Network Development Report

West Midlands

April 2022

Contents

Introduction

The Network Development Reports cover targeted areas of the extra high voltage (EHV) and 132 kV distribution networks where developments are expected on the 0-10 year window. For information on the methodology used to undertake the studies and how stakeholder feedback is taken into account, please refer to the Network Development Plan Methodology Report. Each section follows a consistent format, as outlined below.

Network Overview

A summary of the network area studied. This includes geographic area, load composition and schematic diagrams of the area of network supplied.

Network Operability Modelling

As part of the network analysis, actions undertaken by network automation schemes and manual switching schemes are modelled. This ensures that following any outage combination which could occur, the subsequent topology of the network most closely represents how the distribution network is operated in real time. The network operability actions are written as a series of Python scripts, and triggered as part of the load flow routine either as a pre-emptive action (i.e. prior to load flow calculation) or as a remedial action (i.e. post load flow calculation).

This section summarises the network automation and manual switching schemes that are modelled.

Network Constraint Summary

Constraints identified on the area of network in focus are summarised in a concise way. Where a Bulk Supply Point or Grid Supply Point group is studied as a whole, each constraint within the group is captured as part of the same network group.

Constraint summary

Table which includes information about the nature of the constraint, including:

- **Constrained assets -** for the area in focus, this encompasses multiple parts of the network which are affected by the same underlying outage conditions. This could be summarised for multiple sections of a circuit or transformers operating as part of a group.
- **Type of constraint -** this could include thermal overloading of assets, voltages outside of statutory limits or demand disconnected for security of supply assessment;
- **Constrained condition** - prevailing load conditions whereby the constraint occurs, relating to the representative study periods which WPD cover in the Network Development Plan;
- **Limiting factor of constrained assets** – the rating of the asset which triggers the constraint; and
- **Outage combination which causes the constraint –** the combination of intact, first or second circuit outages that trigger the constraint. In areas of network with complex running arrangements the most critical outage combination is not evident, which necessitates the analysis methodology as outlined in the NDP Methodology Report.

Scenario identification

A table to outline the trigger years for constraints on the network area studied. This captures the earliest year that a network investment decision needs to be taken.

Solution options

A summary of the solutions which have been considered to alleviate the projected constraint. These are modelled for their technical suitability and are summarised in a table under the following categories:

- Reinforcement, covering new-build solutions to increase the capacity of the network in focus. This could include new assets or the removal of ancillary rating limitations on existing assets. In addition, the Network Development Plan analysis can highlight where additional substations could be established as an alternative solution for load growth as a more coordinated solution.
- Operational mitigation covers actions which WPD can take to mitigate constraints without the requirement for additional network capacity. This could include proposals to change running arrangements or limit access windows where arranged outages can be taken.
- Load Management Schemes cover plant, equipment and software systems that together manage network loading and voltages. This is achieved by either controlling demand and/or generation connected to the network, operating switchgear to change the topology of the network and/or controlling the settings of tap-change controllers, reactive compensation equipment and flexible power links. Load management schemes can be utilised to manage both demand and generation driven constraints, however this is dependent on the technical/contractual ability for customers to accept curtailment.
- Flexibility covers actions by network users (through contracts with the DNO) to reduce network loading for a given condition by increasing, reducing or shifting their net import or export.

Not all solution options are mutually exclusive to one another, a combination of different solutions can be utilised to undertake low regret investment. The appraisal of different solution options allows for a more coordinated assessment of future network developments to accommodate scenario projections.

Further optioneering will be carried out for all schemes, including a full cost benefit analysis using the Common Evaluation Methodology (CEM) tool as part of the Distribution Network Options Assessment (DNOA) process to assess the use of flexibility against conventional reinforcement (where flexibility is deemed a viable option). These decisions will be published in the next iteration of the DNOA.

Meaford BSP

Network Overview

Meaford C Bulk Supply Point (BSP) is a 132/33 kV network consisting of two 45/90 MVA Grid Transformers (GT). The BSP supplies the following 33/11 kV Primary substations that feed the local areas: Meaford, Cotes Heath, Eccleshall, High Offley, Gnosall, Hinstock, Hookgate, Simplex, Bearstone, Hill Chorlton, and Market Drayton.

The transformers run in parallel and in the event of an outage on one Grid Transformer, the other picks up the BSP's demand. Due to the rural nature of the Primary substations within Meaford C BSP, interconnection at 11 kV and 33 kV is quite limited as the voltage levels could not be sustained.

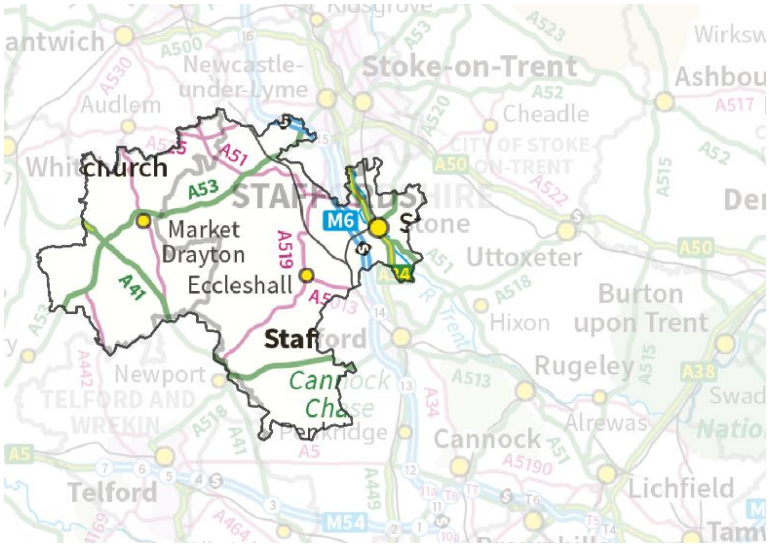

Figure 1 Meaford C BSP geographic network coverage

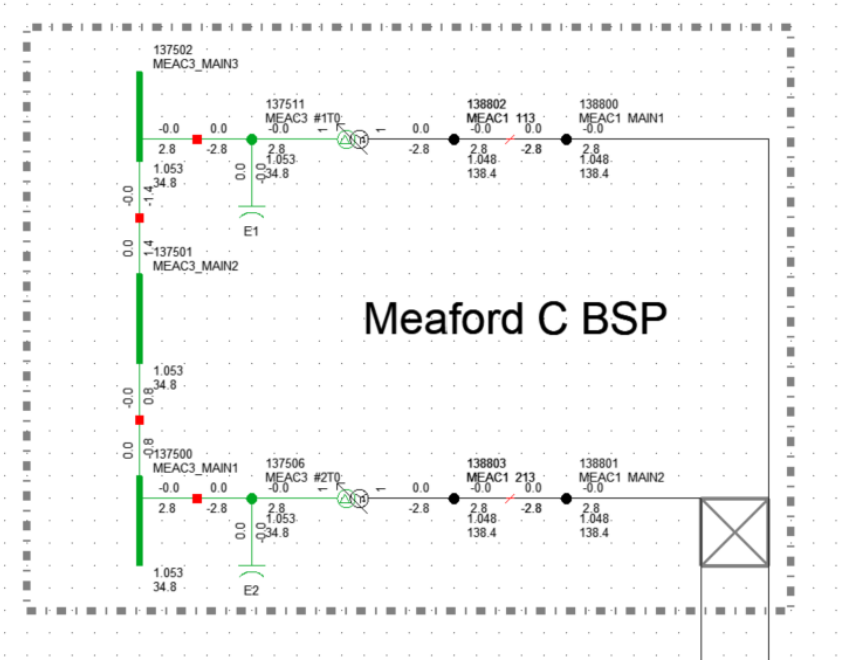

Figure 2 Meaford C BSP network schematic

Constraint summary

Generation | **Demand**

With projected load growth and numerous new connection demand schemes proposed to develop in the area, the 132/33 kV transformers are likely to overload following an outage on the other.
The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	132/33 kV transformers at Meaford C BSP	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand	
Limiting factor of constrained assets	Rating of the 132/33 kV transformers	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage affecting either 132/33 kV transformer
	Second Circuit Outage	Arranged outages at 11 kV leading to demand transfer into the BSP group, followed by a fault on one of the Grid Transformers.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

	Study year			
Scenario	**Baseline**	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	**Summary**
Reinforcement	Extend Barlaston 132 kV switching site and install a new 132/33 kV transformer at to support the existing two Grid Transformers at Meaford C. Works will also include 33 kV busbars and circuits, interconnected with the existing board at Meaford C.
Operational mitigation	Very limited due to the First Circuit Outage constraint and the potential Engineering Recommendation P2/7 non-compliance for a Class D group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class D group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Meaford Primary

Network Overview

Meaford C Primary is a 33/11 kV site consisting of three 12/24 MVA transformers (T3, T4 and T5) supplying the local areas within Meaford and Barlaston. T4 and T5 run in parallel at 11 kV and back feed each other. T3 runs radially but gets back fed by T4 and T5 following an arranged outage on the transformer or its incoming supplies.

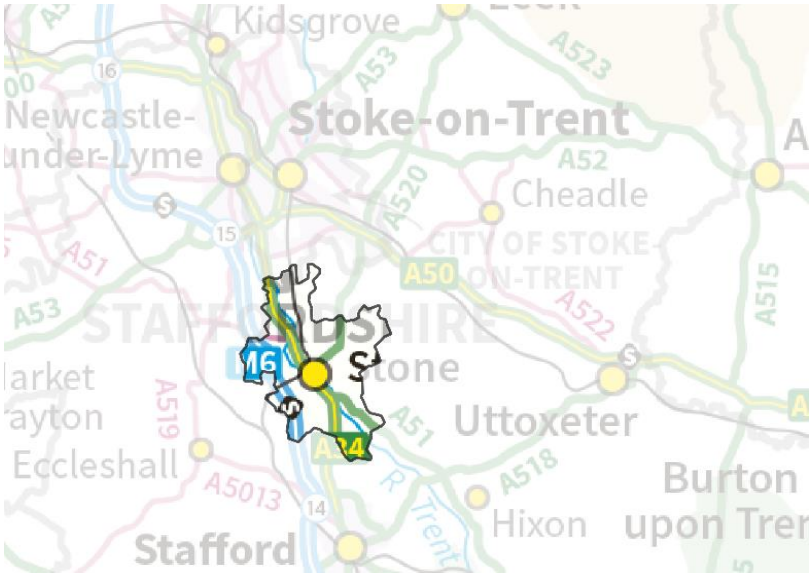

Figure 3 Meaford C Primary geographic network coverage

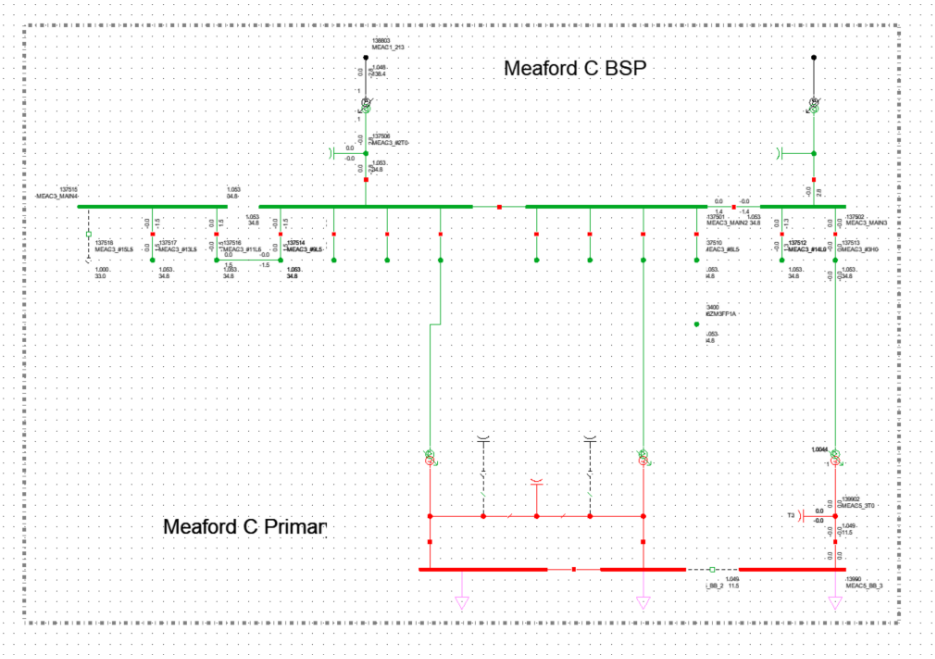

Figure 4 Meaford C Primary network schematic

Constraint summary

Generation | **Demand**

With projected load growth in the area, T4 and/or T5 are likely to overload following:

- Arranged First Circuit Outage (FCO) on T3 leading to supplies being back fed from T4 and T5
- Arranged FCO on T3, followed by a Second Circuit Outage (SCO) on either T4 or T5, or
- Fault outage on either T4 or T5 leading to supplies being back fed via the other transformer

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	33/11 kV transformer (T4 and/or T5)	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Intermediate Warm Peak Demand (FCO and SCO constraints) Summer Peak Demand (SCO constraint only) Winter Peak Demand (SCO constraints only)	
Limiting factor of constrained assets	Rating of the 33/11 kV transformers for T4 and/or T5	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	An arranged outage on T3, or A fault outage on T4 or T5.
	Second Circuit Outage	Arranged outage on T3, followed by a fault outage on T4 or T5.

Scenario identification

The table below highlights how the constraints occur during the 0-10 year period across the different scenarios studied.

First Circuit Outage constraint scenarios:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				
System Transformation				
Consumer Transformation				✓
Leading the Way			✓	✓
WPD Best View				✓

Second Circuit Outage constraint scenarios:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Option 1: Uprate T4 and T5 to 20/40 MVA transformers with associated 11 kV circuit breaker works.
	Option 2: Install a fourth 33/11 kV transformer (with associated 33 kV and 11 kV busbar works to facilitate the connection), and run the Primary as a 2+2 site with evenly split demands and suitable 11 kV interconnections.
Operational mitigation	Operational mitigation is very limited for the FCO constraint. For the SCO constraint, the downstream network can be split to avoid thermal overloads. Alternatively, arranged outages can be limited to periods where demand is low but this can be impractical due to the period of time certain arranged outages require.
Load Management Schemes	This is very limited due to the potential non-compliance for a Class C group demand under Engineering Recommendation P2/7.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Eccleshall Primary

Network Overview

Eccleshall Primary substation is a single 33/11 kV transformer site supplying a relatively rural area. There are two 33 kV circuits into the site from Meaford BSP forming a ring between Eccleshall, High Offley, Gnosall, and Hinstock Primary substations. The site relies on 11 kV interconnections from Cotes Heath and Stafford Primary substations for the loss of supply to its transformer, which is a 10/13 MVA unit.

