Cellarhead GSP Network

Network Development Report – West Midlands

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Electricity Distribution

nationalgrid

Contents

Cellarhead GSP Network

1. Network Overview

Cellarhead is a 132 kV Grid Supply Point (GSP) that supplies the majority of Stoke, connecting over 278,000 customers. The network comprises of several 132 kV circuits distributed across the region, connecting eight Bulk Supply Points (BSPs) which in turn supply multiple primary substations and Extra High Voltage (EHV) customers. The GSP also supplies part of the Scottish Power (SP) Manweb network via a direct circuit from Cellarhead and two others from within NGED's distribution network.

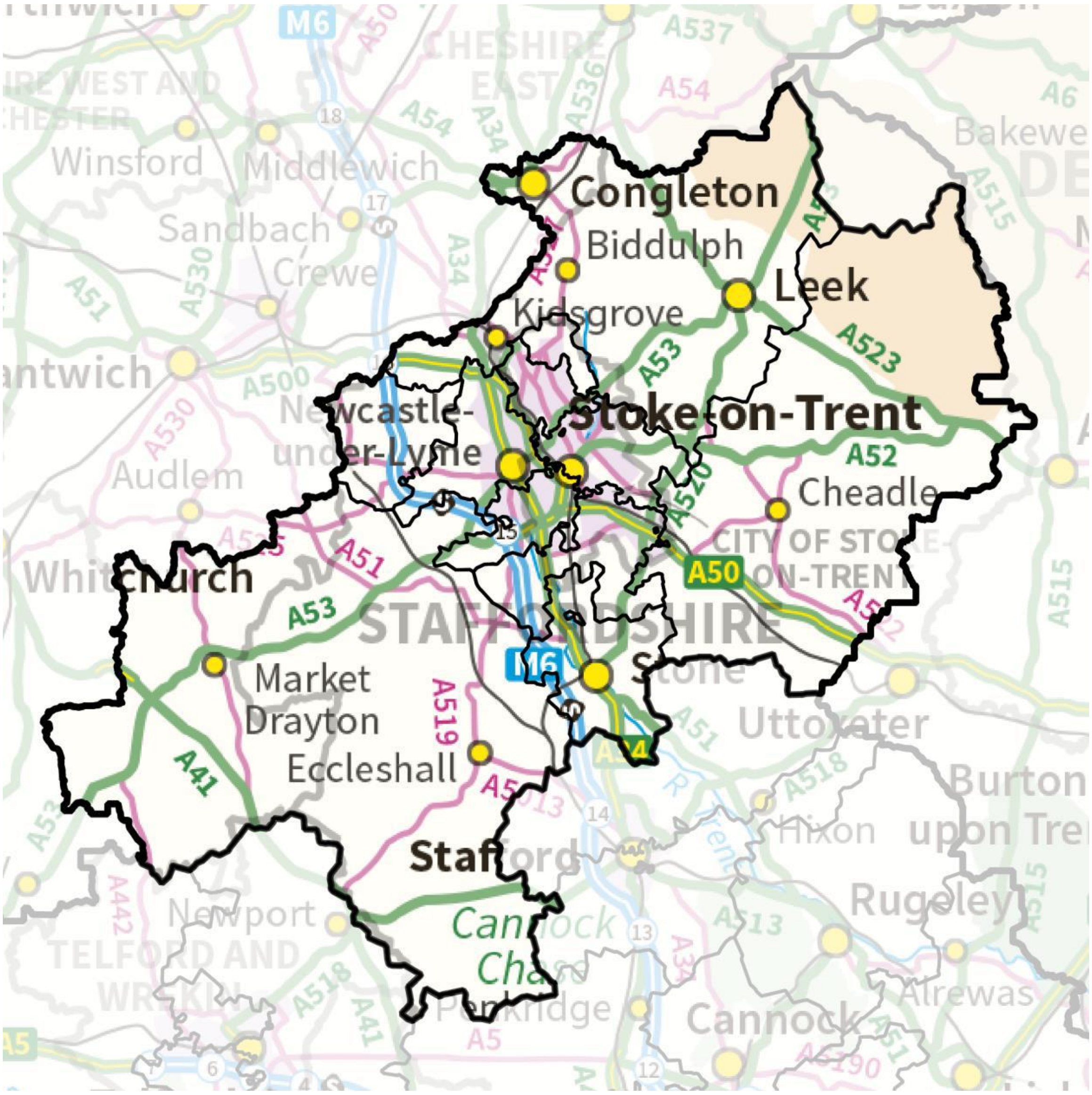

Figure 1.1 Cellarhead GSP geographic network coverage

This report discusses existing and future network constraints over a 0-10 year horizon associated with Cellarhead GSP and its downstream network. It uses the methodology outlined in the Network Development Plan Methodology Report with Network Operability Modelling applied as outlined further below.

For the purposes of this analysis the NGED Best View Distribution Future Energy Scenario (DFES) has been used to study each year up to and including 2034. Representative days for each of the four seasons (Winter, Intermediate Cool, Intermediate Warm, and Summer) have been studied to cover the edge case scenarios for the network.

1.1 Network Topology

Cellarhead GSP is a 400/132 kV site fed via four 240 MVA Super Grid Transformers (SGTs), with a fifth one on hot-standby, running 2+2 split through a two-section 132 kV double busbar arrangement. The GSP supplies eight BSPs within NGED, categorised below into two zones for clarity and reference purposes further down in the report:

- Zone 1: Whitfield, Burslem, and Newcastle BSPs (includes part of Manweb's network)
- Zone 2: Forsbrook, Longton, Meaford, Stagefields, and Boothen BSPs

Both zones are fed via a total of seven 132 kV infeeds from Cellarhead that are heavily interconnected, partly via Barlaston switching station. There are also three 132 kV circuits into SP Manweb's network (one directly from Cellarhead and two from NGED's distribution network), and two interconnectors to Rugeley GSP that normally run open.

