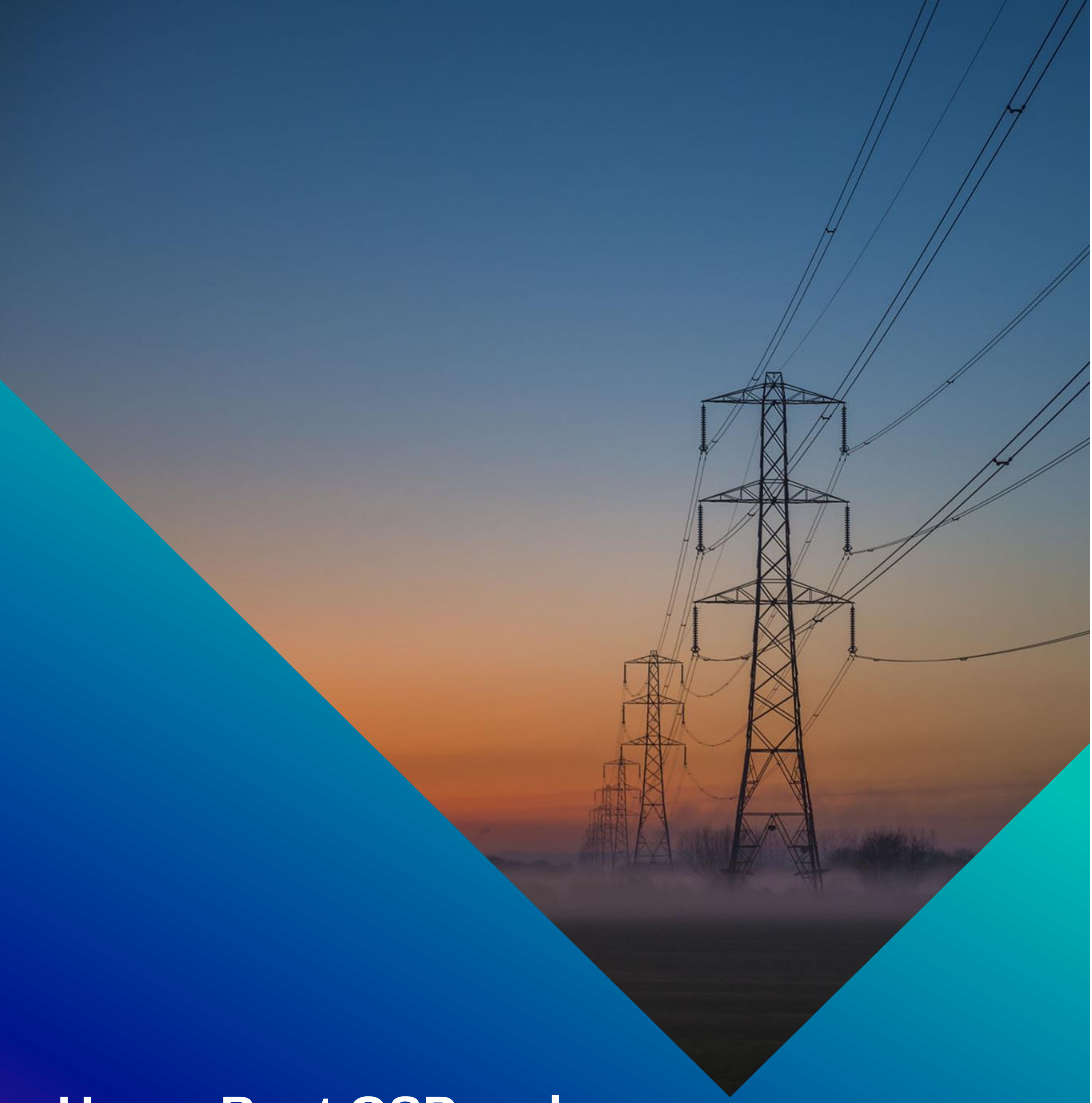

Upper Boat GSP and Associated 132 kV and 33 kV Networks

Network Development Report – South Wales

May 2024

Electricity Distribution

nationalgrid

Contents

Upper Boat GSP and Associated 132 kV and 33 kV Networks

1. Network Overview

Upper Boat Grid Supply Point (GSP) feeds a large geographical area and is supplied from the interconnected 275 kV National Grid Transmission Network. This group supplies over 170,000 customers and includes a large amount of distributed generation that has been connected to the network in recent times, due to the significant renewable energy potential seen across the area. Upper Boat is an unconventional network supplied by two 275/132 kV and two 275/33 kV SGTs. The 132 kV and 33 kV networks are remotely coupled by a small GT at Mountain Ash. The 132 kV busbar at Upper Boat is arranged as a ring of 12 section breakers, without line or transformer-incomer breakers. Upper Boat GSP currently has a maximum demand of 230 MVA and under NGEDs DFES Best View scenario this is projected to rise over 310 MVA by the year 2034.

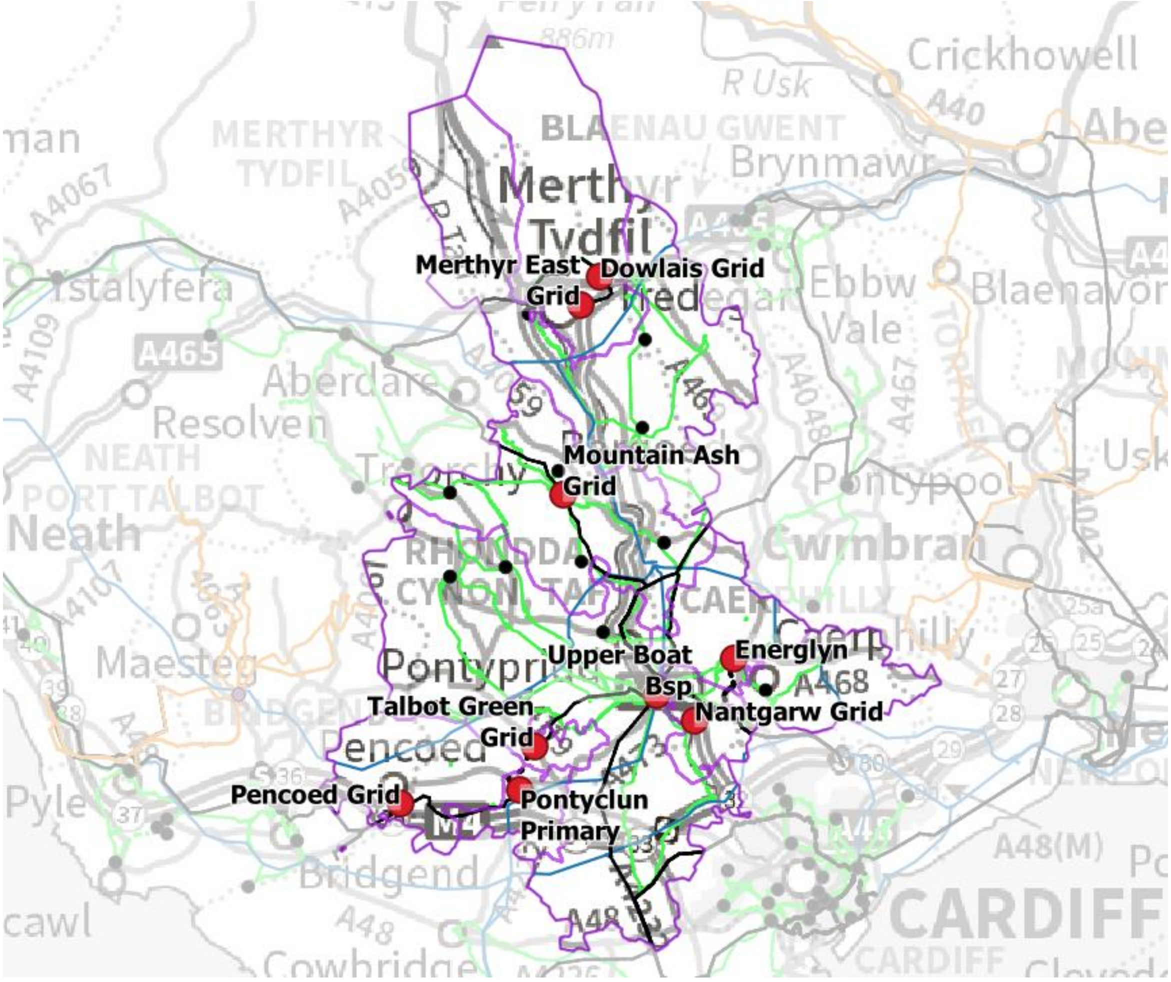

Figure 1.1 Upper Boat GSP geographic network coverage

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 and 132 kV circuits which supply and are supplied by Upper Boat GSP. 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. The two most onerous half-hours have been studied for each of the five representative days considered: Winter Peak Demand, Intermediate Warm Peak Demand, Intermediate Cool Peak Demand, Summer Peak Demand and Summer Peak Generation.

