Alfreton BSP

Network Development Report – East Midlands

May 2024

Electricity Distribution

nationalgrid

Contents

Alfreton 33 kV

1. Network Overview

Alfreton Bulk Supply Point (BSP) is supplied from Chesterfield Grid Supply Point (GSP) in National Grid Electricity Distribution's (NGED's) East Midlands licence area. The BSP is fed directly from Chesterfield via a 132 kV dual circuit (the CH-route).

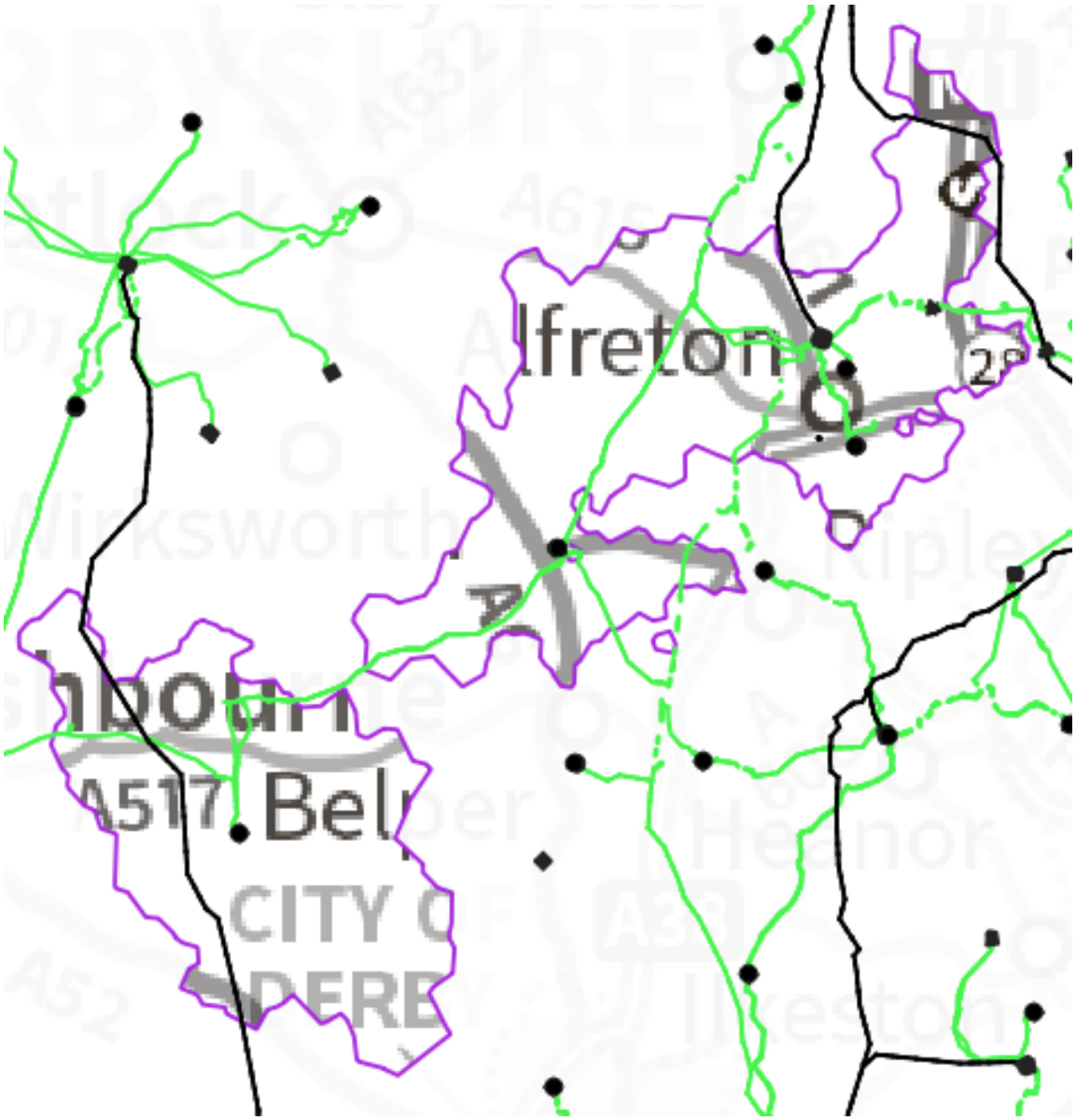

Figure 1.1 Alfreton geographic network coverage

This report discusses all existing and future network constraints over a 0-10 year horizon identified on the Grid Transformers (GTs) at, and the 33 kV network supplied from Alfreton BSP. This uses the methodology outlined in the Network Development Plan Methodology Report with Network Operability Modelling applied as outlined below.