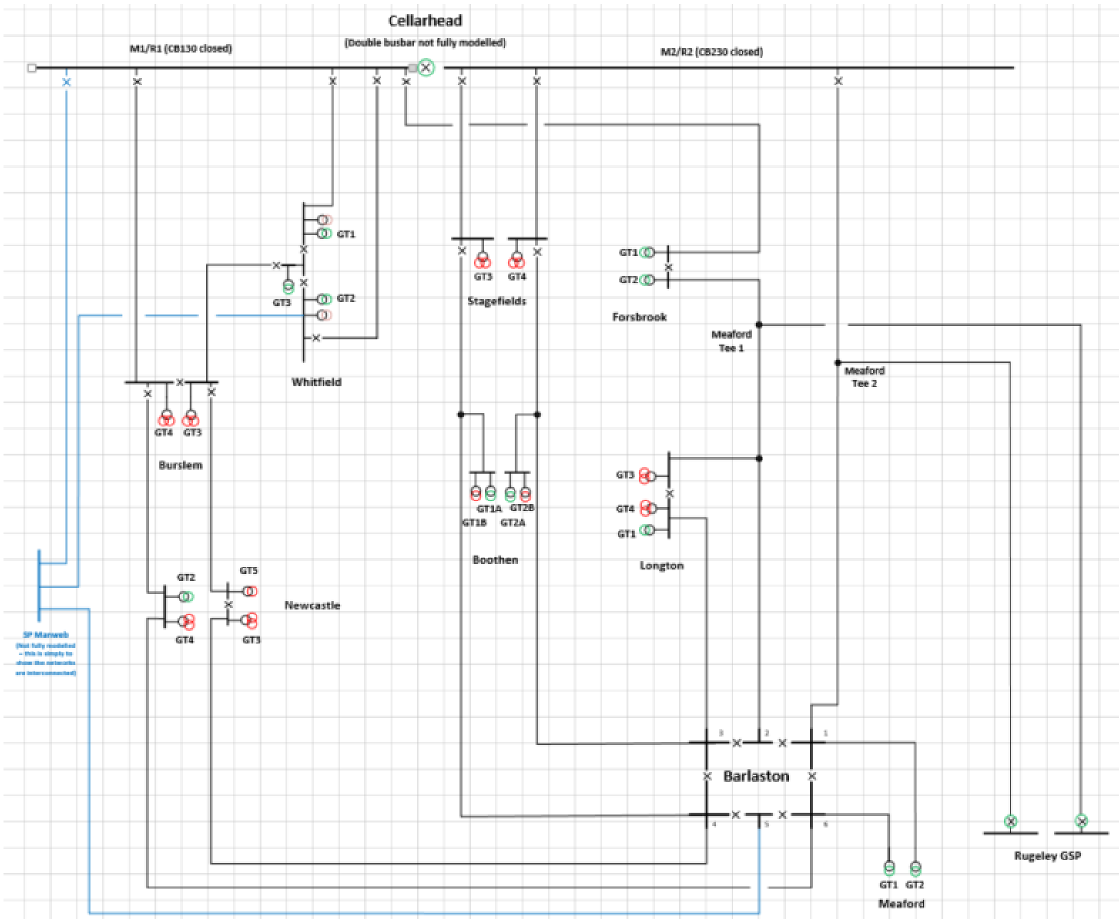

Figure 1.1.1 Cellarhead GSP schematic

A few of the BSPs within Cellarhead also have 33 kV networks downstream:

- Whitfield BSP consists of 3x 132/33 kV Grid Transformers (GTs), suppling 7x primary substations through mostly radial feeders with interconnections at remote ends normally run open.
- Newcastle BSP consists of a single 132/33 kV transformer, in addition to a pair of three-winding 132/11/11 kV transformers and a single 132/11 kV GT. The 33 kV supplies two primary substations and is interconnected with Whitfield BSP, normally run open.
- Meaford C BSP consists of 2x 132/33 kV GTs (with a third being installed), supplying 10x primary substations via several 33 kV circuits that are largely interconnected and run in parallel with each other.
- Forsbrook BSP consists of 2x 132/33 kV GTs, suppling 9x primary substations through mostly radial feeders with interconnections at remote ends normally run open.

1.2 Network Operability Modelling

The analysis modelling covers automation and manual switching schemes that represent how the network is generally operated. Some of the main ones are listed below.

Cellarhead 132 kV:

- The GSP busbars include a few automation schemes as listed below:
  - The SGT on hot-standby is brought in for the loss of either SGT connected to M1/R1, or for the loss of any two SGTs
  - The bus-section circuit breaker (CB120) is closed for a loss of either SGT connected to M2/R2
- Arranged or fault outages leading to loss of a GT at Stagefields, Boothen, Longton, and Burslem BSPs results in the 11 kV being closed in to backfeed.

Whitfield BSP:

- Arranged outages affecting any of the GTs results in the network between the remaining two GTs in-service being run split.
- Arranged outages that split up the 33 kV network at Whitfield results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged outages affecting either infeed to the Endon-Cheddleton-Leek group results in the other circuit being closed in, and Leek T2 transferred to Congleton 33 kV.
- Arranged outages to the infeeds to Congleton results in the other feeder picking up the site.
- Arranged or fault outages affecting the infeed to Golden Hill Bank results in the 33 kV CB at Talke being closed in to backfeed.
- Arranged or fault outages leading to loss of a primary transformer at Endon, Leek, Congleton, and Knypersley results in the 11 kV at these sites being closed in to backfeed.

Newcastle BSP:

- Arranged or fault outages affecting the infeed to Scot Hay or Talke primary substations results in the 33 kV CB at Talke being closed in to backfeed
- Arranged or fault outages leading to loss of a 132/11 kV or three-winding 132/11/11 kV GT at Newcastle results in the 11 kV being reconfigured to backfeed from the other transformer(s).

Meaford C BSP:

- Arranged outages that split up the 33 kV network at Meaford C results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged outages affecting the infeed to Simplex primary results in the site being transferred to Forsbrook BSP.
- Arranged or fault outages leading to loss of a primary transformer at Meaford or Cotes Heath results in the 11 kV at these sites being closed in to backfeed.

Forsbrook BSP:

- Arranged outages affecting either infeed to Kingsley Holt-Cauldon-Cauldon Cement results in the demand being moved to the other feeder.
- Arranged or fault outages affecting either infeed to the Simplex-Tean-Cheadle ring results in the 33 kV CB at Cheadle being closed in to back feed.
- Arranged or fault outages leading to loss of a primary transformer at Cheadle, Simplex, Kingsley Holt, and Cauldon results in the 11 kV at these sites being closed in to backfeed.

