Churchill BSP

Network Development Report – South West

May 2024

Electricity Distribution

nationalgrid

Contents

Churchill BSP

1. Network Overview

Churchill Bulk Supply Point (BSP) supplies a mixture of rural and urban sections of 33 kV network in North Somerset. It is supplied from the N-route 132 kV circuit which is fed from Sandford Grid Supply Point (GSP), with two 60/90 MVA 132/33 kV grid transformers supplying the group. Churchill BSP supplies approximately 36,000 customers.

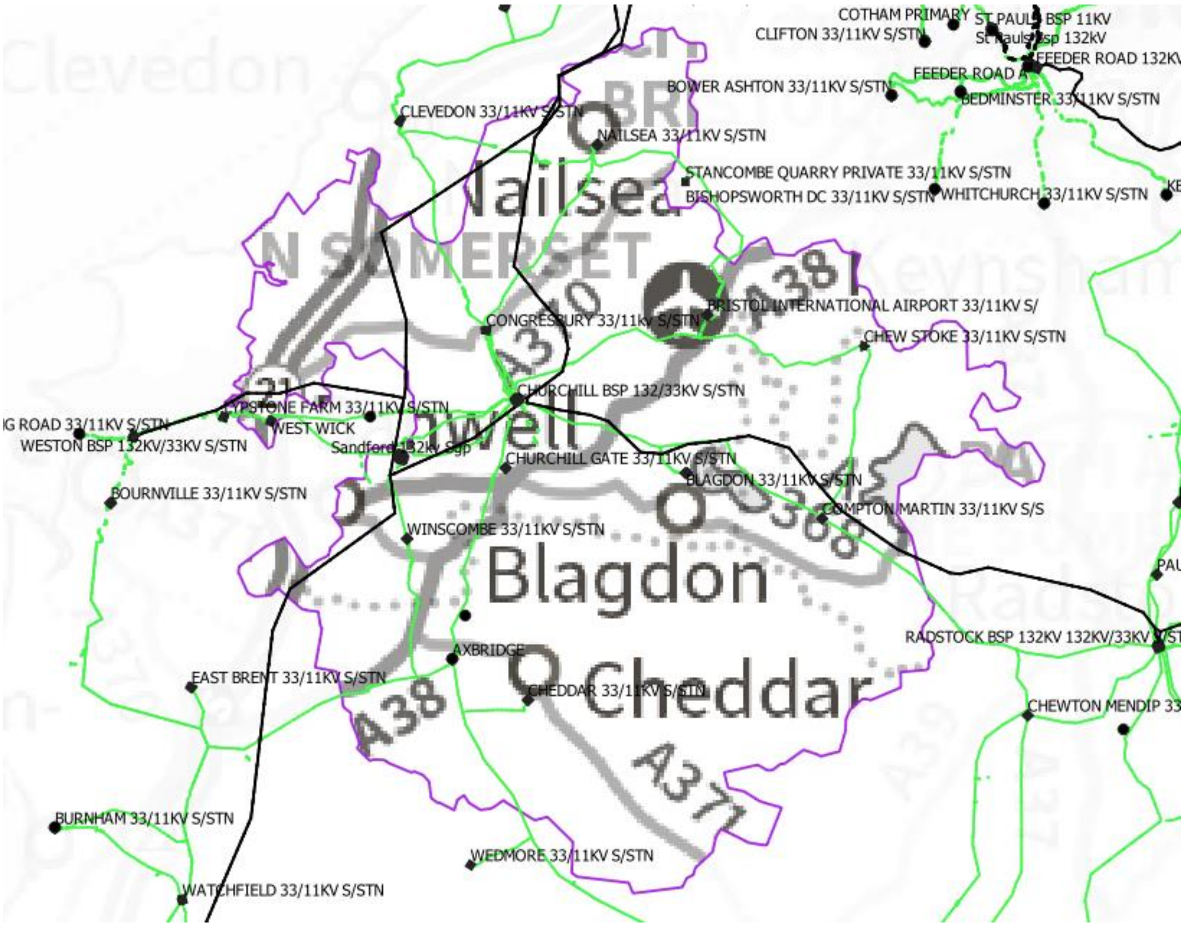

Figure 1.1 Churchill BSP geographic network coverage

This report discusses all existing and future network constraints over a 0-10 year horizon associated with the 33/11 kV transformers, 33 kV circuits, 132/33 kV transformers which supply and are supplied by Churchill BSP. This uses the methodology outlined in the Network Development Plan Methodology Report with Network Operability Modelling applied as outlined below.