1.1 Network Topology

The Upper Boat 132 kV GSP network is arranged as follows:

- SGT1 and SGT4 currently run in parallel supplying Upper Boat 132 kV GSP
- Nantgarw and Energlyn are 132/11 kV BSP substations fed from Upper Boat 132 kV on the R route. This is a ladder arrangement with a tee off leading to Nantgarw substation.
- Upper Boat – Talbot Green – Pontyclun – Pencoed. This section, supplied initially from the UE route, includes three 132/11 kV BSPs, as well as interconnectors (normally open) to Pyle GSP at Pencoed.
- Upper Boat – Mountain Ash BSP (tee off to Pengam BSP) – Dowlais BSP – Merthyr East. This section contains two 33 kV networks as well as a 132/11 kV substation.
- There is a tee off to Pengam BSP, which is normally run open as an interconnector to the Rassau GSP group.
- There are interconnectors to Swansea North GSP via Hirwaun BSP, which are normally run open on the D route.
- The U route out of Upper Boat offers interconnection to Aberthaw GSP, via the LL route (normally open from Aberthaw). For either an SGT1 or SGT4 outage, Aberthaw SGT3 (if available) can be switched into service (split away from the Cardiff East/Aberthaw group) to provide support to the Upper Boat group under outage via the LL and U route.

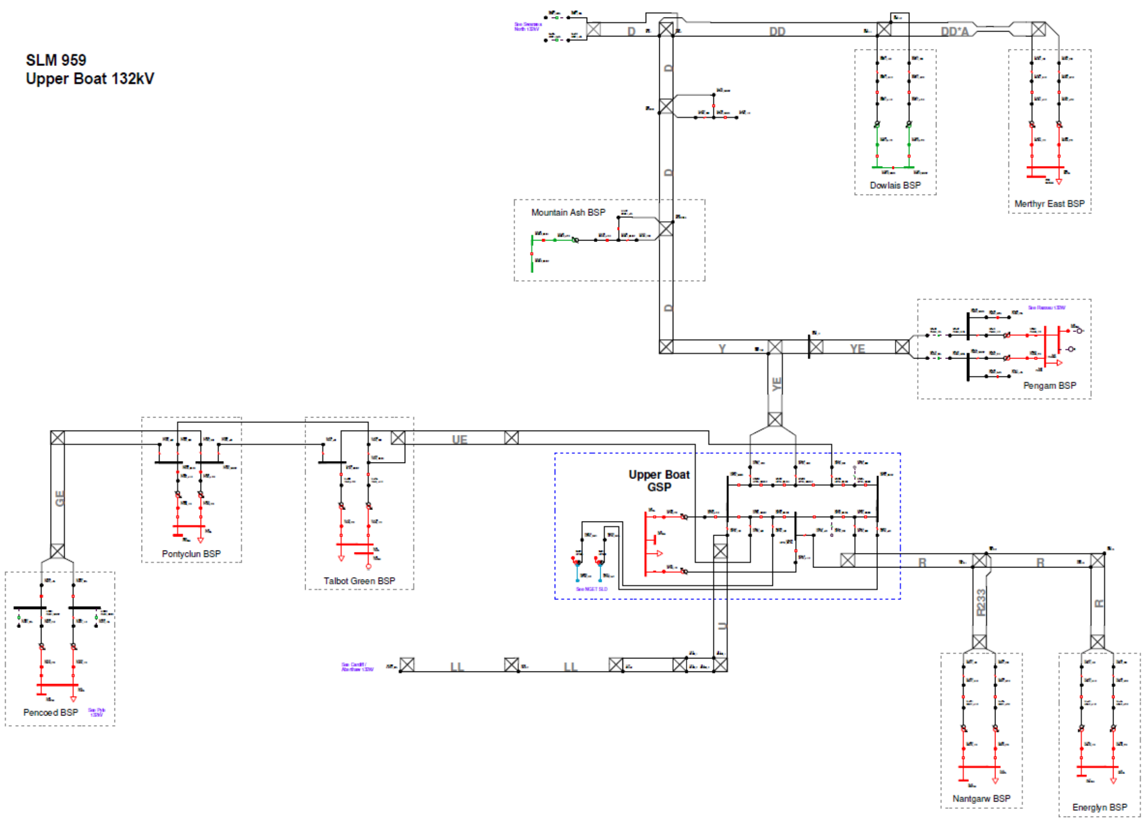

Figure 1.2 Upper Boat 132 kV network

The Upper Boat 33 kV GSP network is arranged as follows:

- SGT2 and SGT3 currently run in parallel and supply the indoor GIS busbar at Upper Boat 33 kV GSP.
- Ironbridge, Morlanga and Creigiau 33/11 kV primaries are fed off a 33 kV ring from Upper Boat Main 2 and Main 4 busbars.
- Mill Street, Tonypandy and Wattstown 33/11 kV primaries are supplied by three 33 kV circuits from Upper Boat Main 1, 2 and 4 busbars.
- Middle Fan Primary is supplied by a 33 kV circuit from Mountain Ash BSP and also via a 33 kV tee off towards Wattstown. At Middle Fan there is an interconnector with Hirwaun 33 kV.
- Gas Yard, Lady Windsor and Nelson primaries are supplied from both Mountain Ash and Upper Boat, with two 33 kV circuits from each supply point. There is a tee off between Gas Yard and Nelson primaries, this interconnects with Dowlais 132/33 kV BSP via a normally open point.
- Energlyn, Trethomas and Caerphilly primaries are supplied by three 33 kV circuits from Upper Boat Main 2, 3 and 4 busbars.
- Mountain Ash primary is supplied by Mountain Ash BSP.
- Mountain Ash BSP couples the 33 kV network with the 132 kV network at Upper Boat GSP and also provides 33 kV interconnection with Dowlais BSP via Nantwen.

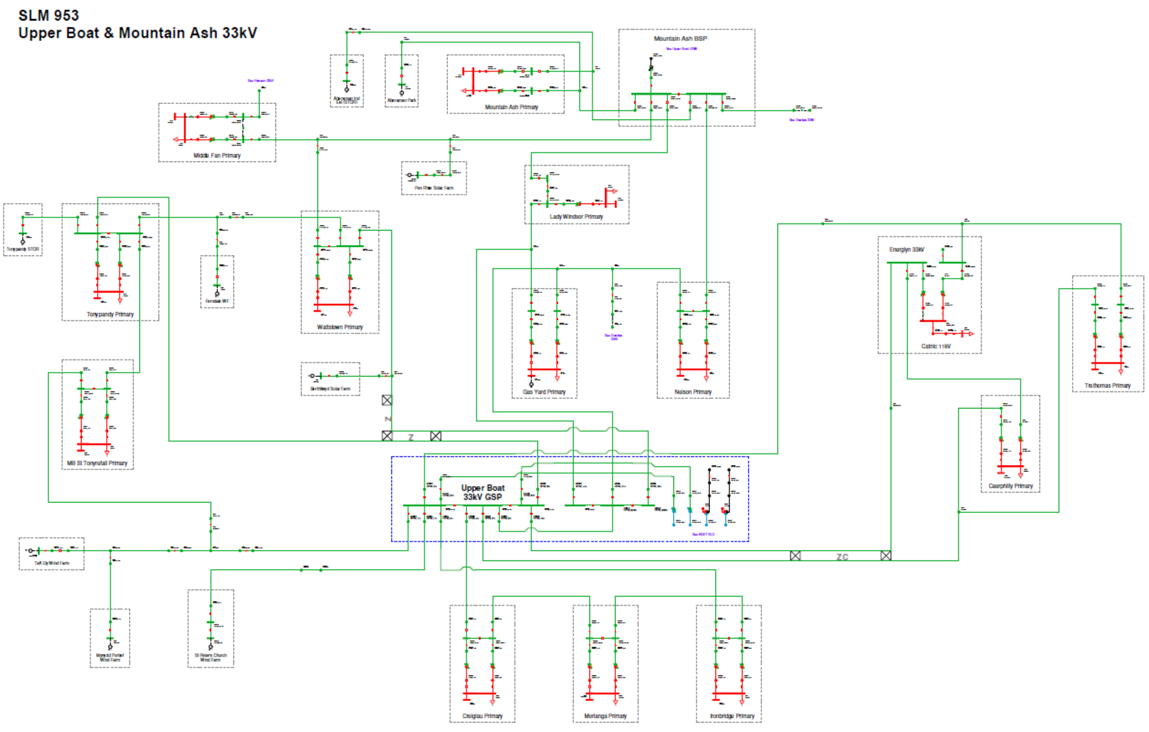

Figure 1.3 Upper Boat 33 kV Network

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.