2. Summary of Network Constraints

The following constraints were identified for the Best View Scenario, for which mitigation options are covered further down in the report:

- Cellarhead 132 kV circuit overloads
  - Cellarhead to Stagefields 132 kV circuits
  - Stagefields to Boothen 132 kV circuits
  - Meaford Tee 2 to Barlaston 132 kV circuit
  - Cellarhead to Whitfield tower line circuit
- Whitfield 33 kV network
  - Whitfield to Congleton 33 kV circuit overload
  - Whitfield to Knypersley_4L5 33 kV circuit overload
  - Knypersley to Congleton 33 kV circuit overload
  - Congleton T1 overload
  - Whitfield to Endon_CB02 circuit overload
  - Endon to Cheddleton 33 kV circuit overload
  - Leek 33 kV network volts
  - Congleton 33 kV network volts
- Cheddleton to Leek 33 kV overload
- Gnosall primary volts and backfeed capacity
- Wetwood Tee to Wetwood_1L3 33 kV overload
- Hookgate to Hinstock 33 kV overload
- Hookgate to Market Drayton_4L3 33 kV overload
- Boothen 132/11 kV GT1B and GT2B overload
- Cheadle and Simplex 33 kV circuits
  - Forsbrook to Cheadle 33 kV overload
  - Forsbrook to Simplex 33 kV overload
- Simplex transformer overload
- Cauldon transformer overload

Transmission-Distribution interface

Cellarhead GSP is a 400/132 kV site and is one of the boundaries between the transmission and distribution networks. New Connection activity at the distribution network, both demand and generation, have triggered constraints at the transmission network with regards to SGT capacity and 400 kV circuit ratings. Several proposals to mitigate are being considered including uprating the existing assets, establishing another GSP near Cellarhead, or establishing a GSP at a location more suitable for the wider region.

3. Network Constraints and Solution Options

3.1 Cellarhead 132 kV circuit overloads

Constraint Overview

Generation | Demand

The Cellarhead 132 kV network is fed via 7x main circuits that are interconnected creating parallels between the two sections of the GSP that normally run open (due to fault level limitations). The group is above 300 MW and therefore needs to comply with Class E requirements under Engineering Recommendation P2.

The table below outlines the constraints identified for Best View, the conditions they occur under, and the triggering year per season.

Table 3.1.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Cellarhead to Stagefields 132 kV circuits	N-2: various arranged outages affecting one of the main infeeds to the group, followed by a fault on one of the two Cellarhead-Stagefields circuits	2027	2027	2028	2028
Stagefields to Boothen Tee 132 kV circuits	N-2: various arranged outages affecting one of the main infeeds to the group, followed by a fault on one of the two Stagefields-Boothen circuits	2027	2027	2028	2028
Meaford Tee 2 to Barlaston 132 kV circuit	N-2: various arranged outages affecting one of the main infeeds to the group, followed by a fault on another	2027	2027	2028	2028
Cellarhead to Whitfield 132 kV tower line circuit	N-1: busbar fault at Cellarhead main 1 taking out the other circuit to Whitfield and the direct circuit to SP Manweb's network from Cellarhead	2027	2027	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.1.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Reinforcing existing 132 kV circuits	✓	×	×	Discounted
3	Installing a new Cellarhead-Longton circuit	✓	✓	×	Viable
4	Installing a new Cellarhead-Burslem circuit	✓	✓	✓	Viable
Operational Mitigation					
5	Load transfers	×	✓	×	Discounted
Load Management Schemes					
6	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
7	Flexibility service procurement	×	✓	×	Discounted

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The constraint is anticipated to trigger by 2027 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads, as described above, and to the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Existing 132 kV circuit ratings as detailed earlier above

Option 2 – Reinforcing existing 132 kV circuits

Estimated capacity released: 30 MVA **Discounted**

Detailed description: Uprating the existing 132 kV circuits that are expected to overload. These tower lines are near their peak rating for the given tower design and therefore uprating them would require substantial tower modification and re-construction. The lengths of these 132 kV double circuit tower lines are as follows:

- Cellarhead to Stagefields: 7.3 km
- Stagefields to Boothen: 2.2 km
- Meaford Tee to Barlaston: 11.5 km
- Cellarhead to Whitfield: 9.6 km

These significant works would only release a modest amount of capacity as the limitation moves on quickly to the other 132 kV circuits within the group including a 16 km double circuit tower line between Barlaston and Newcastle, and a 5 km cable circuit between Whitfield and Burslem.

New limiting factor: The other 132 kV circuit ratings within the group

Option 3 – Installing a new Cellarhead-Longton circuit

Estimated capacity released: 100 MVA+ **Viable**

Detailed description: Adding an eighth feeder into the group, the works involve:

- Establishing a new 132 kV bay at Cellarhead.
- Installing a new 12 km 132 kV circuit between Cellarhead and Longton. Due to the route passing through built up areas, the circuit is anticipated to be a cable circuit.
- Carrying out 132 kV busbar modification works at Longton.
- Uprating the tower line circuit between Longton and Barlaston, approximately 6.6 km long.
- Assessing Cellarhead, Whitfield, Longton, Forsbrook, and Burslem to determine more accurate fault level capability of assets and structures.

New limiting factor: The other 132 kV circuits within the group

Option 4 – Installing a new Cellarhead-Burslem circuit

Estimated capacity released: 100 MW+ **Viable**

Detailed description: The solution is based around reinforcing the network to a point where a split arrangement under normal running can be established between zones 1 and 2 (i.e. between Forsbrook/Longton/Stagefields/Boothen/Meaford and Whitfield/Burslem/Newcastle/SP Manweb). The works include the following:

- Establishing a new bay at Cellarhead and moving the Forsbrook feeder to the M1/R1 side, keeping all feeders to zone 2 on the same paralleled sections.
- Installing a three section 132 kV busbar arrangement at Barlaston switching station to detach the two Barlaston-Newcastle circuits and the Barlaston-Radway Green circuit from the existing arrangement. This creates a spare bay for the ongoing Meaford GT3 works.
- Interconnecting the two busbar arrangements at Barlaston via suitably rated cable circuits (274 MVA would suffice), and operate them normally open.
- Extending Burslem 132 kV busbars and installing a new 9 km cable circuit from Cellarhead M1/R1 section to Burslem, utilising the bay left behind by the Cellarhead-Forsbrook feeder. The new cable is to have a minimum summer sustained rating of 274 MVA which is likely to require 1600 mm copper XLPE cable laid flat.
- Decommissioning the reactor at the existing Cellarhead-Burslem circuit as it becomes unnecessary due to network impedances being more evenly distributed.
- Extending the 132 kV busbars in Whitfield's 33 kV side of the compound, and reconfigure the connections for a couple of BESS schemes proposing to connect on to the interconnector within Whitfield. The reconfiguration includes looping them through the extended busbars in between the Burslem circuit and Whitfield GT3 connection, rather than being looped in to the interconnector within Whitfield substation. This will provide the ability to split Whitfield-Burslem whilst allowing the BESS schemes to be supplied via Burslem and without affecting Whitfield GT3. The impact on SP Manweb's feeder via Barlaston would also not be significant.
- Conducting surveys and further assessment at Whitfield, Burslem, and Newcastle to ascertain the sites' fault level capabilities.