For the purposes of this analysis the NGED Best View Distribution Future Energy Scenario (DFES) has been used to study the years 2022 (baseline), 2028 and 2034, with consideration given to how proposals could change under the other scenarios. Five representative days have been studied across the four seasons: Winter Peak Demand, Intermediate Warm Peak Demand, Intermediate Cool Peak Demand, Summer Peak Demand and Summer Peak Generation.

1.1 Network Topology

Alfreton BSP has two 33 kV busbars fed by two 132/33 kV GTs, both rated to 60/90/117 MVA. Alfreton BSP supplies six primary substations: Ambergate, Blackwell, Meadow Lane, Ravensdale Park, Somercotes, and Wessington. Ravensdale Park, Ambergate and Wessington are supplied via two shared 33 kV circuits, with all other primaries being fed directly from Alfreton BSP. All of the primaries fed from Alfreton BSP have two 33/11 kV transformers, with the exception of Wessington, which is a single transformer primary.

Alfreton BSP is interconnected with Chesterfield, Annesley, Spondon, Heanor, and Winster BSPs. All interconnectors are normally open. Interconnection with Chesterfield BSP is via a normal open points at Wessington primary, with Annesley BSP via Blackwell primary, with Winster BSP via Ravensdale Park, and with Spondon and Heanor BSPs via a 33 kV circuit from Alfreton BSP that is also normally open at Ambergate.

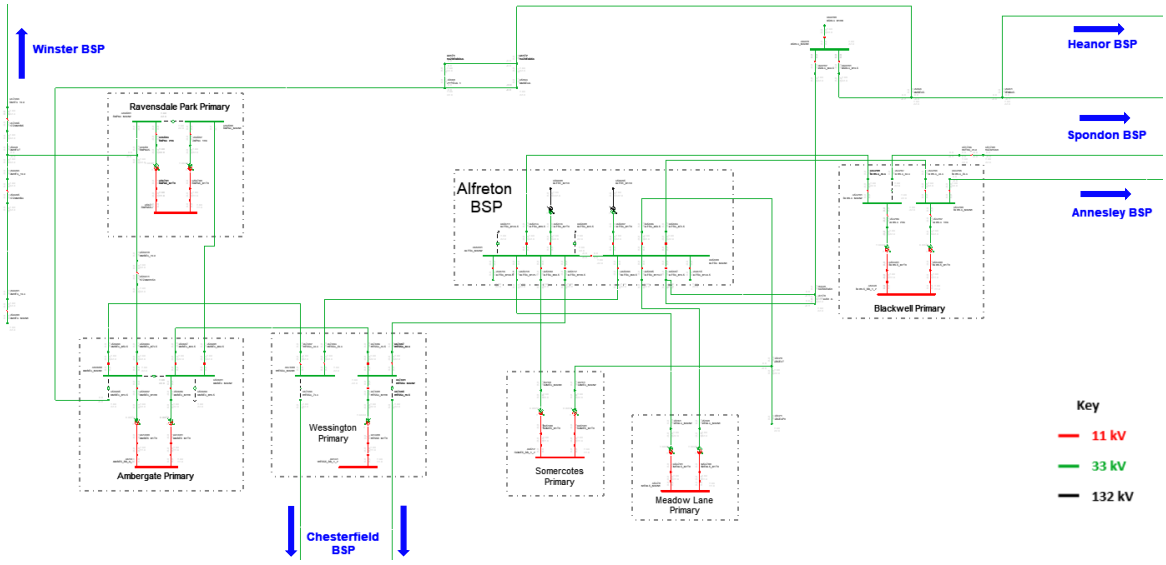

Figure 1.1.1 Alfreton 33 kV network single line diagram

1.2 Network Operability Modelling

The following network automation and manual switching schemes have been modelled in the analysis of this area, aligning to how the network is currently operated.