- In the event of an Upper Boat SGT2 or SGT3 outage, Upper Boat 33 kV Main 1 is disconnected from Upper Boat 33 kV GSP and the 33 kV network is split with Mountain Ash BSP. Wattstown, Gas Yard, Nelson and Lady Windsor primaries are supplied by Mountain Ash BSP during such outage conditions.
- In the event of an Upper Boat SGT1 or SGT4 outage, Aberthaw SGT3 can be split away from the Aberthaw/Cardiff East group to support the Upper Boat group via the Upper Boat to Aberthaw GSP 132 kV circuit.
- Pencoed and Pontyclun can transfer across onto the Pyle GSP group via the interconnection at Pencoed BSP in the event of an Upper Boat 132 kV arranged outage.
- For the loss of an infeed to a transformer at any of the primaries fed from the Upper Boat group under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.
- Curtailment of all connected load management schemes within the group are modelled at a variety of outage conditions, as outlined in customer connection agreements.
- Various winter arranged outages not permitted due to SCO overloads.
- Various SCO overloads solved by network reconfiguration for arranged outages.

2. Summary of Network Constraints

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

- Upper Boat 33 kV circuit constraints under SCO conditions
- Trethomas Primary transformer overloads under SCO conditions
- Mill Street / Tonypandy / Upper Boat 33 kV circuit overloads under FCO conditions
- Pencoed Grid Transformer constraints under FCO conditions
- Upper Boat 132 kV Meshed busbar limitations under SCO
- Mountain Ash GT2 overloads
- Gas Yard Primary 33 kV Circuit Constraints
- Upper Boat 33 kV SGT constraints
- Energlyn Primary to Energlyn tee off overloads
- Mountain Ash busbar outage 33 kV constraints
- Creigiau Primary transformer constraints
- Tonypandy Primary 33 kV circuit overloads

3. Network Constraint Details and Solution Options

3.1 Upper Boat - Mountain Ash 33 kV circuit overloads

Constraint Overview

Generation Demand

For an arranged outage of an Upper Boat 33 kV busbar section, all of the supply for Mountain Ash is fed through a single 33 kV circuit between Upper Boat - Tonypandy - Mountain Ash. This leads to overloads on the previously mentioned circuits in the event of an SCO fault on Mountain Ash GT2.

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
Various Upper Boat – Mountain Ash 33 kV circuits including routes from Upper Boat – Tonypandy/Mill Street-Mountain Ash.	Arranged Upper Boat 33 kV bar outage	Mountain Ash GT2	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 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 Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing 33 kV circuits	✓	×	×	Discounted
2	Reconfigure/Reinforce 33 kV circuits	✓	✓	✓	Viable
Operational Mitigation					
3	Switch in Mountain Ash GT1	✓	✓	✓	Viable
Load Management Schemes					
4	Post-fault transfers	×	×	×	Discounted
Flexibility services					
5	Procure flexibility within the Upper Boat group	×	×	×	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. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Mill Street, Tonypandy, Wattstown, Mountain Ash, Lady Windsor, Gas Yard, Nelson and Mountain Ash Primary.

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

Option 1 – Reinforce existing 33 kV circuits

Capacity Released for constraint(s) considered: 33 MVA **Discounted**

Detailed description: All of the 33 kV circuit sections between Upper Boat – Mountain Ash via Tonypandy and Mill Street would need to be significantly upgraded.

New limiting factor for constraint(s) considered: Capacity of the uprated 33 kV circuits

Option 2 –Reconfigure/reinforce 33 kV circuits

Capacity released for constraint(s) considered: 60 MVA **Viable**

Detailed description: In order to alleviate the constraint, the 33 kV circuit between Upper Boat and the Gas Yard T2 tee off could be reselected from Upper Boat Main 1 to Upper Boat Main 3 busbar. This means that in the event of a 33 kV busbar outage at Upper Boat, only 1 of the 3 main feeds between Mountain Ash and Upper Boat is lost. This stops the issue of all the demand needed for Mountain Ash being supplied by one circuit, which can lead to overloads.

As well as this change, in order to secure network integrity and to avoid any 33 kV circuit thermal issues, the Upper Boat to Gas Yard T1/T2 tee off 33 kV circuit sections require reinforcement

The Gas Yard T1 tee to Upper Boat 33 kV circuit has a 120m limiting section of 33 kV circuit that would require uprating.

The Gas Yard T2 tee to Upper Boat 33 kV circuit has a 156m limiting section of 33 kV circuit that would require uprating.

These works will alleviate the constraints observed.

New limiting factor for constraint(s) considered:

Capacity of the two uprated 33 kV circuits under FCO conditions

Option 3 – Switch in Mountain Ash GT1 for an arranged 33 kV bar outage at Upper Boat

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

Detailed description: Mountain Ash GT1 is currently run on hot standby and is switched into service for an outage of either Upper Boat 275/33 kV SGT as well as an outage of Mountain Ash GT2.

It is proposed that Mountain Ash GT1 is switched into service for all 33 kV busbar outages at Upper Boat. This alleviates the constraint and is highly cost effective.

New limiting factor for constraint(s) considered: Capacity of the Mountain Ash GTs

Option 4 – Post-fault transfers

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

Detailed description: Post fault transfers cannot be utilised as the overload is significantly beyond post-fault ratings meaning there is no window to reduce the load on the 33 kV circuits through load management.

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

Option 5 – Procure flexibility at the primaries within the Upper Boat 33 kV group

Estimated Flexibility Required (MVA): 30 MVA + **Discounted**

Detailed description: Flexibility services are not viable due to the very high amount of flexibility required to alleviate the constraint.

Solution Recommendation

It is recommended to assess the possibility of switching Mountain Ash GT1 into service for all 33 kV busbar outages at Upper Boat GSP. This allows for the network integrity issues to be resolved, as well as being the most cost effective option.

3.2 Trethomas primary transformer overloads

Constraint Overview

Generation | **Demand**

Following an arranged 33 kV busbar outage of Upper Boat Main 2, a subsequent SCO fault to Caerphilly primary T2 can lead to Trethomas 33/11 kV primary transformers to experience severe through flows.

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 year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Trethomas Transformers T1 and T2 Loss of load at Caerphilly primary	Arranged Upper Boat 33 kV main 2 busbar outage	Fault on Caerphilly 2T0	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 required.

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 Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce 11 kV circuits to transfer demand to other primaries.	✓	✓	✓	Viable
2	Install a Bus section breaker at Trethomas	✓	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Caerphilly/Trethomas	×	×	×	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. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Trethomas Primary.

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

Option 1 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: 7 MVA — Viable

Detailed description: 7 MVA of load would need to be transferred in order to mitigate the constraint, which could be done by transferring load from Caerphilly and Trethomas primaries to Energlyn 132/11 kV BSP. This would have to be done pre-emptively for a 33 kV busbar outage of Upper Boat Main 2.

7 MVA is a very high amount of demand to transfer through the 11 kV network, meaning a dedicated 11 kV interconnector would need to be built between Caerphilly primary and Energlyn BSP. There is plenty of spare capacity at Energlyn BSP, and due to the close vicinity of both Trethomas and Caerphilly, this is a viable option.

New limiting factor for constraint(s) considered: Capacity of 11 kV interconnectors

Option 2 – Add a 33 kV bus section breaker to Trethomas primary

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

Detailed description: The installation of a 33 kV bus section breaker at Trethomas primary would prevent the load from both Caerphilly and Trethomas flowing through the Trethomas 33/11 kV transformers, alleviating the constraint.

New limiting factor for constraint(s) considered:

Capacity of the existing 33 kV circuits from Energlyn-Trethomas-Caerphilly

Option 3 – Procure flexibility at Trethomas and Caerphilly Primary Substations

Estimated Flexibility Required (MVA): 7 MVA + — **Discounted**

Detailed description: Flexibility services could be procured at Caerphilly and Trethomas to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured.

Solution Recommendation

It is recommended to assess the possibility of installing a 33 kV bus section breaker at Trethomas primary. This is the most cost effective option whilst also being the most beneficial.