New limiting factor: The 132 kV circuit rating to Stagefields BSP

Option 5 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: Cellarhead GSP has very limited 11 kV transfers to other GSPs and no 33 kV transfers. There are 132 kV interconnections to Rugeley but these are only utilised in post fault N-2 conditions due to limitation at Rugeley GSP.

New limiting factor: the existing 132 kV circuit ratings within the group

Option 6 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: A few MVAs

Discounted

Detailed description: There are two considerations for this option:

- Post fault intertrip scheme via the circuits to Rugeley: complicated to implement due to the number of scenarios and the limited transfer capacity available; it would also help zone 2 of the Cellarhead network and would be of very little benefit to the constraints within zone 1.
- Post fault intertrip scheme to disconnect load: this would not comply with the requirement of Class E under Engineering Recommendation P2.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 7 – Flexibility service procurement

Estimated Flexibility Required (MW): 4 MW+

Discounted

Detailed description: Flexibility services through generation turn up and/or demand turn down may be of some benefit in certain pockets within the network; however due to the interconnected 132 kV circuits dispatching flexibility services to mitigate for a particular outage could cause an overload elsewhere under a different fault outage scenario. It would also not resolve the generation constraints.

New limiting factor: the existing 132 kV circuit ratings within the group

Solution Recommendation

In addition to the thermal constraints identified above, the 132 kV network at Cellarhead has the following additional limitations:

- Network operability restrictions: the number of interconnector circuits makes the power flow through the 132 kV network near impossible to pre-determine therefore leading to safety and security risks, inefficient running of the network, and challenges in assessing and connecting customers.
- Fault level headroom which is fairly limited especially with consideration to the levels of proposed generation connections and some of the options proposed at the GSP at the transmission-distribution interface.

Option 3, although adds thermal capacity, worsen the limitations above by making the network more complicated and increases fault levels further.

It is therefore recommended to pursue option 4 of installing a new Cellarhead to Burslem 132 kV circuit and splitting the network between zones 1 and 2; as this solution adds similar levels of capacity to option 3 but also simplifies the network, reduces fault levels (an assessment of current capabilities are still required), and sets up the network for more efficient reinforcement options longer term.

3.2 Whitfield 33 kV Network

Constraint Overview

Generation Demand

Whitfield BSP is fed via 3x 132/33 kV GTs and supplies several primary substations through a mix of overhead and underground 33 kV circuits.

Endon, Cheddleton and Leek primary substations are Class C under P2, supplied via a pair of 33 kV circuits that run split, with an interconnection to Congleton (also run split).

Knypersley, Goldenhill Bank, and Congleton are approaching Class D under P2 and are supplied via two Whitfield-Knypersley 33 kV circuits, and a third Whitfield-Congleton circuit, with Goldenhill Bank branching off Knypersley busbars.

The table below outlines the constraints identified for Best View, the conditions they occur under, and the triggering year per season.

Table 3.2.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Whitfield to Congleton 33 kV circuit overload	N-1: Outage of the Knypersley-Congleton 33 kV circuit; or Outage within the Endon-Cheddleton-Leek network resulting in Leek T2 being moved to Congleton via the 33 kV interconnector	2028	2029	2030	2033
Whitfield to Knypersley_CB04 33 kV circuit overload	N-1: Outage at Whitfield BSP resulting in the loss of the Congleton circuit and one of the Endon feeders	2026	2027	2028	2032
Knypersley to Congleton 33 kV circuit overload	N-1: Outage of the Whitfield-Congleton circuit; or Outage at Whitfield 33 kV main 1 taking out the Congleton feeder and one of the Endon feeders	Baseline	Baseline	Baseline	2027
Congleton T1 overload	N-1: Outages resulting in loss of supply to T4 and T5, putting all the demand on T1	Baseline	Baseline	Baseline	2027
Whitfield to Endon_CB02 circuit overload	N-1: Fault outage taking out the Whitfield-Endon-Leek 33 kV circuit, putting all the demand on this circuit	2031	2030	-	-
Endon to Cheddleton 33 kV circuit overload	N-1: Fault outage taking out the Whitfield-Endon-Leek 33 kV circuit	-	2033	-	-
Leek 33 kV network volts	N-1: Outages at Whitfield BSP, or any of the 33 kV circuits to Endon	Baseline	Baseline	Baseline	Baseline
Congleton 33 kV network volts	N-1: Outages at Whitfield BSP, or any of the 33 kV circuits to Congleton or to Endon resulting in Leek T2 being moved over	2030	2031	2034	-

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.2.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Reinforcing existing 33 kV network	✓	✓	×	Viable
3	Installing a new Whitfield-Congleton circuit	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers and outage window restriction	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	×	✓	×	Discounted

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA **Discounted**

Detailed description: Some of the constraints are imminent with the demand projected to continue increasing. Doing nothing could therefore lead to thermal overloads, voltages outside of statutory limits, and to the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Low volts and rating of existing circuits

Option 2 – Reinforcing existing 33 kV network

Estimated capacity released: 12 MVA **Viable**

Detailed description: Uprating the existing 33 kV network which includes circuits that are a mixture of underground cable and overhead lines (OHL).

