The Leicester Group

Network Development Report – East Midlands

May 2024

Electricity Distribution

nationalgrid

Contents

Leicester Group 33 kV

1. Network Overview

Leicester, Leicester East and Leicester North are three Bulk Supply Points (BSPs) in National Grid Electricity Distribution's (NGED's) East Midlands licence area. All three BSPs are fed from Enderby Grid Supply Point (GSP). Leicester BSP is fed directly from Enderby via two 132 kV dual circuits, with Leicester East and Leicester North each being fed by 132 kV dual circuits from Leicester BSP. These three BSPs collectively make up the Leicester group, feeding at total of 18 primary substations in and around Leicester under normal running arrangements.

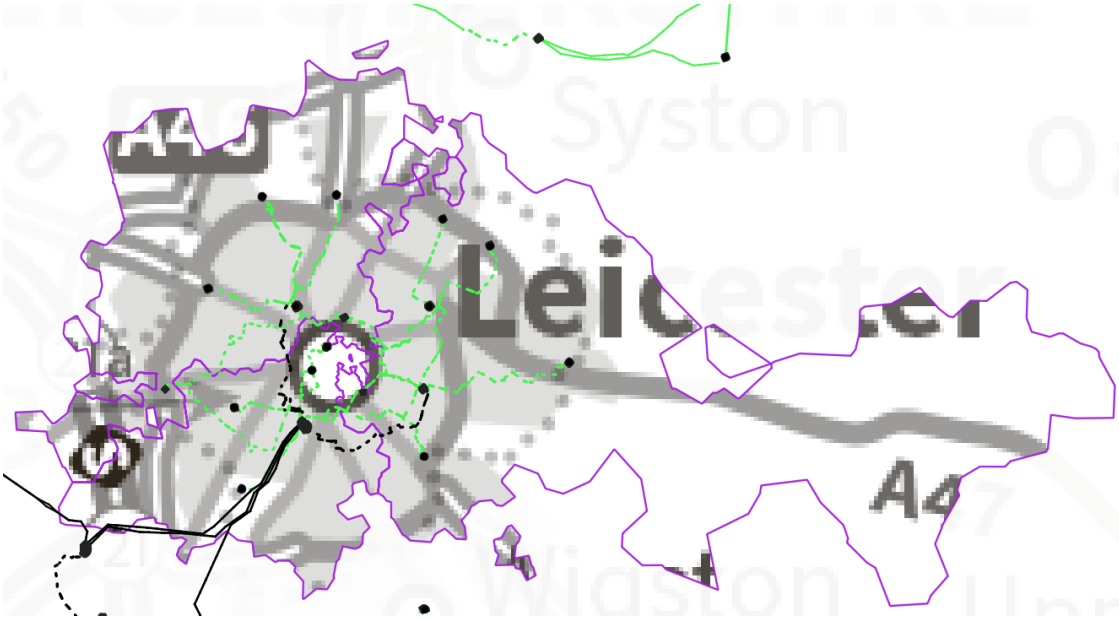

Figure 1.1 Leicester Group geographic network coverage

This report discusses all existing and future network constraints over a 0-10 year horizon identified on the 33 kV network fed from Leicester, Leicester East and Leicester North BSPs. 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

Leicester BSP has two 60/120/156 MVA GTs which feed two 33 kV busbars. The BSP feeds six primary substations under normal running arrangements: Braunstone, Jupiter, Leicester, Mansfield Street, Redcross Street and Hockley Farm Road T2. Leicester primary is located at the same site as Leicester BSP. All of the primaries are fed directly from the BSP and have two 33/11 kV transformers each. Leicester BSP is interconnected with both Leicester East and Leicester North BSPs. The interconnection with Leicester North is via an 11 kV loose couple at Hockley Farm Road (which is supplied from both BSPs and is normally run parallel at 11 kV). The interconnection with Leicester East BSP is via two pairs of 33 kV circuits, one to Highfields primary and one which tees off to Stoneygate primary (with normal open points at 33 kV at Highfields primary and Leicester BSP respectively).

Leicester East BSP has two 60/120/156 MVA GTs which feed two 33 kV busbars. The BSP feeds seven primary substations under normal running arrangements: Hamilton, Highfields, Leicester East, Salutation, Stoneygate, Thurmaston and Thurnby. Leicester East primary is located at the same site as Leicester East BSP. All of the primaries are fed directly from the BSP and have two transformers each (33/6.6 kV in the case of Leicester East, Salutation and Stoneygate and 33/11 kV in the case of the remaining primaries). Leicester East BSP is interconnected with Leicester North BSP via a pair of 33 kV circuits to Lero primary (where there are two normal open points) and with Leicester BSP as described above.

