

# Aberthaw & Cardiff East Group incl. associated 132kV network

Network Development Report – South Wales

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 **Electricity  
Distribution**

**nationalgrid**

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## Document Revision and Review

Date	Comments/Changes
20/09/2023	Initial draft for review

# Aberthaw & Cardiff East Group & Associated 132 kV Network

## 1. Network Overview

Aberthaw and Cardiff East Grid Supply Points (GSPs) supply the city of Cardiff and part of the surrounding area. The two GSPs operate in parallel via three interconnecting 132 kV circuits and the group is coupled across National Grid's 275 kV and 400 kV transmission network.

This area supplies over 210,000 customers which include several significant industrial connections. A large amount of distributed generation has also been connected to the network in recent times, due to the significant renewable energy potential seen across the area.

This network is normally run standalone supplying numerous Bulk Supply Points (BSPs), whilst also benefiting from points of interconnection to Upper Boat GSP and Uskmouth GSP.

The Aberthaw and Cardiff East group currently has a maximum demand of 483 MVA and under NGEDs DFES Best View scenario this is projected to rise up to 587 MVA. This figure could grow significantly based on large developments proposed within the area.

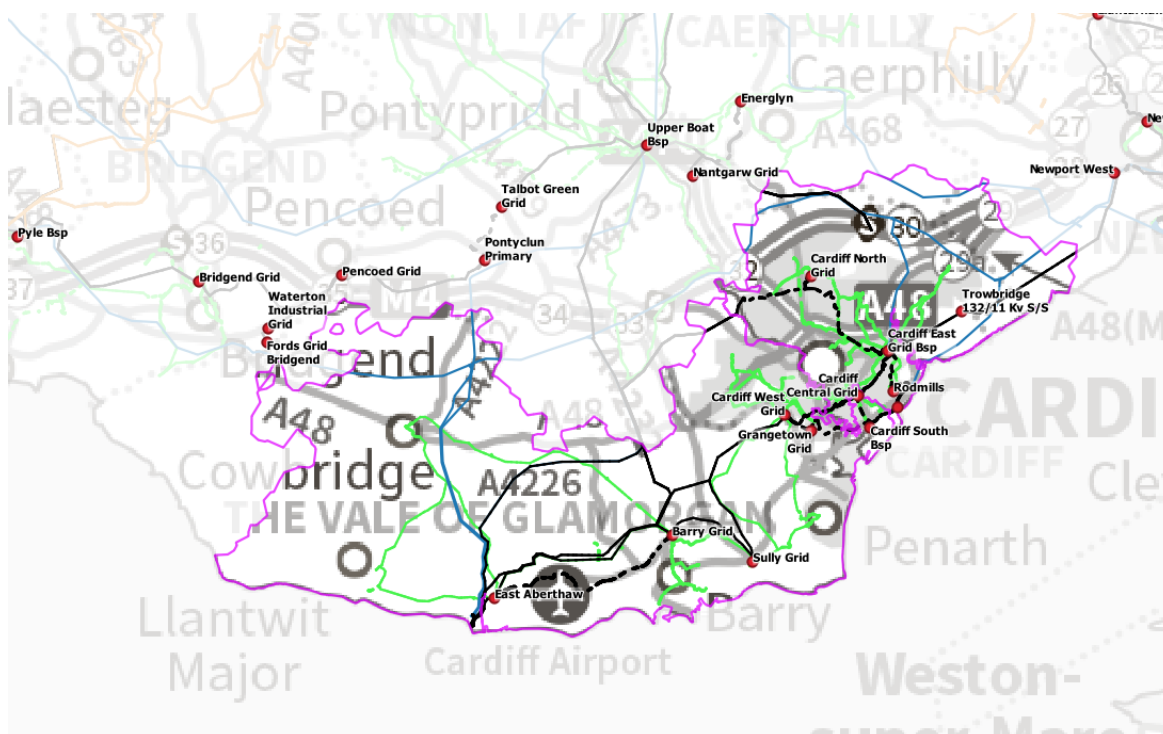


Figure 1.1 Aberthaw & Cardiff East group geographic network coverage

This report discusses all existing and future network constraints over a 0-10 year horizon associated with the 132/33kV transformers and 132kV circuits which supply and are supplied by the Aberthaw and Cardiff East group. 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 Aberthaw and Cardiff East network is arranged as follows:

- At Aberthaw GSP, there is a 275 kV double busbar that supplies five incoming circuits and three 275/132 kV Super Grid Transformers (SGTs):
  - Aberthaw SGT1 & SGT2: 180 MVA
  - Aberthaw SGT3: 240 MVA
- The three 132 kV connected SGTs supply a 132 kV double busbar arrangement with two SGTs typically in-service and SGT3 on hot-standby.
- At Cardiff East GSP, two incoming 275 kV circuits supply two 275/132 kV SGTs:
  - Cardiff East SGT2 & SGT3: 240 MVA
- The two 132 kV connected SGTs supply a three section 132 kV busbar arrangement with both SGTs typically in service.
- Aberthaw and Cardiff East GSPs operate in parallel via three interconnecting circuits through the Cardiff 132 kV network.
- The following 132/11 kV Bulk Supply Point (BSPs) are supplied by this group:
  - Cardiff South, Grangetown, Rover Way, Sully and Trowbridge
- The following 132/11 kV Bulk Supply Point (BSPs) are supplied by this group:
  - Brynhill, Cardiff Central, Cardiff North, Cardiff West and East Aberthaw
- Cardiff East has a pair of 132/33 kV and a pair of 132/11 kV Grid Transformers (GTs) fed directly from the 132 kV busbar arrangement within the GSP compound, supplying a 33 kV and 11 kV network respectively.

SLM 949  
Cardiff & Aberthaw 132kV

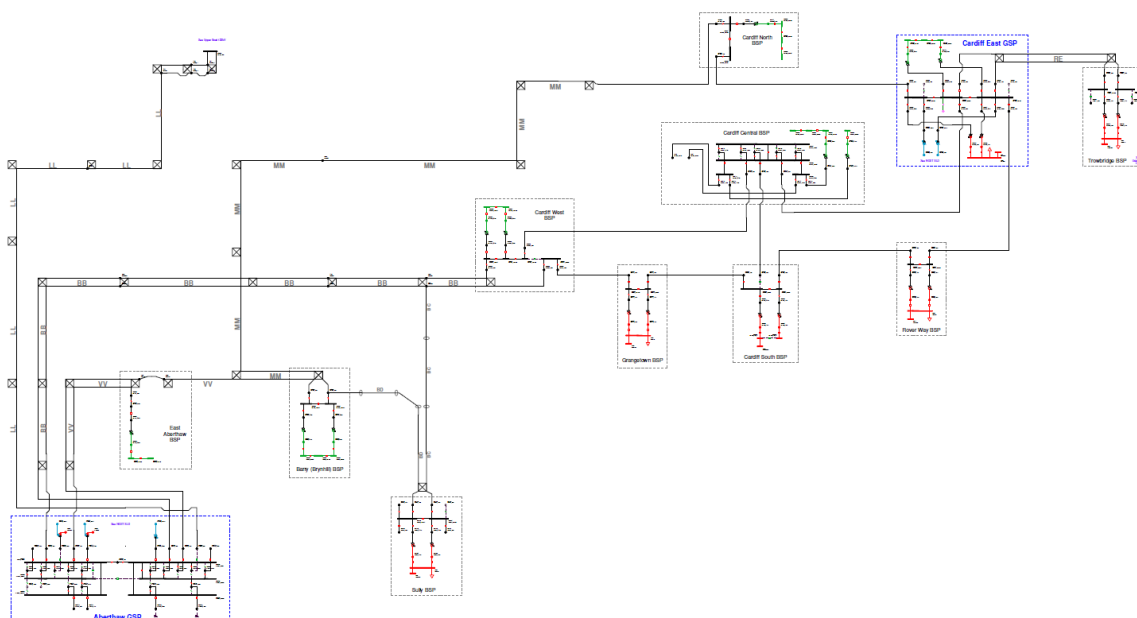


Figure 1.1.1 Aberthaw & Cardiff East 132 kV network single line diagram

## 1.2 Network Operability Modelling

The following network automation and manual switching schemes have been modelled in the analysis of this area, aligning to how the network is currently operated.