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

1.1 Network Topology

The Churchill BSP network is arranged as follows:

- Two 132/33 kV grid transformers fed by two 132 kV circuits from Sandford GSP
- A 33 kV outdoor switchboard supplying the 33 kV circuits, which is being replaced with an indoor 33 kV 3 panel switchboard as an asset replacement programme.
- West Wick Primary substation is supplied via two transformer feeders with 33 kV connected generators teed-off both circuits, with normally open 33 kV interconnection with Weston BSP via isolators at West Wick
- A 33 kV ring supplying Winscombe, Axbridge, Cheddar and Churchill Gate Primaries, along with connections to one 33 kV connected generator and a demand connection. The ring has normally open 33 kV interconnection at Weston BSP via Brent Knoll switching station and Bridgwater BSP via Watchfield (with a tee-off to provide standby supply to Burnham).
- A 33 kV ring supplying Congresbury, Nailsea and Bristol Airport Primaries plus a 33 kV demand customer.
- A 33 kV circuit supplying Chewstoke, Blagdon and Compton Martin Primaries. A normal open point exists at Chewstoke providing an alternative feed from Churchill BSP to Bristol Airport circuit.

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.

- The 33 kV busbar running arrangement at Churchill is altered for a variety of circuit and busbar outages to maintain network integrity. This will be redundant following the replacement of the outdoor busbar with the new indoor busbar.

- For arranged outages of the 1S0 circuit breakers at Axbridge and Winscombe Primary substations, one of the primary transformers is run with the 11 kV circuit breaker open (i.e on 'hot standby'). This is to reduce the risk of through-flow for credible next faults on the network, where the 11 kV network at the primary becomes a link to the wider 33kV network and could overload transformers.

- For arranged outages on 9L5 circuit breaker at Churchill, 2L5 at Chewstoke is closed.

- For arranged outages on 1S4 at Blagdon Primary or 1L3 at Chewstoke, 2L5 at Chewstoke is closed.

2. Summary of Network Constraints

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

- Cheddar T1 overload
- Cheddar Single Transformer primary 11 kV backfeed overloads
- Blagdon and Compton Martin Single Transformer primary transformer overloads and 11 kV backfeed overloads and low voltage
- Churchill Congresbury/Nailsea/Airport circuit ring overloads and low volts
- Churchill Grid Transformer ancillary overloads

3. Network Constraint Details and Solution Options

3.1 Cheddar T1 overload

Constraint Overview

Generation | Demand

The table below outlines the nature of the network constraints identified in the network analysis, with the worst overloads seen at winter peak demand.

Table 3.1.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Cheddar T1 overload	None (intact)	None	2028	2029	2030	2032

Uncertainty under other Distribution Future Energy Scenarios: As this constraint occurs under baseline, there is no uncertainty about future forecasts. There is a risk that demand reduces, however this is not forecast under any scenario so mitigation against this constraint is definitely required.

Solution Options

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

Table 3.1.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Replace existing transformer	✓	✓	✓	Viable
2	Install additional transformer and 33kV circuit	×	×	×	Discounted
Operational Mitigation					
3	Transfer demand to other Primaries	✓	×	✓	Viable
Load Management Schemes					
4	Uprate the existing transformers via use of cyclic ratings	×	×	×	Discounted
Flexibility services					
5	Procure flexibility	✓	✓	✓	Viable

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA — Discounted

Detailed description: Doing nothing to mitigate the constraint would result in overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would not be a technically viable solution.

New limiting factor for constraint(s) considered: N/A

Option 1 – Replace existing transformer

Capacity Released for constraint(s) considered: 9 MVA Viable

Detailed description: This would involve replacing the existing transformer with a 7.5/15MVA unit. Given the age of the transformer (installed 1960) this would have a dual benefit in terms of releasing capacity and replacing aging assets.

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

Option 2 – Install additional transformer and 33kV circuit

Capacity Released for constraint(s) considered: 0 MVA Discounted

Detailed description: Installing an additional transformer would mitigate the intact overloads but this would then become a N-1 (first circuit outage) constraint which would still need to be mitigated. Therefore, this option is not technically viable.

New limiting factor for constraint(s) considered: Existing transformers.

