development Plan will supersede the Shaping Subtransmission series of reports from 2022, using a similar analysis methodology.

Interaction with other Western Power Distribution documents

During 2020 and 2021 Western Power Distribution published documents which relate to available capacity and headroom on the distribution network. The interaction between these publications and the Network Headroom Report is outlined below.

RIIO-ED2 Business Plan

As part of the submission of a Business Plan for the RIIO price control period, WPD undertook strategic analysis of the distribution networks to identify areas of investment for the period from 2023-2028. The input growth rates and analysis methodology used for the Network Headroom Report is consistent with the RIIO-ED2 planning process; however there are expected to be some differences between the publications due to individual assessment of schemes already included as part of reinforcement to be delivered across the remainder of RIIO-ED1 or though the Green Recovery schemes included in the RIIO-ED2 Business Plan. The automated analysis to create the Network Headroom Report can be used to provide an indication where network constraints could occur. In order for any investment to be triggered as part of connections or price control planning processes, the Network Headroom Report must be examined in greater detail by network planning engineers to fully understand the extent of the constraint.

As aforementioned in this report, the Network Headroom Report is intended to be used as a publication for stakeholder consultation. The aim of the consultation is to identify if the Network Development Plan Form of Statement provides the correct level of information to stakeholders.

Long Term Development Statement

The Long Term Development Statement (LTDS) is a publication compiled in accordance with Electricity Distribution Licence Condition 25, to assist existing and future users of Western Power Distribution's network in identifying and assessing opportunities available to them for making new or additional use of our Distribution System.

As part of the statement, Table 3 presents forecasts of peak demand on our system in average cold spell conditions. This captures the annual peak demand for each node in the extra high voltage (EHV) power system model for each licence area, to allow for users to apply load assumptions in network assessment. Table 3 also includes a forecast of peak demand for future years, which is based on the WPD Best View scenario. Due to the timing of the publication of the Long Term Development Statement in November and Distribution Future Energy Scenarios in December, the forecast load information is based on the previous year's DFES forecasts and WPD Best View. As a result, the 2020 submission of the LTDS growth rates is not expected to align with the Network Headroom Report.

Ofgem committed to hold a working group to reform the LTDS in their 'Next steps on Key Enablers for DSO document'. Although delayed, the working group aims to update the LTDS by addressing the interoperability of network data to improve the sharing of planning data and so provide stakeholders with greater understanding of opportunities on the network.

Network Capacity Map

The Network Capacity Map provides an indication of the ability of the distribution network to connect large-scale developments to major substations. It can be viewed as a visual representation of some of the data contained in the Long Term Development, with additional information provided for the generation headroom of WPD substations. Information of the National Grid Transmission Statement of Works responses are also included, which can affect connection availability.

The Network Capacity map is regularly updated with snapshot of connection information incorporating recently connected generation, accepted but not yet connected generation and quoted generation connections. These figures regularly change as quotations are issued and expire. As a result, the Network Capacity Map reflects a 'committed' network position, which does not directly correspond to a single scenario or year used as part of the DFES process. Customers with accepted connection offers do not always progress through to connection, which DFES publications take a view on connection likelihood. In addition, DFES forecasts include the growth of small scale low carbon technologies, which would not typically be captured by a large scale connection offer.

Scenario Forecasting

The first step in WPD's load related planning methodology is establishing a forecast of future network loads across each of our four licence areas. Since 2015, WPD has been undertaking scenario planning work through Distribution Future Energy Scenarios reports, updating these on a two-yearly cycle to provide a forward looking 10 year window of potential low carbon technology uptakes. Since 2020 the DFES process has been run by WPD on an annual cycle to ensure consistency in reporting for all licence areas.

DFES: Volume Projections

Distribution Future Energy Scenarios provide granular scenario projections for the growth (or reduction) of generation, demand and storage technologies which are expected to connect to the GB electricity distribution networks. The WPD DFES also includes projections for new housing growth and increase in commercial and industrial developments. The projections are also informed by stakeholder engagement to understand the needs and plans of local authorities and other stakeholders.

