SSEN DISTRIBUTION

SSEN Network Development Plan

Methodology & Assumptions

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Scottish & Southern Electricity Networks

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1 Introduction

The Clean Energy Package comprises European legislation (including EU Directive 2019/944)[1] to drive a unified energy strategy for delivering the Paris agreement. In December 2020, it was transposed into domestic legislation through a number of changes to the Electricity Distribution Licence. This included the introduction of standard licence condition (SLC) 25B. SLC 25B requires Distribution Network Operators (DNOs), including our two licensees Southern Electric Power Distribution plc (SEPD) and Scottish Hydro Electric Power Distribution plc (SHEPD), to publish a Network Development Plan (NDP), setting out their investment plans for the next five to ten year period in relation to 11kV networks and above. It must include:

a) A description of those parts of the DNO's network that are most suited to new connections and distribution of further quantities of electricity;

b) A description of those parts of the DNO's network where reinforcement may be required to connect new capacity and new loads;

c) Information that supports the secure and efficient operation, coordination, development and interoperability of the interconnected system; and

d) Flexibility or Energy Efficiency Services that the DNO reasonably expects to need as an alternative to reinforcement.

To ensure consistency in reporting across all DNOs in terms of SLC 25B, the Energy Networks Association (ENA) prepared a report that sets out the agreed form of sharing data with stakeholders, customers and consumers. The proposal for the Form of Statement of Network Development Plans[2] was developed as part of the Open Networks workstream 1B, which proposed a standardised Standard Network Capacity Report. To meet the requirements of SLC 25B, the NDP is split into 3 distinct reports, as illustrated in Figure 1 below; the red box highlights the part this document represents:

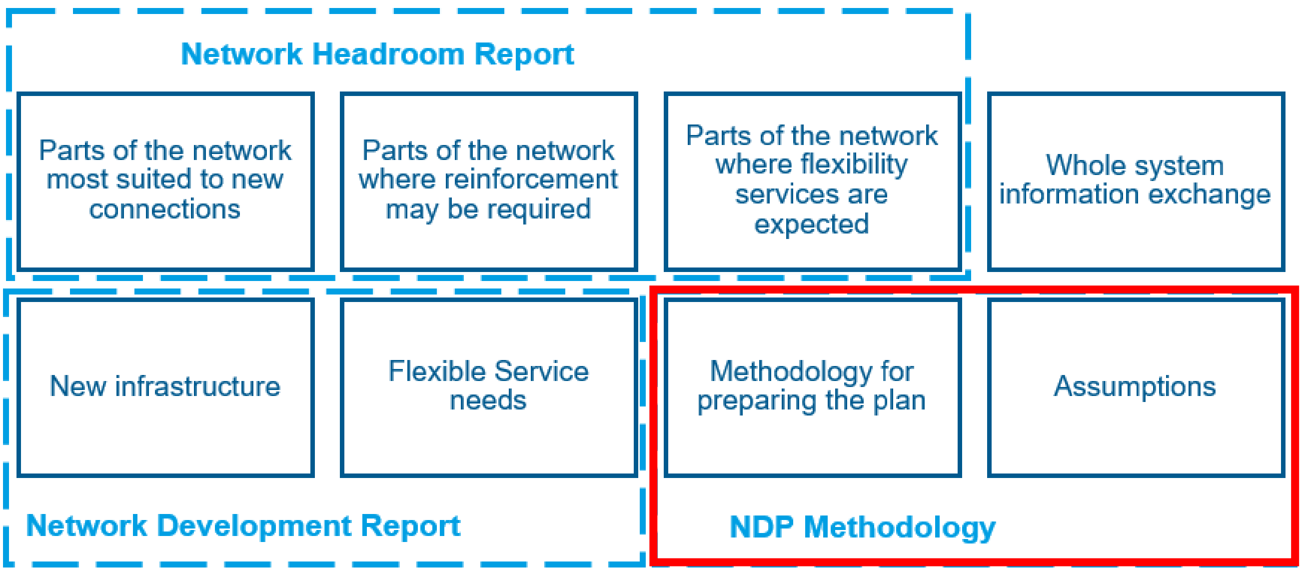

Figure 1 - NDP Reporting Structure

[1] Clean Energy Package (EU Directive 2019/944)
[2] ENA NDP Form of Statement Template and Process (22 Dec 2021)

Network Development Report (NDR)

The NDR serves to provide the reader with valuable additional information on key projects set for delivery in terms of new infrastructure to be installed and upcoming flexible services to be employed. The aim of the information is to provide users with visibility over our network plans and signpost requirements for flexibility services so that users can target developments.