Option 3 – Transfer demand to other Primaries

Capacity Released for constraint(s) considered: Viable

Up to 5MVA (dependant on 11kV circuit capacity)

Detailed description: Axbridge is nearby to Cheddar and is shown to have transformer capacity out to 2034. Therefore, this could be an option to reduce demand on Cheddar and prevent the overload if there are sufficient 11kV circuits. However, due to the age of the transformer it is recommended to replace it to facilitate demand growth and ensure reliability.

New limiting factor for constraint(s) considered: N/A

Option 4 – Uprate the existing transformers via use of cyclic ratings

Capacity Released for constraint(s) considered: 0MVA Discounted

As Cheddar is a single transformer primary the transformer does not run in parallel with a second transformer. Therefore, it is already subject to an increased aging rate as it experiences the full load during normal running (compared to 50% for parallel operation) and cannot be uprated.

New limiting factor for constraint(s) considered: N/A.

Option 5 – Procure flexibility

Estimated Flexibility Required (MVA): 0.5MVA+ Viable

Detailed description: Flexibility services could be procured to alleviate projected demand and generation overloads. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement, subject to a cost benefit analysis confirmation through the DNOA process. Following this, whilst demand transfers may possibly be achieved to Axbridge to deload Cheddar, it is recommended to replace the existing transformer with a 7.5/15MVA unit to allow for long term growth in the area and replace an aging asset.

3.2 Cheddar Single Transformer primary 11kV backfeed overloads

Constraint Overview

Generation | Demand

The table below outlines the nature of the network constraints identified in the network analysis, with the worst overloads seen at winter peak demand.

Table 3.2.1 constraint(s) and condition under which constraint occurs

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
11kV backfeed overloads	Cheddar T1 Fault	None	Baseline	Baseline	Baseline	Baseline

Uncertainty under other Distribution Future Energy Scenarios: Under Leading the Way Scenario, this constraint is predicted to arise in 2026 and under Falling Short it is predicted to arise in 2031.

Solution Options

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

Table 3.2.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install additional primary transformer and 33kV circuit	✓	×	×	Discounted
2	Reinforce circuits for 11kV backfeed	✓	✓	✓	Viable
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
3	Procure flexibility on overloaded feeders under backfeed conditions	✓	✓	✓	Viable

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA — Discounted

Detailed description: Doing nothing to mitigate the constraint would result in overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would not be a technically viable solution.

New limiting factor for constraint(s) considered: N/A

Option 1 – Install additional primary transformer and 33kV circuit

Capacity Released for constraint(s) considered: 5 MVA — Discounted

Detailed description: This option would involve connecting in a second 33kV circuit via a new circuit to Cheddar and installing a second primary transformer. The existing 33kV circuit is not set up for this meaning very significant reinforcement would be required at a significant. In addition, the existing transformer is only 5MVA meaning the site would still be limited by this under N-1 of the new transformer. Therefore this is not an economical option.

New limiting factor for constraint(s) considered: Existing 7.5/15MVA transformer

Option 2 – Reinforce circuits for 11kV backfeed

Capacity released for constraint(s) considered: — Viable

Up to 5MVA dependent on 11kV upgrades carried out.

Detailed description: This option would involve assessing upgrades for the existing 11kV backfeeds which supply Cheddar during a transformer fault/arranged outage. This would be in order to upgrade the existing circuits or install new 11kV circuits to release capacity. As this infrastructure already exists it is likely to prove a lot more simple and cost-effective than a second transformer and 33kV circuit.

New limiting factor for constraint(s) considered: Upgraded 11kV circuits

Option 3 – Procure flexibility on overloaded feeders under backfeed conditions

Estimated Flexibility Required (MVA): — Viable

0.5MVA+ (located on overloaded 11kV feeders)

Detailed description: Flexibility services could be procured to alleviate projected overloads. This could defer reinforcement, however there is a risk that it is not possible to secure sufficient flexibility on the affected feeders.

Solution Recommendation

It is recommended determine if flexibility can be procured on the overloaded feeders in order to defer reinforcement. Following this and to provide growth capacity in the area an assessment of existing 11kV circuits used to supply Cheddar during a transformer or fault/outage should be carried out to determine the most cost-effective 11kV upgrades to prevent overloads.

3.3 Blagdon and Compton Martin Single Transformer Primaries Transformer Overloads and 11kV backfeed overloads and low voltage

Constraint Overview

Generation Demand

The table below outlines the nature of the network constraints identified in the network analysis, with the worst overloads seen at winter peak demand.