The circuits involved are:

- Whitfield to Congleton: 13.3 km in length of mainly OHL circuit to be uprated to a minimum of 40 MVA winter cyclic rating.
- Whitfield to Knypersley: 2.6 km in length to be uprated to a minimum of 55 MVA winter cyclic rating; therefore it is anticipated to be an all underground circuit to achieve this.
- Knypersley to Congleton: 9 km in length to be uprated to a minimum of 50 MVA winter cyclic rating; therefore it is anticipated to be an all underground circuit to achieve this.
- Whitfield-Endon_CB02: 8.2 km in length to be uprated to a minimum of 50 MVA winter cyclic rating; therefore it is anticipated to be an all underground circuit to achieve this.
- Endon-Cheddleton: 5 km in length to be uprated to a minimum of 35 MVA summer cyclic rating.
- Assessing fault level capability at Knypersley primary.

The reinforcement works will also require 33 kV busbar reconfiguration at Congleton to avoid having T4 and T5 being picked up by T1 under certain outage conditions.

New limiting factor: Rating of the circuits

Option 3 – Installing a new Whitfield-Congleton circuit

Estimated capacity released: 40 MVA

Viable

Detailed description: Installing an additional Whitfield-Congleton 33 kV circuit; the works will include:

- Extending the 33 kV switchgear board at Whitfield (on the GT3 side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel.
- Extending the 33 kV switchgear board at Congleton (on the T5 side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel.
- Installing approximately 12 km of 33 kV circuit between Whitfield and Congleton; to be rated no less than 36 MVA summer and 40 MVA winter cyclic, and maintain a split arrangement at Congleton 33 kV.
- Transferring Leek T2 onto Congleton 33 kV under normal running; or alternatively setting an intertrip or a sequence scheme to move it across under a fault outage condition instead of picking it up via T1.

New limiting factor: Rating of the Knypersley-Congleton circuit

Option 4 – Operational mitigation: Load transfers and outage window restriction

Estimated capacity released: Limited

Discounted

Detailed description: There are some transfers within the group but these would shift the constraints in one direction or another, and transfers out of the group are very limited.

Some of the Baseline constraints may be managed by restricting transfers during arranged outages and/or disabling automation schemes in anticipation of a demand increase, but these are not enduring solutions due to obligations of maintaining our assets and meeting compliance with P2.

This option, although it may be utilised temporarily, is discounted as a permanent solution.

New limiting factor: Low volts and rating of existing circuits

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The groups affected fall within Class C (Endon-Cheddleton-Leek) and Class D (Knypersley-Congleton-Goldenhill Bank) under Engineering Recommendation P2 which, for a first circuit outage, would require restoration of group demand within 15 minutes (Class C), and immediate restoration of group demand minus 20 MW with full restoration within 3 hours (Class D); therefore demand disconnection schemes (or similar) would make these networks non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 4 MW+

Discounted

Detailed description: Flexibility services through generation turn up and/or demand turn down may be beneficial for a few select outages triggering thermal constraints, but it would not mitigate some of the more complicated scenarios nor the observed voltage constraints across the 33 kV network.

New limiting factor: Low volts and rating of existing circuits

Solution Recommendation

It is recommended to pursue option 3 above (installing a new Whitfield-Congleton circuit) as it provides more capacity, better network configuration, and is likely to be more economic considering the lengths of circuits needing to be uprated/undergrounded under option 2 (reinforcing the existing network).

As mentioned above, option 4 (operational mitigation) can also be implemented in the interim to manage some of the baseline constraints but it is not a viable long term solution.

3.3 Cheddleton to Leek 33 kV overload

Constraint Overview

Generation Demand

Leek primary substation is Class C under P2, supplied from Whitfield BSP via two circuits; one through Endon and another through Cheddleton.

During arranged outages at 33 kV affecting any of the circuits, Leek T2 is transferred to Congleton although this is not always achievable due to constraints on the Knypersley-Congleton network.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.3.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Cheddleton to Leek 33 kV overload	N-1: Outages affecting the normal 33 kV infeed to Leek T2 putting its demand on T1	2030	2030	2030	2033

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.3.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Reinforcing the existing circuit	✓	✓	×	Viable
3	Installing a new Endon-Leek circuit	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA Discounted

Detailed description: The constraint is anticipated by 2030 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing circuit

Option 2 – Reinforcing the existing circuit

Estimated capacity released: 12 MVA Viable

Detailed description: Uprating the existing 33 kV circuit between Cheddleton and Leek. The works involve:

- 1.3 km of OHL to be uprated to 200 mm All Aluminium Alloy conductor (AAAC)
- 200 metres of 185 mm copper underground cable to be replaced with standard 400 mm copper cable

New limiting factor: Rating of the Endon-Leek 33 kV circuit

Option 3 – Installing a new Endon-Leek circuit

Estimated capacity released: 40 MVA Viable

Detailed description: Installing an additional Endon-Leek 33 kV circuit; the works will include:

- Extending the 33 kV air-insulated busbars at Endon to establish a new bay
- Installing a second 33 kV bus-section circuit breaker at Endon
- Extending the 33 kV switchgear board at Leek (on the T2 side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel
- Installing approximately 8 km of 33 kV circuit between Endon and Leek to achieve a minimum winter cyclic rating of 37 MVA; anticipated to be 400 mm copper cable (for underground sections) and 200 mm AAAC designed to 75 degrees (for OHL sections)

New limiting factor: Rating of the Whitfield-Endon circuits

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Up to 10 MVA Discounted

Detailed description: Interconnection at 33 kV and 11 kV has been considered,

At 33 kV, there is interconnection where Leek T2 can be transferred onto Congleton but this:

- Does not resolve all conditions leading to the overload of the Cheddleton-Leek circuit (such as an outage at T2 putting all the demand on T1 which is fed via the Cheddleton-Leek)
- creates constraints on the Knypersley-Congleton network

At 11 kV, transfers are very limited and insufficient to mitigate the constraint.

New limiting factor: Low volts and rating of existing circuits

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: Up to 10 MVA

Discounted

Detailed description: Leek primary is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 8 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the existing circuit

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (uprating the existing circuit) as it is likely to be the most economical, deliverable, and avoids complicating the network.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.4 Gnosall primary volts and backfeed capacity

Constraint Overview

Generation | **Demand**

Gnosall primary is single transformer 33/11 kV primary substation within Meaford C BSP. It is supplied via a single 33 kV circuit from High Offley which is part of the Hookgate-Hinstock-High Offley-Wetwood 33 kV ring. Gnosall and High Offley (also a single transformer primary) backfeed each other at 11 kV.

