The Northampton Group

Network Development Report – East Midlands

May 2024

Electricity Distribution

nationalgrid

Contents

The Northampton Group

1. Network Overview

Northampton, Northampton East and Northampton West are three Bulk Supply Points (BSPs) fed from Grendon Grid Supply Point (GSP) in National Grid Electricity Distribution's (NGED's) East Midlands licence area. They collectively make up the Northampton group, feeding at total of 19 primary substations in and around Northampton under normal running arrangements.

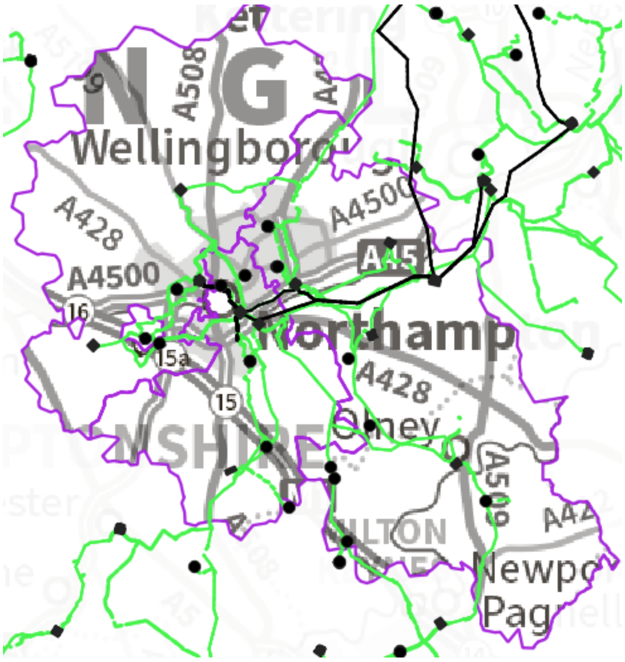

Figure 1.1 Northampton Group geographic network coverage

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

Northampton BSP has two Grid Transformers (GTs), both rated to 45/90/117 MVA. The BSP feeds eight primary substations under normal running arrangements: Northampton, Roade, Wootton, Campbell Street, Abington T1, Brackmills T1, Banbury Lane T2 and Pineham T1. Northampton primary is located at the same site as Northampton BSP. All of these primaries are fed directly from Northampton BSP. Northampton BSP is heavily interconnected with the other two Northampton group BSPs via normal open points at Abington, Pineham, Banbury Lane (Northampton West) and Brackmills (Northampton East). There is also a 33 kV circuit directly between Northampton and Northampton West, which is normally run open.

Northampton West BSP has two GTs, both rated to 45/90/117 MVA. The BSP feeds eight primary substations under normal running arrangements: Northampton West, Kingsthorpe, Ellesmere Avenue, Bugbrooke, Banbury Lane T1, Pineham T2, Abington T2 and Chapel Brampton T1. Northampton West primary is located at the same site as Northampton West BSP. Banbury Lane T1 is fed via Pineham primary and Chapel Brampton T1 is fed via Kingsthorpe primary.

Northampton East BSP has two GTs, both rated to 45/90/117 MVA. The BSP feeds seven primary substations under normal running arrangements: Northampton East, Boothville, Wellingborough Road, Denton, Olney, Earls Barton and Brackmills T2. Northampton East primary is located at the same site as Northampton East BSP. Hanslope Park primary is fed from Bradwell Abbey BSP, but can be transferred into Northampton East BSP. A 33 kV circuit from Northampton East also interconnects the BSP with Kettering and Northampton West (via Chapel Brampton primary).

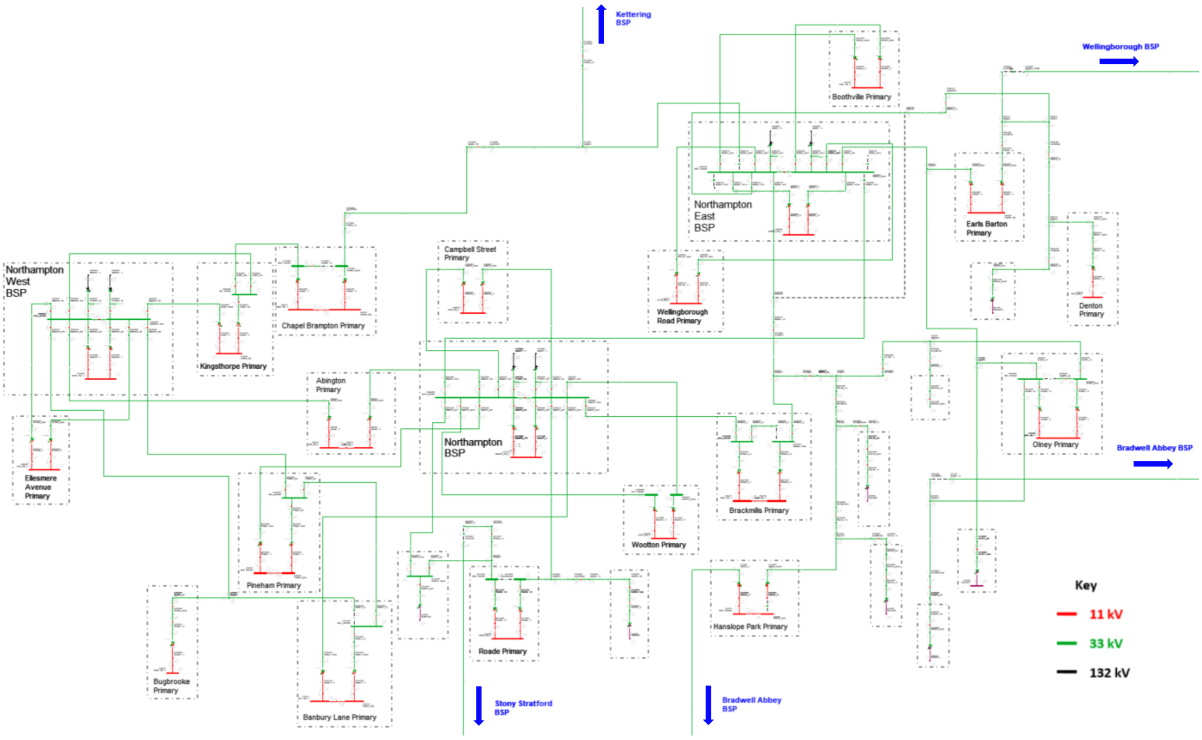

Figure 1.1.1 Northampton Group 33 kV network single line diagram

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 identified operationally or to account for proposed network changes.

- The 33 kV networks downstream of the three Northampton group BSPs are split for an arranged outage on the bus section breakers:
  - For Northampton this involves splitting Wootton, Roade, Campbell Street, and Northampton primary (which are all fed from both bars), Brackmills (which loose couples with Northampton East) and Banbury Lane, Pineham and Abington (which all loose couple with Northampton West) at 11 kV.
  - For Northampton West this involves splitting Kingsthorpe, Ellesmere Avenue and Abington (which are all fed from both bars), Banbury Lane, Pineham and Abington (which loose couple with Northampton) and Chapel Brampton (which loose couples with Kettering) at 11 kV.
  - For Northampton East this involves splitting Olney, Earls Barton, Wellingborough Road, Boothville and Northampton East primary (which are all fed from both bars) and Brackmills (which loose couples with Northampton) at 11 kV.
- Bugbrooke primary is backfed from Weedon primary for an arranged outage on its transformer or 33 kV feeder circuit. For an outage on the main 2 busbar at Northampton West BSP, the normal open point (NOP) between Banbury Road and Bugbrooke is closed to keep Bugbrooke supplied.
- For the loss of an infeed to a transformer at most of the primaries within the Northampton group under arranged outages, the lower voltage side circuit breaker is opened 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:

- Overloads are observed on the transformers at Olney primary for a fault or arranged outage on the other transformer or 33 kV infeed.
- For either an outage on the 33 kV infeed to Olney T1 or an arranged outage there followed by a fault on the 33 kV circuit to Earls Barton T2, overloads are seen on the 33 kV circuit from Northampton East BSP to the Earls Barton tee by 2028.
- By 2028, overloads are projected for both the transformers at, and 33 kV circuits to Ellesmere Avenue primary during arranged or fault outages on the other transformer/infeed.
- Overloads are observed on the transformers at Chapel Brampton primary for a fault or arranged outage on the other transformer or 33 kV infeed by 2028.
- Overloads are observed on the transformers at Kingsthorpe primary for a fault or arranged outage on the other transformer or 33 kV infeed by 2034.
- For an arranged or fault outage on the 33 kV circuit from Northampton West to the Kingsthorpe main 1 (33 kV) busbar, overloads are seen on the 33 kV circuit from Northampton East BSP to the Earls Barton tee by 2028.
- T2 at Northampton West primary is projected to overload by 2034 for an arranged or fault outage on T1 (or the main 1 33 kV busbar at Northampton West BSP).
- Overloads are observed on the transformers at Wootton primary for a fault or arranged outage on the other transformer or 33 kV infeed by 2034.
- An N-2 outage of an arranged outage on the main 1 (33 kV) busbar at Northampton followed by a fault on either GT at Northampton West is projected to cause overloads on the other Northampton West GT by 2028. Overloads are also observed from 2028 for an N-1 fault or arranged outage on either GT.
- An N-2 outage of an arranged outage on the main 2 (33 kV) busbar at Northampton followed by a fault on either GT at Northampton East is projected to cause overloads on the other Northampton East GT by 2028. By 2034, overloads are also observed for an N-1 fault or arranged outage on either GT.
- An N-2 outage of an arranged outage on the main 1 (33 kV) busbar at Northampton East followed by a fault on either GT at Northampton is projected to cause overloads on the other Northampton GT by 2028. By 2034, overloads are also observed for an N-1 fault or arranged outage on either GT.
- The group load of the three Northampton BSPs (Northampton, Northampton East and Northampton West) is projected to exceed 300 MW by 2034. This will significantly increase the N-2 restoration requirements for the group and necessitate intervention. A number of future demand constraints have also been identified on the 132 kV circuits to Northampton and Northampton East BSP.

2.2 Olney primary transformer 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
Olney primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	-	Baseline	Baseline	2034

Uncertainty under other Distribution Future Energy Scenarios: As this constraint is present in the baseline, it is an issue regardless of the scenario. Under Consumer Transformation and Leading the Way overloads are also seen in winter.

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 both transformers at Olney to 12/24 MVA units.
2	Uprate both transformers at Olney to 20/40 MVA units.
Operational Mitigation	
3	Review seasonal ratings.
Flexibility Services	
4	Procure flexibility under Olney 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 both transformers at Olney to 12/24 MVA units

Viable

Capacity released for constraint(s) considered: Up to 5 MVA

New limiting factor for constraint(s) considered: 33 kV circuit to Olney T1

Detailed description: Uprating both transformers at Olney primary to 12/24 MVA units would resolve this constraint. The full capacity of the transformers would not be freed up, as the 33 kV circuit to T1 would become the limiting factor, but circuit works could be carried out at a later date as required to further increase capacity. Forecasts indicate that the new transformer capacity is close to the demand forecast in 2050 for Olney primary. Another constraint limiting capacity at Olney is on the 33 kV circuit from Northampton East to the Earls Barton tee as described in Section 2.3 of this report (this constraint will not restrict capacity at Olney if one of the possible solutions discussed is progressed). This replacement would also benefit the condition of the transformers, which are both over 60 years old.

Option 2 – Uprate both transformers at Olney to 20/40 MVA units

Discounted

Capacity released for constraint(s) considered: Up to 5 MVA

New limiting factor for constraint(s) considered: 33 kV circuit to Olney T1

Detailed description: Uprating both transformers at Olney primary to 20/40 MVA units would resolve this constraint. As with option 1, this would both resolve the constraint and benefit the condition of the transformers. This option has been discounted on the basis that it would not free up any more capacity than installing 12/24 MVA units due to the 33 kV circuit restriction. Although 33 kV circuit works could be carried out in the future, extensive works would be required to free up the full capacity of 20/40 MVA units. Forecasts indicate most of this capacity would not be required. If demand grows faster than expected or an economic opportunity to transfer demand from another nearby primary is identified, then installing 20/40 MVA units may become the optimal reinforcement solution.

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 in the baseline and 2028 for intermediate cool and intermediate warm. 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 or intermediate warm ratings (which may be overly pessimistic). This solution is dependent on an internal review and would not be a long term solution (by 2034 overloads are also seen in summer).

Option 4 – Procure flexibility under Olney 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 Olney primary. This could be carried out alongside the operational mitigation discussed in option 3 above. This flexibility may potentially overlap with any flexibility procured to manage the constraint identified on the 33 kV circuit between Northampton East and the Earls Barton tee discussed in Section 2.3 of this report. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The optimal reinforcement solution identified is to uprate both transformers to 12/24 MVA units (with 20/40 MVA units to be considered if demand forecasts change significantly). In the short term, a review of seasonal transformer ratings could potentially defer this constraint.

2.3 Northampton East to Earls Barton Tee 33 kV circuit overloads

Constraint Overview

Generation | Demand

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

Table 2.3.1 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
33 kV circuit from Northampton East to the Earls Barton tee overload	Arranged or fault outage on the 33 kV infeed to T1 at Olney primary	None	2034	2028	2028	-
33 kV circuit from Northampton East to the Earls Barton tee overload	Arranged outage on the 33 kV infeed to T1 at Olney primary	Fault on the 33 kV circuit to Earls Barton T2	2028	2028	2028	-

Uncertainty under other Distribution Future Energy Scenarios: For the higher growth scenarios, Leading the Way and Consumer Transformation, overloads may also occur in other seasons for N-1 and N-2 outages by 2028 and 2034. There are no scenarios under which N-1 overloads are not 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 the 33 kV circuit from Northampton East to the Earls Barton tee.
2	Unstitch Earls Barton and Olney primaries.
Operational Mitigation	
3	Various operational mitigations.
Flexibility Services	
5	Procure flexibility under Earls Barton and Olney primaries.

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 the 33 kV circuit from Northampton East to the Earls Barton tee

Discounted

Capacity released for constraint(s) considered: Dependent on load growth at Earls Barton and Olney primaries

New limiting factor for constraint(s) considered: Transformer ratings at both primaries

Detailed description: Uprating the section of 33 kV circuit from Northampton East to the Earls Barton tee would resolve this constraint and free up capacity at Earls Barton and Olney primaries. The full circuit length is around the same rating, so would need fully uprating to add capacity (around 1.6 km of circuit works). This option has been discounted given the similar costs required for option 2 (which, as described below, has numerous additional benefits).

Option 2 – Unstitch Earls Barton and Olney primaries

Viable

Capacity released for constraint(s) considered: The demand of Olney or Earls Barton primary

New limiting factor for constraint(s) considered: Transformer ratings at both primaries

Detailed description: If a new 33 kV circuit were built from Northampton East to the Earls Barton tee, the existing circuit could be used to feed Earls Barton T1, and the new circuit could be used to feed Olney T2. As with option 1 this would resolve the constraint, but would also confer additional network benefits. Firstly, this solution would remove an address from the existing circuit (eliminating an existing network complexity issue and improving network operability). Secondly, it would allow Brackmills and Olney primaries to be transferred into Northampton BSP (as discussed as an option in Section 2.11 of this report) without breaching Engineering Recommendation P18 (Complexity of Distribution Circuits Operated at or above 22kV). These additional benefits, compared with option 1, make this the preferable reinforcement solution at a similar cost (although slightly higher given the need for a new 33 kV circuit breaker), requiring around 1.6 km of circuit works (subject to detailed route investigation and land rights).