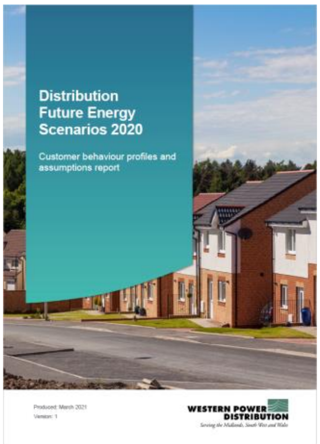
The development of DFES has enabled WPD to take a more proactive approach to network planning. Stakeholders were consulted via a series of consultation events, as well as direct engagement with local authority planners and climate emergency officers.

WPD publishes the DFES volume data as part of a suite of documents:

- **Stakeholder Engagement Report**: after a series of webinars are hosted to launch the DFES process and gather feedback from stakeholders, a report for each licence area summarises how WPD will account for the stakeholder feedback provided.
- **Methodology Slides**: summary of the DFES process, including data sources and how regional allocations factors are used for different technologies considered.
- **Technology Summary Report**: a set of reports outlining the scenario projections out to 2050 for each of the technologies considered for each of the WPD licence areas.
- **Regional Review**: a short review of the technology summary reports for each licence area to learn about DFES at a high level.
- **Local Authority Scenario Report**: a bespoke report of scenario projections for each Local Authority area in the WPD licence areas.

The DFES projections are also displayed as part of an interactive map on the WPD website.

DFES: Customer Behaviour Assumptions



The next step in the DFES process is to account for customer behaviour to the projected volumes. This is used to take into consideration the expected demand and generation profiles of new and existing customers connected to the distribution network. This includes assumptions for how customers connected to the distribution network will change over time due to increase in energy efficiency and pricing-led Demand Side Response (DSR).

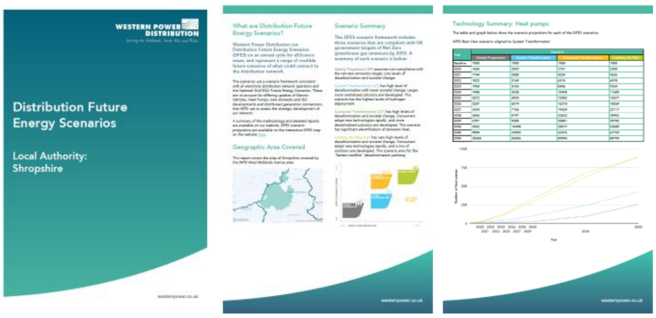
When the customer behaviour assumption in this document are applied to the DFES projections a load set of MW/MVAr values can be generated. This load set is a key input to the network analysis processes, whereby the DFES projections are assessed to identify any network constraints. It is worth noting that any customer behaviour assumptions must be made with reference to the purpose and level of network analysis that is being undertaken.

Further information on the customer behaviour assumptions is available as part of the DFES: Customer Behaviour Assumptions Report.

Deriving a WPD Best View

The WPD Best View is a single scenario which is used to inform forecasting market information, regulatory reporting, network datasets and future business plans. It is a dataset built at primary substation level, providing demand, generation and storage volume forecasts which can be combined with technology assumptions to infer MVA capacity requirements.

The WPD Best View is a not a single central outlook, but instead is derived from bespoke assessment of Local Area Energy Plans (LAEPs) and local delivery capability to enable WPD to assign a Distribution Future Energy Scenario for each Local Authority and hence all substations within that area.

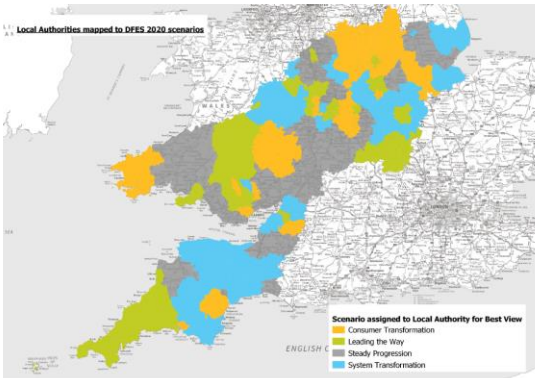


To support proactive engagement of the Local Authorities, Local Areas and Local Enterprise Partnerships, a DFES report has been created for each Local Authority region within the WPD area. Each Local Authority DFES report contains some information on the electrical assets within the region being fed, a map of the area and then a technology specific breakdown of the profiled uptake expected within the region across the four energy scenarios used within the industry. Finally, a fifth "WPD Best View" is also provided, this is the expected Low Carbon Technology (LCT) uptake that WPD is currently forecasting for future investment requirements.

