Avonmouth BSP

Network Development Report – South West

May 2024

Electricity Distribution

nationalgrid

Contents

Avonmouth BSP

1. Network Overview

Avonmouth Bulk Supply Point (BSP) supplies a mostly urban area of 33 kV network. It is supplied from two 132/33 kV GTs at Avonmouth BSP, fed via 132kV circuits from Seabank GSP. Avonmouth BSP supplies approximately 48,800 customers.

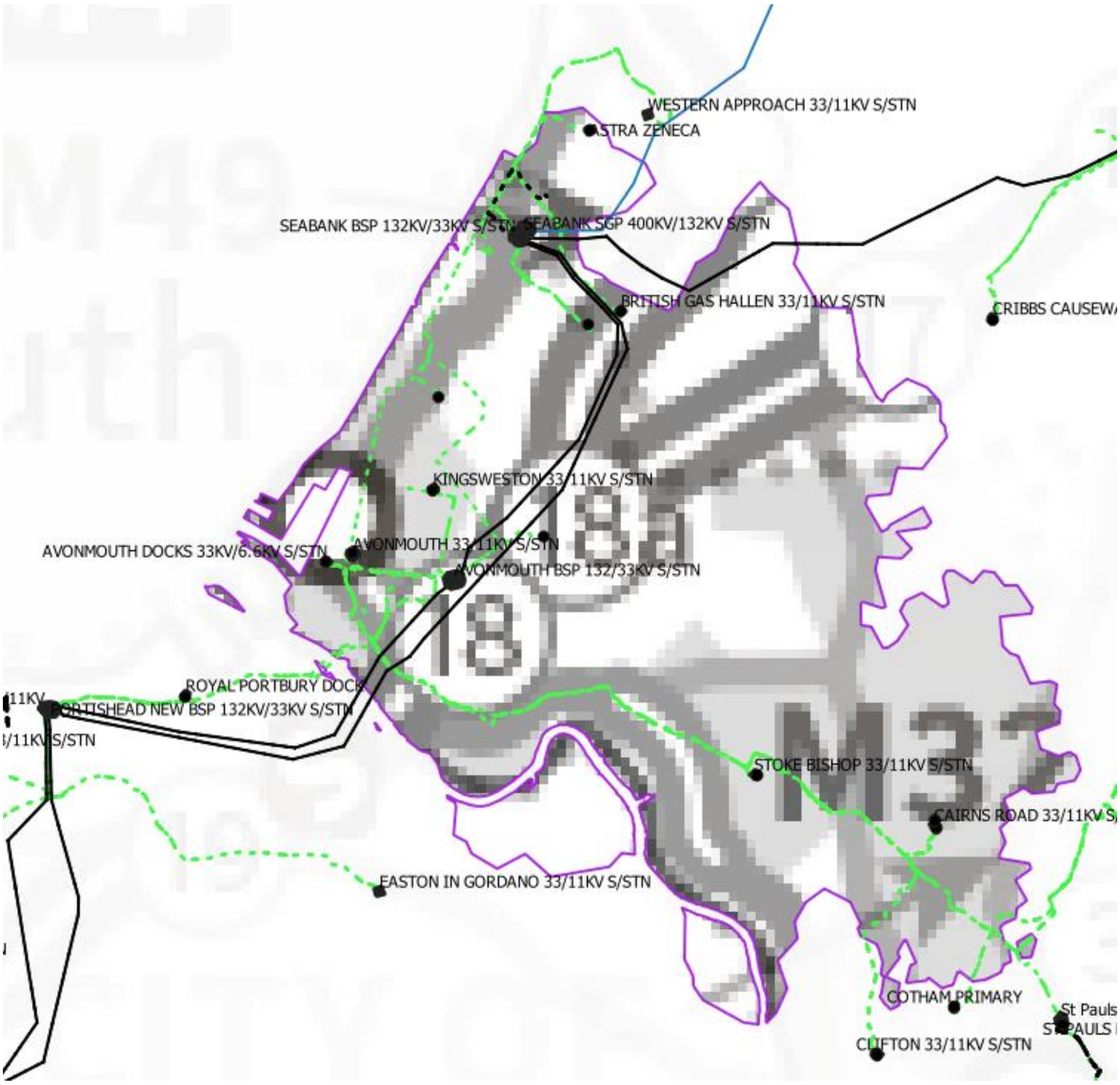

Figure 1.1 Avonmouth BSP geographic network coverage

This report discusses all existing and future network constraints over a 0-10 year horizon associated with the 33/11kV transformers, 33kV circuits and 132/33kV transformers which supply or are supplied by Avonmouth 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 Avonmouth BSP network is arranged as follows:

- GT1 and GT2 currently run in parallel supplying Avonmouth BSP.
- Four 33kV circuits supply four 33/11kV transformers at Cairns Road Primary
- Cairns Road Primary has T1 on hot standby with a manual switching scheme to switch T1 in for a fault/outage of the other transformers at Cairns Road
- Avonmouth Primary is a three transformer primary, supplied by three 33 kV circuits.
- A 33 kV ring supplying Stoke Bishop Primary, with normally open 33 kV interconnection with Feeder Road BSP via Broadweir.
- Avonmouth Docks Primary is a 33/6.6 kV three transformer primary, supplied by three 33kV circuits, with T1 and T2 running in parallel.
- A 33 kV ring supplying Kingsweston Primary, along with connection to a 33kV generator.
- A normally open 33kV circuit connects Avonmouth BSP to Portishead BSP.

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.

- For a fault/outage of a Cairns Road Transformer or associated 33kV circuit the transformer on hot-standby is switched in to mimic manual actions by the control room.
- For the loss of an infeed to a transformer at any of the primaries fed from Avonmouth BSP under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.
- For the loss of an infeed to a grid transformer at Avonmouth BSP under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.

2. Summary of Network Constraints

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

- Avonmouth Grid Transformer overloads
- Avonmouth Grid Transformer reverse power flow limitation
- Avonmouth to Cairns Road 33kV circuit overloads