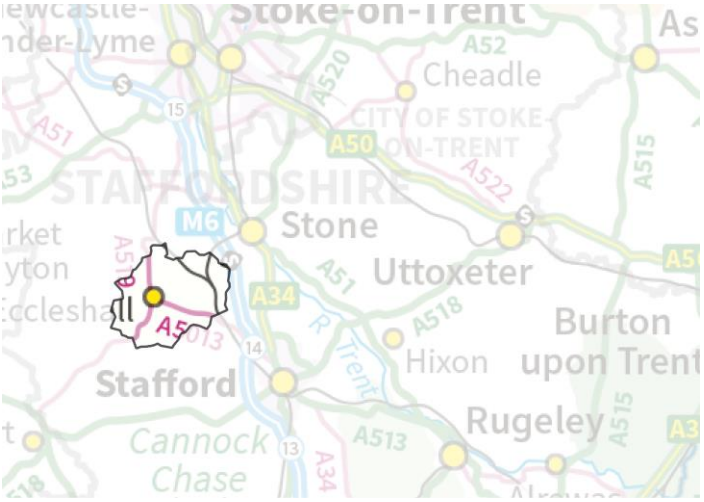

Figure 5 Eccleshall geographic network coverage

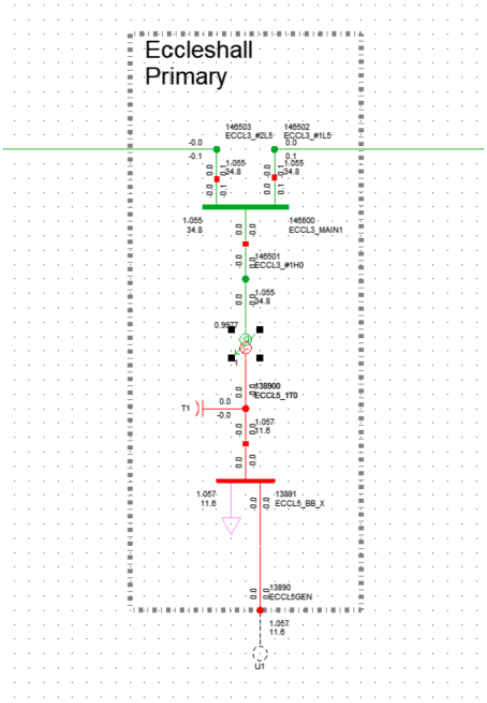

Figure 6 Eccleshall network schematic

Constraint summary

Generation Demand

For the arranged or fault outage on the infeed to the Primary Transformer at Eccleshall, the 11 kV interconnecting circuits are likely to overload and the voltages drop to below 0.94 per unit.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	11 kV interconnections between Eccleshall and neighbouring Primary substations	
Type(s) of constraint	Thermal overload and voltage constraint of 11 kV network	
Constrained condition(s)	Winter Peak Demand	
Limiting factor of constrained assets	11 kV network varying from 0.05in^2 Copper to 50mm^2 Aluminium conductors.	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged or fault outage on the 33/11 kV transformer
	Second Circuit Outage	Not applicable

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way			✓	✓
WPD Best View				✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install a second 33/11 kV transformer at Eccleshall Primary substation. This will include 33 kV busbar extension and 11 kV circuit breakers added in to facilitate the connection.
Operational mitigation	Very limited due to the First Circuit Outage constraint and the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Flexibility services	Generation turn up and/or demand turn down via the 'Dynamic' product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Hill Chorlton Primary

Network Overview

Hill Chorlton Primary substation is a single 33/11 kV transformer site supplying a relatively rural area. There is one 33 kV infeed into the site, teed off a circuit between Cotes Heath and Hookgate Primary substations. The site relies on 11 kV interconnections from Cotes Heath and Newcastle Primary substations for the loss of supply to its transformer, which is a 6.25 MVA unit.

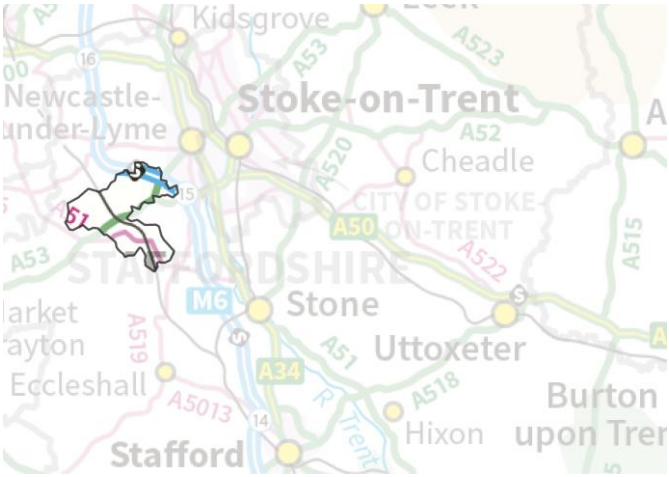

Figure 7 Hill Chorlton geographic network coverage

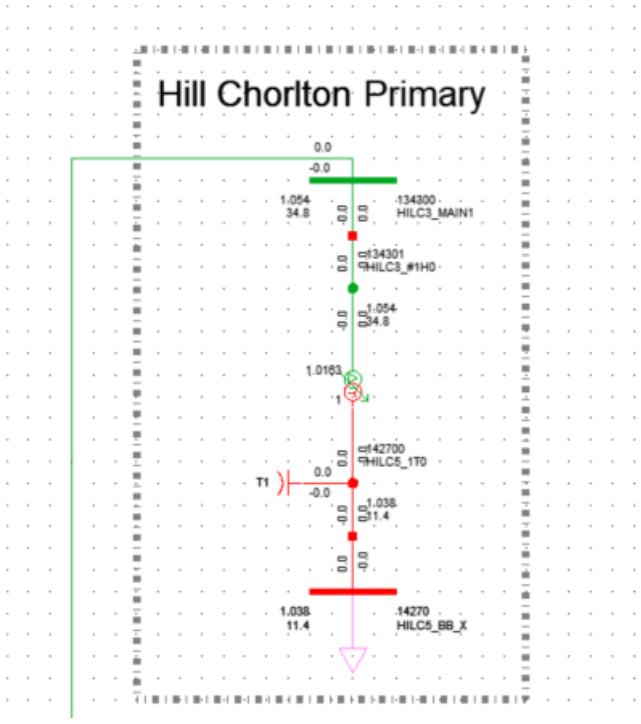

Figure 8 Hill Chorlton network schematic

Constraint summary

Generation Demand

For the arranged or fault outage on the infeed to the Primary Transformer at Hill Chorlton, the 11 kV interconnections are likely to overload and the voltages drop to below 0.94 per unit.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	11 kV interconnections between Hill Chorlton and neighbouring Primary substations	
Type(s) of constraint	Thermal overload and voltage constraint of 11 kV network	
Constrained condition(s)	Winter Peak Demand	
Limiting factor of constrained assets	11 kV network varying from 0.05 in^2 Copper to 50 mm^2 Aluminium conductors	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged or fault outage on the 33/11 kV transformer
	Second Circuit Outage	Not applicable

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression			✓	✓
System Transformation			✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install a second 33 kV circuit and convert the current tee arrangement into a loop; then uprate the existing 33 kV circuit and install a second 33/11 kV transformer with associated 33 kV and 11 kV busbar extensions.
Operational mitigation	Very limited due to the First Circuit Outage constraint and the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Dynamic’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Hookgate – Hinstock 33 kV circuit

Network Overview

Hookgate to Hinstock circuit is part of a 33 kV ring that feeds Eccleshall, High Offley, Gnosall, Hinstock, and Hookgate Primary substations. The group has two main infeeds from Meaford C BSP: a direct circuit from Meaford C to Eccleshall, and another circuit from Meaford to Hookgate/Eccleshall/High Offley via Wetwood tee.

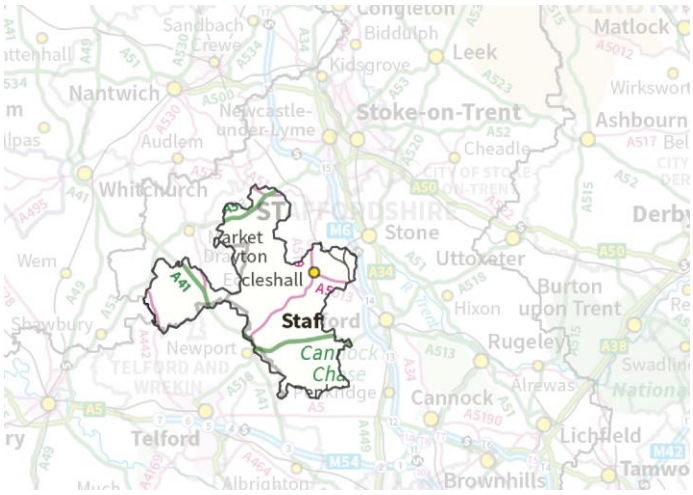

Figure 9 Hookgate to Hinstock geographic network coverage

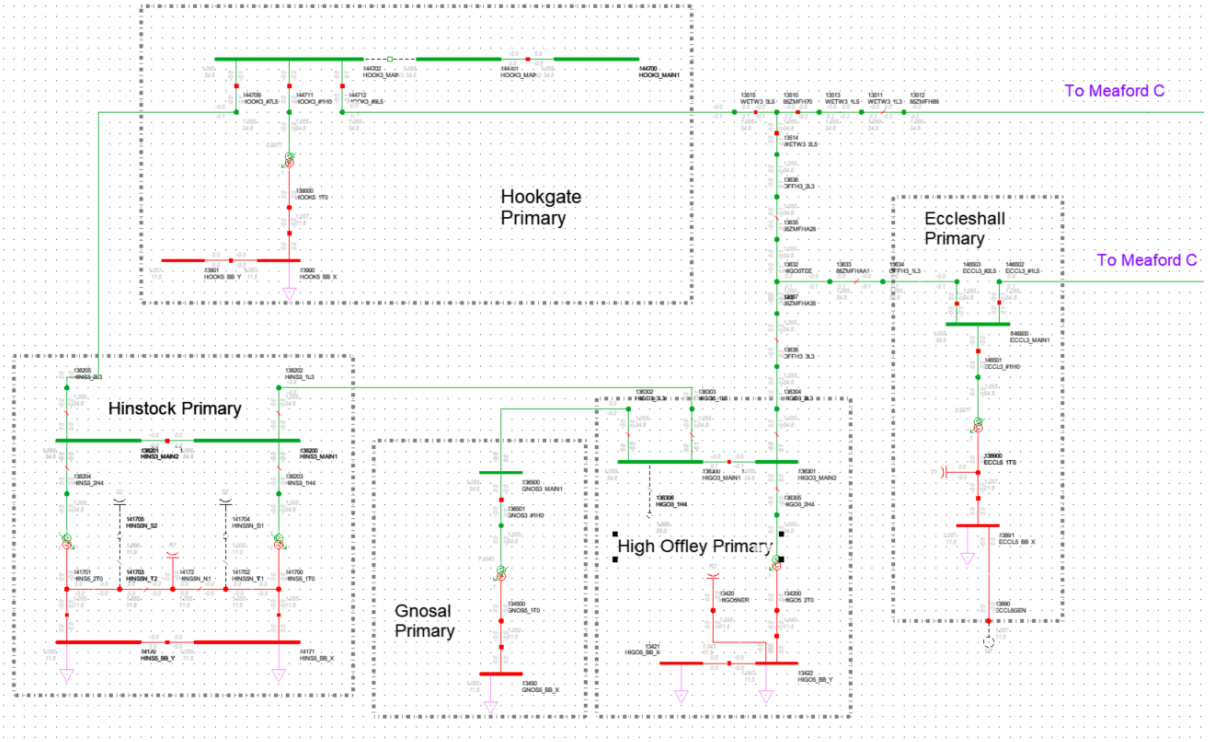

Figure 10 Hookgate to Hinstock network schematic

Constraint summary

Generation | **Demand**

The network is currently configured such that the Hookgate-Hinstock 33 kV circuit would be expected to supply Hinstock, High Offley, and Gnosall Primary substations for the loss of the infeed between Wetwood Tee and High Offley Primary. This is anticipated to overload the circuit in the near future as the demand in the area grows.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	33 kV circuit between Hookgate and Hinstock Primary substations	
Type(s) of constraint	Thermal overload and voltage restriction	
Constrained condition(s)	Winter Peak Demand	
Limiting factor of constrained assets	Circuit rating of sections mostly consisting of 0.1 in^2 Aluminium conductor Steel reinforced (ACSR), accompanied with long feeding distances	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage on the circuit between Wetwood Tee and High Offley
	Second Circuit Outage	Not applicable due to network reconfiguration during the arranged outage.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				
System Transformation				
Consumer Transformation				✓
Leading the Way				✓
WPD Best View				

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Uprate the existing 33 kV circuit between Hookgate and Hinstock Primary substations
Operational mitigation	Limit the arranged outage to seasons outside of Winter Peak Demand; or transfer load away from the group via the 11 kV network prior to an arranged outage.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage.

Hookgate – Bearstone 33 kV circuit

Network Overview

Hookgate to Bearstone circuit is one of three 33 kV circuits that feed Market Drayton Primary substation. Two of the infeeds to Market Drayton are direct 33 kV circuits from Hookgate Primary and they run in parallel to each other. The third circuit from Hookgate loops via Bearstone and goes on to connect to Market Drayton, however this circuit is normally run open at Market Drayton.

For the arranged outage on either of the two direct circuits between Hookgate and Market Drayton, this third circuit is closed in to support Market Drayton's demand.

Without any further operational intervention, this third circuit (Hookgate – Bearstone - Market Drayton) will likely overload following a subsequent fault on the remaining direct circuit between Hookgate and Market Drayton.

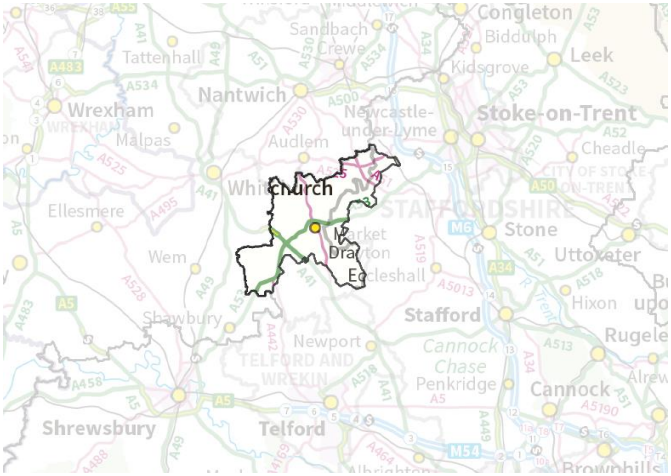

Figure 11 Hookgate to Bearstone geographic network coverage

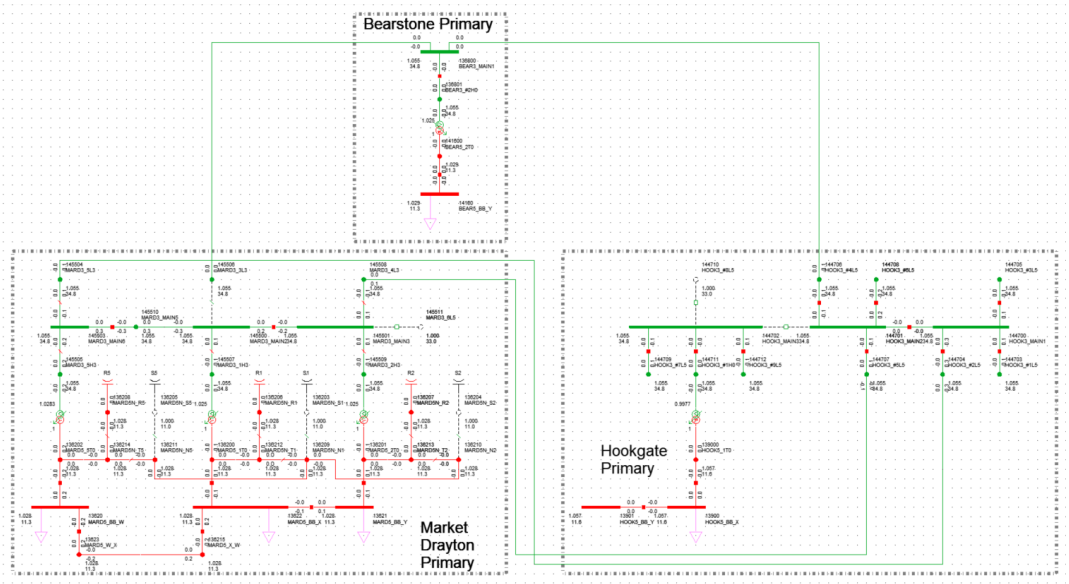

Figure 12 Hookgate to Bearstone network schematic

Constraint summary

Generation Demand

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	33 kV circuit between Hookgate and Bearstone Primary substations	
Type(s) of constraint	Thermal overload and voltage restriction	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2025)	
Limiting factor of constrained assets	Circuit rating of sections mostly consisting of 0.1 in^2 ACSR overhead line (OHL)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	No observed constraints until 2032, following the arranged outage on either of the direct 33 kV circuits between Hookgate and Market Drayton.
	Second Circuit Outage	An arranged outage on one of the direct Hookgate-Market Drayton 33 kV circuits, followed by a fault on the second direct circuit.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Uprate the existing 33 kV circuit between Hookgate, Bearstone and Market Drayton Primary substations
Operational mitigation	There is limited transfer capacity during the arranged FCO to alleviate the SCO constraint, so the other viable option is to rearrange Market Drayton's 11 kV busbars and network (during the arranged FCO) such that it runs split without creating a loose couple via downstream 11 kV customers fed out of Market Drayton Primary substation.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the 'Secure' product.