- The 33 kV network downstream of Alfreton BSP is split for an arranged outage on the 33 kV bus section circuit breaker, to prevent loose couples. This involves splitting Ambergate, Blackwell, Meadow Lane, Somercotes, and Ravensdale Park primaries at 11 kV.
- For the loss of an infeed to a transformer at Blackwell, Meadow Lane, or Somercotes under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.
- For an arranged outage on the Alfreton – Ambergate TA 33 kV circuit, the normal open point (third infeed) at Ambergate is closed to secure the supply on the network.
- For an arranged outage on Alfreton – Wessington TB – Ambergate TB circuit, or on Alfreton BSP's main 2 33 kV busbar, the two normally open circuit breakers at Ambergate (third infeed and bus section) are closed to maintain security of supply.
- For an arranged outage on Ambergate main 2, the normal open point (third infeed) at Ambergate is closed to secure the supply on the network.
- For an arranged outage on either transformer at Ambergate primary, or on the main 1 busbar section at Alfreton BSP, Ambergate is paralleled at 33 kV to prevent back-energisation and maintain security of supply.
- For an arranged outage on Alfreton – Wessington TB circuit, or on the transformer at Wessington, the demand at Wessington is transferred at 11 kV to Ripley, Danesmoor, Blackwell and Cromford primaries.
- For an arranged outage on Ambergate main 1 or main 2, the 11 kV circuit breaker of the respective transformer at Ravensdale Park will be opened to prevent back-energisation and islanding.
- For an arranged outage on either circuit between Ambergate and Ravensdale Park, the 33 kV bus section at Ambergate is closed to prevent back-energisation.

2. Network Constraints and Solution Options

2.1 Summary of Network Constraints

The following constraints were identified for the Best View Scenario, for which mitigation options will be discussed:

- Wessington primary is a single transformer substations limited by its 11 kV backfeed capacity, which will be exceeded by 2028.
- Sections of the Alfreton – Wessington – Ambergate 33 kV circuits are expected to overload by 2028. Low voltage and high voltage constraints are also observed at the remote ends of the circuits under various network conditions, due to anticipated demand and generation growth in the area.
- Transformer T1 at Ambergate overloads by 2028 under an N-1 fault condition.

2.2 Wessington primary 11 kV backfeed overloads

Constraint Overview

Generation **Demand**

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

Table 2.2.1 constraint(s) and conditions under which constraint(s) occur

Constraint	N-1 Condition	Subsequent N-2 Condition	First studied year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Insufficient 11 kV backfeed capacity at Wessington	Arranged or fault outage on the transformer at, or infeed to, Wessington primary	None	2028	-	-	-

Uncertainty under other Distribution Future Energy Scenarios: This constraint is also forecasted under the System Transformation scenario by 2028, and is exacerbated most significantly under the Leading the Way and Consumer Transformation scenarios, where the constraint could appear as early as 2025. Under Falling Short, the backfeed capacity is also expected to be exceeded by 2034.

Solution Options

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

Table 2.2.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
Reinforcement					
1	Install an additional 33/11 kV transformer and one 33 kV circuit	✓	✓	✓	**Viable**
2	Install an additional 33/11 kV transformer and two 33 kV circuits	✓	✓	✓	**Viable**
3	Upgrade the 11 kV backfeeds to Wessington	✓	×	✓	**Viable**
Flexibility services					
4	Procure flexibility under Wessington primary	✓	×	✓	**Viable**

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full Cost Benefit Analysis (CBA). This CBA will be subsequently carried out by the DNO to determine the optimal reinforcement solution, which will then be tested against market provided flexibility by the DSO as part of the Distribution Network Options Assessment (DNOA) process.

Option 1 – Install an additional 33/11 kV transformer and 33 kV circuit

Viable

Capacity released for constraint(s) considered: Dependent on sections uprated

New limiting factor for constraint(s) considered: Sections of the existing 33 kV circuits

Detailed description: Installing an additional transformer at Wessington primary would increase the firm capacity of the site significantly, provided the 33 kV circuits are also upgraded. The existing 33 kV circuit between Alfreton and Wessington requires upgrading regardless of the works at Wessington (See Section 2.3).

In order to maintain network compliance with Engineering Recommendation P18, a new 33 kV circuit from Alfreton to Wessington primary is required, alongside a new 33 kV circuit breaker at Alfreton. The new circuit could instead be installed between Alfreton BSP and the existing 33 kV overhead line between Wessington and Ambergate, which would provide the added benefit of shortening the overall circuit length between Alfreton and Ambergate, therefore supporting with the voltage constraints as described in Section 2.3.

This arrangement would provide additional capacity; however, the complexity of the existing 33 kV circuit remains in place, as it would still need to support three primary substations during an N-1 event. This is already challenging from a thermal, voltage, and protection perspective. Option 2 is an enhancement of this option, which rationalises this section of the network for improved security, resilience, and operation.