- Cairns Road Primary Transformer Overloads
- Kingsweston Transformers and 33kV circuits generation overload

3. Network Constraint Details and Solution Options

3.1 Avonmouth Grid Transformer 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 3.1.1 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
Avonmouth GT1 overload	Avonmouth GT2 or associated busbar fault/outage	None	2028	2028	2034	2034
Avonmouth GT2 overload	Avonmouth GT1 or associated busbar fault/outage	None	2028	2028	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: Under Leading the Way Scenario, this constraint is predicted to arise in 2025 and under falling short is it 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 3.1.2 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 transformers	✓	×	×	Discounted
2	Install additional transformer	✓	✓	✓	Viable
3	Install new BSP	✓	✓	✓	Viable
Operational Mitigation					
4	Transfer demand to other BSPs with 33kV reinforcement if required	✓	×	✓	Viable
Load Management Schemes					
5	Uprate the existing transformers via use of cyclic ratings	✓	✓	✓	Viable
Flexibility services					
6	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 transformers

Capacity Released for constraint(s) considered: Unknown **Discounted**

Detailed description: As the grid transformers are already 90MVA units which are the highest rating NGED currently procures, this would involve replacing the transformers with larger custom purchased transformers. This would be at significant cost whilst not releasing a lot of capacity. Therefore, this option has been discounted.

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

Option 2 – Install additional transformer

Capacity Released for constraint(s) considered: 90MVA **Viable**

Detailed description: Installing a third transformer alongside switchgear and civil works would allow two transformers to remain in service for a fault of either of the existing circuits, preventing an overload. This would involve removing limitations caused by overhead line and cable sections on the existing 132kV circuits or installing a third 132kV circuit to provide 180MVA circuit capacity or more during all seasons to match the 90MVA transformer ratings. This would then become an N-2 issue which would need to be mitigated by splitting transformer parallels during an arranged outage.