Option 3 – Various operational mitigations

Discounted

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

New limiting factor for constraint(s) considered: N-1 constraints

Detailed description: There are a number of operational mitigation options for managing this constraint which could help alleviate the N-2 constraint:

- Restrict outage seasons: by 2028, the most onerous constraint is for an N-2 scenario, so restricting outage seasons could help mitigate this constraint. One disadvantage of this option is that it reduces network operability.
- Alternative running arrangements: During arranged outages on the 33 kV circuit to Olney T1, Earls Barton primary could be fed fully from the 33 kV circuit to T2. This could help alleviate the N-2 constraint, but would not provide any benefit for the N-1 constraint (and would also reduce security of supply).

Neither of these options would help alleviate the N-1 constraint also seen by 2028, so would not be sufficient to significantly defer reinforcement.

Option 4 – Procure flexibility under Earls Barton and Olney 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 circuit between Northampton West and Kingsthorpe main 2. This could be carried out in conjunction with a combination of operational mitigation options discussed above (e.g. flexibility could be used to manage the N-1 constraint, while the N-2 constraint could be managed operationally). This flexibility may potentially overlap with any flexibility procured to manage the constraints identified on the primary transformers at Olney (discussed in Section 2.2 of this report). The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

There are a number of operational mitigations discussed which could potentially be used to manage the N-2 constraint (restricting outage seasons and utilising alternative running arrangements), but these would not help alleviate the N-1 constraint also seen on this network. The optimal reinforcement strategy identified is to install a second 33 kV circuit, to allow Olney and Earls Barton primaries to be unstitched.

2.4 Ellesmere Avenue 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 2.4.1 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
Ellesmere Avenue primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	2028	2028	2028	2028
Ellesmere Avenue primary transformer overloads	None	None	-	2034	2034	-
Northampton West to Ellesmere Avenue 33 kV circuit overloads	Arranged or fault outage on the other transformer or infeed	None	2028	2028	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: Similar overloads are observed by 2028 in the higher growth scenarios (Consumer Transformation and Leading the Way). Even under the lower growth scenarios, System Transformation and Falling Short, overloads are observed by 2028.

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)

Option	Description
Reinforcement	
1	Uprate both transformers and circuits to Ellesmere Avenue primary.
2	Install a third transformer and circuit to Ellesmere Avenue primary.
Flexibility Services	
3	Procure flexibility under Ellesmere Avenue primary.

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA has been carried out for this constraint as part of the RIIO-ED2 Business Plan. The use of flexibility will also be periodically tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Uprate both transformers and circuits to Ellesmere Avenue primary

Viable

Capacity released for constraint(s) considered: Up to 15 MVA

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

Detailed description: Uprating both transformers at, and 33 kV circuits to Ellesmere Avenue primary would resolve this constraint in the short and medium term. The transformers would be uprated to 20/40 MVA units, the highest rating used by NGED as standard on the network. This replacement would also benefit the condition of the transformers, which are both almost 60 years old.

The 33 kV circuits from Northampton West BSP to Ellesmere Avenue primary are each around 1.8 km in length. Almost the entire length of both circuits will require uprating to match the ratings of the new 20/40 MVA transformers (for a total of around 3.5 km of circuit works). Installing highly rated circuits would be a prudent investment, as demand forecasts indicate further intervention will be required by 2034 (or not long after) as the new capacity of the substation is reached. This further intervention could involve building a new primary at or near Ellesmere Avenue which, if the opportunity is taken to oversize the cables installed, could be supplied from the same circuits as the existing primary. Retaining the existing 33 kV cables would be even more preferable, as the existing circuits could then be used to feed a potential new primary separately, but this carries the disadvantage of using up two additional 33 kV circuit breakers at Northampton West BSP.

Option 2 – Install a third transformer and circuit to Ellesmere Avenue 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 Ellesmere Avenue 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 Northampton West 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. This is unlikely to change in the future because as noted in Section 2.10 of this report there is insufficient space for a third GT or 33 kV busbar at Northampton West. This solution would also not benefit the condition of the existing transformers.

Option 3 – Procure flexibility under Ellesmere Avenue 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 Ellesmere Avenue primary. Flexibility will not however benefit the condition of the transformers at the primary. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The optimal reinforcement strategy identified is to uprate both the 33 kV infeed circuits and 33/11 kV transformers at Ellesmere Avenue primary. The 33 kV circuits to the primary could be oversized to provide options for future reinforcement, to cater for the high demand growth forecast. No operational mitigations have been identified, as this constraint occurs under N-1 outages in all seasons by 2028 (and even under intact network conditions by 2034).

2.5 Chapel Brampton primary transformer overloads

Constraint Overview

Generation | **Demand**

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

Table 2.5.1 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
Chapel Brampton primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	-	2028	2034	-

Uncertainty under other Distribution Future Energy Scenarios: Similar overloads are observed in 2028 and 2034 for the higher growth scenarios (Leading the Way and Consumer Transformation). Even under the Falling Short scenario, overloads are observed by 2034.

Solution Options

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

Table 2.5.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate both transformers at Chapel Brampton to 12/24 MVA units.
2	Uprate both transformers at Chapel Brampton to 20/40 MVA units.
Operational Mitigation	
3	Review seasonal ratings.
Flexibility Services	
4	Procure flexibility under Chapel Brampton 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 at Chapel Brampton to 12/24 MVA units

Discounted

Capacity released for constraint(s) considered: Up to 1 MVA

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

Detailed description: Uprating both transformers at Chapel Brampton primary to 12/24 MVA units would benefit the condition of the transformers, which are both over 60 years old. It would not, however, free up substantial capacity (with the winter cyclic ratings only increasing by around 1 MVA). This option has therefore been discounted, as it would not be an enduring solution.

Option 2 – Uprate both transformers at Chapel Brampton to 20/40 MVA units

Viable

Capacity released for constraint(s) considered: Dependent on demand growth at Kingsthorpe

New limiting factor for constraint(s) considered: Northampton West to Kingsthorpe (main 2) 33 kV circuit

Detailed description: Uprating both transformers at Chapel Brampton to 20/40 MVA units would resolve this constraint and, as with option 1, would benefit the condition of the transformers. The capacity of the substation would still be limited by the 33 kV circuits into Chapel Brampton (the most restrictive of which is the 33 kV circuit from Northampton West to Kingsthorpe primary main 2, as discussed in Section 2.7 of this report). These circuit works could be carried out at a later date to free up the full capacity of the new transformers (demand forecasts indicate this extra capacity will be required). Needing to increase circuit capacity into Chapel Brampton could provide an opportunity to transfer the primary fully into either Kettering or Northampton West BSP. This possibility (and the implications for each BSP) will need to be considered in more depth closer to the required intervention, as forecasts evolve.

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 in 2028 and 2034 for intermediate cool and intermediate warm. 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 or intermediate warm ratings (which may be overly pessimistic). This solution is dependent on an internal review and would not be a long term solution.

Option 4 – Procure flexibility under Chapel Brampton 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 Chapel Brampton primary. This could be carried out alongside the operational mitigation discussed in option 3 above. This flexibility may potentially overlap with any flexibility procured to manage the constraint identified on the 33 kV circuit between Northampton West and Kingsthorpe main 2 discussed in Section 2.7 of this report. Flexibility will not, however, benefit the condition of the transformers at the primary. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The uprating of both transformers at Chapel Brampton primary has been identified as the optimal reinforcement solution. 20/40 MVA units should be installed in preparation of future load growth, with 33 kV circuit works being required further into the future to free up the additional capacity created. In the short term, a review of transformer ratings may potentially delay the need for reinforcement (subject to an internal review and the transformer's condition not triggering intervention first).

2.6 Kingsthorpe primary transformer overloads

Constraint Overview

Generation | **Demand**

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

Table 2.6.1 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
Kingsthorpe primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	2034	2034	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: Similar overloads are observed by 2034 for the higher growth scenarios (Leading the Way and Consumer Transformation). Under System Transformation and Falling Short intervention is not triggered before 2034.