WPD Best View Process

WPD believes that where DNO LCT volume forecasts align with LAEP forecasts, this should be regarded as highly certain, as long as that LAEP can demonstrate that it represents the wants of local stakeholders, that the requirements are reasonable and built up from quality evidence of need and that there is a competent plan for delivery. A number of these factors that demonstrate a high certainty of decarbonisation delivery can be assessed through reviewing the LAEPs in a lens consistent with Ofgem's LAEP Best Practice checklist, which WPD has used to develop a LAEP scoring criteria. This methodology allows the quality of the LAEP to be assessed against consistent criteria and is carried out by WPD's senior regional managers. Each Local Authority is assigned one of the four DFES scenarios that most closely aligns with the local ambition and delivery capability. This approach supports the application of a particular DFES scenario to an area and the ranking of that LAEP against others with a similar DFES scenario classification.

The DFES scenario is chosen by closely comparing the ambition of the planned volumes across all technology types within the area, and then further ranked on how close this ambition is likely to be to the needs of stakeholders (engagement completed), how accurate the modelling is and the capability of the area to deliver. A single DFES scenario is currently chosen to approximately represent all technologies, but there is scope in the future for differentiation between expected uptakes of technologies to also be simultaneously assessed.



Before the WPD Best View is finalised, the licence area totals are checked against national ambition to ensure WPD targets are aligned to deliver governmental policy. Scenario boundaries across the rankings may be moved to more closely aligned, assuming incentives and policy is directed at achieving national Net Zero ambitions. Each primary substation also receives a disaggregation of this “WPD Best View” and this is used to inform the growth rates required for investment across the network. The result is a Best View scenario which captures the varying levels of ambition across the WPD licence areas

Network Impact Assessment

This section outlines the analysis methodology used to obtain the network headroom figures contained in the Network Headroom Report. On the WPD website, a workbook for each licence area contains the network headroom for both additional demand and generation connections across the four DFES scenarios as well as the WPD Best View. These are included for all years out to 2050. The methodology for both demand and generation headroom is discussed separately below.

After the expected customer behaviour assumptions are applied to the DFES volume projections, a data set of the expected loads from demand and generation on the WPD network is generated. This data is then mapped to a network model in power system analysis software to undertake detailed network analysis.

Starting load assumptions

A yearly load survey is undertaken to determine the true demand at each Primary, BSP and GSP substation. This load survey unmasks generation and flexibility to give the true underlying demand at a substation. This observed data is used for the starting load assumptions relevant to the voltage level and purpose of the network analysis at the EHV level. A weather correction factor produced by TESLA on behalf of WPD accounts for key weather variables. It is provided at hourly granularity and is applied to the demand prior to finding the underlying peak demand. Weather correcting demand allows for extreme weather conditions to be offset, enabling more accurate comparisons with historic data to be carried out.

As the Network Headroom Report uses the latest published LTDS Table 3 data for the starting load assumptions, these are based on an engineering load survey covering the 2019/20 fiscal year. As a result, the peak demand figures for each substation were largely captured before the start of the COVID-19 pandemic.

Creation of growth rates

After the expected customer behaviour assumptions are applied to the DFES volume projections, a data set of the expected loads from demand and generation on the WPD network is generated. As noted in the DFES: Customer Behaviour Assumptions Report, each technology is profiled for 48 half hourly periods for a selection of representative days to calculate the headroom:

Purpose of assessment	Demand Headroom Assessment	Generation Headroom Assessment
Representative Day	• **Winter Peak Demand** • **Summer Peak Demand** • **Intermediate Cool Peak Demand** • **Intermediate Warm Peak Demand**	• **Summer Peak Generation**
Justification	The peak demand in all four seasons is assessed with minimum coincident generation. Coverage of all seasons allows for an assessment of the network's capability to meet not only annual peak demand conditions but also the demand conditions during periods of planned maintenance on the network.	The peak generation representative day is assessed with minimum coincident demand. This aims to provide an assessment of the network's capability to handle generation output. The season where generation constraints most normally occurs is during summer, with relatively low demand and high output of renewable generation.

Table 1: Representative Day descriptions used for Network Headroom Report analysis

It is not sufficient to look only at an aggregated demand or load when undertaking longer term strategic planning. There is a need to understand the constituent demand and generation that make up an aggregated load profile, as this enables modelling of changing customer behaviour over time. This lower level volume driven methodology ensures greater accuracy when determining projected growth and is not just based on historic trends.