Table 3.3.1 constraint(s) and condition under which constraint occurs

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
11kV backfeed overloads and low voltage on 11kV network	Blagdon Transformer fault/outage	None	Baseline	Baseline	Baseline	Baseline
Blagdon Transformer overload	Churchill Gate Single transformer primary fault/outage	None	Baseline	Baseline	Baseline	Baseline
11kV backfeed overloads and low voltage on 11kV network	Compton Martin Transformer fault/outage	None	Baseline	Baseline	Baseline	Baseline

Uncertainty under other Distribution Future Energy Scenarios: As this constraint occurs under baseline, there is no uncertainty about future forecasts. There is a risk that demand reduces, however this is not forecast under any scenario so mitigation against this constraint is definitely required.

Solution Options

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

Table 3.3.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	**Discounted**
Reinforcement					
1	Install new/replace primary transformer and new 33kV circuits	✓	✓	✓	**Viable**
2	Reinforce circuits for 11kV backfeed	✓	✓	✓	**Viable**
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
3	Procure flexibility on overloaded feeders under backfeed conditions	✓	✓	✓	**Viable**

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

Detailed description: Doing nothing to mitigate the constraint would result in overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would not be a technically viable solution.

New limiting factor for constraint(s) considered: N/A

Option 1 – Install new/replace primary transformers and new 33kV circuits

Capacity Released for constraint(s) considered: 5 MVA

Viable

Detailed description: This option would involve connecting in additional 33kV circuits, switchgear and transformers at one or both of Blagdon and Compton Martin. This will require an assessment of the geography of the area, existing site configurations and potential cable routes. In addition, the 11kV network will need to be assessed to determine if it possible to only upgrade one 33kV site in conjunction with 11kV upgrades to improve backfeed capacity. As Blagdon transformer is also forecast to overload this may be the better site to upgrade to tackle both transformer and 11kV backfeed overloads.

New limiting factor for constraint(s) considered: Existing transformers and 11kV network

Option 2 – Reinforce circuits for 11kV backfeed

Capacity released for constraint(s) considered:

Viable

Up to 5MVA dependent on 11kV upgrades carried out.

Detailed description: This option would involve assessing upgrades for the existing 11kV backfeeds which supply Blagdon, Compton Martin and Churchill gate during a transformer fault/arranged outage. This would be in order to upgrade the existing circuits or install new 11kV circuits to release capacity. This would not solve the constraints in isolation as Blagdon transformer is also forecast to overload as well as the 11kV backfeeds.

New limiting factor for constraint(s) considered: Upgraded 11kV circuits

Option 3 – Procure flexibility on overloaded feeders under backfeed conditions

Estimated Flexibility Required (MVA):

Viable

1MVA+ (located on overloaded 11kV feeders)

Detailed description: Flexibility services could be procured to alleviate projected overloads. This could defer reinforcement, however there is a risk that it is not possible to secure sufficient flexibility on the affected feeders.

Solution Recommendation

It is recommended firstly to determine if flexibility can be procured on the overloaded feeders in the area in order to defer reinforcement.

Following this, it is recommended to carry out a cost benefit analysis of the 11kV and 33kV options to solve these constraints. The most cost-effective option is likely to be a combination of 11kV reinforcement as well as 33kV reinforcement involving installing additions circuits, switchgear and transformers and improving 11kV backfeed capabilities. This will be subject to a study of the 11kV network and the ability of the primary substations to be expanded to become two transformer sites.

3.4 Churchill/Congresbury/Nailsea/Bristol Airport ring 33kV circuit overload (studied following new 33kV switchboard)

Constraint Overview

Generation **Demand**

The table below outlines the nature of the network constraints identified in the network analysis, with the worst overloads seen during N-2 (arranged outage period).

Table 3.4.1 constraint(s) and condition under which constraint occurs

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**
Churchill 2L5 to Congresbury 33kV circuit overload	2T0 section (affecting 10L5 and 1L5) 33kV busbar fault with new indoor board	None	2034	-	-	-
Churchill 2L5 to Congresbury 33kV circuit overload	2T0 section (affecting 10L5 and 1L5) 33kV busbar fault with new indoor board	Churchill 3L5 fault	Baseline	Baseline	Baseline	Baseline
Churchill 2L5 to Nailsea circuits 33kV circuit overloads AND Low voltage at single customer sites	2T0 section (affecting 10L5 and 1L5) 33kV busbar arranged outage with new indoor board	Churchill 3L5 fault	Baseline	2028	2028	Baseline
Churchill 10L5 to Congresbury	Churchill 2L5/associated busbar outage	Churchill 3L5 fault	2034	-	-	-
Various circuit overloads to be reviewed following board change	Various arranged outages	Various faults	TBC	TBC	TBC	TBC

Uncertainty under other Distribution Future Energy Scenarios: As this constraint occurs under baseline, there is no uncertainty about future forecasts. There is a risk that demand reduces, however this is not forecast under any scenario so mitigation against this constraint is definitely required.