Solution Options

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

Table 2.6.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate both transformers at Kingsthorpe to 12/24 MVA units.
2	Uprate both transformers at Kingsthorpe to 20/40 MVA units.
Flexibility Services	
3	Procure flexibility under Kingsthorpe 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 at Kingsthorpe primary to 12/24 MVA units

Discounted

Capacity released for constraint(s) considered: 1 MVA

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

Detailed description: Uprating both transformers at Kingsthorpe primary to 12/24 MVA units would benefit the condition of the transformers, which are both almost 60 years old. It would not however free up much capacity (with the winter cyclic ratings only increasing by just over 1 MVA). This option has therefore been discounted as it would not be an enduring solution.

Option 2 – Uprate both transformers at Kingsthorpe primary to 20/40 MVA units

Viable

Capacity released for constraint(s) considered: Dependent on demand growth at Chapel Brampton

New limiting factor for constraint(s) considered: Northampton West to Kingsthorpe (main 2) 33 kV circuit

Detailed description: Uprating both transformers at Kingsthorpe to 20/40 MVA units would resolve this constraint and, as with option 1, would benefit the condition of the transformers. The 33 kV circuit to Kingsthorpe T1 is already highly rated, enough to not be a limiting factor even after the transformers are replaced. The 33 kV circuit to T2 on the other hand is expected to be constrained by 2034, which will need addressing (as discussed in Section 2.7 of this report).

Option 3 – Procure flexibility under Kingsthorpe 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 Kingsthorpe primary. This flexibility may potentially overlap with any flexibility procured to manage the constraint identified on the 33 kV circuit between Northampton West and Kingsthorpe main 2 discussed in Section 2.7 of this report. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The uprating of both transformers at Kingsthorpe primary has been identified as the optimal reinforcement solution. 20/40 MVA units should be installed in preparation of future load growth, with the uprating of the 33 kV circuit to T2 then being required to free up this extra capacity (as discussed in Section 2.7 of this report). No operational mitigations have been identified to manage this constraint as it is present in all seasons for N-1 outages in 2034.

2.7 Northampton West to Kingsthorpe main 2 33 kV circuit overloads

Constraint Overview

Generation | **Demand**

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

Table 2.7.1 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
33 kV circuit from Northampton West to Kingsthorpe main 2 overload	Arranged or fault outage on the Northampton West to Kingsthorpe main 1 circuit	None	2034	2034	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: Similar overloads are observed by 2034 for the higher growth scenarios (Leading the Way and Consumer Transformation). Under System Transformation and Falling Short, intervention is not triggered before 2034.

Solution Options

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

Table 2.7.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate the 33 kV circuit from Northampton West to Kingsthorpe main 2.
2	Install a second 33 kV circuit from Northampton West to Kingsthorpe.
Operational Mitigation	
3	Alternative running arrangements.
Flexibility Services	
4	Procure flexibility under Kingsthorpe and Chapel Brampton primaries.

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 the 33 kV circuit from Northampton West to Kingsthorpe main 2

Discounted

Capacity released for constraint(s) considered: Dependent on load growth at Kingsthorpe and Chapel Brampton primaries

New limiting factor for constraint(s) considered: Transformer ratings at both primaries

Detailed description: Uprating the section of 33 kV circuit from Northampton West to Kingsthorpe main 2 would resolve this constraint and free up capacity at Kingsthorpe and Chapel Brampton primaries. Most of the 3 km circuit would need uprating to free up significant capacity. This option has been discounted given the similar costs required for option 2 (which as described below has numerous additional benefits).

Option 2 – Install a second 33 kV circuit from Northampton West to Kingsthorpe

Viable

Capacity released for constraint(s) considered: The demand of Kingsthorpe or Chapel Brampton primary

New limiting factor for constraint(s) considered: Transformer ratings at both primaries

Detailed description: If a new 33 kV circuit were built from Northampton West to Kingsthorpe, the existing circuit could be used to feed Chapel Brampton T1, and the new circuit could be used to feed Kingsthorpe T2. This would resolve this constraint, freeing up circuit capacity at both primaries (in the case of Kingsthorpe, it would allow the full capacity of 20/40 MVA transformers to be utilised if they were installed as discussed as an option in Section 2.6 of this report). It would also improve network operability, and would require a similar amount of circuit works and expenditure to option 1 (except for the additional requirement for a 33 kV circuit breaker).

Option 3 – Alternative running arrangements

Discounted

Capacity released for constraint(s) considered: None

New limiting factor for constraint(s) considered: Security of supply

Detailed description: A number of alternative running arrangements have been considered which could alleviate this constraint. Chapel Brampton primary could be fed fully from Kettering BSP under normal running arrangements, or Kingsthorpe primary could be fed fully on the 33 kV circuit to T1. Both of these options would reduce loading on the constrained circuit, but both options have been discounted as they would compromise security of supply at the two primaries.

Option 4 – Procure flexibility under Kingsthorpe and Chapel Brampton 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 circuit between Northampton West and Kingsthorpe main 2. This flexibility may overlap with any flexibility procured to manage the constraints identified on the primary transformers at Chapel Brampton and Kingsthorpe (discussed in Section 2.5 and Section 2.6 of this report respectively). The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

Installing a new 33 kV circuit from Northampton West BSP to Kingsthorpe primary is likely the optimal reinforcement solution due to the additional benefits it confers over simply uprating the existing circuit. No operational mitigations have been identified to manage this constraint as it occurs for N-1 outages in every season in 2034.

2.8 Northampton West primary T2 overloads

Constraint Overview

Generation | Demand

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

Table 2.8.1 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
Northampton West primary T2 overloads	Arranged or fault outage on T1 or the main 1 33 kV busbar at Northampton West	None	-	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: Even under the higher growth scenarios (Leading the Way and Consumer Transformation), overloads are not observed in the other seasons. Under System Transformation and Falling Short intervention is not triggered before 2034.

Solution Options

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

Table 2.8.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate T2 at Northampton West primary to 20/40 MVA.
Operational Mitigation	
2	Review seasonal ratings.
Flexibility Services	
3	Procure flexibility under Northampton West 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 T2 at Northampton West primary to 20/40 MVA

Viable

Capacity released for constraint(s) considered: 12 MVA

New limiting factor for constraint(s) considered: Northampton West GT capacity

Detailed description: Uprating T2 at Northampton West to 20/40 MVA to match the existing T1 would increase the capacity of the primary and resolve this constraint. Minimal circuit works will be required to release this capacity, as the primary is located at the same site as Northampton West BSP. This replacement would also benefit the condition of the existing transformer which is over 60 years old.

Option 2 – 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 in 2034 for intermediate cool and intermediate warm. 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 or intermediate warm ratings (which may be overly pessimistic). This solution is dependent on an internal review and would not be a long term solution.

Option 3 – Procure flexibility under Northampton West 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 Northampton West primary. This could be carried out alongside the operational mitigation discussed in option 2 above. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

Uprating T2 at Northampton West primary to match T1 (a 20/40 MVA unit), alongside approximately 20 m of 33 kV cables (subject to route determination), will resolve this constraint, adding significant capacity to the primary. In the short term, a review of seasonal transformer ratings could potentially defer the need for investment (unless the condition of the transformer triggered intervention first).

2.9 Wootton primary transformer overloads

Constraint Overview

Generation | **Demand**

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

Table 2.9.1 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
Wootton primary transformer overloads	Arranged or fault outage on the other transformer or infeed	None	2034	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: Under the Leading the Way scenario, overloads are also seen in summer by 2034. There are no scenarios under which overloads are seen before 2028. Intervention is not triggered before 2034 for the System Transformation and Falling Short scenarios.