The 11 kV circuit breaker at Trethomas T1 could be opened to prevent the through flows, however this would leave Caerphilly primary on single circuit risk. Considering this, adding the 33 kV bus section breaker would both improve network integrity as well as security of supply.

3.3 Upper Boat – Mill Street – Tonypandy 33 kV circuit overloads

Constraint Overview

Generation | **Demand**

For an arranged or fault outage of Upper Boat 33 kV Main 2 or Main 4 busbar, the demand of Mill Street and Tonypandy primaries causes FCO overloads on the remaining 33 kV circuits from Upper Boat to Tonypandy/Mill Street.

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 year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
33 kV circuits (various sections) between Upper Boat, Mill Street and Tonypandy.	Upper Boat 33 kV busbar outage (Main 2 or 4)	N/A	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 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 Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing 33 kV circuits	✓	×	×	Discounted
2	Establish a new 33 kV circuit	✓	✓	×	Viable
Operational Mitigation					
3	Switch in Tonypandy to Wattstown circuit	✓	×	✓	Discounted
Flexibility services					
4	Procure flexibility at Mill Street and Tonypandy primaries.	✓	✓	✓	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. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Mill Street and Tonypandy Primaries.

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

Option 1 – Reinforce existing 33 kV circuits

Capacity Released for constraint(s) considered: 3 - 15 MVA

Discounted

Detailed description: The 33 kV sections between Upper Boat – Mill Street – Tonypandy would need to be uprated to greater than 25 MVA, in order to nullify the constraint. This could be costly however as large sections would need to be reprofiled from 50 degrees to 75 degrees (which may require remedial works), in addition to overlaying sections of 33 kV underground cable to a higher rating.

Furthermore, this would not be a long term solution as high load growth projected on Tonypandy would mean that close to 33 kV circuits close to 30/35 MVA would need to be built in order to futureproof the group. This would also increase the amount of 33 kV circuits needing to be uprated to 31 km, which would lead to a costly and reinforcement scheme providing relatively little benefit to the network.

Due to the increased load growth (from 2030 onwards) this 33 kV section needs to be uprated to at least 30 MVA to deal with the increased loading on Tonypandy and Mill Street primary, however whilst looking at the baseline constraint this would not be necessary until between 2028 and 2030.

New limiting factor for constraint(s) considered: Capacity of the uprated 33 kV circuits

Option 2 – Establish a new 33 kV circuit

Capacity released for constraint(s) considered: 27 MVA

Viable

Detailed description: A new 33 kV circuit could be built between Upper Boat Main 3 and a new tee off between Mill Street and Tonypandy. The circuit should be rated at around 27 MVA to accommodate the group demand of Tonypandy and Mill Street primaries.

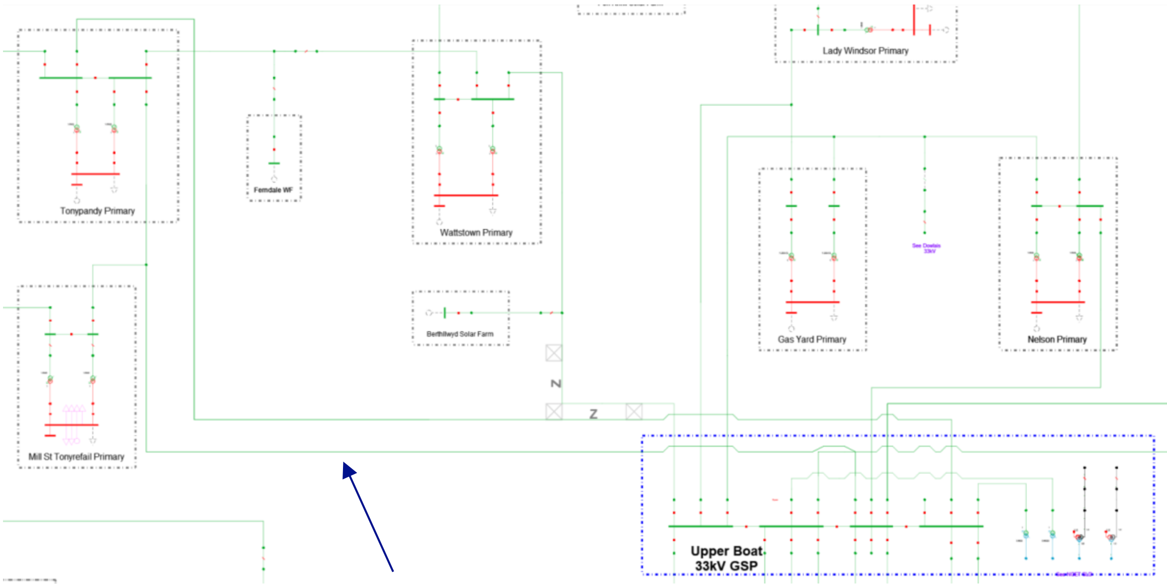

Figure 3.3. Concept design for new 33 kV circuit from Upper Boat to Tonypandy/Mill Street tee off

New limiting factor for constraint(s) considered:

Group demand exceeding that of the new 33 kV circuit in the event of a Tonypandy Main 2 outage

Option 3 – Switch in Tonypandy to Wattstown 33 kV circuit in the event of a 33 kV busbar outage at Upper Boat.

Capacity Released for constraint(s) considered: N/A **Discounted**

Detailed description: In the event of an Upper Boat 33 kV SGT outage (which occurs under a 33 kV main busbar 2 arranged outage) the 33 kV network is split to de-load Upper Boat. Closing this 33 kV circuit breaker would recouple the network, and in the event of an SCO Upper Boat SGT outage, could cause power flow between the islanded mesh sections via the 33 kV network.

This option has been discounted due to the risk of coupling between the 132 kV and 33 kV networks at Upper Boat GSP.

New limiting factor for constraint(s) considered:

Coupling between Upper Boat and Mountain Ash

Option 4 – Procure flexibility at Tonypandy/Mill Street 33 kV primaries

Estimated Flexibility Required (MVA): 2 MVA + **Viable**

Detailed description: Flexibility services could be used in the event of this specific outage, however due to the constraint arising occurring under an FCO, large volumes of flexibility would be required during intermediate warm, intermediate cool and winter maximum demand periods.

Solution Recommendation

Operational mitigation should be explored initially, to determine if these overloads can be managed. Following this, it is recommended to assess the possibility of constructing a dedicated new 33 kV circuit from Upper Boat to a tee off between Mill Street and Tonypandy

This would be highly beneficial in terms of futureproofing the network, as well as alleviating this network constraint.

3.4 Pencoed 132/11 kV Grid Transformer overloads

Constraint Overview

Generation **Demand**

The Pencoed 132/11 kV Grid Transformers experience through-flow issues in the event that the Bridgend-Pencoed 132 kV circuits are switched in under an arranged outage of a Pontyclun 132 kV busbar section, followed by an SCO fault on one of the Bridgend-Pencoed 132 kV circuits. This results in the demand for both Pontyclun and Pencoed BSPs flowing through either Pencoed GT1 or GT2, depending on the fault.

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 3.4.1 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
Pencoed 132/11 kV Grid transformers 1 and 2	Pontyclun 132 kV busbar outage	Fault on Pyle – Bridgend – Pencoed 132 kV circuit	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 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 Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing 132 kV Transformers	✓	×	×	Discounted
2	Install a bus section breaker at Pencoed Substation	✓	✓	✓	Viable
Operational Mitigation					
3	Avoid taking the arranged outage of Pontyclun during high network loading	✓	✓	✓	Viable
Flexibility services					
4	Procure flexibility at Pontyclun and Pencoed BSPs.	✓	✓	✓	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. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Pontyclun.

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

Option 1 – Reinforce existing 132/11 kV Transformers

Capacity Released for constraint(s) considered: 30 MVA

Discounted

Detailed description: The existing 30 MVA grid transformers could be uprated to accommodate the extra loading. As 30 MVA are the largest 132/11 kV two winding transformers available, three winding 60 MVA units would be required. Whilst this is the best option regarding Pencoed BSP for future load growth, this may not be the most cost effective solution. Therefore it should be discounted in the near term, but could be utilised if high load growth is projected.

New limiting factor for constraint(s) considered: Capacity of the three winding transformers.

Option 2 – Build new 132 kV bus section breaker

Capacity released for constraint(s) considered: N/A

Viable

Detailed description: A new 132 kV bus section breaker could be built between Main 1 and 2 at Pencoed BSP. This is to stop through flow under such outage conditions. This would form a credible solution and secure the substation long term against this combination of outages causing a constraint.