The primary is Class B under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.4.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Gnosall primary volts and backfeed capacity	Intact; N-1: Outage of the transformer at High Offley, putting its demand on Gnosall.	2028	2028	2029	2031

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.4.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the 11 kV network to Eccleshall	✓	✓	✓	Viable
3	Adding a High Offley-Gnosall 33 kV circuit	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The constraint is anticipated by 2028 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Low volts and capacity of 11 kV interconnection

Option 2 – Upgrading the 11 kV network to Eccleshall

Estimated capacity released: 9.75 MVA **Viable**

Detailed description: Uprating the 11 kV network between Gnosall and Eccleshall, the works include:

- Extending the 33 kV switchgear board at Eccleshall, or installing another 3-panel board and reconfiguring the connectivity such that each 3-panel board has an infeed, a transformer breaker and an interconnector
- Installing a second 33/11 kV transformer at Eccleshall rated 7.5/15 MVA
- Extending/installing an 11 kV switchgear board to allow for two transformer incomers, a bus-section circuit breaker, and sufficient number of feeders
- Upgrade the 11 kV interconnection between Eccleshall and Gnosall to allow at least 10 MVA of transfer capacity, which may be achieved with 400 mm copper cable circuit sections

New limiting factor: Rating of the existing transformer at Gnosall

Option 3 – Adding a High Offley-Gnosall 33 kV circuit

Estimated capacity released: 9.75 MVA Viable

Detailed description: Adding a new High Offley-Gnosall 33 kV circuit, the works include:

- Extending the 33 kV busbars at High Offley to allow for a second bay to Gnosall connected to the Eccleshall/Westwood side of the busbars
- Installing approximately 8 km of 33 kV circuit from High Offley to Gnosall
- Installing a second 33/11 kV transformer at Gnosall
- Extending/installing an 11 kV switchgear board to allow for two transformer incomers, a bus-section circuit breaker, and sufficient number of feeders

New limiting factor: Rating of the existing transformer at Gnosall

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: 0 MVA Discounted

Detailed description: Gnosall is quite rural and already relies on 11 kV backfeed for security of supply, and this is the current limiting factor.

New limiting factor: Low volts and capacity of 11 kV interconnection

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA Discounted

Detailed description: Gnosall primary is Class B under Engineering Recommendation P2 which would require restoration of the group demand minus 1 MW within 3 hours for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant in the foreseeable future as the shortfall is projected to exceed 1 MW.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 8 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Low volts and capacity of 11 kV interconnection

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (reinforcing Eccleshall and its 11 kV interconnection to Gnosall) as it provides a wider benefit of securing Eccleshall in the long term, and is likely to be more economical and deliverable.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the DNOA process.

3.5 Wetwood Tee to Wetwood_1L3 33 kV overload

Constraint Overview

Generation | **Demand**

Hinstock, High Offley, and Gnosall are 33/11 kV primary substations (within Meaford C BSP) that form part of a 33 kV ring fed via Hookgate primary on the one side, and Wetwood Tee/Eccleshall on another. The Wetwood Tee and Eccleshall are two infeed sources tee'd together at High Offley Tee.

The ring is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.5.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Wetwood Tee to Wetwood_1L3 33 kV overload	N-1: Outage of the 33 kV circuit between Meaford C and Eccleshall	Baseline	Baseline	Baseline	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.5.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the existing circuit	✓	✓	×	Viable
3	Adding a Hookgate-Wetwood 33 kV circuit	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The constraint is imminent, with the demand projected to continue increasing. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the existing circuit

Option 2 – Upgrading the existing circuit

Estimated capacity released: 14 MVA **Viable**

Detailed description: Uprating the existing circuit (which is a 60 metre span of 0.075 in Cadmium Copper OHL circuit) with 200 mm AAAC, matching the circuit to back to Hookgate, and down to High Offley Tee.

New limiting factor: Rating of the Hookgate-Hinstock 33 kV circuit

Option 3 – Adding a Hookgate-Wetwood 33 kV circuit

Estimated capacity released: 30 MVA **Viable**

Detailed description: Adding a circuit between Hookgate and Wetwood Tee to unstitch the tee point, works include:

- Extending the 33 kV switchgear board at Hookgate (on the primary transformer's side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel.
- Installing approximately 5 km of 33 kV circuit from Hookgate to Wetwood Tee to unstitch the tee point. Circuit to be rated no less than 37 MVA winter cyclic which is anticipated to be of 400 mm copper underground cable or 200 mm AAAC OHL designed to 75 degrees.

New limiting factor: Rating of the Hookgate-Hinstock 33 kV circuit

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs **Discounted**

Detailed description: The substations within this ring are quite rural with very limited transfer capacity at 11 kV, and therefore insufficient to mitigate the constraint.

New limiting factor: Rating of the existing circuit

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The ring is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 8.5 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Low volts and rating of existing circuit

Solution Recommendation

It is recommended to pursue option 2 above (uprating the existing circuit) as it provides the most value for money considering the works involve uprating a 60 metre span of 33 kV OHL circuit.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it may be tested against the flexibility market as part of the DNOA process. This flexibility option however, although may be technically viable, is not likely to be as cost-effective when considering the initial set up costs.

3.6 Hookgate to Hinstock 33 kV overload

Constraint Overview

Generation Demand

Hinstock, High Offley, Gnosall are 33/11 kV primary substations (within Meaford C BSP) that form part of a 33 kV ring fed via Hookgate primary on the one side, and Wetwood Tee/Eccleshall on another.

The ring is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.6.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Hookgate to Hinstock 33 kV overload	N-1: Outage of the 33 kV circuit between Wetwood Tee and High Offley	2034	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.6.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the existing circuit	✓	✓	×	Viable
3	Adding a Hookgate-Hinstock 33 kV circuit	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The constraint is anticipated to trigger by 2034, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the existing circuit

Option 2 – Upgrading the existing circuit

Estimated capacity released: 15 MVA **Viable**

Detailed description: Uprating the existing circuit, mainly consisting of 11.7 km of 0.1 in Aluminium Conductor Steel Reinforced (ACSR) OHL conductor, to 34 MVA winter cyclic rating (matching the other side of the ring). The new conductor is anticipated to be 200 mm AAAC OHL, and for sections that may need to be undergrounded, 400 mm copper cable would be sufficient and would also help improve the volts within the ring.