Whitfield – Knypersley-Congleton circuits

Network Overview

Knypersley, Congleton, and Goldenhill Bank Primary substations are 33/11 kV sites fed from Whitfield BSP. Knypersley and Goldenhill Bank consist of two 33/11 kV transformers, whereas Congleton consists of three 33/11 kV transformers, having the larger demand of the three and located the furthest away from Whitfield BSP.

Three circuits supply the group,

- two from Whitfield to Knypersley (run closed at Knypersley), and they supply Knypersley, Goldenhill Bank, and Congleton T1, and0
- a third from Whitfield to Congleton, supplying Congleton T4 and T5

There is also a 33 kV interconnector, normally run open at Leek, between Congleton and Leek Primary substations which can be used to transfer Leek T2 onto Congleton 33 kV busbars.

Network Operability Modelling

The circuits operate such that:

- A first circuit arranged outage on either circuit between Whitfield and Knypersley will put the demand on the other circuit, leaving the Whitfield-Congleton circuit to continue picking up Congleton T4 and T5.
- A first circuit arranged outage on the circuit between Whitfield and Congleton will result in Congleton 33 kV busbars being closed, moving the demand onto the Whitfield – Knypersley circuits.
- A first circuit arranged outage affecting the infeed of any of the three Whitfield 132/33 kV Grid Transformers will lead to the 33 kV network being run split between the other two Grid Transformers to maintain network integrity for any subsequent circuit fault.
- An outage on the Endon-Leek 33 kV circuit leads to the transfer of Leek T2 onto the Knypersley/Congleton side.

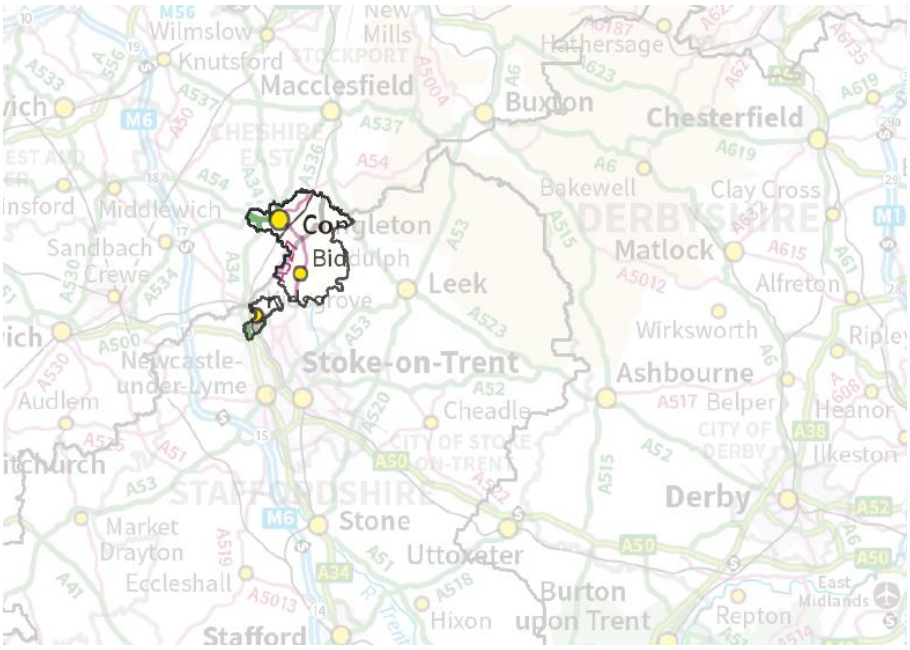

Figure 13 Knypersley, Congleton, and Goldenhill Bank geographic network coverage

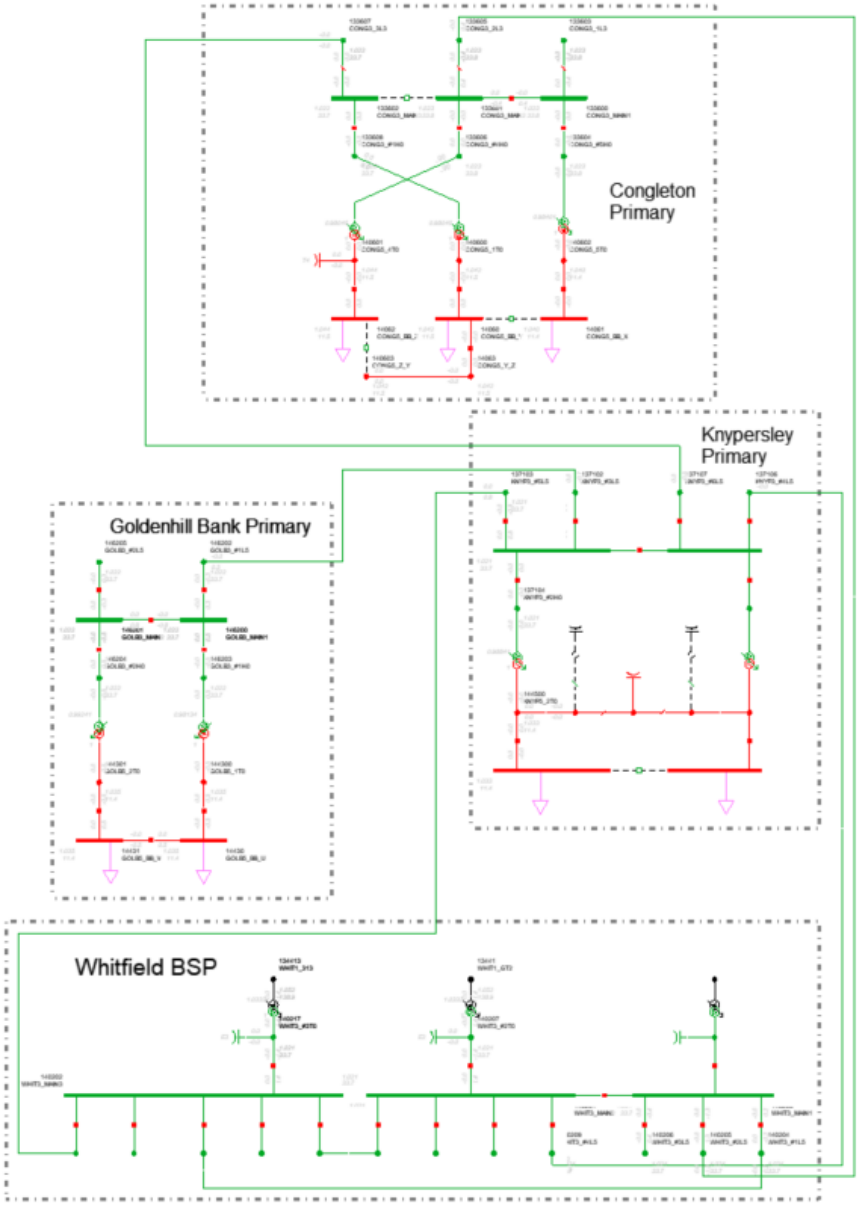

Figure 14 Knypersley, Congleton, and Goldenhill Bank network schematic

Constraint summary

Generation Demand

An arranged first circuit outage at Whitfield 33 kV Main 1 busbar would affect the infeed to Whitfield-Congleton 33 kV circuit, and would also lead to the 33 kV busbars at Knypersley being run open in order to split up the Whitfield 33 kV network.

As a result, the following two circuits are likely to overload:

- Knypersley – Congleton 33 kV circuit as it would be picking up the entire Congleton demand.
- Whitfield – Knypersley (4L5) 33 kV circuit as it would be picking up 50% of Knypersley's demand in addition to the entire Congleton demand

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Knypersley-Congleton circuit and Whitfield-Knypersley (4L5) circuit	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand	
Limiting factor of constrained assets	Circuit rating (mixture of 0.175 mm^2 ACSR OHL, 300 mm^2 Copper and 400 mm^2 Copper underground cables)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage at Whitfield 33 kV Main 1
	Second Circuit Outage	Not applicable due to the radial arrangement of the circuits following an arranged outage.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way			✓	✓
WPD Best View				✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Construct a new 33 kV circuit between Whitfield and Congleton, with associated 33 kV busbar works at both Whitfield and Congleton. This will further allow for Leek T2 to be transferred from the Whitfield-Endon-Cheddleton network and on to Congleton thereby alleviating potential thermal overload on the Whitfield-Endon 3L5 33 kV circuit.
Operational mitigation	Limit the period where arranged outages are taken to the summer seasons. Alternatively, load could be transferred out of the group for an arranged outage, however this is quite limited due to the long feeding distances involved.
Load Management Schemes	Very limited due to the potential non-compliance under Engineering Recommendation P2/7 for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Dynamic’ product.

Ironbridge – Shrewsbury 132 kV Circuit

Network Overview

Ironbridge substation is a Grid Supply Point (GSP) that consists of three 400/132 kV Super Grid Transformers (SGT). The SGTs run split at Ironbridge 132 kV busbars due to fault level limitations. They do however run in parallel with Shrewsbury GSP, which is a single 400/132 kV SGT site, via two 132 kV circuits.

The Ironbridge-Shrewsbury GSP group supplies the demand fed out of Ironbridge 132/33 kV BSP, Shrewsbury 132/33 kV BSP, Ketley 132/33 kV BSP, and Hortonwood 132/11 kV BSP. Ketley and Hortonwood are looped in via the 132 kV circuits between Ironbridge and Shrewsbury.

For an arranged outage on the SGT at Shrewsbury, the two 132 kV circuits are expected to pick the demand of Ketley, Shrewsbury, and Hortonwood BSPs.

Figure 15 Ketley, Shrewsbury and Hortonwood geographic network coverage

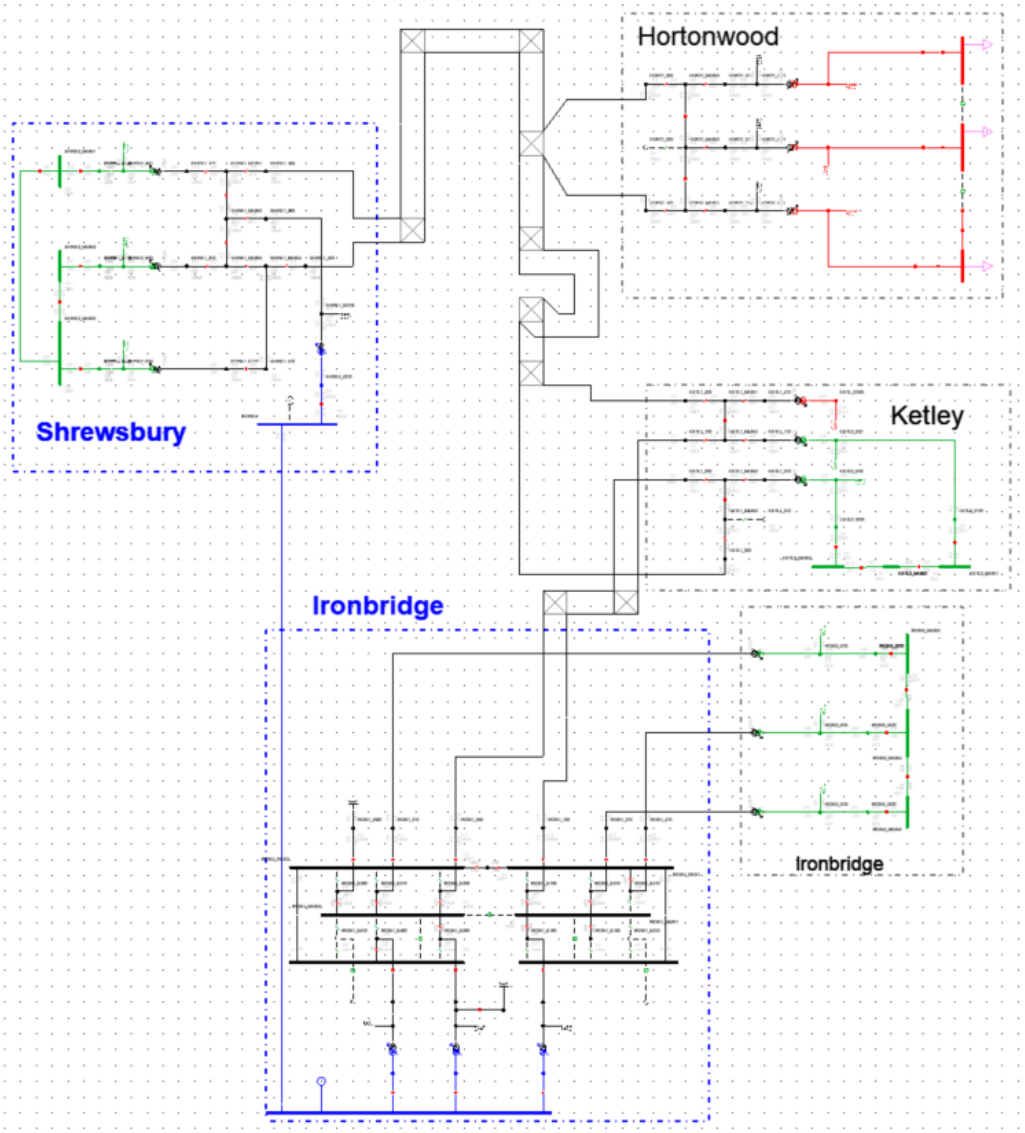

Figure 16 Ironbridge-Shrewsbury network schematic

Constraint summary

Generation Demand

Under an arranged first circuit outage on Shrewsbury SGT, followed by a fault on one of the 132 kV circuits between Ironbridge and Shrewsbury, the remaining 132 kV circuit would be expected to pick up the entire demand of Ketley, Shrewsbury and Hortonwood BSPs, which can potentially lead to a thermal overload.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Either 132 kV circuit between Ironbridge and Shrewsbury GSPs	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand: All scenarios Intermediate Warm Peak Demand: • 2025: Leading the Way and Consumer Transformation only • 2028 onwards: All scenarios	
Limiting factor of constrained assets	Circuit rating (mixture of 0.175 in^2 ACSR tower line and 1000 mm^2 Copper cable)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	No observed constraints
	Second Circuit Outage	Arranged outages of the SGT at Shrewsbury followed by a fault on one of the 132 kV circuits between Ironbridge and Shrewsbury.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression		✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install a second 400/132 kV 240 MVA SGT at Shrewsbury GSP and introduce open points at suitable locations along the two 132 kV circuits between Ironbridge and Shrewsbury to split the group under normal running arrangement. This will also help mitigate some of the fault level restrictions at Ironbridge.
Operational mitigation	Restrict the period where arranged outages are taken to the summer season only. This however could be quite limiting and challenging as outage coordination of SGTs can extend beyond this period.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class D group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Dynamic’ product.