The NDR is to provide a list of high-level plans for network interventions and flexible service requirements over the next 10 years along with the following information:

Table 1 - Scope of the Network Development Report

Flexibility services	New infrastructure
○ Magnitude; ○ Year of intervention & likely duration ○ Location of the requirement; ○ Nature of requirement / flexibility product.	○ Timing and high-level scope of intervention; ○ Details of connectivity; ○ Asset quantities & approximate lengths ○ Equipment ratings; ○ Approximate locations.

Network Headroom Report (NHR)

The main objective of the NHR element of the NDP is to indicate where it is anticipated that there will be network capacity to accommodate future connections, where further capacity may be necessary and where flexibility services may be required.

The NHR will include the following components of distribution networks:

- Substations where the greatest voltage is more than 20kV, normally:
    - Bulk Supply Points, BSPs (typically 132/33kV or 132/11kV,66/22kV), and
    - Primary substations (typically 66/11kV, 33/11kV or 33/6.6kV,22/11kV,22/6.6kV).
- In Scotland, 132/33kV substations are known as Grid Supply Points (GSPs) rather than BSPs, due to the lower transmission/distribution boundary and would therefore be excluded from the network capacity reporting part of the NDP.

Table 2 - Minimum Requirements for NHR

Date Range	Up to 2050
Data Granularity	Every year for the first ten years and then five years thereafter
Forecast Scenarios	Distribution Future Energy Scenarios (DFES)[3&4]
Reported headroom/deficit	Demand & Generation
Network Coverage	Distribution voltages down to the secondary primary substation (typically 11kV

Network Development Plan (NDP) Methodology & Assumptions

The purpose of the NDP Methodology & Assumptions, this specific document, is to ensure that the documents utilised, forecasts proposed, and calculations used are clear to the reader. It details the end-to-end process starting with forecasting to our best view development plan.

[3] SHEPD Distribution Future Energy Scenarios 2021 – Results & Methodology Report (Published 04 March 2022)
[4] SEPD Distribution Future Energy Scenarios 2021 – Results & Methodology Report (Published 04 March 2022)

2 Headroom Capacity Methodology

2.1 Demand Headroom

This section describes the methodology behind the calculation of the available demand headroom at each Primary (66-33-22 kV/11-6.6 kV) and BSP (132-66 kV/33-22-11 kV) substation in the SEPD licence area and each Primary (33/11 kV) substation in the SHEPD licence area. Note that GSP substations (132 kV/33 kV) are not included in the SHEPD licence area as these are classed as Transmission infrastructure.

Given the rapidly changing consumption patterns of new demand and storage technologies, it is becoming more difficult to identify the single worst-case network condition that will determine the available demand headroom of a substation. Therefore, the demand headroom calculation is based on seasonal peak demand profiles with minimum coincident generation, both for the baseline substation demand and the forecasted demand and storage technologies.

The baseline peak demand profile of each Primary and BSP substation for each season (Winter, Summer, Spring and Autumn) was produced from 2020/21 measured data and consists of 48 half-hourly average readings, which represent a 24-hour period. These half-hourly readings correspond to the day where the peak demand of each substation occurred for each season.

SSEN's DFES analysis produced scenario forecasts for the connected capacity of storage and low carbon demand technologies, as well as projections for new housing growth and new commercial and industrial developments at each Primary Substation up to 2050, for both licence areas. More specifically, the key demand and storage technologies which were utilised by SSEN Distribution to produce the forecasted peak demand profiles for each substation are as follows:

- Electric Vehicle Chargers (Domestic off-street, Domestic on-street, Workplace, Fleet, Enroute local, Destination, Car Park)
- Domestic Heat Pumps (Hybrid, Non-Hybrid)
- Domestic Direct Electric Heating
- New Developments (Domestic, Factory and Warehouse, Hospital, hotel, Medical, Office, Other, Restaurant, Retail, School & College, Sport & Leisure, University, Data Centres)
- Air Conditioning
- Battery Storage (Standalone Grid Services)

A seasonal half-hourly demand profile was produced for each demand and storage category listed above. These profiles were combined with the installed capacity projections for demand and storage at each substation.

The aggregated power profiles of the projected installed capacity of demand and storage were combined with the baseline peak demand profile of each substation to create its forecasted peak demand profile for each season, for each year to 2050 under all DFES scenarios.

The peak value of the demand profile of each substation was then compared with its firm capacity in order to identify the available demand headroom or deficit.

Based on the above, the demand headroom is defined, per DFES scenarios, per substation, per year (from 2022 – 2050), as follows:

Demand Headroom = Substation Firm Capacity – Forecasted Maximum Demand

It must be highlighted at this point that this exercise mainly focuses on the available demand headroom at the substation level only. Within this analysis, the methodology has taken into account potential circuit limitations for radial circuits, since this is considered within the published firm capacity values. However, for highly interconnected ring networks, there is a possibility that the methodology would provide an overestimate of the available headroom, as this might be reduced by circuit limitations. To account for some of the upstream circuit limitations or interconnected networks, the headroom methodology considers any upstream circuit constraints for substation groups which were identified to require reinforcements within the RIIO-ED2 period (2023 – 2028).