New limiting factor: Rating of the Wetwood-High Offley 33 kV circuit

Option 3 – Adding a Hookgate-Hinstock 33 kV circuit

Estimated capacity released: 40 MVA Viable

Detailed description: Adding a circuit between Hookgate and Hinstock, the works include:

- Extending the 33 kV switchgear board at Hookgate (on the primary transformer's side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel
- Extending the 33 kV busbars at Hinstock to allow for a new incoming circuit
- Installing approximately 12 km of 33 kV circuit from Hookgate to Hinstock
- Reviewing the protection operation of the 33 kV network

New limiting factor: Rating of the Wetwood-High Offley 33 kV circuit

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited Discounted

Detailed description: The substations within this ring are quite rural with very limited transfer capacity at 11 kV, and therefore insufficient to mitigate the constraint.

New limiting factor: Rating of the existing circuit

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA Discounted

Detailed description: The ring is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 1.5 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Low volts and rating of existing circuit

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (uprating the existing circuit) as it is more likely to be cost-effective and deliverable, without complicating the network further.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the DNOA process.

3.7 Hookgate to Market Drayton_4L3 33 kV overload

Constraint Overview

Generation | Demand

Market Drayton is a 33/11 kV primary substation consisting of three transformers and is supplied via three circuits, two directly from Hookgate primary and the third via Bearstone normally run open at a disconnector at Market Drayton.

A fault outage on one of direct circuits from Hookgate puts all of the demand on the second direct feeder; and under an arranged outage, closing in the circuit from Bearstone would not be feasible as it would require the primary to run split to cater for the next credible fault, but splitting the primary is also unfeasible due to the distribution of the 11 kV demand and having 11 kV customers with parallel feeders from the primary.

The site is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.7.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Hookgate to Market Drayton_4L3 33 kV overload	N-1: Outage of the larger of the direct 33 kV circuits between Hookgate and Market Drayton	2030	2030	2029	2034

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.7.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating Hookgate-Market Drayton_4L3 33 kV circuit	✓	✓	×	Viable
3	Uprating Hookgate-Bearstone-Market Drayton circuit	✓	✓	✓	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2029, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the Hookgate to Market Drayton_4L3 33 kV circuit

Option 2 – Uprating Hookgate-Market Drayton_4L3 33 kV circuit

Estimated capacity released: 9 MVA

Viable

Detailed description: Uprating the existing circuit (mainly consisting of 7.5 km of 0.175 in ACSR OHL conductor) to 40 MVA winter cyclic rating. The new conductor is anticipated to be 200 mm AAAC OHL (designed to 75 degrees), and for sections that may need to be undergrounded, 400 mm copper cable may be sufficient.

New limiting factor: Rating of Hookgate-Market Drayton_5L5 33 kV circuit

Option 3 – Uprating Hookgate-Bearstone-Market Drayton circuit

Estimated capacity released: 28 MVA

Viable

Detailed description: Upgrading the Hookgate-Bearstone-Market Drayton circuit, the works include:

- Uprating the circuit between Hookgate and Bearstone to achieve a minimum rating of 37 MVA winter cyclic:
  - 5 km of OHL, upgrading the 0.1 in ACSR to 200 mm AAAC (designed to 75 degrees)
  - 500 metres of underground cable, upgrading it to 400 mm copper
- Uprating the Bearstone to Market Drayton 33 kV circuit (mainly consisting of 7.6 km of 0.1 in ACSR OHL conductor) to a minimum of 37 MVA winter cyclic rating. The new conductor is anticipated to be:
  - 200 mm AAAC OHL design to 75 degrees, and
  - 400 mm copper cable for the sections that may need to be undergrounded
- Installing a 3-panel 33 kV board at Bearstone, and moving the current open point to the feeder circuit breaker at Bearstone, instead of having it on a disconnector at Market Drayton

New limiting factor: Rating of the Hookgate to Market Drayton_4L3 33 kV circuit

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited

Discounted

Detailed description: The substation is rural with very limited transfer capacity at 11 kV, and therefore insufficient to mitigate the constraint.

New limiting factor: Rating of the Hookgate to Market Drayton_4L3 33 kV circuit

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 3 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the Hookgate to Market Drayton_4L3 33 kV circuit

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 3 above (uprating the circuit via Bearstone) as it creates much more capacity, and provides a wider benefit of improving network volts and making the network more secure under N-2 conditions which in turn can improve Customer Interruptions (Cis) and Customer Minutes Losses (CMLs).

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the DNOA process.

3.8 Boothen 132/11 kV GT1B and GT2B overload

Constraint Overview

Generation Demand

Boothen BSP consists of two 132/11 kV transformers (GT1B and GT2B) and a third 33/11 kV (T3) fed from a pair of 132/33 kV transformers that primarily supply generation customers. The 11 kV part of Boothen consists of five interconnected sections. The site is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.8.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Boothen GT1B and GT2B overload	N-1: Outage of either of GT1B or GT2B overload the other	Baseline	Baseline	Baseline	2029

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.8.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Adding a 4th transformer	✓	✓	×	Viable
Operational Mitigation					
3	Load transfers	✓	✓	×	Viable
Load Management Schemes					
4	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
5	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is imminent, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the transformers

Option 2 – Adding a 4th transformer

Estimated capacity released: 23 MVA

Viable

Detailed description: Adding a 33/11 kV transformer to support the existing, the works include:

- Extending the 33 kV busbars on the GT2A side
- Installing a second 12/24 MVA 33/11 kV transformer connected to a new 11 kV section interconnected with the existing
- Carrying out site checks allowing the existing transformers (GT1B and GT2B) to utilise their cyclic ratings

New limiting factor: Rating of the transformers

Option 3 – Operational mitigation: Load transfers

Estimated capacity released: 15-20 MVA

Viable

Detailed description: The site currently runs split at 11 kV with GT1B and GT2B backfeeding each other, and T3 picking up some demand under normal running only. The solution is to better utilise all transformers and is in two-fold:

- Splitting the demand (for an outage of any of the three transformers) between the remaining two in-service
- Carrying out site checks allowing the existing transformers (GT1B and GT2B) to utilise their cyclic ratings

New limiting factor: Rating of the transformers

Option 4 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 5 – Flexibility service procurement

Estimated Flexibility Required (MW): 15 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

It is recommended to pursue option 3 above (transferring load during the outage) as it is likely to be the most cost effective solution and could allow for better utilisation of the assets by potentially enabling the cyclic rating of the transformers.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it may be tested against the flexibility market as part of the DNOA process. The flexibility option however, although may be technically viable, is not likely to be as cost-effective when considering the initial set up costs.