Leicester North BSP has two 45/90/117 MVA GTs which feed three 33 kV busbars. The BSP feeds six primary substations under normal running arrangements: Beaumont Leys, Birstall, Groby Road, Hockley Farm Road T1, Leicester North and Lero. Leicester North primary is located at the same site as Leicester North BSP. All of the primaries are fed directly from the BSP and have two transformers each (with the exception of Beaumont Leys which has three). Lero primary is a 33/6.6 kV site, with the other five primaries all being 33/11 kV sites. Leicester North BSP is interconnected with the other two BSPs in the Leicester group (Leicester and Leicester East) as described above.

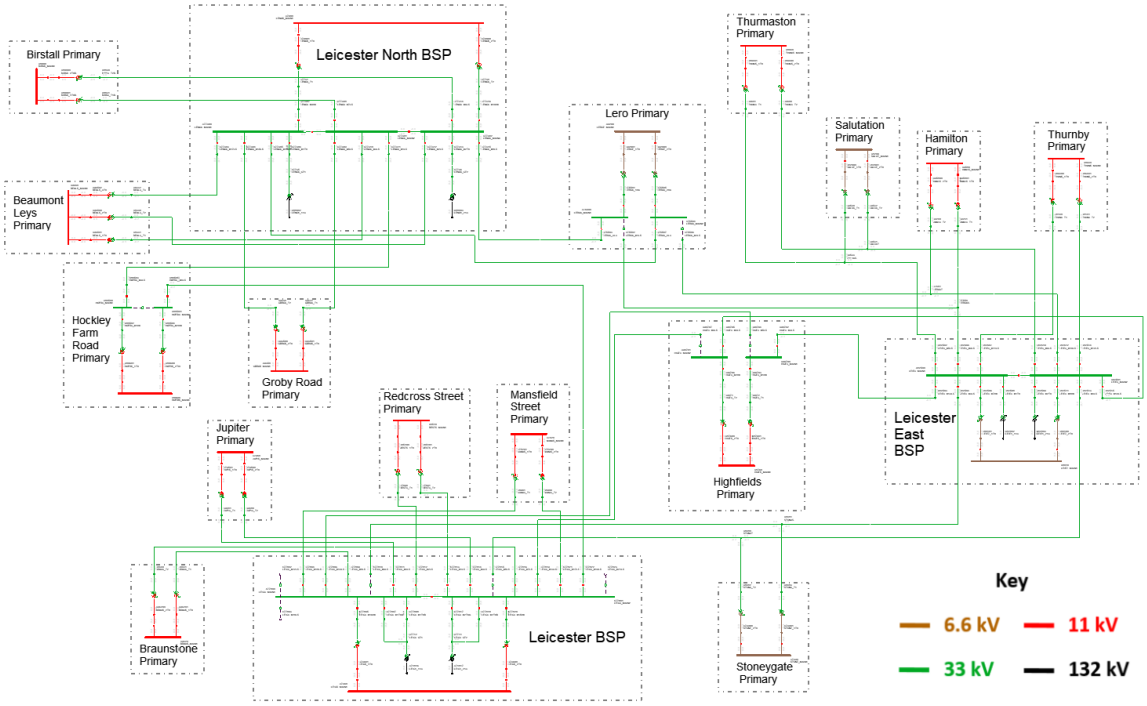

Figure 1.1.1 Leicester Group 33 kV network single line diagram

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, as well as proposed actions to manage some constraints operationally.

- The 33 kV networks downstream of Leicester, Leicester East and Leicester North BSPs are split for an arranged outage on the 33 kV bus section coupler (or in the case of Leicester North for arranged outages on either 33 kV bus section coupler or on the main 2 33 kV busbar):
    - For Leicester, this involves splitting Braunstone, Jupiter, Redcross Street, Mansfield Street and Leicester primaries at 11 kV, and transferring Hockley Farm Road fully into Leicester North.
    - For Leicester East, this involves splitting Stoneygate, Leicester East, Highfields, Thurmaston, Salutation, Hamilton and Thurnby primaries at 11 kV or 6.6 kV.
    - For Leicester North, this involves splitting Birstall, Beaumont Leys, Groby Road, Leicester North and Lero primaries at 11 kV or 6.6 kV and transferring Hockley Farm Road fully into Leicester.
- For an outage on the main 2 or main 3 132 kV busbars at Leicester BSP, either 132 kV circuit from Leicester to Leicester North or either GT at either Leicester or Leicester North the loose couple between the two BSPs is broken by splitting Hockley Farm Road at 11 kV.
- For an arranged outage on either infeed to Highfields primary, it is transferred into Leicester BSP.
- For an outage on the infeed from Leicester or Leicester North BSP, Hockley Farm Road primary is fed fully from the other BSP (i.e. for an outage on the circuit from Leicester BSP the site is fed fully from Leicester North BSP and vice versa).
- For the loss of an infeed to a transformer at any of the primaries within the Leicester group under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.
- In future year studies Beaumont Leys primary is split at 11 kV as required to prevent overloads on its transformers for subsequent faults.