Ironbridge – Star Aluminium 33 kV Circuit

Network Overview

Broseley, Worfield, Star Aluminium, and Quatt T2 are 33/11 kV Primary substations fed out of Ironbridge BSP via three 33 kV circuits that run in parallel to each via Star Aluminium 33 kV busbars:

- Ironbridge to Broseley/Star Aluminium
- Ironbridge to Worfield/Broseley/Star Aluminium
- Ironbridge to Star Aluminium

Quatt T2 is normally supplied via a direct 33 kV circuit from Star Aluminium busbars, but Quatt T1 is fed from Stourport BSP and the Primary could be transferred from one BSP to the other depending on the arranged outage taken.

The 33 kV network also includes two 33 kV connected customers; one connected off the Broseley - Star Aluminium circuit, and the other off the Worfield - Star Aluminium circuit.

Network Operability Modelling

The circuits operate as follows:

- Run in parallel under normal configuration
- Under a first circuit fault on either of the three infeeds from Ironbridge, the other two circuits are expected to pick up the demand
- Under a first circuit arranged outage on either of the three infeeds, Quatt T2 is transferred over to Stourport BSP, and the 33 kV network between the remaining two circuits is run split/radial to protect the circuits from thermal overload against a second outage.

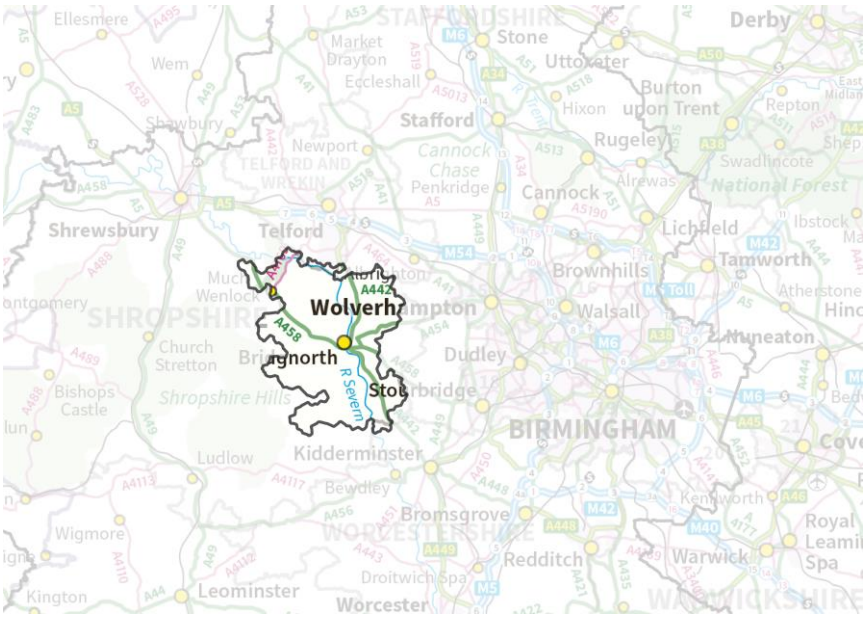

Figure 17 Broseley, Worfield, and Star Aluminium geographic network coverage

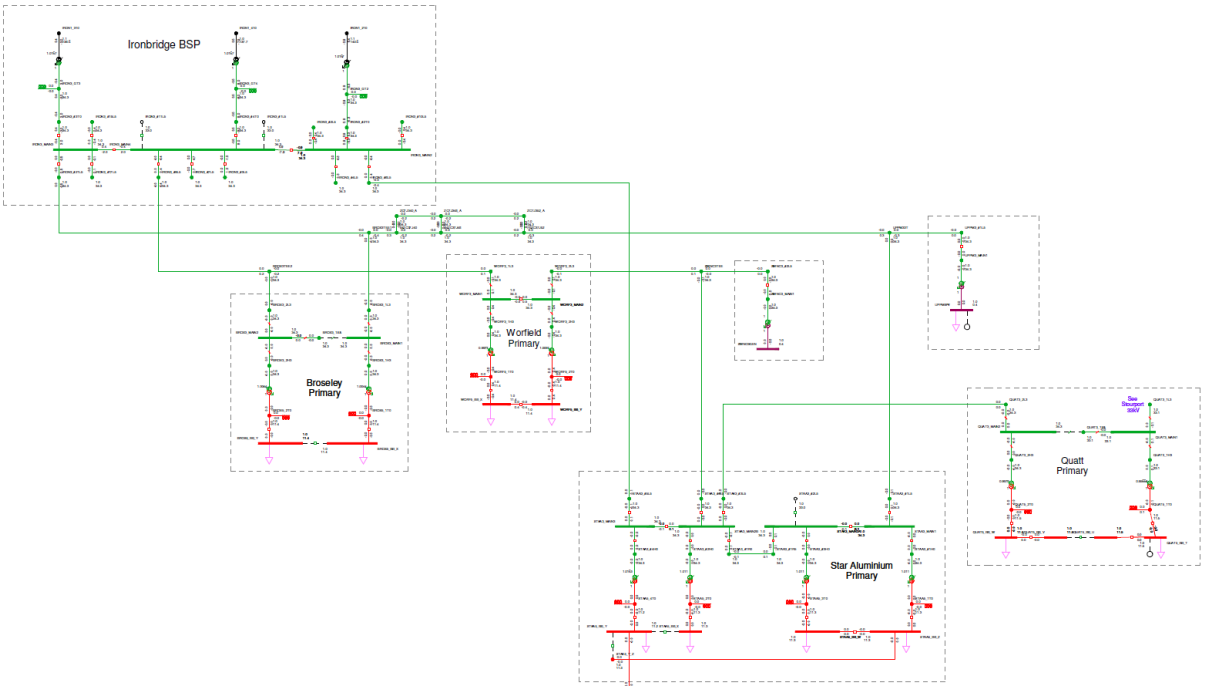

Figure 18 Broseley, Worfield, and Star Aluminium network schematic

Constraint summary

Generation Demand

Following a fault on one of the 33 kV circuits supplying the group (more specifically the direct Ironbridge – Star Aluminium circuit), the remaining two in-service circuits are likely to overload as they attempt to pick up the demand. The constraint extends to all three circuits as the demand grows in future years and across different scenarios. The 33 kV network volts at the remote ends also drop to below 0.94 per unit.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	33 kV circuits from Ironbridge BSP to Broseley, Worfield, Star Aluminium and Quatt T2 group	
Type(s) of constraint	Thermal overload and voltage constraint	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2025)	
Limiting factor of constrained assets	Circuit rating of sections mostly consisting of 0.175 in^2 ACSR OHL, accompanied with long feeding distances.	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage affecting one of the three infeeds to the group
	Second Circuit Outage	Arranged outage affecting one of the three infeeds, followed by a fault on another.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install a fourth 33 kV circuit into the group, specifically between Ironbridge and Star Aluminium, and split the network into two smaller groups under normal running arrangement.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Star Aluminium Primary

Network Overview

Star Aluminium Primary is a 33/11 kV site fed via three 33 kV circuits from Ironbridge BSP. The site consists of a four-section 33 kV board that runs closed under normal running configuration. Two of the 33 kV busbar sections supply T2 and T4 which feed Star Aluminium's normal distribution load, and the other two 33 kV busbar sections supply T1 and T3 which feed a single customer.

T2 is a 15/17.5 MVA transformer and T4 is a 12/24 MVA transformer, they run split at 11 kV due to fault level limitations. Under an arranged outage on either T2 or T4, the remaining in-service transformer is expected to pick up the demand of the local distribution area.

Figure 19 Star Aluminium Primary geographic network coverage

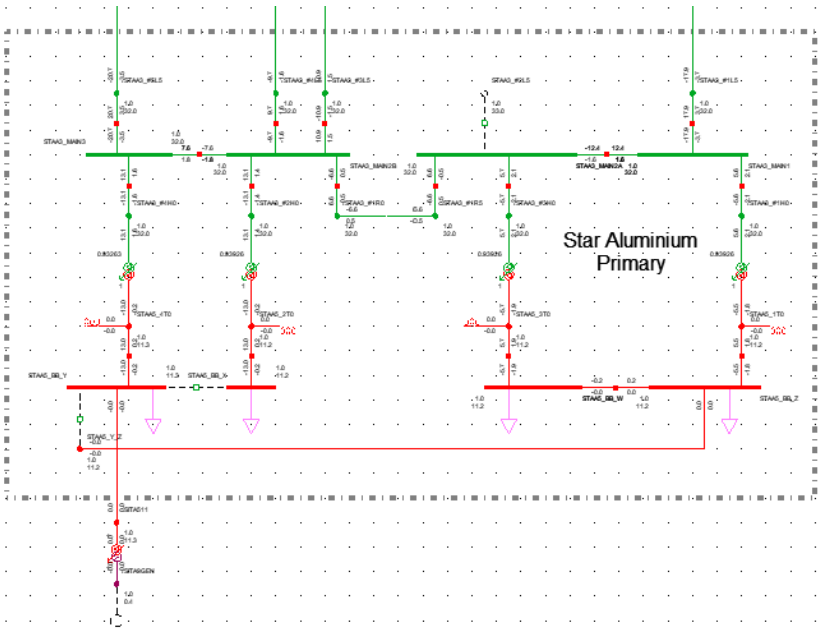

Figure 20 Star Aluminium Primary network schematic

Constraint summary

Generation | **Demand**

Under a First Circuit Outage on T4, T2 picks up the demand of the distribution side within Star Aluminium Primary which could cause thermal overloads.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Star Aluminium 33/11 kV transformer T2	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2025)	
Limiting factor of constrained assets	15/17.5 MVA transformer rating	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage resulting in the loss of transformer T4.
	Second Circuit Outage	Not applicable due to loss of supply to the group.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression	✓	✓		✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace transformer T2 with a 20/40 MVA unit, this will further allow the transformer to support T1 and T3 as the demand grows.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Shrewsbury 33 kV Ring

Network Overview

Shrewsbury 33 kV ring is fed out of Shrewsbury BSP which consists of three 45/90 MVA transformers run in parallel. The ring supplies the following 33/11 kV Primary substations: Harlescott, Rowton, Weirhill, Bayston Hill, Berrington, Malehurst, Priestweston, and Bishops Castle T2. There are also several 33 kV connected customers (predominantly generator connections) along various parts of the ring.

It is supplied via four main circuits, two from Shrewsbury - Harlescott and two from Shrewsbury - Weirhill/Bayston Hill. These are interconnected to each other via the rest of the Primary substations.

There is also a 33 kV interconnection to Ludlow BSP which allows for the transfer of Priestweston and Bishops Castle T2 over to Ludlow; similarly Bishops Castle is often transferred into the ring from Ludlow BSP for various arranged outages on the Ludlow network.

Network Operability Modelling

The circuits operate as follows:

- Under normal configuration, the ring runs closed
- Under a fault outage on any busbar or circuit including one of the main four infeeds, the remaining circuits are expected to pick up the demand within the ring.
- Under a first circuit arranged outage affecting:
    - the 132 kV parallel between Shrewsbury and Ironbridge GSP, or
    - Shrewsbury 33 kV main busbars, or
    - One of main 33 kV circuit infeeds to the ring

  The rest of the ring is split up into radial feeders to protect the network against overloads following a subsequent second circuit fault outage. Priestweston and Bishops Castle T2 are also transferred onto Ludlow BSP under these conditions if the demand during the arranged outage requires.

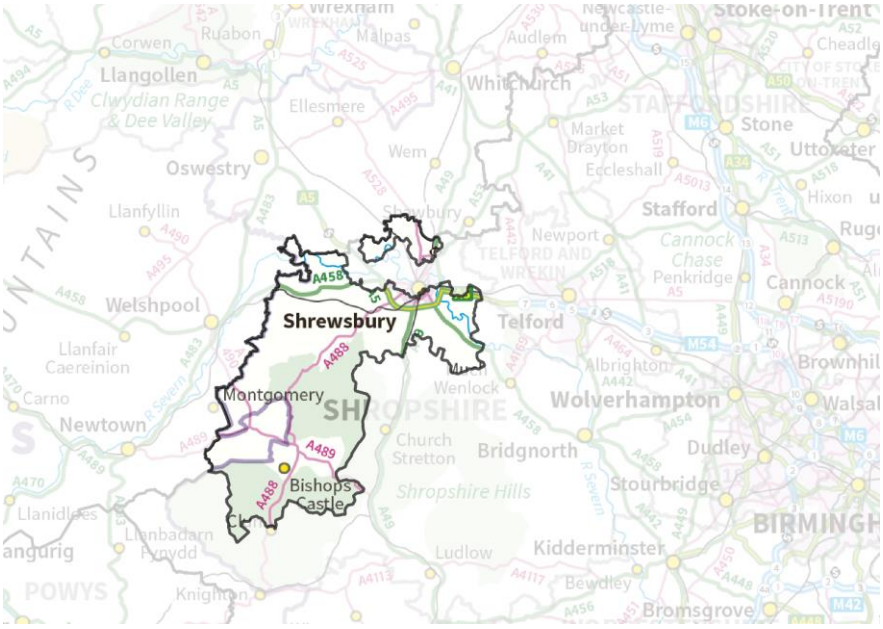

Figure 21 Shrewsbury Ring geographic network coverage

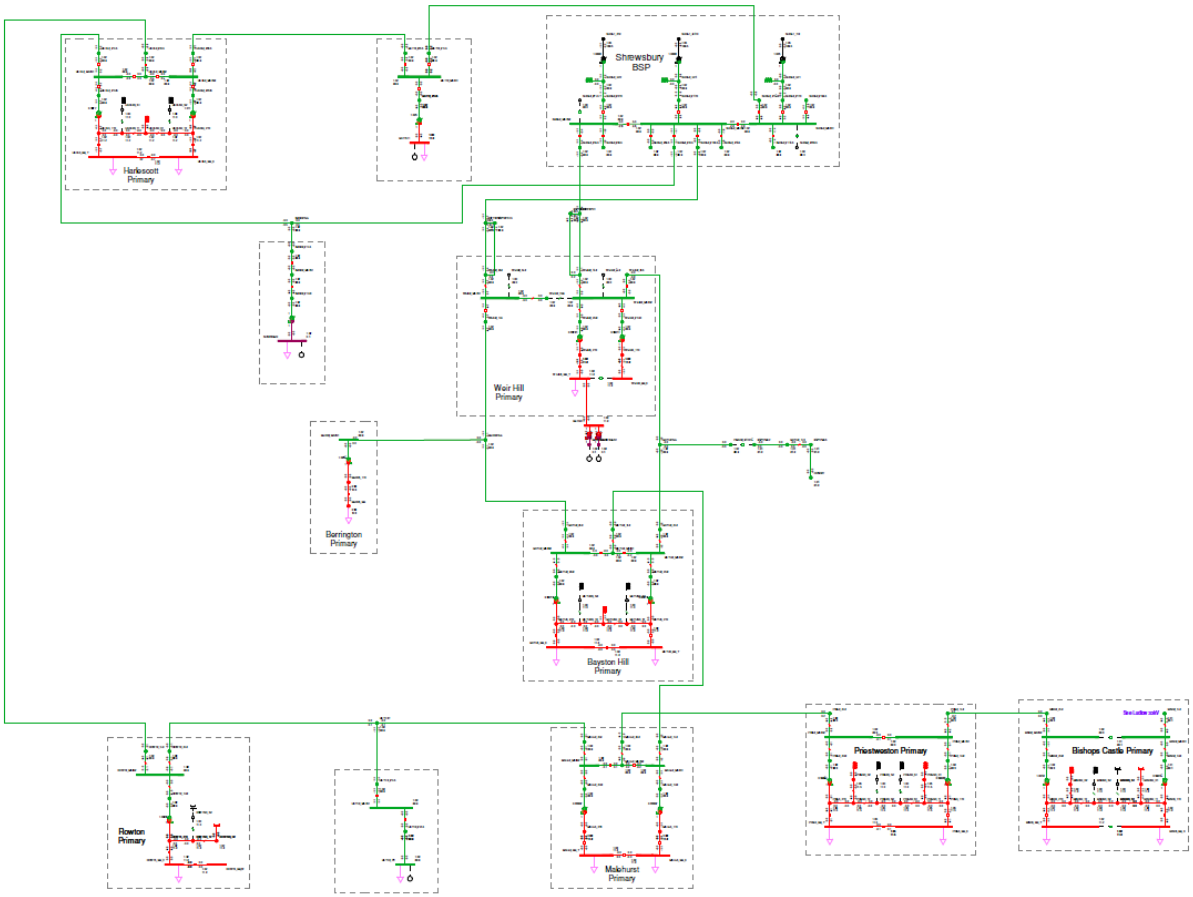

Figure 22 Shrewsbury Ring network schematic

Constraint summary

Generation Demand

Under various first fault outages on the main infeeds to the ring or the 33 kV busbars at Shrewsbury, circuits within the ring are likely to overload (specifically the Shrewsbury-Weirhill/Bayston Hill/Berrington circuits). The voltage levels at various parts of the ring (especially at the remote ends) also drop to below statutory limits given the presence of several 33 kV connected customers.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Circuits within the ring including Shrewsbury-Weirhill/Bayston Hill/Berrington circuits	
Type(s) of constraint	Thermal overload and voltage constraint	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand:	
Limiting factor of constrained assets	Circuit rating (mixture of 0.15 in^2 and 0.175 in^2 ACSR OHL conductors)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Fault outage at Shrewsbury 33 kV busbars or one of the main infeeds to the ring
	Second Circuit Outage	Various arranged first circuit outages followed by second circuit outages within the 33 kV ring or at Shrewsbury 33 kV busbars would worsen the constraints mentioned above.