- Aberthaw SGT3 is currently run on hot standby with an auto-close scheme in place to operate for the loss of either Aberthaw SGT1 or SGT2.
- Aberthaw SGT3 can also be brought into service for an arranged outage of Cardiff East SGT 2 or SGT3.
- The LL-route 132 kV circuit offers interconnection with Upper Boat GSP, which is held normally open on line breaker 605 at Aberthaw GSP.
- For an arranged SGT outage at Upper Boat, the Aberthaw 132 kV main bar is split away from the reserve bar and is used to connect Aberthaw SGT3 to the Upper Boat group via Aberthaw 605.
- The R-route 132 kV circuit offers interconnection with Uskmouth GSP, which is held normally open on line breakers 305 and 405 at Trowbridge BSP. This interconnection is primarily used to improve supply security.
- For the loss of an infeed to a transformer at any of the primaries fed from within the Aberthaw and Cardiff East 132 kV network 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. In addition to such sites that are required to participate in an Aberthaw/Cardiff East Distribution Active Network Management (DANM) scheme to manage the power flow on constrained 132 kV circuits.
- Various winter arranged outages not permitted due to SCO overloads.
- Various SCO overloads solved by network reconfiguration for arranged outages.

## 2. Network Constraint Details and Solution Options

### 2.1 Aberthaw and Cardiff East 132 kV Group

The table below summarises the scale of the background load growth forecast to connect to the Aberthaw and Cardiff East 132 kV network up to 2034 under NGEDs DFES Best View scenario.

**Table 2.1.1 Maximum demand forecast to connect to the Aberthaw & Cardiff East group**

DFES Scenario	Demand		
	Baseline	2028	2034
Best View	407 MW	420 MW	512 MW

**Table 2.1.2 Maximum generation forecast to connect to the Aberthaw & Cardiff East group**

DFES Scenario	Generation		
	Baseline	2028	2034
Best View	121 MW	198 MW	321 MW

## 2.2 Large Scale Demand Growth

The area to the west of Cardiff has been outlined in Local Development Plans for some time as an area proposed for large scale development. As suggested in previous Shaping Subtransmission reports published by National Grid Electricity Distribution, if such industrial and commercial demand growth were to materialise it would require consideration as to how the network development plan needs to change to accommodate this level of growth.

By 2034 and in-line with Local Development Plans and several large new connections that are expected to connect within the group, this figure could rise in excess of 1200 MW.

The constraints this could cause and the network reinforcement required to mitigate against this level of growth will be dependent on the geographic locations of the connecting demand and their capacity.

With new developments proposed at 11 kV, 33 kV and at 132 kV, the load forecast is expected to rapidly increase. This group becomes vulnerable to outage conditions throughout the 0-10 year horizon period as a result of the load growth projections. These limitations are highlighted below.

## 2.3 Aberthaw and Cardiff East 132 kV Group Capacity

### Constraint Overview

 **Generation**  **Demand**

For arranged outages in the Upper Boat 132 kV network, Aberthaw SGT3 can be utilised to provide support to Upper Boat GSP. A subsequent fault of the Aberthaw/Pyle/Cardiff East 275 kV circuit can lead to three SGTs remaining in-service to supply the entire group:

- Aberthaw SG1 & SGT2 and Cardiff East SGT3

Fault outages of the Aberthaw/Pyle/Cardiff East 275 kV circuit are of particular concern, since they leave Aberthaw and Cardiff East supplied by remote parts of the transmission network.

NGEDs Aberthaw and Cardiff East 132 kV network is coupled across National Grid's transmission network. Load share between Cardiff East GSP and Aberthaw GSP can alter drastically depending upon the loading and configuration of the transmission network. In turn, this affects the loading of NGEDs 132 kV and 33 kV circuits between Cardiff East GSP and Aberthaw GSP.