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:

- In 2028 overloads are observed on T2 at Braunstone primary, and in 2034 overloads are also seen on the 33 kV infeeds (in both cases during arranged or fault outages on the other infeed or transformer).
- Overloads are observed on both the transformers at and the 33 kV circuits to (before the tee point) Salutation primary for arranged or fault outages on the other circuit/transformer.

2.2 Braunstone T2 and 33 kV circuit 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
Braunstone T2 overloads	Arranged or fault outage on T1 at Braunstone or the 33 kV infeed to T1	None	2028	2028	2028	2034
Leicester – Braunstone 33 kV circuit overloads	Arranged or fault outage on the other 33 kV circuit or transformer	None	2034	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: The highest demand growth at Braunstone is seen under the Leading the Way scenario, followed by Consumer Transformation. This higher growth exacerbates the constraints described above, but overloads are still not observed on the 33 kV circuits in 2028. The lowest demand growth is seen under System Transformation and Falling Short, but overloads are still observed on T2 at least 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)

Option	Description
Reinforcement	
1	Uprate T2 and the 33 kV circuits to Braunstone primary.
2	Install a third transformer and 33 kV circuit to Braunstone primary.
Flexibility Services	
3	Procure flexibility under Braunstone primary.

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 – Uprate T2 and the 33 kV circuits to Braunstone primary

Viable

Capacity released for constraint(s) considered: 3 MVA from upgrading T2 and a further 12 MVA from upgrading both 33 kV circuits

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

Detailed description: Initially, as constraints are first observed on T2 at Braunstone, the transformer could be uprated to 20/40 MVA (which would match the existing 20/40 MVA T1). Around 3 km of 33 kV circuit across the two infeeds would then need uprating to free up the full capacity of the transformers at Braunstone (but this may not need to be carried out at the same time as uprating T2).

When uprating the 33 kV circuits to Braunstone primary, higher rated cables could be installed (higher than required for the demand of Braunstone alone), to allow a future new primary to be fed from these circuits. A new primary may at some point be required in the area as high load growth is forecast at both Braunstone and Leicester primaries (beyond the ratings of 20/40 MVA transformers by 2050 in both cases). Doing so may require the 33 kV overhead line section between Leicester and Braunstone to be uprated as well. This would depend on whether the 33 kV circuits to the new primary were teed off before or after the overhead line section (which would be dependent on where a viable primary site could be located and on where the load develops within the area).

Option 2 – Install a third transformer and 33 kV circuit to Braunstone primary

Discounted

Capacity released for constraint(s) considered: Minimal

New limiting factor for constraint(s) considered: Transformer ratings for a busbar fault

Detailed description: Installing a third transformer at Braunstone primary would not free up significant capacity at the site. This is due to the fact that there are only two 33 kV busbars at Leicester BSP, so two of the primary transformers would need to be supplied from a single busbar and would consequently both be lost for a fault or arranged outage on that busbar. This option would also require a third 33 kV circuit to the primary, would underutilise T1 at Braunstone (which is already a 20/40 MVA unit) and would add network complexity by creating a three transformer primary.

Option 3 – Procure flexibility under Braunstone primary

Viable

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

Detailed description: Flexibility services could be procured to alleviate the projected overloads on T2 at Braunstone primary, and on the 33 kV circuits from Leicester BSP to Braunstone. T2 at Braunstone could also potentially be upgraded and then flexibility used to manage the 33 kV circuit constraints only. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

Uprating T2 at Braunstone primary would resolve the transformer constraint seen in 2028. To resolve the circuit constraint seen in 2034 most of both of the 33 kV circuits to Braunstone would also need to be uprated (freeing up the full capacity of the transformers). The potential need for a new primary in the area further into the future has also been discussed.

2.3 Salutation primary transformer and circuit overloads

Constraint Overview

Generation **Demand**

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			
			Winter	Int Cool	Int Warm	Summer
Salutation primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	2034	2028	2034	-
Leicester East to the Salutation tee 33 kV circuit overloads	Arranged or fault outage on either 33 kV circuit or 33 kV busbar at Leicester East	None	2034	2034	-	-

Uncertainty under other Distribution Future Energy Scenarios: Under the higher growth scenarios (Consumer Transformation and Leading the Way) transformer and circuit overloads are observed in other seasons in 2028 and 2034. Under these scenarios overloads are also seen on the 33 kV circuits from the tee off point to Salutation primary. Falling Short is the only scenario under which no overloads are observed by 2034.