3.9 Cheadle and Simplex 33 kV circuits

Constraint Overview

Generation Demand

Cheadle, Tean, and Simplex are 33/11 kV primary substations fed out of Forsbrook BSP via two 33 kV circuits (Forsbrook-Cheadle, and Forsbrook-Simplex) forming a ring with a normal open point at the 33 kV bus-section at Cheadle. Simplex has another feeder from Meaford BSP which picks up T2 under normal running. The group is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.9.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Forsbrook to Cheadle 33 kV overload	N-1: Arranged outage of the Forsbrook-Simplex circuit	2032	2030	2032	-
Forsbrook to Simplex 33 kV overload	N-1: Arranged outage of the Forsbrook-Cheadle circuit	-	2033	-	-

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.9.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating circuits either side of the ring	✓	✓	×	Viable
Operational Mitigation					
3	Load transfers	✓	✓	×	Viable
Load Management Schemes					
4	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
5	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2030, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the Forsbrook to Simplex 33 kV circuit

Option 2 – Uprating circuits either side of the ring

Estimated capacity released: Up to 20 MVA

Viable

Detailed description: Uprating the existing circuits either side of the rings, these include:

- Uprating the Forsbrook-Cheadle 33 kV circuit by replacing approximately 350 m of underground cable with 630 mm copper, matching the rest of the circuit
- Uprating the Forsbrook-Simplex 33 kV circuit by replacing approximately 1.5 km of existing oil filled cable with 630 mm copper cable in an attempt to match the rest of the circuit

New limiting factor: Rating of the Forsbrook to Simplex 33 kV circuit

Option 3 – Operational mitigation: Load transfers

Estimated capacity released: 10-15 MVA

Viable

Detailed description: The ring has a 33 kV interconnection to Meaford BSP via Simplex, so the proposal here would be to utilise this, under the constrained outages specified, to pick up all of Simplex on Meaford C BSP.

New limiting factor: Rating of the Forsbrook to Simplex 33 kV circuit

Option 4 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 5 – Flexibility service procurement

Estimated Flexibility Required (MW): 6 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the Forsbrook to Simplex 33 kV circuit

Solution Recommendation

It is recommended to pursue option 3 above (transferring load during the outage) as it is likely to be the most cost effective solution and allows for better utilisation of the network.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it may be tested against the flexibility market as part of the DNOA process. This flexibility option however, although may be technically viable, is not likely to be as cost-effective when considering the initial set up costs.

3.10 Simplex Transformer overload

Constraint Overview

Generation | **Demand**

Simplex is a 33/11 kV primary substation where T1 if fed out of Forsbrook BSP, and T2 out of Meaford C BSP, with the 11 kV normally run open. The transformers back feed each other under arranged and fault outages. The site is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.10.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Simplex transformer overload	N-1: Outage of either of the two 33/11 kV transformers	2026	2025	2026	2027

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.10.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating existing transformers	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2025, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the existing transformers

Option 2 – Uprating existing transformers

Estimated capacity released: 24 MVA

Viable

Detailed description: Uprating the existing assets, the works include:

- Uprating the existing 33/11 kV transformers (commissioned in 1967) from 7.5/15 MVA to 20/40 MVA units
- Replacing the existing 1200 amp 11 kV board with a 2000 amp board

New limiting factor: Rating of the new transformers

Option 3 – Adding a third transformer

Estimated capacity released: 14 MVA

Viable

Detailed description: Adding a third transformer at Simplex, the works include:

- Installing a new 33 kV switchgear board, interconnected with the exiting, to create three busbar sections
- Installing an additional 2-section 11 kV board suitably interconnected with the existing
- Installing a third 7.5/15 MVA transformer and transferring sufficient demand to it
- Assessing the fault levels at Simplex with consideration for a split running arrangement

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: The solution involves transferring 11 kV demand to other neighbouring substations but these interconnections are limited and insufficient to mitigate the constraints.

New limiting factor: Rating of the exiting transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 9 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (uprating the existing transformers) as it is a more deliverable scheme, avoids complicating the network, and is likely to be more economical especially when considering the age of the existing transformers.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the DNOA process.

3.11 Cauldon Transformer overload

Constraint Overview

Generation Demand

Cauldon is a 33/11 kV primary substation fed out of Forsbrook BSP. The site has two transformers that normally run split, but back feed each other under arranged and fault outages. The site is Class B, expected to become Class C by 2030, under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.11.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Cauldon transformer overload	N-1: Outage of either of the two 33/11 kV transformers	2034	2030	2031	2032

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

A list of each of the options considered for this constraint is given in the table below.

Table 3.11.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating existing transformers	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational Mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed CBA by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2030, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the existing transformers

Option 2 – Uprating existing transformers

Estimated capacity released: 9 MVA

Viable

Detailed description: Uprating the existing 33/11 kV transformers (one commissioned in 2018, and another in 2020) from 7.5/15 MVA to 12/24 MVA units.

The 11 kV board is already 1250 amp rated so no further works would be required.

New limiting factor: Rating of the new transformers

Option 3 – Adding a third transformer

Estimated capacity released: 14 MVA

Viable

Detailed description: Adding a third 33/11 kV transformer at Cauldon, the works include:

- Extending the 33 kV busbars to make provisions for an additional bay
- Installing two 33 kV bus-section circuit breakers to create a 3-section busbar configuration
- Installing an additional two section 11 kV board suitably interconnected with the existing
- Installing a third 7.5/15 MVA transformer and transferring sufficient demand to it
- Assessing the fault levels at Cauldon with consideration for split running arrangement

New limiting factor: Rating of the 33 kV incomers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: The solution involves transferring 11 kV demand to other neighbouring substations but these interconnections are limited and insufficient to mitigate the constraints.

New limiting factor: Rating of the exiting transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class B under Engineering Recommendation P2, anticipated to become Class C by 2030. This would therefore require restoration of the group demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 9 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the existing transformers

Solution Recommendation

With regards to reinforcement build options, and considering the existing transformers are relatively new, both option 2 (uprating the existing transformers) and option 3 (adding a third transformer) have merit and are closely matched.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the DNOA process.

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Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB
nationalgrid.co.uk

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