New limiting factor for constraint(s) considered:

The 132 kV circuits between Pontyclun BSP and Pencoed BSP.

Option 3 – Avoid taking the outage during times of high loading on the network

Capacity Released for constraint(s) considered: N/A

Viable

Detailed description: Due to the overload causing the constraint only appearing under winter peak and intermediate cool rating loadings, the constraint could be mitigated by choosing a day with lighter peak loading than would be seen on winter peak or intermediate cool loadings. This could be used to defer the need for reinforcement or flexibility in the short term.

New limiting factor for constraint(s) considered:

Summer loading on Pencoed and Pontyclun BSPs.

Option 4 – Procure flexibility at Pencoed and Pontyclun 132/11 kV BSPs

Estimated Flexibility Required (MVA): 2 MVA

Viable

Detailed description: Flexibility services could be used in the event of this specific outage.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement, subject to a cost benefit analysis and confirmation through the DNOA process or alternatively use specific low loading outage windows in the short term.

The medium to long term view will be to consider establishing a 132 kV bus section breaker at Pencoed BSP.

3.5 Upper Boat 132 kV meshed busbar limitations

Meshed busbar arrangement has fundamental limitations due to SCO outages causing sections of the mesh becoming islanded due to outages combinations such as an SGT infeed combined with another bus section of the mesh. This can result in severe through flow/loose coupling issues to islanded sections of the busbar.

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 year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Sections of the 132 kV meshed busbar becoming islanded under SCO conditions.	Arranged 132 kV busbar section outage	SGT outage or circuit outage that feeds into the meshed busbar.	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 required.

Solution Options

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

Table 3.5.1 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install motorised isolators on Upper Boat 132 kV meshed busbar	✓	✓	✓	Viable
2	Reconfigure the site to be a double busbar arrangement	×	✓	×	Discounted
Operational Mitigation					
3	Open downstream breakers to prevent loose coupling between islanded sections of the busbar.	✓	✓	✓	Viable
Flexibility services					
4	Procure flexibility at Upper Boat GSP	×	×	×	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: Meshed busbars have fundamental disadvantages under SCO conditions, when compared to a standard busbar arrangement. There are particular fault permutations at Upper Boat 132 kV substation that can lead to large sections of the busbar being islanded. This in turn can results in loose couples leading to overloads.

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

Option 1 – Install motorised isolators on Upper Boat 132 kV meshed busbar

Capacity Released for constraint(s) considered: N/A — Viable

Detailed description: Installing motorised isolators on the Upper Boat 132 kV busbar sections would allow greater flexibility regarding restoring supply to islanded sections of the meshed busbar. The ability to not require manual switching to open the line side isolators is highly advantageous, and would help mitigate the disadvantages of the mesh by limiting the amount of Customer Minutes Lost (CMLs) due to the greatly reduced time needed to restore supply.

As the meshed busbar arrangement has fundamental design limitations with loose couplings, circuit breakers need to be left open to prevent overloads in the event of a busbar outage. This would leave large sections of the network at single circuit risk. Being able to mitigate this design flaw makes adding motorised isolators a viable solution.

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

Option 2 – Reconfigure the existing 132 kV busbar to a double busbar arrangement

Capacity released for constraint(s) considered: N/A — Discounted

Detailed description: Rebuilding the existing substation from a meshed arrangement to a double busbar arrangement would be highly advantageous as this would avoid the SCO problems associated with a meshed busbar layout. This would give the GSP greater security of supply as the need to open certain breakers would be avoided, meaning the circuits would not be on single circuit risk. Having a reserve bar would mean that for an arranged bar outage, all of the feeders could be switched over to the reserve bar.

The limiting factor for changing the configuration of the 132 kV busbar would be space. Upper Boat GSP is limited with regards to space available within the compound and this option would be discounted on this basis.

New limiting factor for constraint(s) considered: Lack of space available within the compound.

Option 3 – Open downstream circuit breakers to prevent loose couples

Capacity Released for constraint(s) considered: N/A

Viable

Detailed description: As loose coupling issues regarding islanded sections of the meshed busbar arrangement is a concern, pre-emptively opening circuit breakers that prevent the couples from occurring in the event of losing another section could be a viable option. The issue with this however, is multiple sections of Upper Boat 132 kV network are now on single circuit risk.

New limiting factor for constraint(s) considered:

Loadings on the circuits that are now put at single circuit risk.

Option 4 – Procure flexibility at Upper Boat GSP

Estimated Flexibility Required (MVA): 30 **-** 50 MVA

Discounted

Detailed description: It is highly unlikely that sufficient flexibility could be procured as a long-term solution, particularly if the dispatch of services is required for extended periods of time.

Solution Recommendation

It is recommended that a technical review of installing motorised isolators in conjunction with exploring operation mitigation to overcome loose coupling issues.

Despite the downside with having several circuits on single circuit risk during the arranged busbar outage, the use of motorised isolators negates this to a certain level because supply could be quickly restored to the islanded parts of the mesh.

3.6 Mountain Ash GT2 transformer overloads

Constraint Overview

Generation | Demand

For an Upper Boat 132 kV main busbar outage, the 33 kV network is split between Upper Boat and Mountain Ash. This results in the Mountain Ash group being supported entirely through Mountain Ash GT2. By 2028, projected increases in load in line with the DFES scenarios results in overloads on Mountain Ash GT2.

Table 3.6.1 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
Mountain Ash GT2	Upper Boat 132 kV bar outage, leading to a split in the 33 kV network at Mountain Ash	N/A	2028	2028	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.3.1 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing GT with a 60/90 MVA unit	✓	✓	✓	Viable
Operational Mitigation					
2	Change split point of the Upper Boat/Mountain Ash 33 kV network.	✓	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Mountain Ash BSP	×	×	×	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: In the event of an Upper Boat 132 kV busbar outage, the 33 kV network at Upper Boat/Mountain Ash is split to prevent coupling issues in the event of losing a second section of the mesh. By 2028, GT2 is showing slight overloads following a network split under arranged busbar outages. Doing nothing to mitigate the constraint would result in thermal overloads for the conditions described above.

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

Option 1 – Replace Mountain Ash GT2 with a 90 MVA transformer

Capacity Released for constraint(s) considered: 45 MVA

Viable

Detailed description: Currently, Mountain Ash GT2 is rated at 45 MVA, under an Upper Boat 132 kV busbar outage the group demand of Mountain Ash GT2 is very close to being exceeded/is slightly exceeded depending on which busbar section is taken out.

As load is predicted to rise significantly between 2028 and 2034 on several primaries in the Mountain Ash group, uprating GT2 to match GT1 would be the best option regarding futureproofing the network.

This would give plenty of capacity between 2028 and when the network is aimed to be split when the proposed GSP in the Hirwaun area is due to be established by 2034.

New limiting factor for constraint(s) considered: 90 MVA firm capacity of Mountain Ash GSP

Option 2 – Change the split point of Upper Boat 33 kV network

Capacity Released for constraint(s) considered: N/A

Viable

Detailed description: Switching Wattstown onto the Upper Boat 33 kV network would alleviate the constraint, reducing the overload from around 100% to 89%. This can be achieved by switching the Wattstown 1L5 and 2L5 33 kV circuit breakers and Wattstown to Tonypandy 33 kV circuit closed. A disadvantage of this change is that it leaves Wattstown on single circuit risk, however due to its low loading in 2028 of 4.48 MW this can be mitigated under Engineering Recommendation P2.

Alternatively, Gas Yard and also potentially Nelson could be switched back onto Upper Boat by closing in the Upper Boat main 1 busbar section and opening the 33 kV circuit breakers 2L5 at Gas Yard, 2L5 at Nelson and 1L5 at Lady Windsor. Whilst this successfully shifts load back onto the

Upper Boat 33 kV network, it leaves Gas Yard, Nelson and Lady Windsor primaries all on single circuit risk.

New limiting factor for constraint(s) considered: Primaries left on single circuit risk.

Option 3 – Procure flexibility at the primaries on Mountain Ash 33 kV group

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured within the area to help alleviate the projected overloads. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

The viability of utilising flexibility will be further considered as part of the DNOA process.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process. Following this, it is recommended that a technical review of replacing the existing Mountain Ash GT2 to a 90 MVA unit is carried out.