Solution Options

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

Table 3.4.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing 33kV circuits	✓	✓	✓	Viable
2	Install additional 33kV circuit	✓	✓	✓	Viable
Operational Mitigation					
3	Transfer demand to other Primaries	×	×	×	Discounted
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility	×	×	×	Discounted

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 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA **Discounted**

Detailed description: Doing nothing to mitigate the constraint would result in overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would not be a technically viable solution.

New limiting factor for constraint(s) considered: N/A

Option 1 – Reinforce existing 33kV circuits

Capacity Released for constraint(s) considered: **Viable**

14.3 MVA (assuming 0.15 in^2 HDC 33kV overhead conductor is re-conductored with 150mm^2 Cu at 75°C temperature profile and there are no other limitations)

Detailed description: This option involves reinforcing the existing overhead line and cable sections which limit the rating of the existing circuits. The section from Churchill 2L5 to Congresbury will need to be significantly uprated. In addition the circuits all the way between Congresbury, Clevedon and Nailsea would need to be reinforced. Due to the significant length of this circuit it is anticipated that installing a new circuit to Bristol Airport, whilst only reinforcing the existing circuit between Churchill and Congresbury due to continued thermal issues following a new circuit, will be a more cost-effective as well as a technically better solution to resolve voltage constraints.

New limiting factor for constraint(s) considered: Existing 33kV cable sections

Option 2 – Install additional 33kV circuits

Capacity released for constraint(s) considered: 17.6 MVA **Viable**

Detailed description: Installing an additional 33kV circuit into the ring will remove overloads and voltage drop issues. It will also improve configurability of the circuits for outage conditions. One option considered is to install an additional 33kV circuit between Churchill BSP and Bristol airport and open a circuit breaker at Nailsea in order to break the ring into smaller sections. This is shown to have significant benefit but does not fully resolve the Churchill to Congresbury 33kV circuit overload meaning reinforcement of this will also be required. This will be subject to a design review following modelling of the new 33kV switchboard to determine if it fully resolves all constraints.

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

Option 3 – Transfer demand to other Primaries

Capacity Released for constraint(s) considered: 0MVA **Discounted**

Detailed description: There are no primary substations nearby outside of the ring with transfer capacity. Therefore this option has been discounted.

New limiting factor for constraint(s) considered: N/A

Option 4 – Procure flexibility

Estimated Flexibility Required (MVA): 3MVA+ **Discounted**

Detailed description: Flexibility services could be procured at substations all around the ring to resolve overloads. However, after market testing, flexibility this has been discounted as it does not resolve the constraints.

Solution Recommendation

It is recommended to carry out a combination of reinforcing existing circuits and installing an additional 33kV circuit to split up the ring (options 1 and 2). The initial proposal, which is subject to a detailed design study following modelling the new indoor Churchill 33kV switchboard, is to reinforce the 33kV circuit between Churchill and Congresbury as well as install an additional 33kV circuit to Bristol airport and split the existing ring at Nailsea. This will improve performance of the ring and remove voltage and thermal constraints observed. Following modelling of this it is possible that additional reinforcement will be needed to fully mitigate all N-2 combinations of outages.

3.5 Churchill Grid Transformer ancillary overloads

Constraint Overview

Generation Demand

The table below outlines the nature of the network constraints identified in the network analysis, with the worst overloads seen at winter peak demand.

Table 3.5.1 constraint(s) and condition under which constraint occurs

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
Churchill GTs ancillaries (CTs)	Fault/outage of either Churchill GT	None	2028	2028	2034	>2034

Solution Recommendation

Churchill Grid Transformers are shown to be limited to 75.4MVA by current transformers associated with the circuit breakers, whilst the nameplate rating of the transformer itself is 90MVA. It is required to investigate any ancillary limitations and do any necessary works to remove them to enable the full 90MVA rating to be used. This would allow the transformers to stay within their rating until 2035 under the demand predicted in DFES Best View.

It is anticipated that the ancillary constraints should be removed through the asset replacement work underway to replace Churchill 33kV switchboard.

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