Option 2 – Install an additional 33/11 kV transformer and two 33 kV circuits

Viable

Capacity released for constraint(s) considered: The demand of Wessington primary, up to the 12/24 MVA transformer capacity

New limiting factor for constraint(s) considered: Existing 33 kV circuit ratings

Detailed description: If two new 33 kV circuits were installed from Alfreton BSP to the existing 33 kV overhead line between Wessington and Ambergate primaries, Wessington primary would be unstitched from the group and remain on its own, supplied through the existing circuits from Alfreton BSP. The existing 33 kV circuits from Alfreton to Wessington would not require reinforcement by 2034 based on the demand at Wessington alone.

The new 33 kV circuits would join onto the existing outgoing 33 kV circuit to supply Ambergate and Ravensdale Park primaries. The proposal would help the thermal and voltage constraints as described in Section 2.3, and release further capacity at these primary substations.

As described in Option 1, for additional support with wider area constraints, the new circuits could be installed between Alfreton and the existing 33 kV overhead line towards Ambergate, rather than to Wessington. A full detailed survey will highlight any challenges and possibilities across these two route options.

Option 3 – Upgrade the 11 kV backfeeds to Wessington

Viable

Capacity released for constraint(s) considered: Dependent 11 kV network

New limiting factor for constraint(s) considered: As before

Detailed description: Uprating 11 kV circuits between Wessington and the surrounding primaries could be used to increase the firm capacity of the site and manage this constraint. The viability and costs associated with this option will need to be assessed as part of a full 11 kV study. It is likely that if this option is viable, it will not provide sufficient capacity to be a long term solution.

Option 4 – Procure flexibility under Wessington primary

Viable

Flexibility service type: Generation turn up/demand turn down.

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the 11 kV backfeeds to Wessington primary. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The optimal long term reinforcement solution for the constraint at Wessington primary is to install a second transformer and two new 33 kV circuits from Alfreton BSP towards Ambergate primary. This separates Wessington primary and releases capacity both locally and at other primaries, as the backfeed arrangements can be removed. This solution resolves the demand constraint on the 33 kV circuits (see Section 2.3) and on the transformers at Ambergate primary (see Section 2.4). Furthermore, increasing capacity and creating a stand-alone 12/24 MVA primary at Wessington will open the possibility of further 11 kV permanent demand transfers into Wessington from adjacent primaries, should this be required.

2.3 Alfreton – Wessington – Ambergate – Ravensdale Park 33 kV circuit constraints

Generation Demand

Constraint Overview

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

Table 2.3.1 constraint(s) and conditions under which constraint(s) occur

Constraint	N-1 Condition	Subsequent N-2 Condition	First studied year constraint is observed in each season under Best View			
Demand			**Winter**	**Int Warm**	**Int Cool**	**Summer**
Alfreton – Wessington – Ambergate – Ravensdale Park low voltage	Fault on Alfreton main 2	None	Baseline	Baseline	Baseline	2028
Alfreton – Wessington – Ambergate – Ravensdale Park low voltage	Fault or arranged outage between Alfreton and Ravensdale Park	None	2028	2028	2028	2028
Alfreton – Wessington – Ambergate thermal overloads	Fault on Alfreton main 2	None	2028	2028	2028	-
Alfreton – Wessington TB thermal overloads	Arranged or fault outage on Alfreton – Wessington – Ambergate TA – Ravensdale Park TB	None	2028	2028	2028	-
Generation			**Summer**			
Alfreton – Wessington – Ambergate – Ravensdale Park – high voltage	Fault or arranged outage on Ambergate main 2 side	None	2034			

Uncertainty under other Distribution Future Energy Scenarios: The demand constraints are exacerbated under the two higher growth scenarios (Leading the Way and Consumer Transformation), where constraints are observed in earlier years. The constraints are also present under various N-2 outage conditions.

The anticipated growth in solar generation at Ravensdale Park in particular is causing high voltages on the circuit. These are present under all scenarios, and are exacerbated under Consumer Transformation and System Transformation.