3.7 Gas Yard 33 kV Circuit Constraints

Following an arranged outage to one of the 33 kV circuits between Upper Boat and Gas Yard primary, a subsequent SCO fault of a 275/132 kV SGT can lead to overloads in line with the DFES scenarios. This causes power flow of the group demand to shift from Mountain Ash 33 kV to Upper Boat 33 kV, leading to the remaining 33 kV circuit from Upper Boat to Gas Yard to 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 3.7.1 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
Upper Boat to Gas Yard T1 tee off or Upper Boat to Gas Yard T2 tee off	Arranged outage of Upper Boat 33 kV to Gas Yard T1/T2 tee off	Fault on 275 kV side of Upper Boat SGT	2028	2028	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.7.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce existing 33 kV circuits	✓	×	✓	Viable
Operational Mitigation					

2	Split group under the arranged condition	✓	×	✓	**Discounted**
3	Load transfer/topology change	✓	×	✓	**Discounted**
4	Load Transfer/reinforce existing 33 kV circuits	✓	×	×	**Discounted**
5	Reinforce existing circuits/build new 33 kV circuit	✓	✓	✓	**Viable**
Flexibility services					
6	Procure flexibility at Mountain Ash BSP	✓	✓	✓	**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 thermal overloads for the conditions described above.

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

Option 1 – Reinforce 33 kV circuits between Gas Yard and Upper Boat

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

Detailed description: As the highest recorded flow for this constraint through the 33 kV Gas Yard T1 and T2 tee circuits is 30.4 MVA, the 4 km sections between Upper Boat and Gas Yard could be reinforced sufficiently to ensure that there is enough capacity to accommodate the constraint.

In line with the high projected load growth between 2028 and 2034, further works may be required to release additional capacity.

New limiting factor for constraint(s) considered: Capacity of the new 33 kV circuits.

Option 2 – Split the 33 kV Upper Boat/Mountain Ash network under the arranged outage

Capacity released for constraint(s) considered: 90 MVA **Discounted**

Detailed description: As the constraint on the 33 kV circuits between Gas Yard and Upper Boat is caused by demand shifting from Upper Boat to Mountain Ash, splitting the network would solve the constraint. A downside to this solution however, is more load is being shifted from Upper Boat 33 kV to Upper Boat 132 kV, increasing the amount of load on the remaining 275/132 kV SGT.

This is undesirable as more customers would be placed on single circuit risk, whereas if the network were not to be split the security of supply would be improved.

New limiting factor for constraint(s) considered: Amount of customers on single circuit risk.

Option 3 – Load Transfer/Topology change

Capacity Released for constraint(s) considered: N/A **Discounted**

Detailed description: In order to mitigate the extra loading between Upper Boat 33 kV and Mountain Ash BSP, Middle Fan primary could be transferred to Hirwaun 33 kV BSP. This helps to deload Mountain Ash BSP but doesn't entirely solve the constraint. Either Lady Windsor 2L5 (for an arranged outage of Upper Boat 15L5) or Nelson 1L5 (for an arranged outage of Upper Boat 11L5) need to be open to alleviate the constraint. This solution is effective in nullifying the constraint, however it is rather unwieldy with having to open certain circuit breakers and performing a load transfer under an FCO arranged condition.

Furthermore, the FCO condition causes around 105% overloads on the existing circuits (without losing the SGT) due primarily to demand growth at Nelson and Gas Yard. Therefore, this solution alone is not suitable without performing post fault switching. The Wattstown to Mountain Ash 33 kV circuit is also very close to exceeding its thermal rating in 2028 using the suggested load transfer/network topology change.

New limiting factor for constraint(s) considered:

Rating of the Wattstown to Mountain Ash 33 kV circuit

Option 4 – Load transfer/reinforce existing 33 kV circuits

Capacity Released for constraint(s) considered: 5 MVA

Discounted

Detailed description: Due to the FCO condition, the 33 kV circuits between Upper Boat and Gas Yard should be uprated to 30/35 MVA. This, allied with transferring Middle Fan over to Hirwaun to deload Upper Boat GSP would be able to mitigate the constraint on these circuits.

This however, is not particularly effective in futureproofing the network when compared to just reinforcing as the flow through the constraint is only reduced marginally when transferring Middle Fan to Hirwaun.

New limiting factor for constraint(s) considered: Capacity of Mountain Ash GT2.

Option 5 – Build a new 33 kV circuit from Upper Boat to Nelson Primary in addition to reinforcing the Gas Yard to Upper Boat 33 kV circuits.

Capacity Released for constraint(s) considered: 5 MVA

Viable

Detailed description: This solution entails building a new circuit from Nelson 33 kV main busbar 2 (of approximately 8km) back to Upper Boat 33 kV main 3 busbar. This would give extra circuit capacity in the event Mountain Ash needs supporting from Upper Boat 33 kV GSP, and also would help futureproof the network.

The existing 33 kV circuits between Gas Yard and Upper Boat require uprating (in accordance with Network Constraint 3.1) to alleviate the constraint.

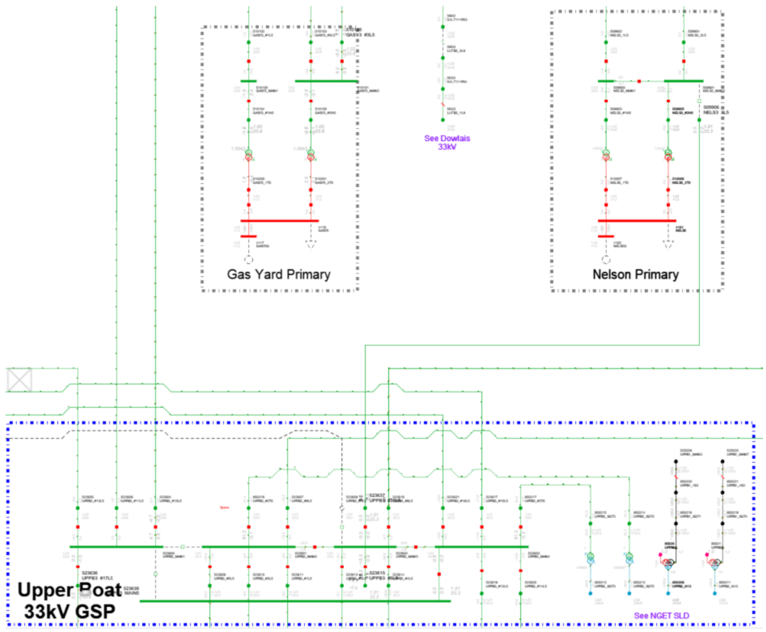

Figure 3.7.1 Proposed Upper Boat to Nelson 33 kV circuit installation

New limiting factor for constraint(s) considered:

Capacity of the 33 kV circuits between Upper Boat and Mountain Ash

Option 5 – Procure flexibility at the primaries on Upper Boat/Mountain Ash 33 kV group.

Estimated Flexibility Required (MVA): 5 MVA (by 2028) Viable

Detailed description: Flexibility services could be procured to help alleviate the projected overloads. This could rise up to 5 MVA by 2028. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

The viability of utilising flexibility will be further considered as part of the DNOA process.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process.

Following this, a technical review of establishing a new 33 kV circuit from Nelson Primary to Upper Boat, in addition to uprating the limiting 33 kV sections of the Gas Yard to Upper Boat circuit, should be carried out. This would be the most effective solution in futureproofing the network, as well as being the most effective way to ensure security of supply requirements are met.

Building this extra circuit would have the dual benefit of allowing the constraint to be mitigated until the network is split, and furthermore will allow for easier restoration of demand from either Upper Boat or Mountain Ash in the event of SCOs after the network split occurs.

3.8 Upper Boat 275/33 kV SGT Constraints

Constraint Overview

Generation | Demand

Due to projected demand and generation growth in line with the DFES scenarios, issues arise under an SCO fault of a 275/33 kV SGT. Firstly, if an arranged Upper Boat 33 kV busbar outage is followed by a fault on a 275/33 kV SGT then sections of islanded busbar are fed through the 33 kV circuits, resulting in multiple sections becoming overloaded. Secondly, if an arranged outage of a 275/132 kV SGT is followed by a 275/33 kV SGT fault then the remaining 275/33 kV SGT becomes overloaded due to the loading shifting towards Upper Boat 33 kV under the arranged outage.