Solution Options

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

Table 2.9.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate both transformers at Wootton primary.
2	Install a third transformer at Wootton primary.
Flexibility Services	
3	Procure flexibility under Wootton 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 at Wootton primary

Viable

Capacity released for constraint(s) considered: Up to 10 MVA

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

Detailed description: Uprating both transformers at Wootton primary to 20/40 MVA units would resolve this constraint. It would immediately free up around 10 MVA of capacity, with the 33 kV circuits to the site becoming the next limiting factor. To free up the full capacity of the 20/40 MVA transformers, which will be required based on current demand forecasts, only around 25 m of cable will need to be uprated.

Option 2 – Install a third transformer at Wootton primary

Discounted

Capacity released for constraint(s) considered: 23 MVA

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

Detailed description: Installing a third primary transformer at Wootton would resolve this constraint, if carried out after a third 33 kV busbar is installed at Northampton BSP as discussed in Section 2.12 of this report, but has been discounted as an option for a number of reasons. Firstly, it would require significantly more 33 kV circuit works (over 4 km, subject to detailed route investigation and land rights, compared with only around 25 m in option 1). Secondly, creating a three transformer primary would create network operability challenges such as having to split the site during arranged outages on any of the transformers. Finally, even assuming a perfect 11 kV configuration which allows the full capacity of the transformers to be utilised, this small amount of additional capacity over option 1 will not be required according to the demand forecasts.

Option 3 – Procure flexibility under Wootton 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 Wootton primary. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

Uprating the transformers at Wootton to 20/40 MVA units would resolve this constraint, and the full capacity of these new units could be unlocked with minimal 33 kV circuit works required. These circuit works could either be carried out in tandem with the transformer upgrades to reduce overall outages required, or carried out at a later date when additional capacity is required.

2.10 Northampton West Grid Transformer overloads

Constraint Overview

Generation | **Demand**

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

Table 2.10.1 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
Northampton West GT overloads	Northampton 33 kV main 1 busbar arranged outage	Fault on either GT at Northampton West BSP	2028	2028	2028	2034
Northampton West GT overloads	Arranged or fault outage on the other GT or 132 kV infeed	None	2034	2028	2034	-

Uncertainty under other Distribution Future Energy Scenarios: Similar overloads are observed in the higher growth scenarios (Leading the Way and Consumer Transformation). N-1 overloads are observed in all scenarios by 2034.

Solution Options

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

Table 2.10.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Install a third GT at Northampton West BSP.
2	Establish a new BSP in Northampton.
3	Install a third GT at Northampton BSP.
Operational Mitigation	
4	Restrict outage seasons.
5	Review seasonal ratings.
Flexibility Services	
6	Procure flexibility under Northampton West BSP.

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA has been carried out for this constraint as part of the RIIO-ED2 Business Plan. The use of flexibility will also be periodically tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Install a third GT at Northampton West BSP

Discounted

Capacity released for constraint(s) considered: None

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

Detailed description: If a third GT could be installed at Northampton West, with an associated 33 kV busbar, this would free up significant capacity at the site. This is however not feasible due to space constraints at the substation, with no opportunities for expansion being identified.

Option 2 – Establish a new BSP in Northampton

Discounted

Capacity released for constraint(s) considered: Dependent on primaries transferred

New limiting factor for constraint(s) considered: N-2 group capacity or total GT capacity

Detailed description: If a fourth BSP were established in Northampton itself, or in close proximity to the city, then existing primaries could be transferred to this new BSP, and new primaries could be built fed from this new BSP. This would allow the three existing Northampton group BSPs (including Northampton West) to be deloaded, resolving this constraint. The extent to which each BSP could be deloaded (and the costs associated with transferring primaries over) would be largely dependent on the location of the new BSP.

This option has been discounted at this time, as it would be significantly more expensive than option 3 discussed below. It is nevertheless likely to be the only option to further increase capacity in the Northampton group in the longer term. Any reinforcement works carried out in the near future should therefore be cognizant of this possibility, so that the network can be prepared without unnecessary expenditure (e.g. having to replace recently installed assets). This is most notable in the solution chosen to add 132 kV circuit capacity into the group as discussed in Section 2.13 of this report.

Option 3 – Install a third GT at Northampton BSP

Viable

Capacity released for constraint(s) considered: Dependent on primaries transferred

New limiting factor for constraint(s) considered: Total GT capacity within the Northampton group

Detailed description: As reinforcement of Northampton West BSP is not possible (as outlined in option 1), one of the only options to resolve this constraint is to instead reinforce Northampton BSP and then transfer demand over from Northampton West. This solution will not only benefit Northampton West, it will also allow Northampton East to be deloaded in a similar way (as discussed in Section 2.11 of this report) and resolve the GT constraints projected at Northampton BSP itself (as discussed in Section 2.12 of this report).

There are a number of primaries which are viable candidates for transfer out of Northampton West BSP. The forecast winter peak demands at BSP peak for each of the primaries fed from Northampton West are given in the table below.

Primary	2034 winter peak demand (MW)
Ellesmere Avenue	40
Northampton West	23
Chapel Brampton	19 (currently split with Kettering)
Kingsthorpe	18
Abington	15 (currently split with Northampton)
Banbury Lane	11 (currently split with Northampton)
Bugbrooke	7
Pineham	5 (currently split with Northampton)

A list of some of the primaries which could potentially be transferred is given below. In particular, the primaries which currently straddle the two BSPs could be transferred, which would have the added benefit of increasing operability of the network.

- Abington: Being one of the aforementioned primaries which are currently fed from both BSPs, and being in reasonably close proximity to Northampton BSP (around 2 km apart, with the current circuits being around 3 km in length) makes Abington a good potential primary for transfer to Northampton. In addition to this, although no constraints have been identified in the next 10 years as part of these studies, demand forecasts indicate that not long past 2034, 20/40 MVA transformers will need to be installed on site. To free up this required capacity, most of both 33 kV circuits into the primary will need uprating. If two sufficiently rated 33 kV circuits were laid from Northampton BSP to transfer the primary, these works will not be required in the future.
- Banbury Lane and Pineham: Similarly to Abington, both of these primaries currently straddle the two BSPs, so transferring them fully into Northampton would reduce network complexity. Although neither primary is as close to Northampton BSP as Abington, they are very close to each other (being under 800 m apart, with an existing 33 kV circuit between the two). Two 33 kV cables could therefore be laid to Banbury Lane to allow both primaries to be picked up (feeding Pineham T2 via the existing 33 kV circuit to Banbury Lane). Additional cables could also be installed (or these two cables oversized) to pick up additional demand in the future, as discussed below.
- Bugbrooke: Bugbrooke is currently a single transformer primary, and there is already a 33 kV circuit from Bugbrooke to Banbury Lane primary. If, as posited above, the new 33 kV circuits to Banbury Lane were oversized, then Bugbrooke could also be transferred into Northampton. Demand growth at Bugbrooke will, at some point, trigger the installation of a second 33/11 kV transformer. This second transformer could also be supplied from Northampton via Banbury Lane, if a second 33 kV circuit were installed between the primaries. This would require some 33 kV circuit works, but significantly less than if new circuits needed to be built back to Northampton or Northampton West.
- Other primaries: If two new 33 kV circuits were laid to Abington, and an additional 33 kV circuit were laid to either Pineham or Banbury Lane, then the existing 33 kV circuits feeding these primaries would become interconnection between Northampton BSP and Northampton West BSP. It may be more economical to instead lay a new cable directly between the two BSPs to create this interconnection, as this distance is significantly less than to Banbury Lane/Pineham. This interconnection could be used to pick up another primary from Northampton West. Ellesmere Avenue, Kingsthorpe and Northampton West primaries may all be unsuitable for transfer as demand forecasts indicate they would not fit on these interconnecting circuits. If a new primary were built (for example near Ellesmere Avenue as discussed as an option in Section 2.4 of this report), then this could be transferred into Northampton. This would only be possible if the new primary were supplied on separate circuits to Ellesmere Avenue primary. In the interim, the two 33 kV interconnector circuits would support the N-2 restoration capacity of both BSPs.

Not all of these transfers will need to be carried out immediately. In the first instance, the straddling primaries could be transferred (possibly Abington being first as the transfer which will require the least 33 kV circuit works), with further transfers implemented as required to deload Northampton West.