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)

Option	Description
Reinforcement	
1	Uprate both transformers and circuits to Salutation primary.
2	Install a third transformer and circuit to Salutation primary.
Operational Mitigation	
3	Review seasonal ratings.
Flexibility Services	
4	Procure flexibility under Salutation primary.

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 both transformers and circuits to Salutation primary

Viable

Capacity released for constraint(s) considered: 15 MVA

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

Detailed description: Uprating both transformers at Salutation primary to 20/40 MVA would resolve the projected transformer constraint at the site. The primary is currently a 33/6.6 kV site, and would need converting to a 33/11 kV site in order to utilise the capacity of the 20/40 MVA transformers. This is because the highest rated switchgear used as standard on the network (2000 A) only provides 23 MVA of capacity when run at 6.6 kV. The 6.6 kV network supplied by Salutation primary would also all need converting to 11 kV.

There are four 33/6.6 kV primaries within the Leicester group: Salutation, Lero, Leicester East and Stoneygate. All four primaries are interconnected at 6.6 kV, with Salutation itself interconnected with Lero and Leicester East primaries. If the Salutation 6.6 kV network were converted to 11 kV, this would either further island the remaining primaries (most notably Lero which is only interconnected with Salutation) or require a large number of 11/6.6 kV transformers to be installed. It may therefore be prudent to proactively convert all of the 6.6 kV network within Leicester to 11 kV. The justification for this conversion is strengthened by the fact that all four of these primaries will need uprating to 20/40 MVA sites before 2040 based on current demand forecasts (possibly significantly earlier than this with the high demand growth forecast in the area). The implications of converting 6.6 kV network to 11 kV are discussed in more detail in the NDP Introduction and Methodology.

In order to free up the capacity created by installing 20/40 MVA transformers, the 33 kV circuits to Salutation will also need uprating (which will resolve the 33 kV circuit constraint outlined above). As Salutation primary is only around 50 m from the tee off the circuits to Thurmaston, laying two new 33 kV cables to the primary is likely the optimal solution. This would allow the two primaries to be unstitched, freeing up circuit capacity at Thurmaston as well. This simplifies the network and improves operability in comparison to uprating the existing circuits (which would require a similar amount of circuit works as most of both circuits would need uprating to free up significant capacity). If the new 33 kV circuits were rated high enough it could create the opportunity to add circuit capacity at Hamilton primary at some point in the future (as the circuits to Hamilton cross the existing circuits to Salutation primary). Demand forecasts do not indicate this extra capacity will be required, but the option value created by installing higher rated circuits may still be worth the marginal additional cost.

Option 2 – Install a third transformer and circuit to Salutation primary

Discounted

Capacity released for constraint(s) considered: Minimal

New limiting factor for constraint(s) considered: Transformer ratings for a busbar fault

Detailed description: Installing a third transformer and 33 kV circuit to Salutation primary would not free up significant capacity at the site. This is due to the fact that there are only two 33 kV busbars at Leicester East BSP, so two of the primary transformers would need to be supplied from a single busbar and would consequently both be lost for a fault on that busbar. Another significant disadvantage of this option is that it would not synergise with the strategic uprating of the 6.6 kV networks within Leicester to 11 kV which is discussed as an option above.

Option 3 – Review seasonal ratings

Viable

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

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

Detailed description: Overloads are only seen by 2028 for intermediate cool. It is therefore possible that this constraint could be delayed slightly by reviewing NGED's internal policy regarding transformer ratings, which does not currently distinguish between summer and intermediate cool ratings (which may be overly pessimistic). This solution is dependent on an internal review and would not be a long term solution (by 2034 transformer overloads are seen in other seasons, and circuit constraints are also projected to occur).

Option 4 – Procure flexibility under Salutation 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 transformers at Salutation primary. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

Uprating both primary transformers at Salutation, and both of the 33 kV infeeds is required to fully alleviate this constraint. Uprating the transformers may also trigger the uprating of the 6.6 kV network to 11 kV (as otherwise the capacity of the new 20/40 MVA transformers could not be utilised). Installing two new 33 kV circuits to the primary has been identified as the most strategic way to resolve the projected circuit constraint. This constraint may potentially be manageable in the short term by reviewing the seasonal transformer ratings, but this is not a long term solution and would not help alleviate the circuit constraint.

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