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 3.8.1 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
Upper Boat SGT3	Arranged outage of Upper Boat 132 kV SGT	Fault on 275/33 kV SGT 2	2028	2028	2028	2028
Circuits on Upper Boat 33 kV network	Arranged Upper Boat 33 kV busbar outage	Fault on 275/33 kV SGT	2028	2028	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.8.1 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reinforce 33 kV circuits as well as split the network under certain arranged conditions	×	×	✓	Discounted
2	Add in new 275 kV SGT infeed and variable selector or a bus section coupler.	✓	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Upper Boat GSP	✓	✓	✓	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: Due to the first SCO, SGT3 at Upper Boat GSP is at 110% of its rating. Similarly, under an arranged 33 kV busbar outage followed by an SGT fault at Upper Boat 33 kV GSP, the Ironbridge-Morlanga 33 kV circuits as well as the Upper Boat to Tonypandy circuits are overloaded up to 130%. Doing nothing would risk damage to the circuits which could potentially lead to demand security issues in the future.

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

Option 1 – Reinforce 33 kV circuits as well as split Mountain Ash in the event of an SCO SGT fault

Capacity Released for constraint(s) considered: 5 - 8 MVA ⬇ Discounted

Detailed description: In order to accommodate the constraint, the affected 33 kV circuits (Tonypandy to Upper Boat 33 kV circuits as well as the Ironbridge/Morlanga/Creigiau 33 kV ring) should be uprated to around 30/35 MVA. This would accommodate the highest recorded power flow for a 33 kV busbar outage followed by an SGT fault. As well as reinforcing, the 33 kV network should be split after the FCO to mitigate a 33 kV SGT SCO fault (when Upper Boat 275/132 kV SGT1/4 is out for maintenance) to deload the circuits further. This would give extra capacity for further load growth. A disadvantage of splitting the network under an arranged condition where SGT1 or 4 is out, is that more customers are being moved onto single circuit risk.

This solution works well for the demand case, however during generation peak it actually makes the problem worse as demand would be shifted away from Upper Boat which is needed to offset the effects of high generation. This solution then, is viable during times of high demand, however during periods of high generation other solutions are needed.

New limiting factor for constraint(s) considered: 30 MVA capacity of the new 33 kV circuits.

Option 2 – New SGT infeed for Upper Boat 33 kV Network

Capacity released for constraint(s) considered: 100 MVA ⬆ Viable

Detailed description: As the constraint relates to an SGT SCO fault, another 275/33 kV SGT infeed could be added to Upper Boat with a variable selector that could switch the SGT between main bar 1 and main bar 3. This would help the group by adding extra capacity for future load growth, as well as nullifying the issue of power flowing between busbar sections via 33 kV circuits in the event of a busbar outage.

A disadvantage to this solution however, is that it would become obsolete if the establishment of the proposed GSP in the Hirwaun area materialises as the network at Upper Boat and Mountain Ash will run permanently split. This would mitigate the capacity issues on the 33 kV SGTs. As well as reduce circuit overloads in the event of an SCO SGT fault.

A more cost effective way of utilising a new SGT infeed is to use a "bus coupler" system whereby a new 33 kV circuit breaker is added to either end of the existing GIS 33 kV board. These two circuit breakers are then connected together via a new 33 kV bus section that can be switched in to prevent a break parallel from occurring. This would alleviate the constraint when it arises and would present a highly cost effective solution.

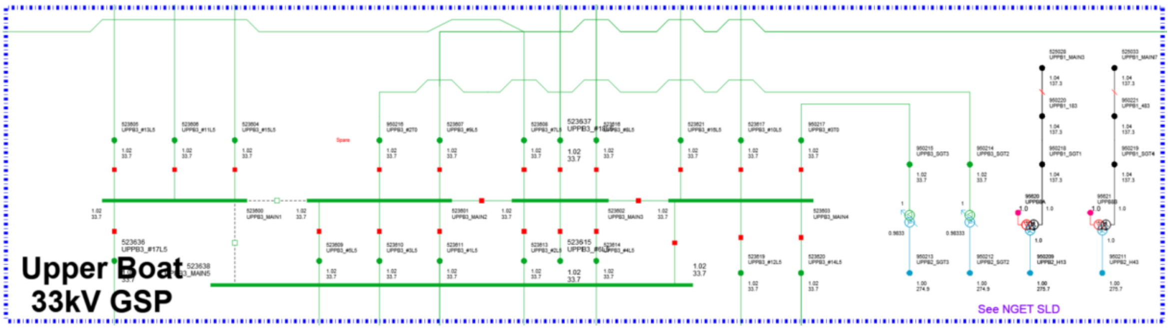

Figure 3.8.1 Proposed 33 kV bus coupler at Upper Boat GSP

New limiting factor for constraint(s) considered: The firm capacity of the SGTs.

Option 4 – Procure flexibility at Upper Boat GSP

Estimated Flexibility Required (MVA): 10 MVA total (for demand) **Viable**

Detailed description: As the constraints are only slightly above 100% for a 2028 best view case, and also considering the number of primaries on the Upper Boat network. 10 MVA could be an achievable target. 6 MVA of flexibility would need to be procured from Tonypandy and Mill Street primaries, as well as 4 MVA on the Ironbridge, Morlanga and Creigiau ring. Reinforcement may still be required on the 33 kV circuits between Tonypandy and Mill Street, as 6 MVA is a large amount to procure via two primaries. This would be an interim solution to potentially defer reinforcement.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process.

Managing the constraint in the medium term should be the priority. However, in the event where Hirwaun GSP does not materialise, then a new SGT infeed with a variable selector should be considered. This will help add extra capacity for both demand and generation, as well as enabling better flexibility in the event of a busbar outage at Upper Boat 33 kV.

As well as the proposed network rearrangement, the 33 kV bus coupler should also be installed. This would futureproof the network against break parallel events for both the generation and demand cases, and is beneficial for network integrity for both before and after Hirwaun GSP is potentially established.

3.9 Energlyn 33 kV Circuit Overload

Constraint Overview

Generation | **Demand**

For the arranged outage of Upper Boat 33 kV main busbar section 2, sections of the 33 kV circuit between Energlyn and Caerphilly experience overloads under an SCO fault of the Upper Boat –

Trethomas 33 kV circuit due to demand growth in line with the DFES projections. This is due to the group demand for Caerphilly primary being fed through a single 33 kV circuit.

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 3.9.1 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
Energlyn to Caerphilly 33 kV circuit sections	Upper Boat 33 kV Main 2 bar outage	Upper Boat-Energlyn-Trethomas 33 kV circuit	2028	2028	2028	2028

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.9.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install sections of 33 kV circuit of a higher rating	×	✓	✓	Viable
Operational Mitigation					
2	Transfer Load to Energlyn BSP under the FCO condition	✓	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Caerphilly and Trethomas primaries	✓	✓	✓	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 thermal overloads for the conditions described above.

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

Option 1 – Install 33 kV circuit section of a higher rating

Capacity Released for constraint(s) considered: 3 MVA

Viable

Detailed description: Currently, a 460m section of 33 kV underground cable is limiting the rating to the point that the constraint is occurring. Removing this section for a larger conductor would raise the rating of the cable from 19 to 22 MVA, whilst also being cost effective, this would defer larger scale reinforcement plans as there is space for additional load growth.

New limiting factor for constraint(s) considered:

Existing capacity of non-uprated 33 kV circuit sections.

Option 2 – Transfer load to Energlyn 132/11 kV BSP

Capacity Released for constraint(s) considered: 2 MVA

Viable

Detailed description: Energlyn 132/11 kV BSP has excess capacity that could be utilised by transferring demand via the 11 kV network. 4 - 5 MVA of demand could be transferred from the nearby primaries via the 11 kV network. This would allow any potential reinforcement plans on the Energlyn-Trethomas-Caerphilly group to be deferred by several years

New limiting factor for constraint(s) considered: Capacity of 11 kV circuits.

Option 4 – Procure flexibility at the primaries on the Energlyn-Trethomas and Caerphilly group.

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: As the constraint is only slightly above 100% for a 2028 Best View case, flexibility services could be procured to help alleviate the projected overloads.

The viability of utilising flexibility will be further considered as part of the DNOA process.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process.

The ideal solution for this constraint would be to use flexibility services, or if this is not possible then transfer demand to Energlyn BSP in the event of the FCO condition. The constraint is marginal enough that it should be able to be managed without reinforcement for several years after the 2028 trigger point.

3.10 Mountain Ash 33 kV busbar outage constraint

Constraint Overview

Generation Demand

Following a permanent split of the Mountain Ash 33 kV and Upper Boat 33 kV networks, 33 kV circuits experience overloads due to a Mountain Ash main 1 busbar outage (either fault or arranged). This is due to a large part of the group demand for the BSP being supplied via a 33 kV circuit from Upper Boat to Nelson. This, allied with load growth projected in line with the DFES scenarios leads to severe overloads on certain 33 kV circuit sections.