In-line with the load growth projected the 132 kV circuits between Aberthaw and Cardiff East become heavily loaded under various network running conditions.

The firm capacity of the group under this SCO combination reduces from 840 MVA to 600 MVA.

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

**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
SGT overloads at Cardiff East And Aberthaw	Arranged Upper Boat 132 kV SGT outage	Aberthaw / Pyle / Cardiff East 275 kV circuit fault (FCO/SCO issue)	2028	2028	2028	2028
Various 132 kV circuit overloads between Aberthaw GSP and Cardiff East GSP	Arranged outage impacting either Aberthaw / Cardiff East 132 kV main busbars	Fault to either Aberthaw to Cardiff East 132 kV circuit				



## 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	x	x	x	Discounted
<b>Reinforcement</b>					
1	Add additional / uprate existing SGTs at Aberthaw and Cardiff East GSPs	✓	✓	✓	Viable
2	Reconductor and/or reprofile the existing 132 kV circuits between Aberthaw and Cardiff East GSPs	x	x	✓	Discounted
3	Maintain a parallel 132 kV network	x	x	x	Discounted
4	Rationalise the 132 kV network into two independent groups	✓	✓	✓	Viable
5	Establish a new Grid Supply Point	✓	✓	x	Discounted
<b>Flexibility services</b>					
6	Procure flexibility across the group	x	✓	✓	Viable

**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 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 the Aberthaw and Cardiff East 132 kV group.

**Existing limiting factor for constraint(s) considered:**

Existing Aberthaw 180 MVA SGT Rating and 132 kV circuit capacity

### Option 1 – Add additional / uprate existing SGTs at Aberthaw and Cardiff East GSPs

**Capacity Released for constraint(s) considered:** Additional SGT capacity

 **Viable**

**Detailed description:** SGT overloads appear across both Aberthaw and Cardiff East GSPs under various outage conditions, including fault outages of the Aberthaw/Pyle/Cardiff East 275 kV circuit. By 2028 additional or replacement SGTs will be required to alleviate the overloads observed.

SGT overloads increase by 2034 and subject to several proposed developments materialising as expected, these overloads can occur under intact network conditions.



By 2028, it is proposed that Aberthaw SGT1 and SGT2 are replaced with 240 MVA units, however due to the load share and imbalance observed between Cardiff East GSP and Aberthaw GSP, Cardiff East SGT overloads remain. Furthermore, significant load growth is anticipated in the Aberthaw region in the upcoming years that is likely to require additional capacity to be released.

It is recommended that a discussion with NGET is had to determine if these overloads are within the short-term ratings of the Aberthaw and Cardiff East SGTs or if any operational mitigation is in place to manage these overloads, such as being able to transfer load out of the group or mitigating measures such as 275 kV or 132 kV auto-close schemes.

Short term ratings for the SGT might be useful to maximise the available capacity, assuming there are available load transfers to redistribute the load. This could defer the overloads by a number of years.

All of the SGTs in the group may require uprating to 360 MVA units alongside an additional 360 MVA unit at Aberthaw GSP before 2034. Due to the nature of the surrounding 132 kV network, detailed network design will be required to assess if uprating the existing SGTs and establishing an additional SGT into this network trigger fault level constraints.

If limits are exceeded, then an alternative solution maybe to rationalise the 132 kV network into two independent groups. This has the dual advantage of also alleviating 132 kV circuit constraints that arise due to the projected load growth across this 132 kV network (please see Option 4).

#### **New limiting factor for constraint(s) considered:**

Aberthaw and Cardiff East 132 kV group fault level

### **Option 2 – Reconductor and/or reprofile the existing 132 kV circuits between Aberthaw and Cardiff East GSPs**

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

 **Discounted**

**Detailed description:** Several Aberthaw to Cardiff East 132 kV circuits overload in-line with the demand/generation growth forecast under various first and second circuit outage conditions. To alleviate the constraints observed by 2028, it is proposed that the following circuits are reprofiled for operation at 75°C in order to allow a higher thermal rating:

- 18km of 132kV dual circuit tower line from Aberthaw GSP to Cardiff West BSP
- 12km of 132kV dual circuit tower line from Aberthaw GSP to Brynhill BSP
- 15km of 132kV dual circuit tower line from Brynhill BSP to Cardiff North BSP

These works would however be subject to a detailed tower line survey and consenting process where necessary.