Solution Options

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

Table 2.3.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
Reinforcement					
1	Reinforce the existing 33 kV circuits	✓	×	✓	**Viable**
2	Install two additional 33 kV circuits from Alfreton	✓	✓	✓	**Viable**
3	Transfer Wessington primary into Chesterfield BSP	✓	×	×	**Viable**
Operational Mitigation					
4	Alternative running arrangements	✓	✓	✓	**Viable**
Flexibility services					
5	Procure flexibility under Ambergate, Ravensdale Park and Wessington primaries	✓	×	✓	**Viable**

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA will be subsequently carried out by the DNO to determine the optimal reinforcement solution, which will then be tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Reinforce the existing 33 kV circuits

Viable

Capacity released for constraint(s) considered: Dependent on which sections are reinforced

New limiting factor for constraint(s) considered: As before

Detailed description: To mitigate both voltage constraints, the overhead lines between Ambergate and Ravensdale Park require restringing. Thermal constraints are present on sections of the circuits between Ambergate and Wessington, as well as Alfreton – Wessington. A full detailed analysis will be undertaken to determine if the reinforcement of the entire circuits is required. If not, it will highlight which are the optimal sections, giving consideration to the delivery challenges in this area.

Option 2 – Install two new 33 kV circuits from Alfreton

Viable

Capacity released for constraint(s) considered: The entire demand at Wessington and further capacity across Ambergate and Ravensdale Park dependent on sections reinforced

New limiting factor for constraint(s) considered: The remaining 33 kV circuits

Detailed description: As an enhancement to the circuit reinforcement described in Option 1, rather than reinforcing the circuits, two new circuits could be installed from Alfreton BSP towards Ambergate primary, which will allow Wessington to be supplied independently from Ambergate and Ravensdale Park. This aligns with the proposal for Wessington (Section 2.2) and Ambergate (Section 2.4) primaries. The new circuits could be installed to Wessington, or along the route of the existing Wessington to Ambergate circuits, whichever is more economical and practical from a delivery perspective. This option also improves network operability and protection through rationalisation.

Additional 33 kV overhead line re-stringing will likely still be required between Ravensdale Park and Ambergate to mitigate the high voltage generation constraint present in 2034. This can be confirmed following full route surveys, when a new study can be undertaken.

Option 3 – Transfer Wessington primary into Chesterfield BSP

Capacity released for constraint(s) considered: The demand of Wessington primary

Viable

New limiting factor for constraint(s) considered: Circuit complexity and voltage constraints

Detailed description: Transferring Wessington into Chesterfield BSP would reduce the loading on the Alfreton to Wessington 33 kV circuits and help mitigate this thermal constraint. This option has been discounted initially as it would increase complexity on the Chesterfield – Grassmoor – Danesmoor – Biwater 33 kV circuits by adding an address, creating a breach of Engineering Recommendation P18. There are also thermal and voltage constraints on these circuits already (as discussed in the Chesterfield / Goitside / Buxton 33 kV report) which would only be exacerbated by the addition of Wessington.

However, if the proposed works to unstitch the Chesterfield – Grassmoor – Danesmoor 33 kV network progress, this could make the transfer compliant. Further reinforcement works may still be required to accommodate the demand on a permanent basis, which may be more extensive than either of the options above. Given the length of circuits from Chesterfield BSP to Wessington primary, voltage constraints are also anticipated.

Option 4 – Alternative running arrangements

Viable

Capacity released for constraint(s) considered: Dependent on mitigation

New limiting factor for constraint(s) considered: As before

Detailed description: The low voltage N-1 constraint is due to potential backfeeding of Wessington primary. A full protection study on this network is recommended, with considerations for order of operation and potential running arrangement changes on the 33 kV network. It is acknowledged that this network is already complex from a protection perspective, which may limit running arrangement changes.

Option 5 – Procure flexibility under Ambergate, Ravensdale Park and Wessington primaries

Viable

Flexibility service type: Generation turn up/demand turn down

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the 33 kV circuits, and potentially the low voltage constraint. This could be carried out alongside the operational mitigation discussed in option 4 above. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Once suitable tools and products are available, flexibility for the generation triggered high voltage constraint (and/or the use of Active Network Management) will also be explored as a mitigation option.

Solution Recommendation

The long term solution for the demand constraints on the Alfreton – Wessington – Ambergate – Ravensdale Park 33 kV circuits, which also benefits the wider area, is to install two new 33 kV circuits from Alfreton towards Ambergate and unstitch Wessington primary. The solution solves this demand constraint, the Wessington demand constraint as described in Section 2.2, and the demand constraint at Ambergate primary as detailed in Section 2.4.

Additional circuit reinforcement works, primarily between Ravensdale Park and Ambergate, will likely still be required to mitigate the generation high voltage constraint by 2034.