Potential voltage constraints and upstream transmission constraints have not been considered within the analysis.

Furthermore, the demand headroom at each substation is calculated by considering the diversity between its baseline peak demand profile and the seasonal power profiles for each demand and storage technology projected to connect to this specific substation. This means that we are not using the 'traditional' demand connection assessment which utilises an absolute maximum demand value for both existing and proposed load.

Based on all of the above, it is possible that additional factors might limit the available demand headroom at each substation, which would be identified as part of a formal connection assessment carried out by SSEN Distribution.

It must be noted that there may be upstream constraints beyond the primary substation or bulk supply point due to substation groups or GSP constraints. Upstream constraints are highlighted in within the Network Headroom Report; however, these constraints are not reflected in the headroom capacity values. Where an upstream constraint is identified any new connection will require a detailed system study to determine the actual headroom capacity.

2.1.1 Data

Table 3 - Demand Headroom Data & Assumptions

Component	**Dataset**	**Description**	**Assumptions**
Demand	Demand Forecast	Demand projection per substation for the 4 Distributed Future Energy Scenarios (DFES)	Half-hourly profiles for both the baseline peak demand and the forecasted demand and storage technologies
Capacity	Firm Capacity	Current firm capacity per substation taken from the Long-Term Development Statement (LTDS)	The base firm capacity per year per substation is added to any additional capacity that is planned to become available within the ED2 Period (2023-2028)
	Planned Released Capacity	New firm capacity which is expected to become available per substation within the ED2 period (2023-2028)	
	Transformer Nameplate Rating	The transformer nameplate rating taken from the SSEN Distribution Generation Heatmap dataset	For a number of substations without firm capacity data, the Transformer Nameplate Rating was used as a substitute for Firm Capacity in the Demand Headroom calculation given above. The Heatmap dataset has been used in this analysis as it will be familiar to stakeholders.

2.2 Generation Headroom

This section describes the methodology behind the calculation of the available generation headroom at each Primary (66-33-22 kV/11-6.6 kV) and BSP (132-66 kV/33-22-11 kV) substation in the SEPD licence area and each Primary (33/11 kV) substation in the SHEPD licence area. Note that GSP substations (132 kV/33 kV) are not included in the SHEPD licence area as these are classed as Transmission.

Given the rapidly changing generation patterns of new distributed generation and storage technologies, it is becoming more difficult to identify the single worst-case network condition that will determine the available generation headroom of a substation. Therefore, the generation headroom calculation is based on seasonal minimum demand profiles with maximum coincident generation, both for the baseline substation demand and for the forecasted distributed and storage technologies.

The baseline minimum demand profile of each Primary and BSP substation for each season (Winter, Summer, Spring and Autumn) was produced from 2020/21 measured data and consists of 48 half-hourly average readings, which represent a 24-hour period. These half-hourly readings correspond to the day where the absolute minimum demand of each substation occurred for each season.

SSEN's DFES analysis produced scenario forecasts for the connected capacity of distributed generation and storage at each Primary Substation up to 2050, for both licence areas. More specifically, the key distributed generation and storage technologies which were utilised by SSEN Distribution to produce the forecasted net flow profiles for each substation are the following:

- Renewable Energy Generation technologies including:
    - Solar PV
    - Onshore and Offshore Wind
    - Hydropower
    - Marine
- Waste and Bio-Resource electricity generation including:
    - Biomass
    - Sewage and Landfill Gas
    - Anaerobic Digestion
    - Energy from Waste
- Fossil Fuel Electricity Generation technologies including:
    - Diesel
    - Natural Gas
- Battery Storage

A seasonal half-hourly generation profile was produced for each distributed generation and storage category listed above. These profiles were combined with the installed capacity forecasts for distributed generation and storage at each substation.

The aggregated generation profiles of the projected installed capacity of distributed generation and storage were combined with the baseline minimum demand profile of each substation to create its forecasted net flow profile for each season, for each year to 2050 under all DFES scenarios. The net flow through the transformers of a substation can be either forward (negative/demand) or reverse (positive/reverse power flow).

The maximum value of the net flow profile of each substation was then compared with its transformer nameplate rating in order to identify the available generation headroom or deficit.