Option 4 – Restrict outage seasons

Viable

Capacity released for constraint(s) considered: Half of the demand of Abington and Pineham primaries

New limiting factor for constraint(s) considered: GT capacity for N-1 outages

Detailed description: By 2028, the most onerous constraint is seen during arranged outages on the main 1 (33 kV) busbar at Northampton BSP, when Abington and Pineham primaries are fed fully from Northampton West. By restricting outages to summer, this N-2 constraint could be alleviated. However, as N-1 constraints are also observed, this option alone is not sufficient to fully manage this constraint by 2028. One disadvantage of this solution is that it reduces network operability.

Option 5 – Review seasonal ratings

Viable

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

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

Detailed description: N-1 overloads are only seen in 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. If utilised alongside the restriction of outages as discussed in option 4 the constraint could potentially be managed in 2028 but by 2034 operational mitigation alone will not be sufficient.

Option 6 – Procure flexibility under Northampton West BSP

Viable

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

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the GTs at Northampton West BSP. This could be carried out alongside the operational mitigations discussed in options 4 and 5 above. For the proposed reinforcement to be deferred, flexibility would also be required to manage the constraints seen at Northampton East and Northampton BSPs discussed in Section 2.11 and Section 2.12 respectively. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

With the reinforcement of Northampton West BSP itself not being possible, the optimal reinforcement solution identified is to install a third GT at Northampton BSP and then transfer primaries over from Northampton West. The advantages and disadvantages of transferring various primaries are discussed above, with Abington, Pineham and Banbury Lane being highlighted as the best candidates initially for transfer into Northampton. A number of operational mitigations may potentially allow these works to be deferred, but this deferral would only be possible if the constraints seen at Northampton East and Northampton (described in Section 2.11 and Section 2.12 of this report respectively) were similarly managed and would regardless not be a long term solution.

2.11 Northampton East Grid Transformer overloads

Constraint Overview

Generation | **Demand**

The table below outlines the nature of the network constraints identified in the network analysis. The 132 kV circuits to Northampton East from Grendon GSP and Northampton BSP are rated similarly to the GTs, and as such see similar overloads. These overloads are covered in Section 2.13 of this report, and would also be alleviated by transferring demand out of the BSP as discussed below.

Table 2.11.1 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
Northampton East GT overloads	Northampton 33 kV main 2 busbar arranged outage	Fault on either GT at Northampton East BSP	2034	2028	2034	2034
Northampton East GT overloads	Arranged or fault outage on the other GT or 132 kV infeed	None	2034	2034	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: Significant N-1 overloads are observed in multiple seasons under all scenarios by 2034. Even under the higher growth scenarios (Leading the Way and Consumer Transformation) no constraints are observed for N-1 constraints by 2028.

Solution Options

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

Table 2.11.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Install a third GT at Northampton East BSP.
2	Establish a new BSP in Northampton.
3	Install a third GT at Northampton BSP.
Operational Mitigation	
4	Restrict outage seasons.
5	Review seasonal ratings.
Flexibility Services	
6	Procure flexibility under Northampton East BSP.

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA has been carried out for this constraint as part of the RIIO-ED2 Business Plan. The use of flexibility will also be periodically tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Install a third GT at Northampton East BSP

Discounted

Capacity released for constraint(s) considered: None

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

Detailed description: If a third GT could be installed at Northampton West, with an associated 33 kV busbar, this would free up significant capacity at the site. As with Northampton East, this option has been discounted due to space limitations at the site.

Option 2 – Establish a new BSP in Northampton

Discounted

Capacity released for constraint(s) considered: Dependent on primaries transferred

New limiting factor for constraint(s) considered: Total GT capacity between the two BSPs

Detailed description: As noted in Section 2.10 of this report, establishing a new BSP in Northampton could allow all of the existing Northampton group BSPs to be deloaded (including Northampton East).

This option has been discounted as an initial solution due to the high expenditure which would be required, but has been left as a possibility to cater for future load growth.

Option 3 – Install a third GT at Northampton BSP

Viable

Capacity released for constraint(s) considered: Dependent on primaries transferred

New limiting factor for constraint(s) considered: Total GT capacity within the Northampton group

Detailed description: Similarly to Northampton West, reinforcement of Northampton East BSP is not possible as outlined in option 1. As such one of the only options to resolve this constraint is to instead reinforce Northampton BSP and then transfer demand over from Northampton. This solution benefits all three BSPs in the Northampton group (with capacity being added directly to Northampton BSP and transfers being possible from the other two BSPs).

There are a number of primaries which are viable candidates for transfer out of Northampton East BSP. The forecast winter peak demands at BSP peak for each of the primaries fed from Northampton East are given in the table below.

Primary	2034 winter peak demand (MW)
Boothville	31
Wellingborough Road	14
Olney	12
Northampton East	12
Brackmills	12 (currently split with Northampton)
Earls Barton	5
Denton	4

A list of some of the primaries which could potentially be transferred is given below:

- Brackmills: As the only primary which is currently fed from both Northampton and Northampton East BSPs, Brackmills is a prime candidate for transfer fully into Northampton. This transfer would improve network operability and remove the loose couple between the two BSPs. This transfer could be achieved by laying two new 33 kV cables to Brackmills from Northampton BSP. This would not require extensive circuit works in comparison to transferring any other primary, as Brackmills primary is only slightly over 1 km from Northampton BSP. There are two additional benefits created by building two new 33 kV circuits to Brackmills. Firstly, it would increase the 33 kV circuit capacity to the primary, allowing for potential future capacity increases if 20/40 MVA transformers are installed. Secondly, it would allow the existing circuit to be repurposed as interconnection between the two BSPs.
- Olney: There are a number of ways the 33 kV interconnection between Northampton and Northampton East that could be created using the existing circuit to Brackmills could be utilised. One is by running the two BSPs in parallel using this and the 33 kV circuit between the two BSPs, which could help support Northampton East for N-1 outages by reducing loading on the GTs. This option has been discounted as a busbar fault at Northampton East could then take out a GT and one of the interconnecting circuits, overloading the remaining 33 kV circuit. Another option is to use these two circuits to pick up an additional primary from Northampton East. Olney could be transferred in this way, as the circuit from Brackmills already continues on to Olney. This would have the added benefit of resolving an existing network complexity issue on this circuit. The other 33 kV circuit could then pick up Olney T2 (which would be supported by the unstitching of Olney and Earls Barton primaries as discussed in Section 2.3 of this report). The existing 33 kV circuit between Northampton and Northampton East is currently run on half of a 132 kV dual circuit between the BSPs, which may eventually be required to be run at 132 kV (as discussed in Section 2.13).
- Other primaries: Many of the primaries supplied from Northampton East are a significant distance from Northampton BSP, and as such it would be quite expensive to build 33 kV circuits directly to them to facilitate a transfer. Northampton East is however only around 3.3 km away from Northampton. It might therefore be economical to lay 33 kV cables directly between the BSPs which could then pick up the existing circuits to some of the primaries. While this is done an extra cable could be laid to replace the 33 kV circuit mentioned above when it is upgraded to 132 kV. If two highly rated 33 kV cables (such as 630mm^2 Cu) were installed then multiple primaries could be transferred together (such as Earls Barton and Wellingborough Road) without reducing circuit capacity into any of the primaries.

As with Northampton West, not all of these transfers will need to be carried out immediately (they can be phased to deload Northampton East as required). Brackmills could be transferred first, followed by Olney and finally additional primaries to be picked up by 33 kV circuits directly between the BSPs (the chosen primaries may change as demand grows and forecasts evolve to ensure the most demand can be transferred without creating future constraints on the new circuits).