2.4 Ambergate primary transformer overload

Constraint Overview

Generation | Demand

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

Table 2.4.1 constraint(s) and conditions under which constraint(s) occur

Constraint	N-1 Condition	Subsequent N-2 Condition	First studied year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Ambergate primary T1 overloads	Fault on Alfreton main 2	None	-	2028	2028	-

Uncertainty under other Distribution Future Energy Scenarios: The demand constraints are present under all scenarios. Under the two higher growth scenarios (Leading the Way and Consumer Transformation), the constraints occur sooner and across more seasons.

Solution Options

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

Table 2.4.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
Reinforcement					
1	Uprate T1 at Ambergate primary with a 20/40 MVA unit	✓	×	×	**Discounted**
2	Uprate both 33/11 kV transformers at Ambergate primary with 20/40 MVA units	✓	×	×	**Discounted**
2	Install a new 33 kV circuit from Alfreton BSP	✓	✓	✓	**Viable**
Operational Mitigation					
3	Alternative running arrangements	✓	×	✓	**Viable**
Flexibility services					
4	Procure flexibility under Ambergate and Wessington primaries	✓	×	✓	**Viable**

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA will be subsequently carried out by the DNO to determine the optimal reinforcement solution, which will then be tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Uprate T1 at Ambergate primary with a 20/40 MVA unit

Capacity released for constraint(s) considered: Dependent on power flow

New limiting factor for constraint(s) considered: Dependent on power flow

Discounted

Detailed description: Only T1 at Ambergate is expected to overload under this fault condition, due to the potential of backfeeding Wessington primary through Ambergate. This results in T1 seeing the full demand of both Ambergate and Wessington primaries, whist T2 will only see the demand at Wessington primary as it flows back up into the 33 kV network. A larger transformer on the T1 side may resolve the constraint; however, this will result in two significantly different transformers running in parallel, which isn't in line with our design and best practice policies, as it can lead to imbalances in power flows which in turn cause other issues on the network.

Option 2 – Uprate both 33/11 kV transformers at Ambergate primary with 20/40 MVA units

Capacity released for constraint(s) considered: Up to the new ratings

Discounted

New limiting factor for constraint(s) considered: New transformer ratings

Detailed description: As an enhancement to Option 1, replacing both transformers at Ambergate primary would resolve this constraint. Both units would need to be uprated to 20/40 MVA to allow for the entire demand to be supported during this event. Although this option would resolve the thermal constraint, this fault condition also leads to voltage constraints on network as described in Section 2.3, which will not be resolved with this reinforcement option. It is also not recommended that this design remains in place long term.

Option 3 – Install a new 33 kV circuit from Alfreton BSP

Capacity released for constraint(s) considered: The demand at Wessington primary, currently around 5.8 MVA and increasing to over 10 MVA by 2050

Viable

New limiting factor for constraint(s) considered: The existing transformers at Ambergate primary, rated at 15/21.5 MVA

Detailed description: Installing an additional circuit from Alfreton to Wessington, or along the route towards Ambergate primary, will separate Wessington primary from the group. The new circuit would supply Ambergate (T2) and Ravensdale Park (T1), whist the old circuit can remain in place to supply Wessington primary. This section of 33 kV circuit between Alfreton and Wessington T2 requires reinforcement due to thermal constraints anyway (see Section 2.3).

This solution removes the constraint by removing the backfeed through network reconfiguration. There is no immediate need to reinforce the transformers at Ambergate primary as a result of Ambergate primary growth alone.

Option 3 – Alternative running arrangements

Viable

Capacity released for constraint(s) considered: Dependent on mitigation

New limiting factor for constraint(s) considered: As before

Detailed description: The constraint is due to potential backfeeding of Wessington primary through the transformers at Ambergate. A full protection study on this network is recommended, with considerations for order of operation and potential running arrangement changes on the 33 kV network. It is acknowledged that this network is already complex from a protection perspective, which may limit running arrangement changes.

Option 4 – Procure flexibility under Ambergate and Wessington primaries

Viable

Flexibility service type: Generation turn up/demand turn down.

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the transformers at Ambergate primary. The viability of utilising flexibility will be further investigated as part of the DNOA process (this will need to be considered in conjunction with the constraints outlined in Section 2.2 and Section 2.3 which trigger the same reinforcement scheme).

Solution Recommendation

The optimal solution for mitigating the constraint is to install an additional 33 kV cable, which aligns with the proposal for Wessington (see Section 2.2) and the Alfreton – Wessington – Ambergate – Ravensdale Park circuit constraints (see Section 2.3). These works can be completed as a whole for demand constraints, or be undertaken in stages.

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