Scenario identification

The table below highlights how the constraints occur during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install two 33 kV circuits from Shrewsbury BSP to a newly established Primary substation at Shelton, consisting of two 20/40 MVA rated 33/11 kV transformers, 11 kV busbars, and 11 kV circuits. The new substation would pick up demand from Primary substations within the ring, mainly Harlescott, Weirhill, and Bayston Hill Primary substations.
Operational mitigation	The SCO constraint could be managed by restricting the arranged outage to the summer months, transferring load away and/or splitting the 33 kV network during the arranged outage. For the FCO constraint, temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential non-compliance for a Class D group demand under Engineering Recommendation P2/7.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Priestweston Primary

Network Overview

Priestweston Primary is a 33/11 kV site fed via a 33 kV circuit from Shrewsbury BSP, via Malehurst Primary. It has a second 33 kV circuit interconnector to Bishops Castle which allows for both Priestweston and Bishops Castle Primary substations to be transferred between Shrewsbury and Ludlow BSPs.

At Priestweston, transformer T1 is a 12 MVA unit and T2 is a 6.5 MVA unit, running in parallel. Under an arranged or fault outage on either T1 or T2, the remaining in-service transformer is expected to pick up the demand of the site.

Figure 23 Priestweston Primary geographic network coverage

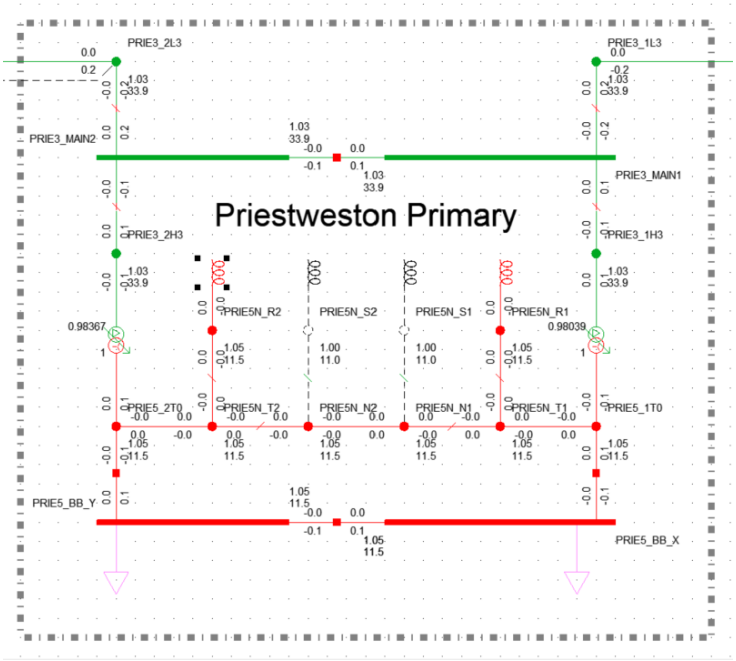

Figure 24 Priestweston Primary network schematic

Constraint summary

Generation Demand

Under a First Circuit Outage on T1, T2 picks up the demand of the site which could cause thermal overloads.
The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Priestweston 33/11 kV transformer T2	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2025)	
Limiting factor of constrained assets	6.5 MVA rating of transformer T2	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage resulting in the loss of transformer T1
	Second Circuit Outage	Not applicable due to loss of supply to the group.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression	✓	✓		✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace transformer T2 with a larger unit.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Wolverhampton West Primary

Network Overview

Wolverhampton West Primary substation is a 33/11 kV site fed from Wolverhampton BSP within Penn GSP. It consists of four 33/11 kV transformers: T3 and T4 (each rated 15 MVA), T5 and T6 (each rated 20/27 MVA).

Network Operability Modelling

The transformers operate as follows:

- T3 and T4 run in parallel and therefore support each other's demand following a first circuit fault outage on either.
- T5 and T6 run split at 11 kV
- For an arranged first circuit outage affecting T5, its demand is transferred to T4 and the parallel between T3 and T4 is split to protect against thermal overload following a subsequent second circuit fault outage.
- Similarly, for an arranged first circuit outage affecting T6, its demand is transferred to T3 and the parallel between T3 and T4 is split to protect against thermal overload following a subsequent second circuit fault outage.

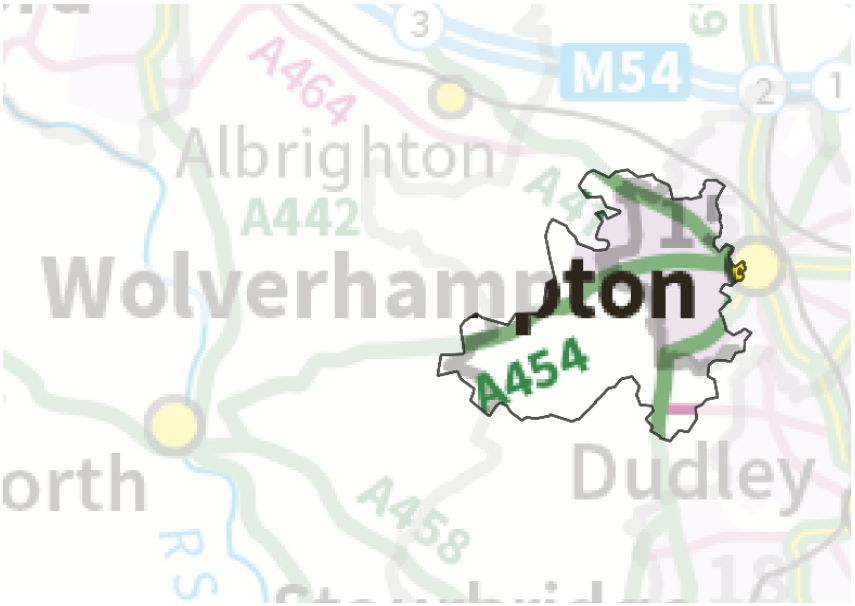

Figure 25 Wolverhampton West Primary geographic network coverage

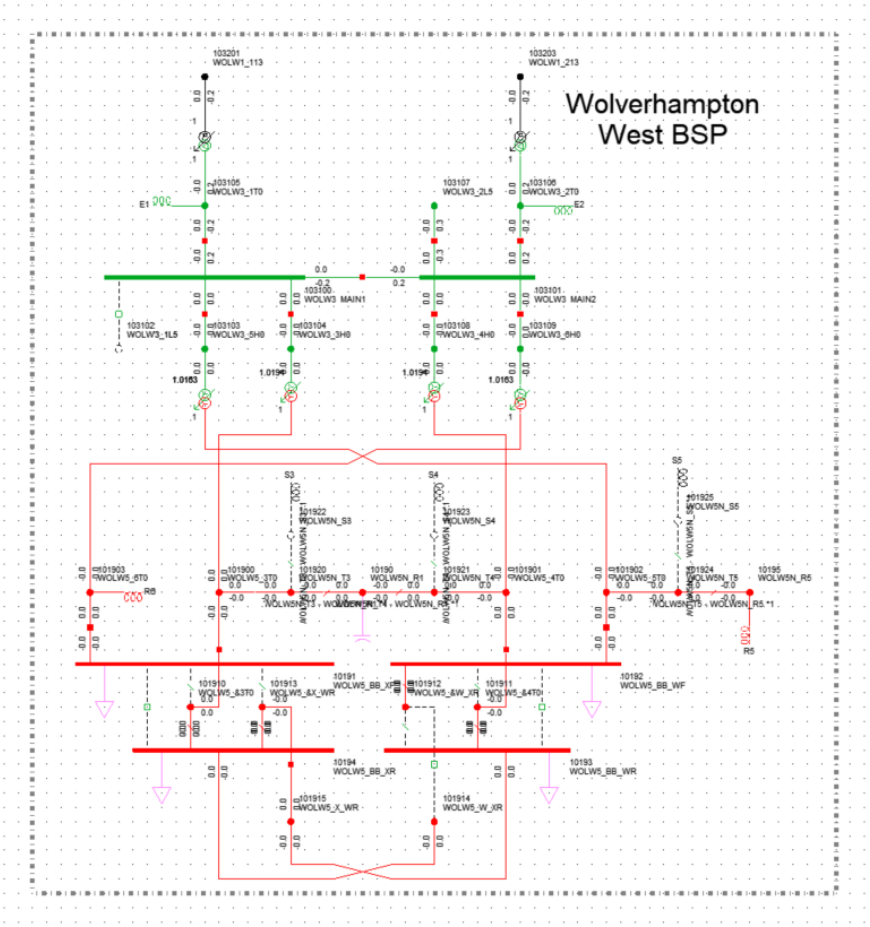

Figure 26 Wolverhampton West Primary network schematic

Constraint summary

Generation Demand

For an arranged outage on T5 the transfer of demand onto T4 results in a thermal overload. Similarly, for an arranged outage on T6 the transfer of demand onto T3 also results in a thermal overload.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Wolverhampton West 33/11 kV transformers T3 and T4	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand	
Limiting factor of constrained assets	15 MVA rating of the 33/11 kV transformers T3 and T4	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage on either T5 or T6 at Wolverhampton West Primary substation.
	Second Circuit Outage	Not applicable due to loss of supply to the group

Scenario identification

The table below highlights how the constraints occur during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace transformer T3 and T4 with 20/40 MVA units, including any associated 11 kV circuit breaker works.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Lye BSP

Network Overview

Lye BSP is a 132/11 kV site fed via two 132 kV circuits from Penn GSP, one via Woodside BSP and the other via Dudley BSP. It consists of three 132/11 kV transformers: GT1 and GT2A (each rated 15/30 MVA), and GT3 (rated 10/20 MVA).

The site also includes 132 kV busbars and bus-section circuit breakers that run closed under normal running configuration; however the 11 kV busbars run split.

Network Operability Modelling

The transformers operate as follows:

- Each transformer runs split under intact network configuration.
- Following an outage on either GT1 or GT2A, the remaining transformer in service supplies the load of both transformers.
- Following an outage resulting in the loos of GT3, the demand is supplied via transformer GT2A.

During the above back feed arrangements, if the demand is not appropriately split between the remaining two in-service transformers, then further 11 kV busbar and network reconfiguration is carried out to achieve this.

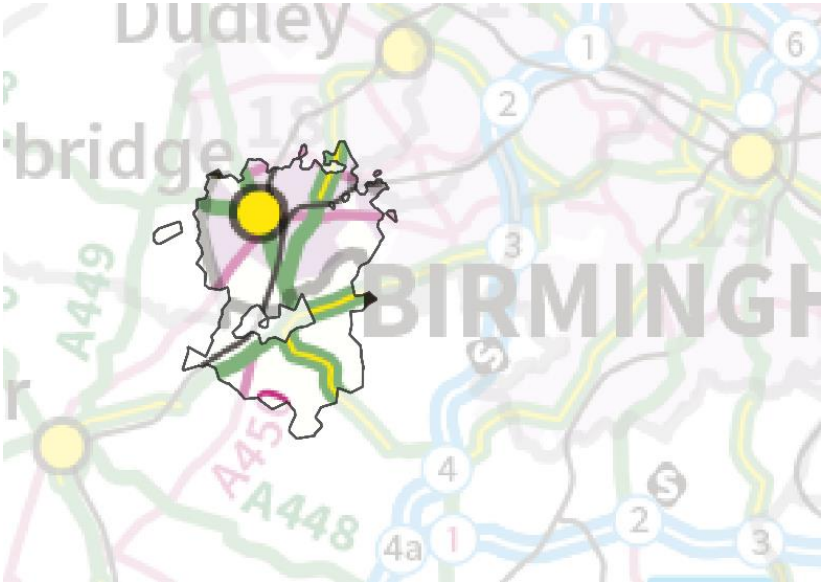

Figure 27 Lye BSP geographic network coverage

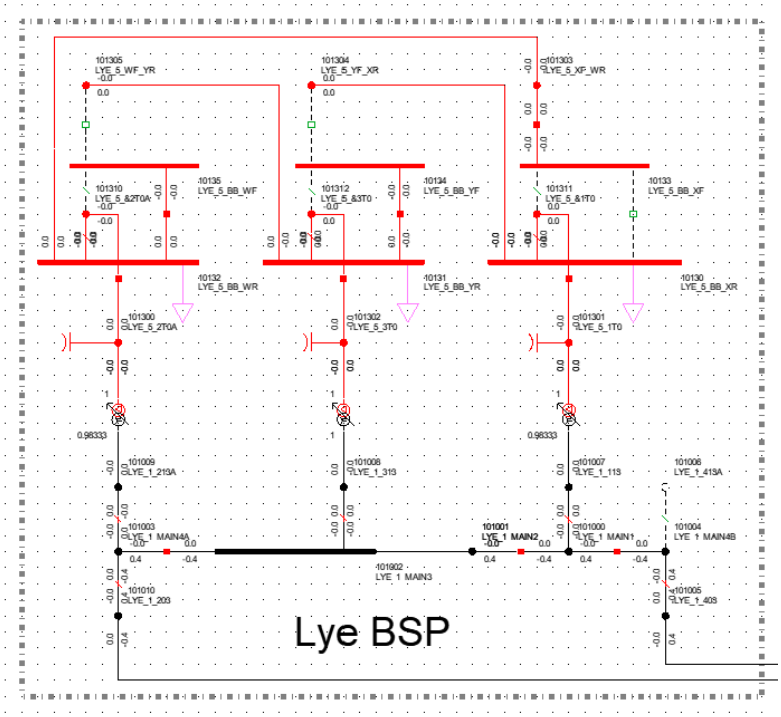

Figure 28 Lye BSP network schematic

Constraint summary

Generation Demand

For an arranged outage on either of the larger transformers, GT1 or GT2A, the remaining in service transformers are likely to overload.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Lye 132/11 kV transformers	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2032)	
Limiting factor of constrained assets	Rating of the 132/11 kV transformers	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage on either of GT1 or GT2A
	Second Circuit Outage	Arranged outage on GT1 or GT2A, followed by a fault outage on GT1 or GT2A.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way			✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Extend the 132 kV and 11 kV busbars and install a fourth 30 MVA 132/11 kV transformer.
Operational mitigation	For the FCO constraint, arranged outages can be limited to the summer seasons; however this is a short term solution as the constraint extends into the summer months towards the end of the 0-10 year period. For the SCO constraint, the split arrangement between the transformers during the arranged outage can be maintained.
Load Management Schemes	Limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Bushbury – Stafford 132 kV Circuit

Network Overview

Stafford BSP and Stafford South BSP are two independent substation each consisting two 132/11/11 kV double bubble transformers. They are supplied via three 132 kV circuits (one from Bushbury GSP and two from Rugeley GSP). The sites are configured such that one 132/11/11 kV transformer per site is fed from Bushbury and the other from Rugeley, run split at 132 kV and at 11 kV.