Option 4 – Restrict outage seasons

Viable

Capacity released for constraint(s) considered: Half of the demand of Brackmills primary

New limiting factor for constraint(s) considered: GT capacity for N-1 outages

Detailed description: In 2028 the most onerous constraint is seen during arranged outages on the main 2 33 kV busbar at Northampton BSP where Brackmills primary is fed fully from Northampton East. By restricting outages to other seasons this N-2 constraint could be alleviated. By 2034 overloads are seen for all seasons and for N-1 constraints, so this would only be a short term solution. One disadvantage of this solution is that it reduces network operability.

Option 5 – 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 in 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 as by 2034 overloads are observed in all seasons.

Option 6 – Procure flexibility under Northampton East BSP

Viable

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

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the GTs at Northampton East BSP. This could be carried out alongside the operational mitigations discussed in options 4 and 5 above. For the proposed reinforcement to be deferred, flexibility would also be required to manage the constraints seen at Northampton West and Northampton BSPs discussed in Section 2.10 and Section 2.12 of this report respectively. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

With the reinforcement of Northampton East BSP itself not being possible, the optimal reinforcement solution identified is to install a third GT at Northampton BSP and then transfer primaries over from Northampton East. The advantages and disadvantages of transferring various primaries are discussed above, with Brackmills being identified as the optimal primary for initial transfer followed by Olney. A number of operational mitigations may potentially allow these works to be deferred, but this deferral would only be possible if the constraints seen at Northampton West and Northampton (described in Section 2.10 and Section 2.12 of this report respectively) were similarly managed and would regardless not be a long term solution.

2.12 Northampton Grid Transformer overloads

Constraint Overview

Generation | Demand

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

Table 2.12.1 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
Northampton GT overloads	Northampton East 33 kV main 1 busbar arranged outage	Fault on either GT at Northampton BSP	2034	2028	2034	-
Northampton GT overloads	Arranged or fault outage on the other GT or 132 kV infeed	None	-	2034	-	-

Uncertainty under other Distribution Future Energy Scenarios: Even under the higher growth scenarios overloads are not observed in any season except intermediate cool in 2028. Under System Transformation and Falling Short overloads are only observed for N-2 outages.

Solution Options

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

Table 2.12.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Install a third GT at Northampton BSP.
2	Establish a new BSP in Northampton.
Operational Mitigation	
3	Restrict outage seasons.
4	Review seasonal ratings.
Flexibility Services	
5	Procure flexibility under Northampton BSP.

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA has been carried out for this constraint as part of the RIIO-ED2 Business Plan. The use of flexibility will also be periodically tested against market provided flexibility by the DSO as part of the DNOA process.

Option 1 – Install a third GT at Northampton BSP

⬆ Viable

Capacity released for constraint(s) considered: Up to 114 MVA

New limiting factor for constraint(s) considered: 132 kV circuit capacity

Detailed description: Installing a third 132/33 kV GT at Northampton would resolve this constraint, adding significant GT capacity to the BSP. It would also allow additional demand to be transferred in from Northampton East and Northampton West BSPs, resolving the GT constraints at those substations as well (these constraints are outlined in Section 2.10 and Section 2.11 of this report).

The new GT at Northampton BSP would be run in parallel with the existing GTs on a new 33 kV busbar. This new busbar would be connected to two switchboards such that it supports either side for faults or arranged outages. This would allow each switchboard to be loaded up to the full capacity of a GT, approximately doubling the capacity of the BSP. The new limiting factor for the substation would become 132 kV circuit capacity. The options for increasing 132 kV circuit capacity into the Northampton Group are discussed in Section 2.13 of this report.

By adding new 33 kV busbars to Northampton BSP, additional circuits out of the substation could be installed (creating opportunities for the transfers from Northampton West and Northampton East BSPs to be carried out). This may be limited by the space available to take 33 kV circuits out of the BSP (with the site being in close proximity to the river Nene).

Option 2 – Establish a new BSP in Northampton

⬇ Discounted

Capacity released for constraint(s) considered: Dependent on primaries transferred

New limiting factor for constraint(s) considered: Total GT capacity between the two BSPs

Detailed description: The possibility of building a fourth BSP in Northampton has been considered in Section 2.10 and Section 2.11 of this report, and has been discounted due to the high costs associated with this option. A new BSP may, however, be the only option to add capacity to the group further into the future. One possible location for a new BSP is at or near the existing Northampton BSP. This would allow demand to be easily transferred from Northampton BSP with little 33 kV circuit works required. The 132 kV circuit works required to facilitate this, along with the advantages and disadvantages of this option in comparison with other potential BSP locations, are discussed in Section 2.13.

Option 3 – Restrict outage seasons

⬆ Viable

Capacity released for constraint(s) considered: Half of the demand of Brackmills primary

New limiting factor for constraint(s) considered: GT capacity for N-1 outages

Detailed description: The most onerous constraint is seen during arranged outages on the main 1 (33 kV) busbar at Northampton East BSP, when Brackmills primary is fed fully from Northampton East. By restricting outages to other seasons this N-2 constraint could be alleviated. As overloads are observed for N-1 outages by 2034, this solution alone will be insufficient to manage this constraint.

Option 4 – 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, and are only seen for N-1 constraints by 2034 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, but could be used in conjunction with the restriction of outages as discussed above to manage this constraint in the short term.

Option 5 – Procure flexibility under Northampton BSP

Viable

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

Detailed description: Flexibility services could be procured to alleviate the projected overloads on the GTs at Northampton BSP. This could be carried out alongside the operational mitigations discussed in options 3 and 4 above. For the proposed reinforcement to be deferred, flexibility would also be required to manage the constraints seen at Northampton East and Northampton West BSPs discussed in Section 2.10 and Section 2.11 of this report. The viability of utilising flexibility will be further investigated as part of the DNOA process.

Solution Recommendation

The optimal reinforcement solution identified is to install a third GT at Northampton BSP. This will also allow demand to be transferred from Northampton East and Northampton West BSPs, resolving the GT constraints projected there, as discussed in Section 2.10 and Section 2.11 of this report. A number of operational mitigations may potentially allow these works to be deferred, but this deferral would only be possible if the constraints seen at Northampton West and Northampton East were similarly managed and would regardless not be a long term solution.

2.13 Northampton Group N-2 and 132 kV circuit constraints

Constraint Overview

Generation | **Demand**

The table below shows the projected growth in group demand between now and 2034 under the Best View scenario.

Table 2.13.1 N-2 condition and group load forecasts

Constraint	N-1 Condition	Subsequent N-2 Condition	Group load			
			Baseline	2025	2028	2034
N-2 restoration requirements	Arranged outage on either 132 kV circuit from Grendon to Northampton BSP	Fault on the remaining 132 kV circuit to Northampton BSP	197	215	244	324

The table below outlines the nature of the network constraints identified on the 132 kV circuits into the Northampton group in the network analysis. These are being considered together with the N-2 security of supply constraint for the group as the potential mitigations and solutions overlap significantly.

Table 2.13.2 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
Grendon CB305 to Northampton BSP 132 kV circuit overload	Grendon main 1 132 kV busbar fault	None	2028	2028	2028	2034
Either Grendon to Northampton 132 kV circuit (the CK-route) overload	Fault on either Grendon to Northampton 132 kV circuit	None	2034	2034	2034	-
Either 132 kV circuit to Northampton East BSP overload	Arranged or fault outage on either infeed to Northampton East	None	2034	2034	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: The group load is set to grow faster for Leading the Way and Consumer Transformation, but is still not set to exceed 300 MW by 2028 in either scenario. Under the other two scenarios (System Transformation and Falling Short) the group load is not forecast to exceed 300 MW by 2034.

The 132 kV circuit constraints are also exacerbated for the higher growth scenarios, and even under the lower growth scenarios, overloads are seen by 2034 for various outage conditions (with the most onerous outage condition being a Grendon main 132 kV busbar fault).

Solution Options

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

Table 2.13.3 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate the existing 132 kV circuits into the Northampton Group.
2	Install a fourth 132 kV circuit into the Northampton Group.
3	Establish a new BSP in Northampton.
Operational Mitigation	
4	Utilise the 33 kV interconnection into the Northampton Group.
Flexibility Services	
5	Procure flexibility under the three Northampton BSPs.