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

Option 3 – Install new BSP

Capacity Released for constraint(s) considered: 180 MVA **Viable**

Detailed description: Installing a new BSP would require two new 132kV circuits and two new 132kV/33kV transformers as well as all ancillaries. This would also involving identifying a credible site to locate the new BSP. This will present significant challenges and costs given that it is an urban area and there are no spare 132kV bays at Seabank GSP, however, it does release the most capacity for the area. Therefore, as part of a cost benefit analysis of the long term options it is worth considering.

New limiting factor for constraint(s) considered: Ability to transfer load off Avonmouth BSP to the new BSP via 33kV circuits.

Option 4 – Transfer demand to other BSPs with 33kV reinforcement if required

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

Detailed description: The nearest BSPs are Seabank BSP and Portishead BSP. Both are shown to have grid transformer capacity beyond 2034, with Seabank BSP having the greater capacity. Seabank BSP is also slightly closer to Avonmouth BSP. Therefore, it may be considered to transfer demand from primaries such as Kingsweston, Avonmouth Local or Avonmouth Docks Primary to Seabank BSP. Alternatively, Cairns Road primary is in the vicinity of Lockleaze BSP and Feeder Road BSPs so there may be demand transfer options to these BSPs.

This will require a review of existing 33kV circuit connection options and consideration of installing new 33kV cables. Due to this being a dense urban area this presents additional cost and difficulty of 33kV reinforcement options to transfer demand, meaning it may be more cost-effective to add additional grid transformer capacity at Avonmouth BSP.

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

Option 5 – Uprate the existing transformers via use of cyclic ratings

Capacity Released for constraint(s) considered: Up to 27MVA

Viable

Detailed description: Uprate the existing transformers via use of cyclic ratings in accordance with British Standard 171/IEC60076 and NGED Standard Technique SD8C. This requires a capability assessment of all ancillaries, such as busbars, isolators, CTs, cables (including cabling within the substation), switchgear, tap changer, transformer bushings, conservator and earthing transformer. In addition, an assessment of the cyclic profile of the load is required to determine if transformer temperature and ageing is within acceptable limits. This would defer reinforcement requirements to beyond 2035 for Avonmouth BSP under Best View predictions.

New limiting factor for constraint(s) considered: winter cyclic rating of GTs

Option 6 – Procure flexibility

Estimated Flexibility Required (MVA): 5MVA+

Viable

Detailed description: Flexibility services could be procured to alleviate projected 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 determine if cyclic ratings are applicable to Avonmouth GTs in accordance with British Standard 171/IEC60076 and NGED Standard Technique SD8C. This could allow the transformers to be rated up to 117MVA which would allow further mitigation to be deferred beyond 2035.

Following this, flexibility could be used to further defer reinforcement, subject to a cost benefit analysis confirmation through the DNOA process.

Further to this, it is recommended to explore existing 33kV transfer options as per option 4 to de-load the BSP, including consideration of 33kV reinforcement if costs are not prohibitive.

Finally, a cost benefit analysis of installing a third grid transformer as well as 132kV circuit reinforcement, compared to installing a new BSP, to de-load Avonmouth BSP should be carried out to determine the best long term solution.

3.2 Avonmouth Grid Transformer reverse power flow limitation

Constraint Overview

Generation Demand

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
Avonmouth GT reverse power flow overload	Fault/outage of Avonmouth GT	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 generation is de-commissioned but this is not seen as likely.

Solution Recommendation

It is recommended to remove the reverse power flow limitations on Avonmouth Grid transformers. This may require reinforcement of ancillaries or upgrades to protection schemes.

3.3 Cairns Road Transformer and 33kV Circuit 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 3.3.1 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
Cairns Road T1 33kV circuit Reactor 1 overload	Fault/outage of Avonmouth Main 1 Busbar	None	Baseline	Baseline	Baseline	2028
Cairns Road T2 33kV circuit Reactor 2 overload	Fault/outage of Avonmouth Main 1 Busbar	None	Baseline	Baseline	Baseline	2028
Avonmouth 25L5 to Cairns Road 33kV circuit overload	Fault/outage of Avonmouth Main 1 Busbar	None	2028	2028	2034	2034
Avonmouth 6L5 to Cairns Road 33kV circuit overload	Fault/outage of Avonmouth Main 1 Busbar	None	2028	2028	2034	2034
Cairns Road T1 Overload	Fault/outage of Avonmouth Main 1 Busbar	None	2028	2028	2028	2034
Cairns Road T2 Overload	Fault/outage of Avonmouth Main 1 Busbar	None	2028	2028	2028	2034
T1/T2/T3/T4 and associated circuits overload	T1/T2/T3/T4 or associated circuits arranged outage	T1/T2/T3/T4 or associated circuits fault	2028	2028	2034	2034