There are a number of committed embedded generators on the Bushbury-Stafford 132 kV side, and in addition to the generation growth in the area, this 132 kV circuit will likely overload during times of high generation and low demand.

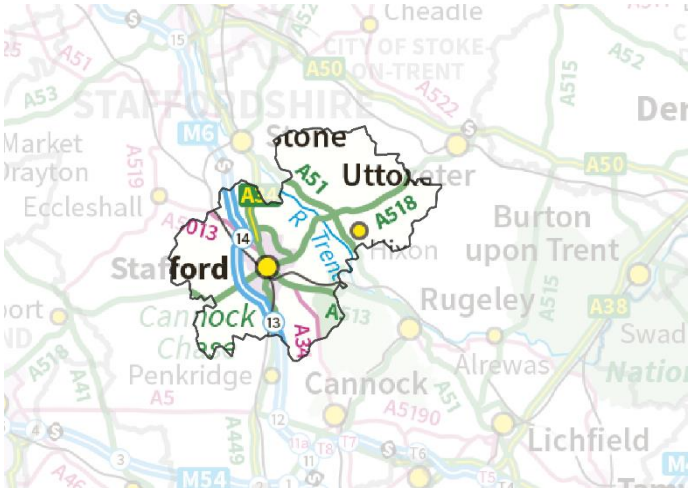

Figure 29 Bushbury-Stafford geographic network coverage

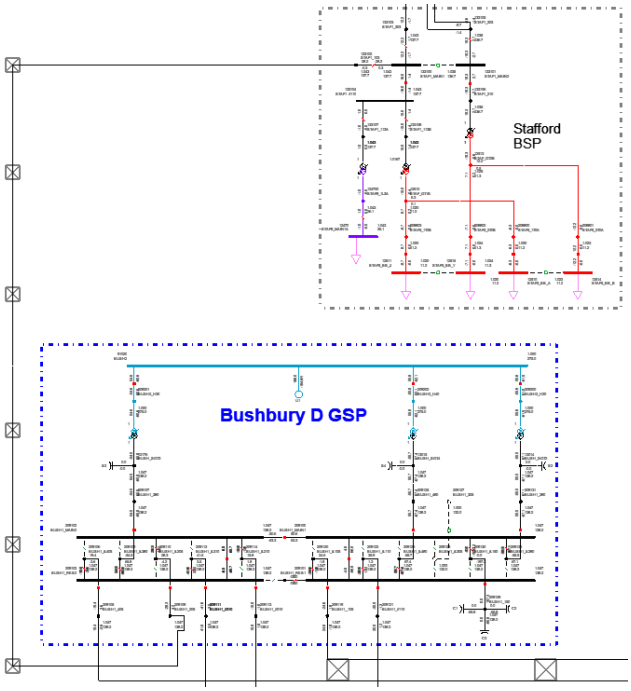

Figure 30 Bushbury-Stafford network schematic

Constraint summary

Generation Demand

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Bushbury – Stafford 132 kV circuit	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Summer Peak Generation	
Limiting factor of constrained assets	132 kV circuit rating mostly consisting of 0.175 in^2 ACSR tower line.	
Outage combination which causes the constraint	Intact	During times of low demand and high generation.
	First Circuit Outage	For an outage on one of the 132 kV circuits from Rugeley, more generation could be exporting to Bushbury therefore exacerbating the issue.
	Second Circuit Outage	A second circuit outage would worsen the constraint highlighted above.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression		✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Uprating the exiting 132 kV circuit between Bushbury and Stafford.
Operational mitigation	Operational mitigation is very limited as the constraint can occur during intact network conditions.
Load Management Schemes	Any additional generation connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.
Flexibility services	Generation turn down and/or demand turn up via the ‘Secure’ product. Dispatch of services may be required for a prolonged period of time given the constraint may be present under intact network conditions.

Lea Marston – Copt Heath 132 kV Circuit

Network Overview

Elmdon BSP, Copt Heath BSP, Solihull BSP, and Shirley GT1 are 132/11 kV networks fed out of Lea Marston GSP via three 132 kV circuits that run as a ring.

Two of these circuits feed the group via Copt Heath through a double circuit tower line, largely consisting of 0.175 in^2 ACSR and 0.175 in^2 Cadmium Copper conductors.

The third circuit supplies the group via Elmdon through a single circuit tower line largely consisting of 0.175 in^2 ACSR conductor.

There is 132 kV interconnection to Kitwell GSP via Shirley BSP which normally runs open. This allows for Shirley GT1 to be transferred from Lea Marston to Kitwell; and similarly for Shirley GT2 and GT3 to be transferred from Kitwell to Lea Marston.

Network Operability Modelling

The group operates as follows:

- The three circuit infeeds to the group run as a closed ring under normal running configuration.
- For a first circuit outage, the remaining two in-service infeeds pick up group demand.
- For a first circuit arranged outage followed by a second circuit fault outage, the remaining in-service infeed is expected to pick up the group demand. Under this scenario however, an assessment to transfer Shirley GT1 to Kitwell GSP during the arranged outage is undertaken. The load transfer is dependent on the group demand of both networks at the time.

Figure 31 Elmdon, Copt Heath, and Solihull geographic network coverage

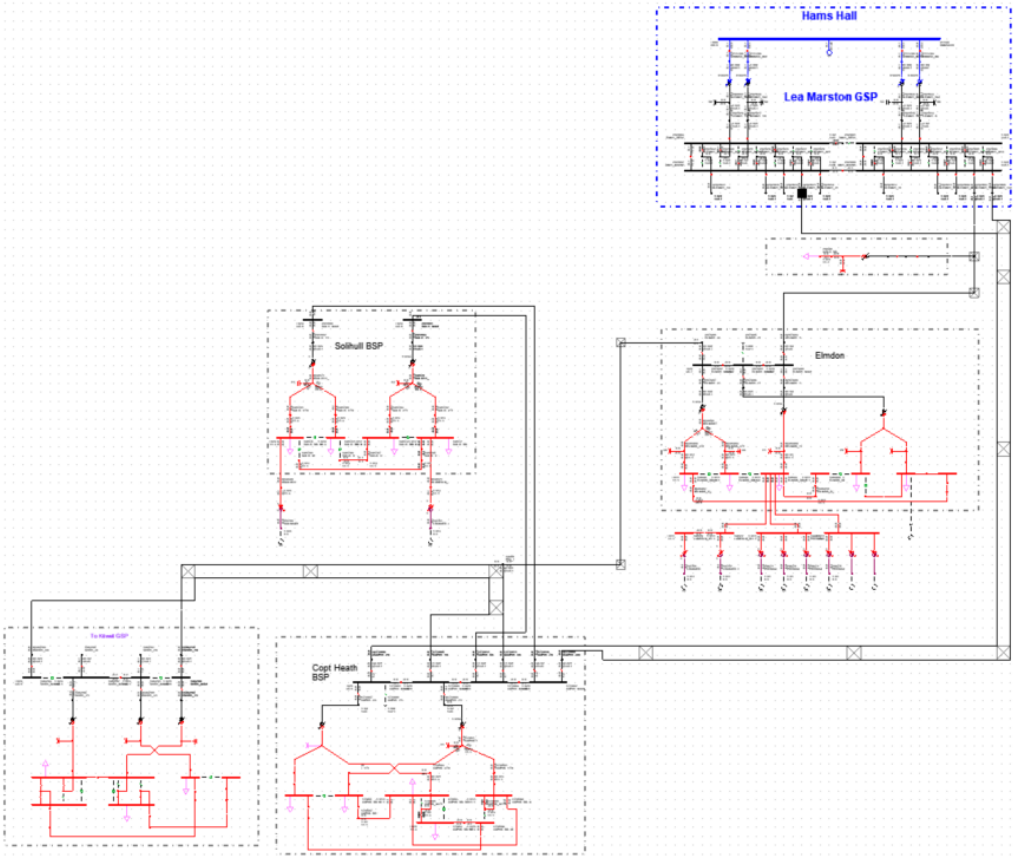

Figure 32 Elmdon, Copt Heath, and Solihull network schematic

Constraint summary

Generation Demand

During an arranged outage affecting one of the three 132 kV infeeds to the group followed by a second circuit fault outage on the second, the remaining in-service infeed is likely to overload when it picks up the group demand.

The tables below outline the nature of the network constraints identified in the network analysis.

Lea Marston – Copt Heath 132 kV circuits:

Constrained assets	Lea Marston – Copt Heath 132 kV circuits	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand	
Limiting factor of constrained assets	132 kV circuit rating (mixture of 0.175 in^2 ACSR and 0.175 in^2 Cadmium Copper conductors)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	No observed constraints
	Second Circuit Outage	A first circuit arranged outage on the Lea Marston – Elmdon circuit, followed by a fault outage on one of the Lea Marston – Copt Heath circuits

Lea Marston – Elmdon 132 kV circuit:

Constrained assets	Lea Marston – Elmdon 132 kV circuit	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand	
Limiting factor of constrained assets	132 kV circuit rating mostly consisting of 0.175 in^2 ACSR tower line	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	No observed constraints
	Second Circuit Outage	A first circuit arranged outage on one of the Lea Marston – Copt Heath circuits, followed by a fault outage on the other.

Scenario identification

The tables below highlights how the constraints occur during the 0-10 year period across the different scenarios studied.

Lea Marston – Copt Heath 132 kV circuits:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression			✓	✓
System Transformation			✓	✓
Consumer Transformation			✓	✓
Leading the Way			✓	✓
WPD Best View			✓	✓

Lea Marston – Elmdon 132 kV circuit:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation				✓
Consumer Transformation			✓	✓
Leading the Way			✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Uprate the three 132 kV circuits feeding the group from Lea Marston (one to Elmdon and two to Copt Heath) to ensure long term resilience of the network.
Operational mitigation	Coordinate any arranged outage to only be taken during the summer months, or split the 132 kV ring during the first circuit arranged outage to avoid a circuit overload following a subsequent second circuit fault outage.
Load Management Schemes	Load management scheme such as Active Network Management or Overload protection could alleviate these constraints during times of high demand and low generation.
Flexibility services	Generation turn up and/or demand turn down via the ‘Dynamic’ product.

Hereford – Ludlow 66 kV network

Network Overview

Hereford/Ludlow 66 kV network is a meshed network supplying the following 66/11 kV Primary substations: Madley, Lower Chadnor, Kington, Presteigne, Bodenham, Leominster, Woofferton, and Knighton. The network is fed via three main infeeds, two from Hereford BSP (consisting of three 132/66 kV transformers) and one from Ludlow BSP (consisting of one 132/66 kV transformer).

The circuits run in parallel under intact network conditions, but under an arranged outage on any of the three infeeds, the 66 kV network is operationally run split between the remaining two infeeds. However under various first circuit fault outages around the meshed network, the following 66 kV circuits are likely to overload during times of high demand and low generation as well as low demand and high generation.

- Hereford – Madley Tee – Lower Chadnor Tee – Kington, and
- Presteigne - Leominster

In addition to this, the 66 kV voltages around the meshed network drop to below statutory limits at demand peak times, and rise to above statutory limits at generation peak times.

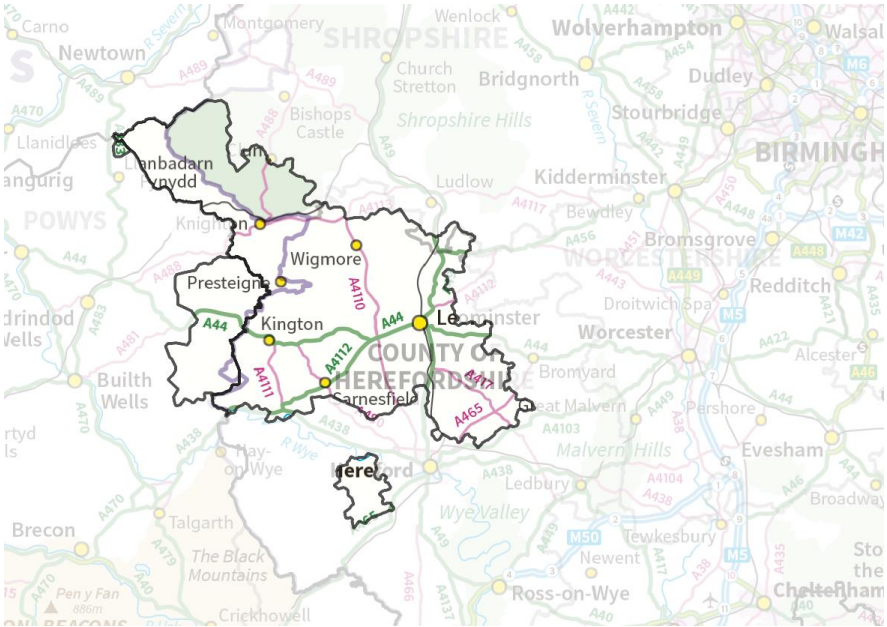

Figure 33 Hereford-Ludlow geographic network coverage

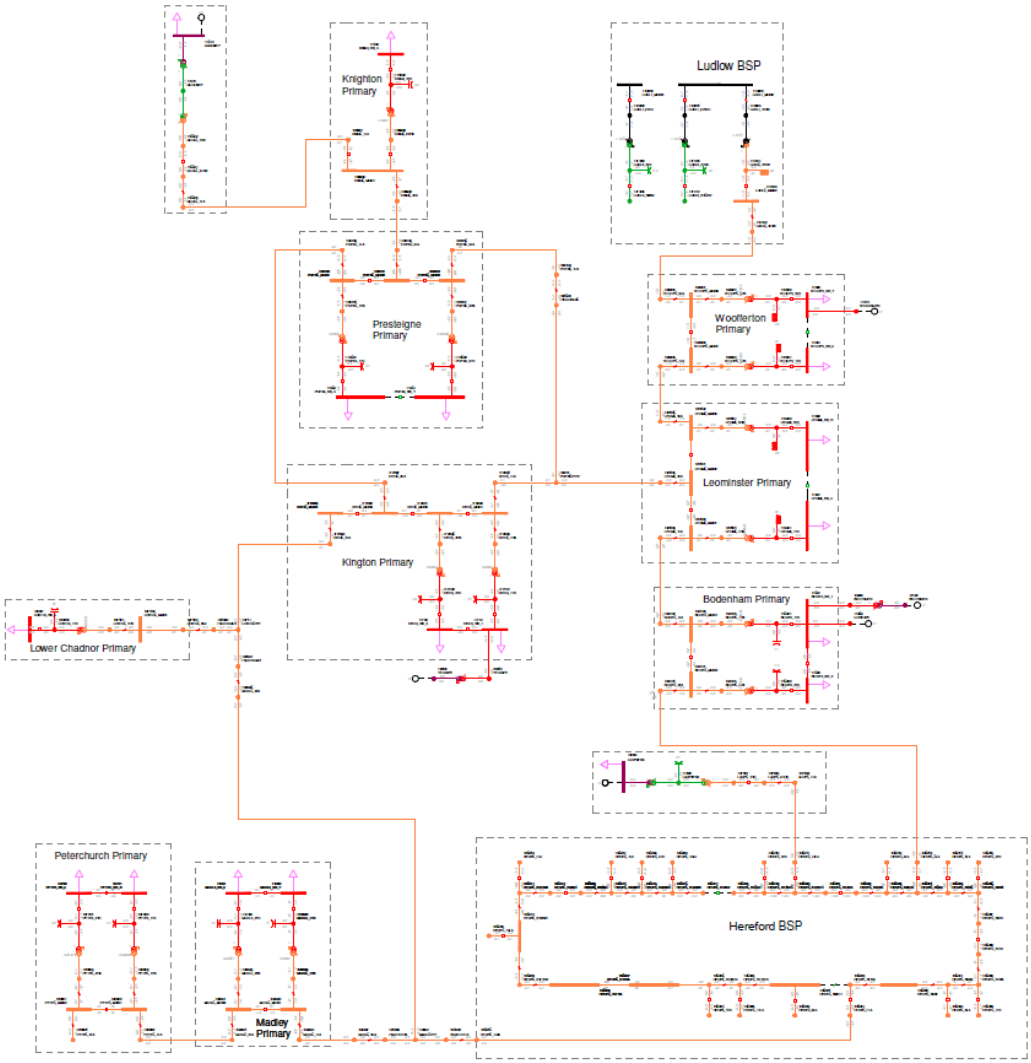

Figure 34 Hereford-Ludlow network schematic

Constraint summary

Generation | Demand

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	66 kV circuits: Hereford - Kington and Presteigne - Leominster	
Type(s) of constraint	Thermal overload and voltages operating outside of statutory limits	
Constrained condition(s)	Winter Peak Demand Summer Peak Generation	
Limiting factor of constrained assets	Long feeding distances combined with relatively small conductors at the infeeds and around the mesh (mixtures of 0.1 in^2 Hard-Drawn Copper (HDC) and 0.1 in^2 ACSR).	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Various circuit/busbar faults around the 66 kV network (especially on circuit sections close to Hereford BSP) cause thermal overloads and voltage levels outside of statutory limits.
	Second Circuit Outage	A second circuit outage would worsen the constraints highlighted above.