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.

Option 1 – Uprate the existing 132 kV circuits into the Northampton Group

Viable

Capacity released for constraint(s) considered: Over 40 MVA

New limiting factor for constraint(s) considered: Security of supply for the Northampton group

Detailed description: The 132 kV circuits from Grendon GSP to Northampton BSP (the CK-route) are being uprated by reconductoring with 500 mm^2 AAAC. This will add significant capacity and help alleviate the constraints on these two circuits. This reinforcement alone is not sufficient to manage the network in the longer term, as there are still insufficient circuits into the group to meet the security of supply requirements of class of supply E under Engineering Recommendation P2. Once the group demand reaches 300 MW new circuits into the group will be required (as discussed in option 2 below). As the most onerous constraint will become the loss of the two CK-route circuits, extra capacity on these circuits will not help defer the security of supply constraint.

Even once a new 132 kV circuit is built into the group, uprating the CK-route circuits will not be wasted investment. This is because it will provide capacity on an enduring basis for Northampton and Northampton West BSPs (capacity that will be required based on the high load growth forecast for the area in the long term).

Uprating the 132 kV circuits to Northampton East would not provide any significant benefit, as they are already rated similarly to the GTs located at the BSP. As discussed in Section 2.11 of this report the GTs at Northampton East cannot be uprated (as they are already the highest rated units utilised by NGED as standard on the network) and there is no room to add a third GT). Without reconfiguring the network at all uprating the 132 kV circuits to Northampton East is not a strategic investment.

Option 2 – Install a fourth 132 kV circuit into the Northampton Group

Viable

Capacity released for constraint(s) considered: Significant capacity added for all constraints outlined above

New limiting factor for constraint(s) considered: GT capacity within the Northampton group

Detailed description: As the Northampton group is forecast to exceed 300 MW by 2034, a fourth 132 kV circuit into the group is required. Uprating the existing circuits and utilising transfers at 33 kV as discussed in option 1 and option 4 will be invaluable in managing the network up to this point, but as soon as the group enters class of supply E under Engineering Recommendation P2, it isn't possible to maintain security of supply without a new 132 kV circuit.

There are two ways of creating a new 132 kV infeed into the group which have been considered, both of which involve taking a new circuit to Northampton East BSP (which is the closest of the three BSPs within the group to Grendon GSP).

The first method of creating a new circuit would be to lay a 132 kV cable from Grendon GSP to Northampton BSP, which would require around 9.5 km of cable (subject to detailed route investigation and land rights). This option would support the network in the short and medium term, relieving the 132 kV circuits on the CK-route and adding significant N-2 restoration capacity to the group. However, this reinforcement is not an enduring solution, as it provides no way to supply a fourth BSP in the Northampton area (which will be required in the long term), and leaves the existing 132 kV circuit to Northampton East as a limiting factor.

The second method considered to create a new 132 kV infeed into the Northampton group is to rebuild the single circuit overhead line to Northampton East as a heavy duty dual circuit. This option may be more difficult to achieve than simply laying a 132 kV cable, but would be far more suitable to support the demand in the longer term, and would create significant option value. The new 132 kV dual circuit would supply Northampton East BSP (deloading the CK-route), and would have the capacity required to feed a new BSP via Northampton East (which a cable would not, as the existing single circuit is only just rated high enough to supply the existing BSP with no capacity to spare). If the new BSP were located at or near Northampton BSP (as discussed in option 3 below), it could be supplied via the existing dual circuit between Northampton East and Northampton.

The new 132 kV circuit into the Northampton group would be supplied from the other side of Grendon GSP (so for the new dual circuit it would be connected to the main 2 and reserve 2 132 kV busbars). This would alleviate the most onerous circuit constraints seen for a fault on the main 1 (132 kV) busbar (which currently leads to the loss of two of the three 132 kV circuits to the Northampton group). This would leave the Northampton group supplied via four 132 kV circuits from four different 132 kV busbars at Grendon GSP, which is a far more secure and operable topology than the existing arrangement.

Option 3 – Establish a new BSP in Northampton

Discounted

Capacity released for constraint(s) considered: Minimal

New limiting factor for constraint(s) considered: 132 kV circuit capacity and the N-2 restoration requirements of the group

Detailed description: Building a new BSP in Northampton is likely to be required to support the area in the long term, based on the high demand growth forecast for the area. This would allow the three existing BSPs to be deloaded as noted in Section 2.10, Section 2.11 and Section 2.12 (the extent to which each BSP could be deloaded would depend on the location of the new BSP). The ideal location for a new BSP, able to support the whole group, would be at or near the existing Northampton BSP (but other locations would be considered and evaluated as demand materialises). Without new 132 kV circuits to supply the new BSP, this option would not be suitable to manage this constraint. The possible methods of creating new 132 kV circuits into the group are discussed in option 2 above.

Option 4 – Utilise the 33 kV interconnection into the Northampton Group

Viable

Capacity released for constraint(s) considered: Demand of various primaries

New limiting factor for constraint(s) considered: 33 kV interconnection to various BSPs

Detailed description: The three BSPs within the Northampton group are heavily interconnected at 33 kV, with a number of primaries straddled between two BSPs. While significant demand would be difficult to transfer under normal running arrangements on the existing network, 33 kV circuit works are proposed in a number of areas to move demand from Northampton West and Northampton East BSPs. These are discussed in more detail in previous sections of this report. For Northampton East BSP in particular, transfers to Northampton BSP (as discussed in Section 2.11 of this report) would help alleviate the projected constraints on the Grendon to Northampton East and Northampton to Northampton East 132 kV circuits.

Transfers within the Northampton group, while beneficial, will not provide any benefit for the overall security of supply constraint for the group (or the 132 kV circuit constraints on the CK-route). Interconnection at 33 kV to BSPs outside of the Northampton group is also insufficient to manage these constraints:

- Interconnection with Bradwell Abbey BSP is via Hanslope Park primary, which is already supplied fully from Bradwell Abbey under normal running arrangements.
- Other 33 kV circuits into the group (from Bradwell Abbey, Wellingborough, Stony Stratford and Kettering) could not be used to transfer demand under normal running arrangements without compromising security of supply (and in some cases creating network complexity and thermal issues).

Transfers out of the group, although not viable under normal running arrangements, can be used to restore demand for N-2 outages and during various arranged outages. This makes the network manageable in the short and medium term, but as soon as the group load for Northampton reaches 300 MW these transfers become insufficient to meet the increased security of supply requirements.

Option 5 – Procure flexibility under the three Northampton BSPs

Discounted

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

Detailed description: Flexibility could potentially be used to manage the 132 kV circuit constraints within the Northampton group. For the security of supply constraint as soon as the group reaches 300 MW and moves into class of supply E under Engineering Recommendation P2 reinforcement will be required. Flexibility cannot be used to lower the security supply requirements of the group, and it would not be technically feasible to use flexibility to facilitate enough transfers to restore the entire group for an N-2 outage.

Solution Recommendation

The constraints on the 132 kV circuits into the Northampton group could be mitigated in a number of ways in the short term. The two 132 kV circuits on the CK-route to Northampton BSP are being uprated, which will free up capacity, and there are a number of 33 kV transfers available to support the network for various outage conditions. Once the Northampton group reaches 300 MW and enters class of supply E under Engineering Recommendation P2 however, the security of supply requirements for the group cannot be met using the existing three circuits (necessitating the creation of a fourth 132 kV infeed into the group).

The most strategic method of creating a fourth 132 kV circuit into the group would be to rebuild the single 132 kV circuit to Northampton East BSP as a dual circuit. This would not only free up circuit capacity for all three BSPs in the group and resolve the security of supply constraint, it would also futureproof the area in preparation for the high demand growth forecast up to 2050. This reinforcement synergises with the plans for the group at 33 kV discussed in previous sections of this report and the possibility of eventually creating a fourth BSP within Northampton.

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