As noted in the forecasting section of this report and the DFES: Customer Behaviour Assumptions Report, the customer behaviour assumptions account for how WPD expects customer electricity usage to change over time. Once the expected load growth of new customers and technologies is overlaid onto the baseline demand, the half hour of peak demand could change to a different time of day or season. This highlights the importance of assessing multiple seasons to ensure projected load growth captures the most credible edge-case peak demand for which distribution networks must be designed to.

Constraint Identification

Demand Headroom Calculation

To assess the current and future available capacity and to identify constraints that require intervention during the DFES time horizon, scenario growth data was compared against the firm capacities for each Primary substation and Bulk Supply Point, whereby:

- A Primary substation refer to a substation where the low voltage side of the voltage transformation is either 11 kV or 6.6 kV. This is consistent with the definition of the Electricity Supply Areas used in the DFES studies. Note that this encompasses sites with 132/11 kV transformation, which are also sometimes referred to as Bulk Supply Points;
- A Bulk Supply Point refers to a substation where the high voltage side of the voltage transformation is 132 kV and the low voltage side of the voltage transformation is either 33 kV or 66 kV.

The firm capacities are consistent with those published in table 3 of the Long Term Development Statement and on the Network Capacity Map application.

The growth rates were at a Primary level, so to produce suitable projections at a BSP level the average growth rates of the primaries downstream from each BSP were applied to the max demands in 2019/20 from the LTDS. This approach helps account for diversity and should produce more accurate projections than simply summating the Primary demand sets. The headroom available at the upstream BSP can be used to infer if there is a potential constraint on the upstream network which could affect the capacity for connections at lower voltage levels.

Generation Headroom Calculation

For the Network Headroom Report, generation headrooms are also included as it is acknowledged that the Network Development Plan must meet the needs of different stakeholders interested in both generation and demand connection capacity. The calculation for the generation headroom consists of two parts, each discussed below.

Thermal headroom

For the Summer Peak Generation representative day, the net loading at each Primary substation and BSP was calculated by subtracting the maximum credible coincident generation output from the expected demand profile each half hour. The half hour where the net loading was minimum was identified as the edge-case required for generation headroom analysis. It is worth noting that this does not necessarily correlate to the half hour of maximum generation output, nor to the half hour of minimum demand. It is particularly important to understand the generation technologies connected within an area to appropriately forecast the worst case network conditions for generation headroom assessment.

The net loading for each Primary substation was compared against the reverse power flow ratings consistent with those used in the WPD Network Capacity Map to calculate the generation headroom. The reverse power flow headrooms are calculated from the LTDS where available, and assumed to be 50% of the firm capacity rating where unavailable in the LTDS. A negative headroom does not necessarily result in a network constraint, as through alternative connection offers and load management schemes such as Active Network Management (ANM), some customers can be constrained for certain outage conditions to ensure no overloading of assets occurs.

Fault level headroom

Consideration of fault level was included because it is a major constraint on generation connections. For the Network headroom Report, an initial fault level assessment was undertaken. The existing maximum prospective fault levels under normal system running conditions and the make and break switchgear ratings at bussing points are taken from the Long Term Development Statement Table 4, which is consistent with the Network Capacity Map.

The additional generation expected to connect at each Primary substation for each year, scenario and generator type was calculated using an expected fault infeed contribution consistent with the figures published in the Western Power Distribution Policy Document: SD7F/2 (Determination of Short Circuit Duty for Switchgear on the WPD Distribution System). This was added onto the existing maximum fault level and compared to the switchgear make and break ratings to calculate a fault level headroom in kA.

In order to provide a single figure for the generation headroom, the fault level headroom in kA was converted to an equivalent assumed power figure of generation to connect to the network. This used an assumed weighted average for the make and break fault infeed contribution of all projected generation to connect across the DFES horizon. The minimum of the thermal and fault level MW headroom is then chosen as the generation headroom for any given year, scenario and Primary substation.