Based on the above, the generation headroom is defined, per DFES scenarios, per substation and per year (from 2022 – 2050), as follows:

Generation Headroom = Transformer Nameplate Rating – Forecasted Maximum Net Flow

It must be highlighted at this point that this exercise mainly focuses on the available generation headroom at the substation level only. Within this analysis, the methodology has taken into account potential circuit limitations for radial circuits, since this is considered within the published transformer nameplate ratings. However, for highly interconnected ring networks, there is a possibility that the methodology would provide an overestimate of the available headroom, as this might be reduced by circuit limitations. To account for some of the upstream circuit limitations or interconnected networks, the headroom methodology considers any upstream circuit constraints for substation groups which were identified to require reinforcements within the RIIO-ED2 period (2023 – 2028), as shown in our Network Development Report.

Potential voltage constraints and upstream transmission constraints have not been considered within the analysis.

Furthermore, the generation headroom at each substation is calculated considering the diversity between its baseline minimum demand profile and the seasonal generation profiles for each distributed generation and storage technology, which is projected to connect to this specific substation. This means that we are not using 'traditional' generation connection assessment, which utilises absolute minimum demand values and maximum existing and forecasted generation output. Therefore, the total generation headroom identified for each substation also includes the available headroom for flexible generation connections.

The above means that it is possible that additional factors might limit the available generation headroom at each substation, which would be identified as part of a formal connection assessment carried out by SSEN Distribution.

It must be noted that there may be upstream constraints beyond the primary substation or bulk supply point due to substation groups or GSP constraints. Upstream constraints are highlighted in within the Network Headroom Report; however, these constraints are not reflected in the headroom capacity values. Where an upstream constraint is identified any new connection will require a detailed system study to determine the actual headroom capacity.

2.2.1 Data

Table 4 - Generation Headroom Data & Assumptions

Component	Dataset	Description	Assumptions
Generation	Generation Forecast	Generation projection per substation for the 4 Distributed Future Energy Scenarios (DFES)	Half-hourly profiles for the forecasted distributed generation and storage technologies
Capacity	Transformer Nameplate Rating	The transformer nameplate rating taken from the SSEN Distribution Generation Heatmap dataset. The Heatmap dataset has been used in this analysis as it will be familiar to stakeholders.	Enhanced emergency transformer ratings were not considered as part of this analysis

3 Methodology Assumptions

3.1 Overall methodology assumptions

- Available Demand and Generation headroom was calculated at the substation level only.
- Within this analysis, the methodology has taken into account potential circuit limitations for radial circuits, since this is considered within the published firm capacity values. However, for highly interconnected ring networks, there is a possibility that the methodology would provide an overestimate of the headroom as circuit limitations may reduce the headroom at substations. To account for some of the upstream circuit limitations:
  - The headroom methodology considers any upstream circuit constraints for substation groups which were identified to require reinforcements within the RIIO-ED2 period (2023 – 2028), please see our Network Development Report.
  - This is done by adjusting the generation and demand capacity, as well as generation and demand at affected substations, to produce an illustrative headroom which incorporates upstream circuit limitations.
  - No upstream network voltage constraints were considered during this analysis
- No upstream transmission constraints were considered during this analysis
- When firm capacity was not available, the transformer nameplate rating was utilised for the calculation of the demand headroom
- The combination of half-hourly baseline demand profiles and half-hourly power profiles for each demand, distributed generation and storage technology were used to calculate the available demand and generation headroom at each substation.
- Regarding the fault level calculations, it must be highlighted that at most sites, not all circuit breakers would be subject to the fault currents provided.

3.2 Limitations

As stated in the assumptions above, the available demand and generation headroom was calculated at the substation level only.

Upstream thermal capacity limitations have been considered by adjustments to generation and demand capacities as well as demand and generation for any substations requiring investment in the RIIO-ED2 period as determined by our “best view” scenario; Consumer Transformation.

Voltage constraints and upstream transmission constraints have not been considered within the analysis.

Additionally, headroom calculations consider the diversity between substation baseline demand profiles and the half-hourly profiles for each demand, distributed generation and storage technology, making this analysis different from using maximum values as per our ‘traditional’ connection assessments. Based on the above, especially for the generation headroom, the values calculated also include the headroom for flexible generation connections.

Given the points raised above, it is highly likely that additional factors might limit the available demand and generation headroom at each substation, which would be identified as part of a formal connection assessment carried out by SSEN Distribution.

The information presented within the NPD is accurate at the point of publication. Future forecasts under the DFES may differ over time as a consequence of government policy, a change in consumer habits, changes to generation portfolio through new connections etc. In addition, our proposed investments may change because of changing forecasts and agreed allowances as set by Ofgem as part of each Distribution Price Control period. Although the NDP provides a view of the future in terms of our investments and potential network constraints; we would encourage any party using this information in their decision-making process to engage with us ahead of lodging an application to connect or offer flexible services.