Scenario identification

The table below highlights how the constraints occur during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Option 1: Install a second 132/66 kV transformer at Ludlow BSP and construct a new 66 kV circuit to Presteigne to reinforce the group.
	Option 2: Uprating the 66 kV circuits around the meshed network to remove the thermal constraints and improve the voltage levels so as to remain above statutory voltage limits.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Both generation turn up/demand turn down as well as generation turn down/demand turn up flexibility contracts could benefit this area in the short term, via the 'Secure' product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Stockton Primary

Network Overview

Stockton Primary substation is a single 33/11 kV transformer site supplying a relatively rural area. There are two 33 kV circuits into the site from Ludlow BSP forming an open ring between Tenbury, Cleobury Mortimer and Stockton Primary substations. The site relies on 11 kV interconnections from Cleobury Mortimer, Stourport, and Kenswick Primary substations for the loss of supply to its transformer, which is a 7.5/15 MVA unit.

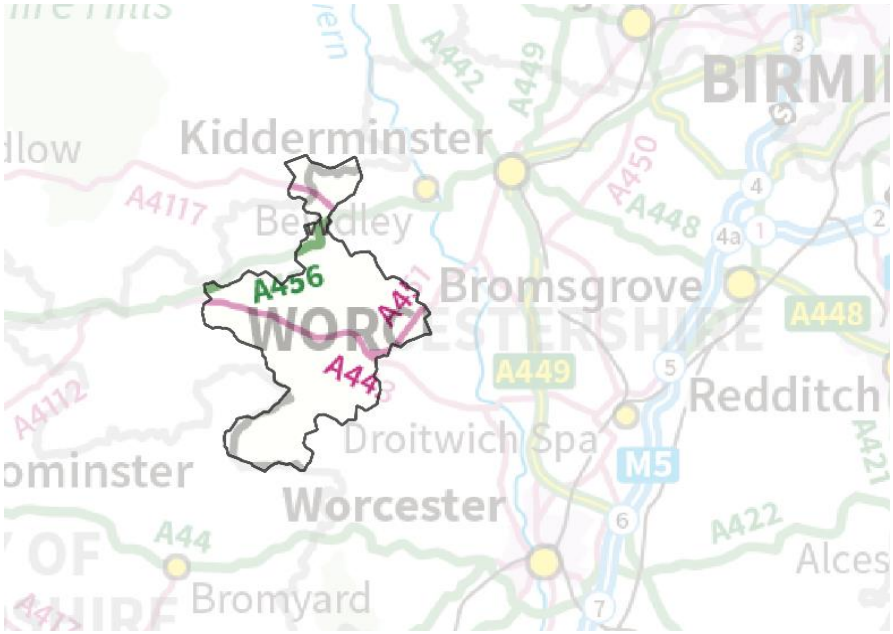

Figure 35 Stockton geographic network coverage

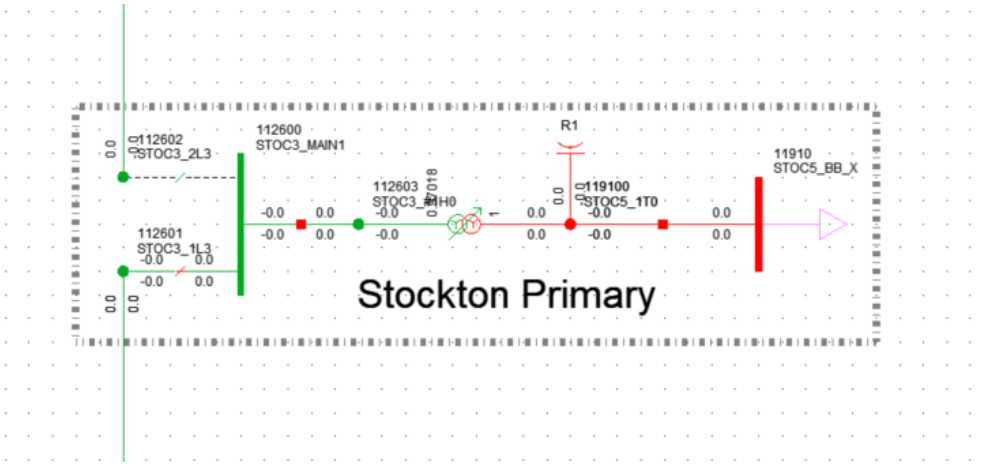

Figure 36 Stockton Primary network schematic

Constraint summary

Generation Demand

For the arranged or fault outage on the infeed to the Primary Transformer at Stockton, the 11 kV interconnections are likely to overload and the voltages drop to below 0.94 per unit.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	11 kV interconnections between Stockton and neighbouring Primary substations	
Type(s) of constraint	Thermal overload and voltage constraint of 11 kV network	
Constrained condition(s)	Winter Peak Demand	
Limiting factor of constrained assets	11 kV network varying from 0.05 in^2 Copper to 50 mm^2 Aluminium.	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged or fault outage on the 33/11 kV transformer
	Second Circuit Outage	Not applicable

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression			✓	✓
System Transformation			✓	✓
Consumer Transformation			✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Install a second 33/11 kV transformer at Stockton Primary substation. This will include 33 kV busbar reconfiguration and 11 kV circuit breakers added in to facilitate the connection of the additional transformer.
Operational mitigation	Very limited due to the First Circuit Outage constraint and the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Dynamic’ product.

Epwell Primary

Network Overview

Epwell Primary is a 66/11 kV site fed via two 66 kV circuits from Feckenham GSP via Shipston Primary. The site consists of two transformers, each rated 10/13 MVA that run split at 11 kV but rely on each other to supply the entire Primary load for the loss of either transformer.

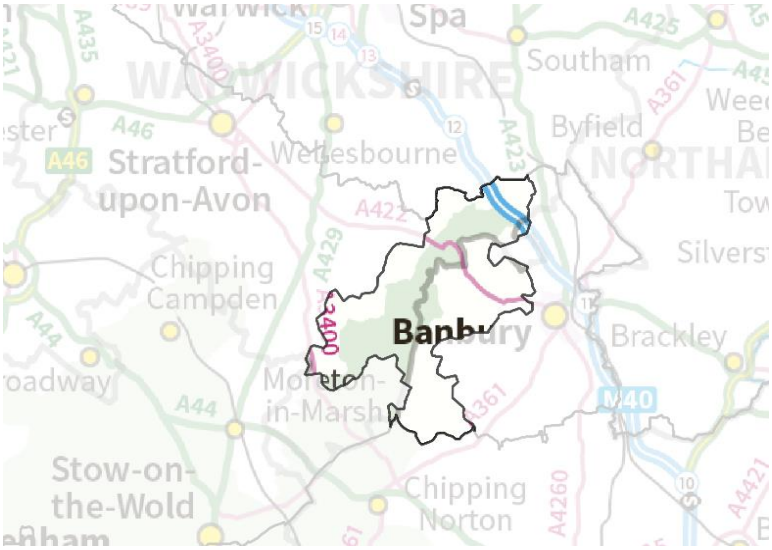

Figure 37 Epwell Primary geographic network coverage

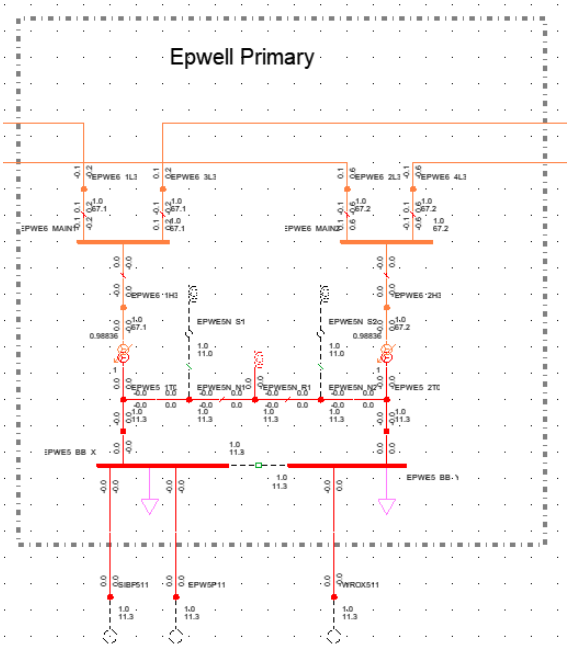

Figure 38 Epwell Primary network schematic

Constraint summary

Generation Demand

Under a First Circuit Outage on one of the transformers, the other is expected to pick up the entire site's demand which is likely to overload it. The constraint gets worse as demand is anticipated to grow further in the area.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Epwell 66/11 kV transformers	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Peak Demand across all seasons	
Limiting factor of constrained assets	10/13 MVA rating of the 66/11 kV transformers	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage on either 66/11 kV transformer
	Second Circuit Outage	Not applicable due to loss of supply to the group

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace both of the existing 66/11 kV transformers with larger units.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the 'Secure' product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Stowfield Primary and St Weonards Primary Substations

Network Overview

Stowfield Primary substation is a single 33/11 kV transformer site supplying a relatively rural area. There is one 33 kV infeed into the site, teed off a circuit between Bixhead and Wyelands Primary substations. The site relies on 11 kV interconnections from St Weonards Primary for the loss of supply to its transformer, which is a 10/13 MVA unit.

St Weonards Primary substation is a single 66/11 kV transformer site supplying a relatively rural area. There is one 66 kV infeed into the site, teed off a circuit between Hereford South and Ross Primary substation. The site relies on 11 kV interconnections from Ross, Pontrilas, and Stowfield Primary substations for the loss of supply to its transformer, which is a 12 MVA unit.

Figure 39 Stowfield and St Weonards geographic network coverage

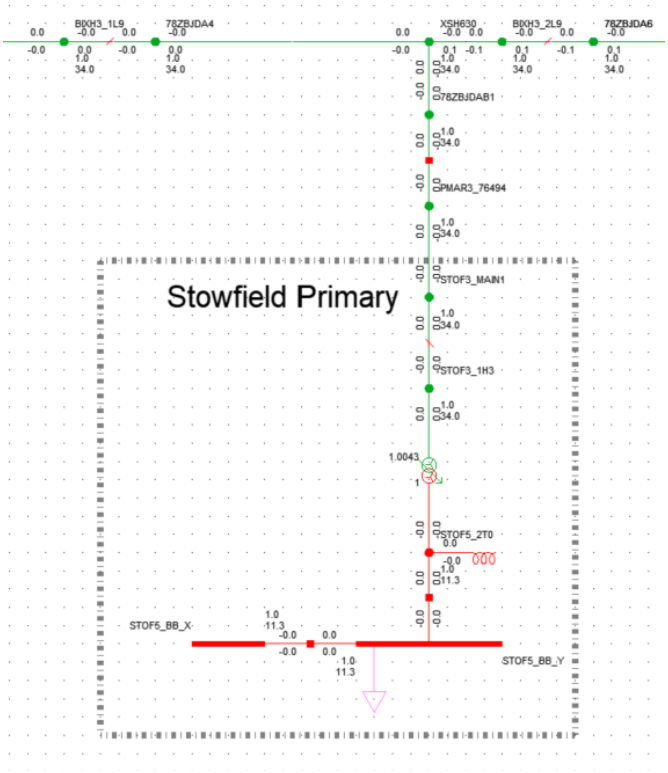

Figure 40 Stowfield network schematic

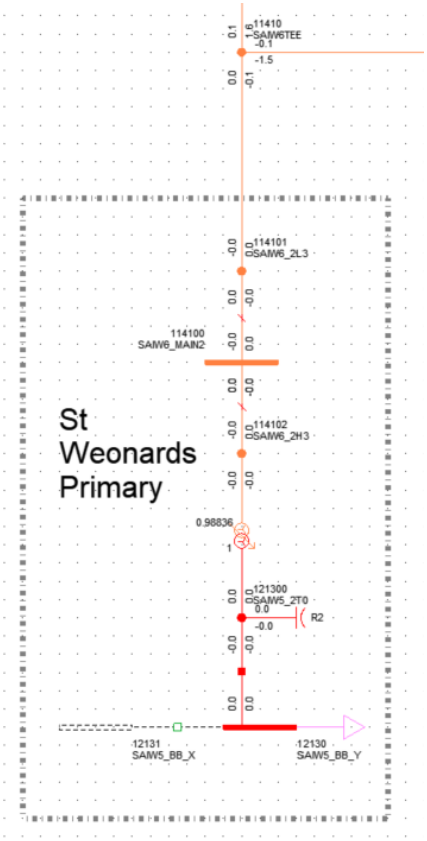

Figure 41 St Weonards network schematic

Generation Demand

Constraint summary

Generation Demand

For the arranged or fault outage on the infeed to the Primary Transformer at Stowfield, the 11 kV interconnections are likely to overload and the voltages drop to below 0.94 per unit.

Similarly, for the arranged or fault outage on the infeed to the Primary Transformer at St Weonards, the 11 kV interconnections are likely to overload and the voltages drop to below 0.94 per unit.

The tables below outline the nature of the network constraints identified in the network analysis.

Stowfield Primary:

Constrained assets	11 kV interconnections between Stowfield and neighbouring Primary substations	
Type(s) of constraint	Thermal overload and voltage constraint of 11 kV network	
Constrained condition(s)	Winter Peak Demand	
Limiting factor of constrained assets	11 kV network varying from 0.1 in^2 Copper to 300 mm^2 Aluminium	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged or fault outage on the 33/11 kV transformer
	Second Circuit Outage	Not applicable

St Weonards Primary:

Constrained assets	11 kV interconnections between St Weonards and neighbouring Primary substations	
Type(s) of constraint	Thermal overload and voltage constraint of 11 kV network	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand (from 2028)	
Limiting factor of constrained assets	11 kV network largely consisting of 50 mm^2 Aluminium OHL conductors	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged or fault outage on the 66/11 kV transformer
	Second Circuit Outage	Not applicable

Scenario identification

The tables below highlight how the constraints occur during the 0-10 year period across the different scenarios studied.