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 3.10.1 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
Various 33 kV circuits from Mountain Ash	Mountain Ash 33 kV main 1 bar outage	-	2030	2030	2030	2030

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.10.1 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install sections of circuit of a higher rating	×	×	×	Discounted
2	Build new circuit from Gas Yard to Mountain Ash.	✓	✓	✓	Viable
Flexibility services					
3	Procure flexibility at primaries on Mountain Ash BSP	✓	×	×	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 thermal overloads for the conditions described above.

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

Option 1 – Install 33 kV circuit section of a higher rating

Capacity Released for constraint(s) considered: N/A

Discounted

Detailed description: Significant amounts of 33 kV circuit would need to be replaced, as the circuit would need to be able to handle around 50 MVA in order to mitigate this constraint. This would be a highly cost inefficient way of solving the constraint.

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

Option 2 – Install a new 33 kV circuit from Gas Yard back to Mountain Ash

Capacity released for constraint(s) considered: 30 MVA

Viable

Detailed description: A new 33 kV circuit could be built back to Mountain Ash BSP main busbar 1 from Gas Yard primary main busbar 2. This new circuit should be rated at around 30 MVA.

This gives an additional path for power flow back from the Lady Windsor/Gas Yard and Nelson group to Mountain Ash BSP.

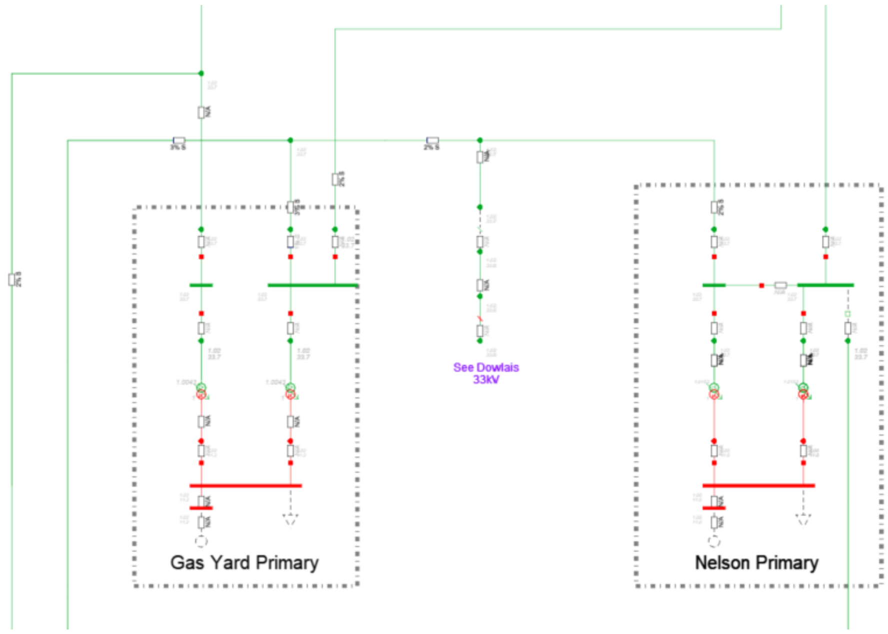

Figure 3.10.1 Concept for the new 33 kV circuit from Gas Yard to Mountain Ash BSP

This solution would be highly effective in futureproofing the group, as well as improving network integrity from both FCO and SCO issues.

New limiting factor for constraint(s) considered: Capacity of the new 33 kV circuit.

Option 3 – Procure flexibility at the primaries on the Nelson – Lady Windsor – Gas Yard group.

Estimated Flexibility Required (MVA): 23 + MVA **Viable**

Detailed description: Flexibility services could be procured within the area to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution due to estimate required. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement. Dispatch of services may be required for extended periods of time at peak demand.

The viability of utilising flexibility will be further considered as part of the DNOA process.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement in the short-term, subject to a cost benefit analysis and confirmation through the DNOA process.

The ideal solution for this constraint would be to build the new 33 kV circuit between Gas Yard and Mountain Ash. This would be the most effective way to release capacity on the Lady Windsor – Gas Yard and Nelson group.

3.11 Creigiau 33/11 kV transformer constraint

Constraint Overview

Generation **Demand**

Due to projected demand growth in line with the DFES scenarios on Creigiau Primary, both transformers (T1/T2) experience overloads due an arranged outage or fault on the adjacent unit.

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 3.11.1 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

Creigiau transformers (T1 and T2)	Loss of an adjacent transformer	-	-	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.11.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate existing 33/11 kV Transformers to CMR units	✓	×	×	Discounted
Operational Mitigation					
2	Review Seasonal Ratings	×	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Creigiau primary	✓	✓	✓	Viable

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

Detailed description: Doing nothing to mitigate the constraint would result in thermal overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Creigiau primary.

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

Option 1 – Reinforce the existing CER transformers to CMR units

Capacity released for constraint(s) considered: Between 1 – 4 MVA

Discounted

Detailed description: As the constraint occurs under intermediate warm/cool demand, the CER units could be changed for CMR units. This gives the advantage of allowing for greater capacity during the summer months, and would secure the site for the medium term future (post 2034). It is worth noting however, that due to forecasted load growth between 2034 and 2040 this solution would likely become obsolete.

New limiting factor for constraint(s) considered: Post 2034 load growth

Option 2 – Review Seasonal Ratings

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

Viable

Detailed description: Overloads are observed under intermediate cool and intermediate warm demands from 2034 onwards. An internal review of the transformer seasonal ratings may conclude that these constraints are not present as early as estimated. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating.

This could defer the overloads by a number of years.

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

Option 3 – Procure flexibility at Creigiau Primary

Estimated Flexibility Required (MVA): 2 MVA +

Viable

Detailed description: Flexibility services could be procured at Creigiau to help alleviate the projected overloads. It is unlikely that sufficient flexibility could be procured as a long-term solution. The viability of utilising flexibility will be further considered as part of the DNOA process. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

This could rise over 2 MVA by 2034.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process. An internal review of the transformer seasonal ratings should be carried out to help address the overloads observed at Creigiau Primary.

3.12 Tonypandy 33/11 kV transformer constraint

Constraint Overview

Generation **Demand**

Due to projected demand growth in line with the DFES scenarios on Tonypandy Primary, both transformers (T1/T2) experience overloads due an arranged outage or fault on the adjacent unit.

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 3.12.1 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
Tonypandy transformers (T1 and T2)	Loss of an adjacent transformer	-	-	2034	2034	-

Uncertainty under other Distribution Future Energy Scenarios: The constraints above are identified under Best View and worsened under some of the other Distribution Future Energy Scenarios. The demand in the region is generally on an upward trend indicating constraints are potentially getting worse if not addressed, but the trigger year may vary depending on how quickly demand and/or generation materialises.

Solution Options

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

Table 3.12.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					

1	Uprate existing 33/11 kV Transformers to CMR units	✓	×	×	Discounted
Operational Mitigation					
2	Review Seasonal Ratings	×	✓	✓	Viable
Flexibility services					
3	Procure flexibility at Tonypandy primary	✓	✓	✓	Viable

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in thermal overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Tonypandy primary.

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

Option 1 – Reinforce the existing CER transformers to CMR units

Capacity released for constraint(s) considered: Between 1 – 6 MVA — Discounted

Detailed description: As the constraint occurs under intermediate warm/cool demand, the CER units could be changed for CMR units. This gives the advantage of allowing for greater capacity during the summer months, and would secure the site for the medium term future (post 2034). It is worth noting however, that due to forecasted load growth between 2034 and 2040 this solution would likely become obsolete.

New limiting factor for constraint(s) considered: Post 2034 load growth

Option 2 – Review Seasonal Ratings

Capacity Released for constraint(s) considered: Dependent on mitigation — Viable

Detailed description: Overloads are observed under intermediate cool and intermediate warm demands from 2034 onwards. An internal review of the transformer seasonal ratings may conclude that these constraints are not present as early as estimated. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating. This could defer the overloads by a number of years.

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

Option 3 – Procure flexibility at Tonypandy Primary

Estimated Flexibility Required (MVA): 3 MVA + — Viable

Detailed description: Flexibility services could be procured at Tonypandy to help alleviate the projected overloads. It is unlikely that sufficient flexibility could be procured as a long-term solution. The viability of utilising flexibility will be further considered as part of the DNOA process. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement. This could rise over 3 MVA by 2034.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a cost benefit analysis and confirmation through the DNOA process. An internal review of the transformer seasonal ratings should be carried out to help address the overloads observed at Tonypandy Primary.

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