Uncertainty under other Distribution Future Energy Scenarios: There is no uncertainty for the baseline constraint. For the constraints predicted to occur in 2028, under Leading the Way Scenario, these constraints are predicted to arise in 2027 and under falling short is it predicted to arise in 2032.

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	Remove reactors and change running arrangement to a 2+2 split	✓	✓	✓	**Viable**
2	Install additional 33kV bar section at Avonmouth BSP to prevent busbar fault taking out two circuits	×	×	✓	**Discounted**
3	Reinforce 33kV circuits and transformers, e.g. by installing a 5th transformer and 33kV circuit	✓	×	×	**Discounted**
4	Install new primary substation	✓	×	×	**Discounted**
Operational Mitigation					
5	Transfer demand to other Primaries with 33kV reinforcement if required	✓	✓	✓	**Viable**
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
6	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 – Remove reactors and change running arrangement to a 2+2 split

Capacity Released for constraint(s) considered: 5 MVA **Viable**

Detailed description: The reactors limit the 33kV circuit rating to 18MVA in winter meaning removal will allow the full 23MVA of the transformer rating to be used. This will require an assessment of fault level as the reactors will no longer be present to limit fault level. By moving to a split arrangement this would help fault level. This could tie in with a planned asset replacement of the 11kV switchboard planned for 2024/5.

New limiting factor for constraint(s) considered: Transformer and circuit capacity

Option 2 – Install additional 33kV bar section at Avonmouth BSP to prevent busbar fault taking out two circuits

Capacity released for constraint(s) considered: Discounted

23 MVA (for busbar fault as only 1 transformer is taken out instead of two)

Detailed description: This would involve installing a 4th 33kV bar section at Avonmouth. It is anticipated this will require a new switchroom, including moving 33kV circuits meaning it would be at significant cost. In addition, an N-2 overload would still occur for the loss of two transformers or associated circuits meaning this does not solve all constraints so is not a viable option.

New limiting factor for constraint(s) considered: N-2 of two transformers (assuming 3 transformers are paralleled for N-1)

Option 3 – Reinforce 33kV circuits and transformers, e.g. by installing a 5th transformer and 33kV circuit

Capacity Released for constraint(s) considered: 23 MVA Discounted

Detailed description: This would involve installing a 5th transformer and 33kV circuit between Avonmouth and Cairns Road. This would allow three transformers to remain in service for a 33kV busbar fault/outage. However, having 5 transformers would not be easily achieved with space constraints and would likely cause issues with fault level. Therefore, given the significant cost this is not a viable option.

New limiting factor for constraint(s) considered: 3 transformer capacity

Option 4 – Install new primary substation

Capacity Released for constraint(s) considered: 46 MVA Discounted

Detailed description: This would involve identifying a viable site to install two 33kV circuits and transformers as well as switchgear and civil works. This would allow Cairns Road Primary to be de-loaded by moving 11kV circuits to the new primary. However, there is capacity at nearby primaries out to 2034 meaning this does not benefit multiple constraints and Avonmouth BSP is limited in capacity by grid transformer capacity meaning the full capacity of the new primary could not be utilised. In addition this comes at a significant cost particularly given the constrained urban area offering limited options for a new primary location. Therefore this is not a viable option.