Stowfield Primary:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				
System Transformation				
Consumer Transformation				✓
Leading the Way				✓
WPD Best View				✓

St Weonards Primary:

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression		✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation	✓	✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	At Stowfield, convert the existing tee arrangement into a looped configuration by installing a second 33 kV circuit to the site, and uprating the existing circuit. Then install a second 33/11 kV transformer, also at Stowfield Primary, and reinforce the 11 kV interconnections between Stowfield and St Weonards Primary substations to alleviate both constraints identified.
Operational mitigation	Limited due to the First Circuit Outage constraints for both sites, and the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class B group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product, for both Stowfield and St Weonards Primary substations. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Alderton Primary

Network Overview

Alderton Primary is a 66/11 kV site connected via two 66 kV circuits, one from Cheltenham BSP (via Marle Hill and Bishops Cleave substations) and the other from Feckenham GSP (via Wormington Primary substation). It is however normally supplied from Cheltenham with 66 kV open points at Wormington. It consists of two 66/11 kV transformers, T1 rated 10/13 MVA and T2 rated 12/15 MVA.

The site runs closed at 66 kV but open at 11 kV, and for an outage on either transformer, the remaining in-service transformer supplies the entire Primary demand.

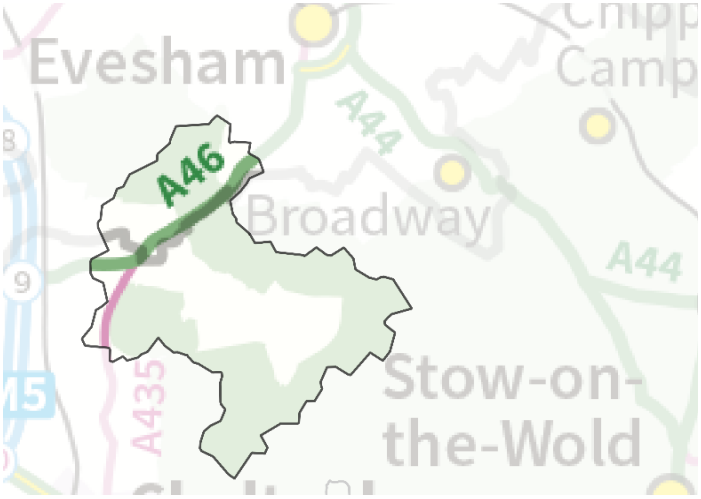

Figure 42 Alderton Primary geographic network coverage

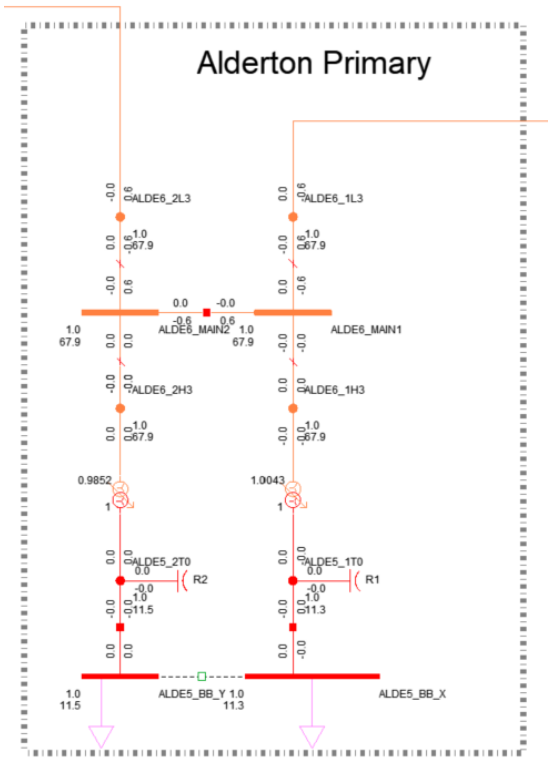

Figure 43 Alderton Primary network schematic

Constraint summary

Generation | Demand

For an arranged outage on T2, transformer T1 supplies the entire Primary demand and is likely to overload during certain seasons and scenarios. Similarly, for an arranged outage on T1, transformer T2 supplies the entire Primary demand but is not projected to overload until 2025.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Alderton 66/11 kV transformers T1 or T2	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand Summer Peak Demand	
Limiting factor of constrained assets	Transformer rating of T1 (10/13 MVA) or T2 (12/15 MVA)	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Arranged outage on T2 or T1
	Second Circuit Outage	Not applicable due to loss of supply to the group

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Transformer T1 Constraint:

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Transformer T2 Constraint:

Scenario	Study year			
	Baseline	2025	2028	2032
Steady Progression			✓	✓
System Transformation			✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace both of the existing 66/11 kV transformers with larger units.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage and across multiple seasons.

Chipping Sodbury BSP

Network Overview

Chipping Sodbury BSP is a 132/33 kV network, fed out of Iron Acton GSP, and consists of two 45/90 MVA Grid Transformers. The BSP supplies the following 33/11 kV Primary substations that feed the local areas: Chipping Sodbury T3, Cowhorn, Naishcombe Hill, Oxbridge, Alveston, and Hammerley Down.

The transformers run in parallel and in the event of an outage on one Grid Transformer, the remaining transformer in service supplies the entire BSP demand.

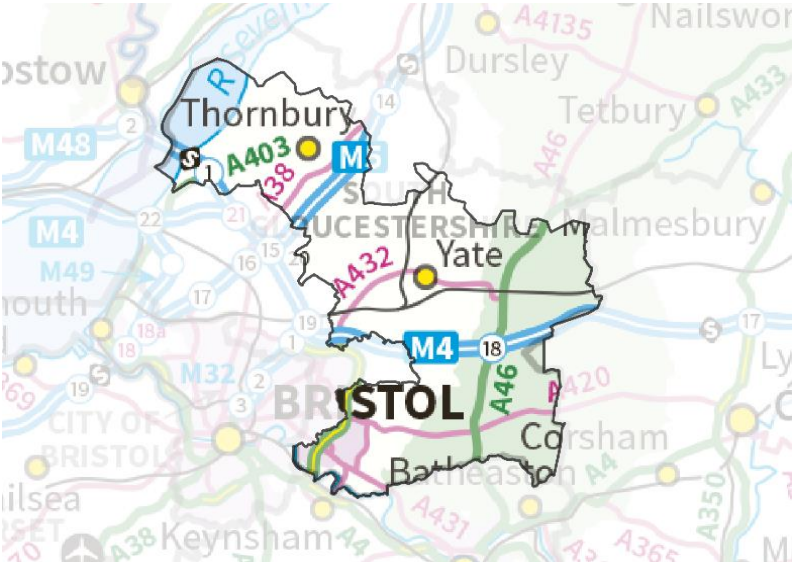

Figure 44 Chipping Sodbury BSP geographic network coverage

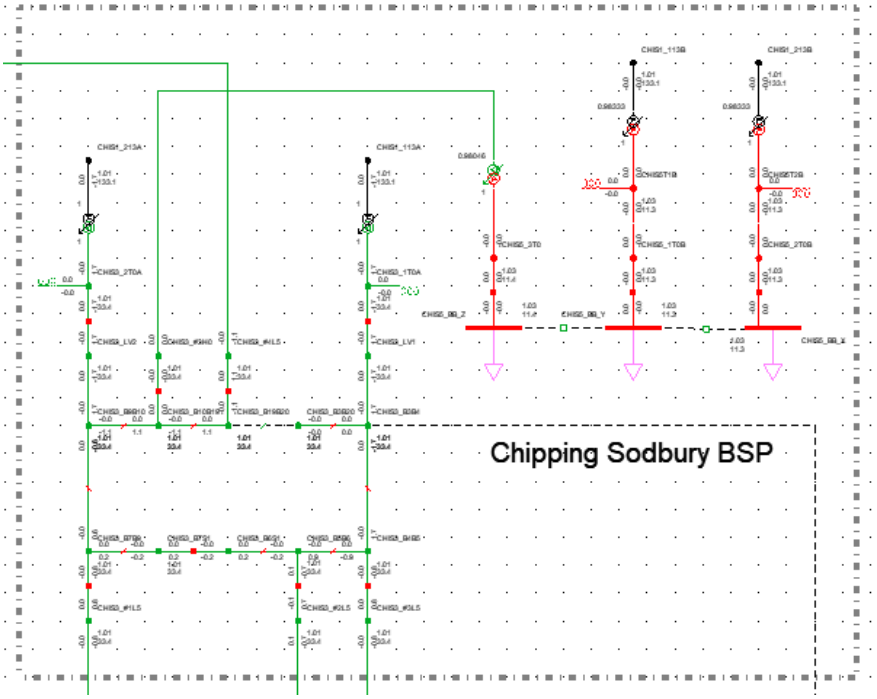

Figure 45 Chipping Sodbury BSP network schematic

Constraint summary

Generation | **Demand**

With projected load growth and numerous new connection demand schemes proposed to develop in the area, the 132/33 kV transformers are likely to overload following a first circuit outage on the other.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	132/33 kV transformers at Chipping Sodbury BSP	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand	
Limiting factor of constrained assets	45/90 MVA rating of the 132/33 kV transformers	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage or fault on either 132/33 kV transformer
	Second Circuit Outage	Arranged outages at 11 kV or 33 kV leading to demand transfer into the BSP group, followed by a fault on one of the Grid Transformers.

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression				✓
System Transformation			✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View			✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Establish a new BSP adjacent to Iron Acton GSP to pick up demand from Chipping Sodbury 33 kV network. The works will include two additional 132 kV bays at Iron Acton GSP, short sections of 132 kV circuits and two 132/33 kV transformers with 33 kV busbars and circuit breakers.
Operational mitigation	Very limited due to the First Circuit Outage constraint and the potential Engineering Recommendation P2/7 non-compliance for a Class D group demand.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class D group demand.
Flexibility services	Generation turn up and/or demand turn down via the ‘Secure’ product. Dispatch of services may be required for an extended period of time given the constraint is present under a First Circuit Outage.

Cowhorn Primary

Network Overview

Cowhorn Primary is a 33/11 kV site fed via two 33 kV circuits from Chipping Sodbury BSP via Wapley Primary. The site consists of two transformers, 12/24 MVA each, that run parallel at 11 kV and so for an outage on one transformer, the remaining transformer in service supplies the entire Primary demand.

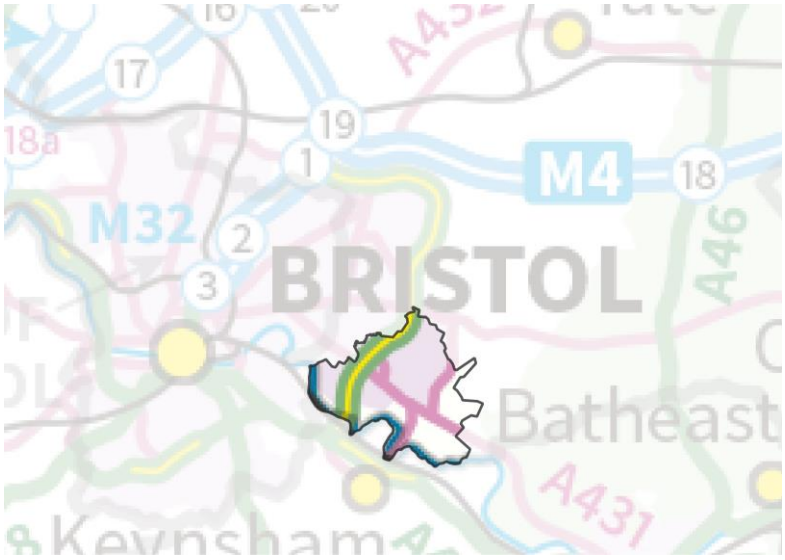

Figure 46 Cowhorn Primary geographic network coverage

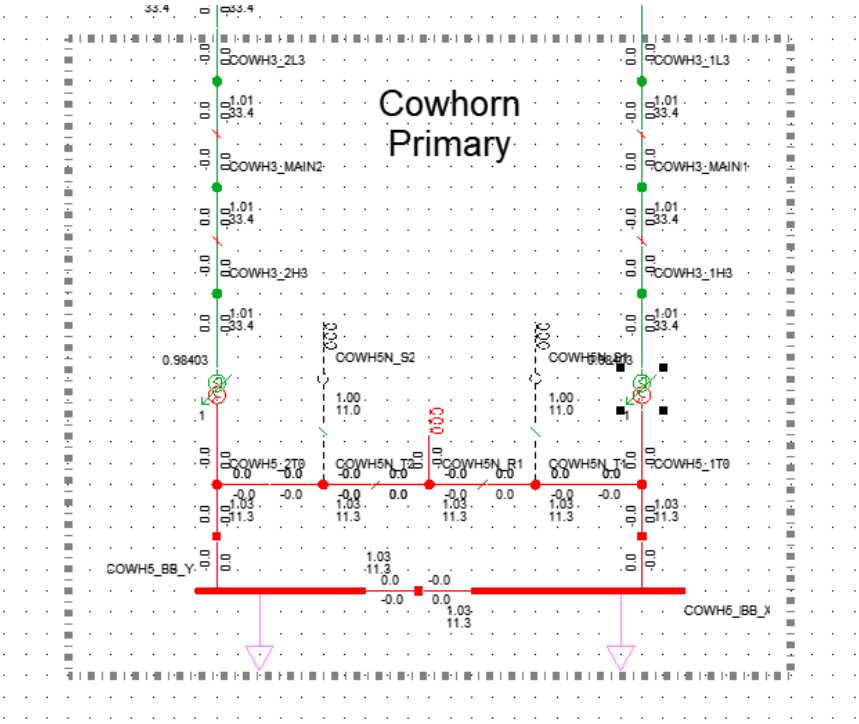

Figure 47 Cowhorn Primary network schematic

Constraint summary

Generation | Demand

Under a First Circuit Outage on one of the transformers, the remaining transformer in service supplies the entire Primary demand, which can cause thermal transformer overloads. The constraint is exacerbated as demand is anticipated to grow further in the area.

The table below outlines the nature of the network constraints identified in the network analysis.

Constrained assets	Cowhorn 33/11 kV transformers	
Type(s) of constraint	Thermal overload	
Constrained condition(s)	Winter Peak Demand Intermediate Warm Peak Demand (from 2025)	
Limiting factor of constrained assets	12/24 MVA rating of the 33/11 kV transformers	
Outage combination which causes the constraint	Intact	No observed constraints
	First Circuit Outage	Outage on either 33/11 kV transformer
	Second Circuit Outage	Not applicable due to loss of supply to site

Scenario identification

The table below highlights how the constraint occurs during the 0-10 year period across the different scenarios studied.

Scenario	Study year			
	Baseline	**2025**	**2028**	**2032**
Steady Progression	✓	✓	✓	✓
System Transformation		✓	✓	✓
Consumer Transformation		✓	✓	✓
Leading the Way		✓	✓	✓
WPD Best View		✓	✓	✓

Solution options

The following solution options could resolve the constraints above. Any final solution will be subject to a cost benefit analysis.

Solution option	Summary
Reinforcement	Replace both of the existing 33/11 kV transformers with 20/40 MVA units.
Operational mitigation	Temporary 11 kV transfers could help mitigate some of the immediate constraints but a more conventional intervention may be necessary as the demand grows.
Load Management Schemes	Very limited due to the potential Engineering Recommendation P2/7 non-compliance for a Class C group demand.
Flexibility services	Generation turn up/demand turn down could benefit this area. Dispatch of services may be required for an extended period of time given the First Circuit Outage constraint.