Modelling limitations

General

1. The impacts of planned reinforcements, contracted flexibility and load management schemes are not included in the Network Headroom Report. For certain outage conditions load management schemes may operate to constrain customers to ensure no overloading of assets occurs. Detailed power systems analysis is required to model the impacts of load management schemes.
2. In the Network Headroom Report, when a potential network constraint is identified no reinforcement is modelled to alleviate the network constraint. This analysis will be required for the Network Development Plan, where detailed power systems analysis require network interventions to be modelled in order to enable model convergence – this will be included as part of the Network Development Reporting part of the NDP as shown in Figure 1.

3. To enable accurate analysis on the distribution network, a representative Transmission model is necessary. This Transmission representation is an equivalent of the full Transmission network and, when incorporated into the WPD power system model, approximates the network behaviour. This data is provided by National Grid as part of the Week 42 data exchange. The size of the equivalent model varies for each licence area, depending on the level of GSP parallel running and interconnection. Currently Transmission models are not provided for future years, scenarios and seasons, which could increase the accuracy of future headroom modelling.
4. Not all substations are included on the Network Headroom Report, as those which supply only a single customer are not reported. This is to comply with the Network Development Plan licence condition 25B.6 A, which states:

   The licensee must include the information required by 25B.3 in every Network Development Plan and must publish the relevant data and information referred to in 25B.4 except if it receives the Authority's consent to:

      (a) omit any details about circuit capacity, power flows, loading, or any other information the disclosure of which would, in the Authority's view, seriously and prejudicially affect the commercial interests of the licensee or any third party;

Thermal headroom analysis

5. For both demand and generation network headroom assessments, a firm capacity style analysis may not fully capture the complex nature in which distribution networks are run. Where areas of the distribution network run interconnected, each distinct area cannot be studied in isolation the network loading is susceptible to changes in other parts of the parallel group. Detailed power systems analysis is required to fully capture the available headroom for the distribution network.

6. A firm capacity style analysis may define the headroom available to connect demand or generation at a particular voltage level, however this may not capture the available headroom at upstream voltage of the distribution network, which may be the limiting factor to connect new demand and generation. Again, detailed power systems analysis is required to fully account for the materiality headroom for different parts of the distribution network.

Fault Level analysis

7. The fault level analysis only considers the additional fault infeed from generation connected at each Primary substation in isolation. It does not account for wider network changes that would affect upstream fault infeed due to the connection of additional distributed generation, removal of generation (particularly synchronous plant) and changes in network topology. To assess changing fault level accurately detailed power system analysis is required, with a future National Grid equivalent model representing the appropriate year, scenario and loading condition.
8. Only three phase faults were considered in the initial fault level analysis for generation headroom assessment.
9. Fault level assessment assumes that new demand and generation would connect directly to the 11 kV or 6.6 kV bar of the Primary substation. As a result, this is a worst-case assumption as no additional impedance assumptions have been made for the connection of new demand and generation.

Next steps

The network Headroom Report outlines the expected format and contents of the capacity reporting element of the Network Development Plan. As part of the launch stakeholders will be invited to provide feedback on the format, which will be incorporated to the Network Development plan publication in 2022. Please contact wpdnetworkstrategy@westernpower.co.uk to provide feedback on the content of the Network Headroom Report.

As part of the transition to a Distribution System Operator, Western Power Distribution have developed analysis tools and techniques to enable automated analysis of distribution networks in more detail than previously possible. This allows for more comprehensive analysis of EHV networks, accounting for all combinations of first and second circuit outage and network automation, load management schemes and manual switching schemes. This ensures the strategic analysis of distribution networks aligns to how the distribution network is operated and also provides confidence of the available network capacity to stakeholders.

However accounting for the combination of every substation on the distribution network, year, scenario, season and half hour and possible combination of outage condition results in a very large number of individual load flow studies required in power systems analysis software. Furthermore, as aforementioned the detailed automated analysis requires network interventions to be modelled when a constraint occurs, in order for a network model to fully converge with the extent of load growth projected to 2050.

As a result, networks must find a balance between undertaking detailed power systems analysis to ensure accuracy of results and ensuring that the analysis is completed in a timely manner with the resource available. WPD plans to continually improve and refine the analysis methodology as part of the strategic investment planning processes and share best practice with other Distribution Network Operators to encourage whole system benefits.

Western Power Distribution (East Midlands) plc, No2366923
Western Power Distribution (West Midlands) plc, No3600574
Western Power Distribution (South West) plc, No2366894
Western Power Distribution (South Wales) plc, No2366985
Registered in England and Wales
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

wpdnetworkstrategy@westernpower.co.uk