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

Option 5 – Transfer demand to other Primaries with 11kV reinforcement if required

Capacity Released for constraint(s) considered: Viable

Up to 13 MVA (based on Stoke Bishop transfer capacity and 11kV circuits being capable)

Detailed description: This would involve moving 11kV circuits and demand over to nearby primaries such as Stoke Bishop, Clifton, Filton and Hewlett Packard. This may require reinforcement of the 11kV circuits to facilitate such transfers. This offers potentially multiple benefits. Firstly, it de-loads Cairns Road preventing N-1 and N-2 overloads if sufficient demand is transferred. In addition, if moving demand to primaries not fed from Avonmouth BSP this would help to de-load the grid transformers and defer expensive 132kV reinforcement.

New limiting factor for constraint(s) considered: 11kV circuit capability

Option 6 – Procure flexibility at Cairns Road

Estimated Flexibility Required (MVA): 4 MVA+ Viable

Detailed description: Flexibility services could be procured at Cairns Road to alleviate projected overloads.

Solution Recommendation

It is recommended to firstly remove the reactors and move to a 2+2 split having two transformers supplying each half of the 11kV busbar at Cairns Road. This will coincide with planned asset reinforcement to replace the 11kV switchboard which, subject to further study, should remove any fault level issues cause by having all four transformers in service.

Following this, overloads are still predicted in 2028 where a 33kV busbar fault takes out two transformers or under N-1 in a 2+2 split, if 3 transformers are not paralleled for this condition.

To solve this flexibility could be procured to reduce demand and potentially defer reinforcement. However, due to large amounts of flex required it is anticipated that demand transfers on the 11kV off Cairns Road will be required to reduce demand and prevent overloads. If transferred to primaries not on Avonmouth BSP this would help the grid transformer constraints also. This may also require 11kV circuit reinforcement to transfer enough capacity to solve the constraints.

3.4 Kingsweston Transformers and 33kV circuits generation overload

Constraint Overview

Generation Demand

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
Kingsweston T1 reverse power flow overload	Fault/outage of Avonmouth 29L5 or associated busbar	None	Baseline	Baseline	Baseline	Baseline
Avonmouth 10L5 33kV circuit generation overload	Fault/outage of Avonmouth 29L5 or associated busbar	None	Baseline	Baseline	Baseline	Baseline
Kingsweston T2 reverse power flow overload	Fault/outage of Avonmouth Main 2 33kV busbar	None	Baseline	Baseline	Baseline	Baseline
Avonmouth 29L5 33kV circuit generation overload	Fault/outage of Avonmouth Main 2 33kV busbar	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 generation is de-commissioned but as the generators were installed recently this is not seen as likely.

Solution Options

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

Table 3.4.1 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 33kV circuit and remove reverse power flow limitation on T1	✓	✓	✓	Viable
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
2	Install Inter-trip or other protection	✓	✓	✓	Viable
Flexibility services					
3	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.

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 33kV circuit and remove reverse power flow limitation on T1

Capacity Released for constraint(s) considered: 12 MVA Viable

Detailed description: This would involve reinforcing approximately 1.4km of 33kV circuit between a 33kV generator and Avonmouth BSP to prevent overloads under peak generation on this circuit. It would also require the reverse power flow limitations on T1 to be removed to prevent overloads due to 11kV generation.

New limiting factor for constraint(s) considered: Transformer and circuit capacity

Option 2 – Install Inter-trip or other protection

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

Detailed description: This would involve installing an inter-trip between the 33kV busbars supplying Kingsweston and the 11kV breakers at Kingsweston to prevent reverse power flow through the primary transformers and by extension 33kV circuit overload on the 29L5 circuit. Other protection may also be considered to achieve the same benefit.

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

Option 3 – Procure flexibility

Estimated Flexibility Required (MVA): 10 MVA+ Discounted

Detailed description: Flexibility is not suitable to manage this constraint as it is generation driven. Managing generation constraints using flexibility procurement is technically feasible, but NGED's processes for calculating flexibility requirements for generation constraints are still in development.

Solution Recommendation

It is recommended to install an inter-trip or similar protection scheme as per Option 2, as well as reinforcing the 33kV circuit between the 33kV generator and Avonmouth BSP and removing T1 reverse power flow limitations as per Option 1. This will resolve all of the constraints to 2034.

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