By 2034, significant load growth is likely to require an additional 132 kV circuit to be installed between Aberthaw and Cardiff East to fully alleviate the 132 kV circuit overloads observed.

As noted above, a reinforcement strategy to rationalise the 132 kV network into two independent groups is likely to provide the most network benefit in the long term, alleviating both SGT and 132 kV circuit constraints (please see Option 4).

#### **New limiting factor for constraint(s) considered:**

Aberthaw to Cardiff East 132 kV circuit capacity under outage conditions

### **Option 3 – Maintain a parallel 132 kV network**

**Capacity released for constraint(s) considered:** Dependent on SGT capacity  **Discounted**

**Detailed description:** Given this large scale demand growth, a reinforcement strategy will be required in order for the Aberthaw and Cardiff East group to continue to operate in parallel. This is to ensure that additional capacity is available to supply both GSPs and the associated network up to the end of this assessment period and beyond.

To maintain a parallel network, a detailed reinforcement plan for the Aberthaw and Cardiff East group could include:

- Replacement of the existing Cardiff East SGTs to 360 MVA units if achievable
- Replacement of the existing Aberthaw SGTs to 360 MVA units if achievable
- Installation of a fourth SGT at Aberthaw GSP (in the order of 360 MVA)
  - This will require 275 and 132 kV switchgear installation and busbar extension works to facilitate an additional SGT unit
- Establishment of a 4th interconnecting 132 kV circuit between Aberthaw and Cardiff East:
  - Return to service the non-energised 132 kV circuit on one side of the MM route between Barry/Brynhill BSP and Cardiff North BSP
  - New 132 kV circuits sections will be required between East Aberthaw BSP & Barry/Brynhill BSP and between the MM route cable termination and Cardiff East GSP, via Cardiff North BSP, to facilitate this interconnection
- Reprofile the existing 132 kV circuits between Aberthaw GSP and Cardiff East GSP to maximise the capacity of existing routes through the Cardiff 132 kV network

Depending on the loading and configuration of the transmission network, load imbalance across the interconnected could still cause circuit constraints, options for preventing or resolving such overloads could include:

- Commissioning overload protection to trip circuit breakers and split the 132 kV network between Aberthaw and Cardiff East if overloads occur.
- Commissioning an operational tripping scheme (OTS) to automatically and immediately split the 132 kV parallel between Aberthaw and Cardiff East in the event of any transmission network outage which would trigger overloads.

With the addition of more 132 kV infeeds into the network, fault level across the network will increase. This could lead to potential fault level issues if this parallel network is to remain. An assessment would be required to determine if switchgear would be rated sufficiently.

#### **New limiting factor for constraint(s) considered:**

Aberthaw and Cardiff East 132 kV group fault level

### **Option 4 – Rationalise the 132 kV network into two independent groups**

**Capacity Released for constraint(s) considered:** Dependent on network split  **Viable**

**Detailed description:** An alternative proposal is to permanently split the 132 kV network between Aberthaw and Cardiff East to futureproof the network moving forward. This proposal has the dual benefit of releasing capacity whilst alleviating the load imbalance currently observed between Aberthaw GSP and Cardiff East GSP.

Additional SGT capacity, as proposed in Option 3, is still a requirement to accommodate the load growth forecast, in particular if the large scale developments materialise to the west of Cardiff (please see Network Constraint 2.3). Reprofitting the existing 132 kV circuits between Aberthaw GSP and Cardiff East GSP will also be a requirement, to ensure each circuits can provide support to either BSP under outage conditions.

It is proposed that a detailed reinforcement plan to permanently split the Aberthaw and Cardiff East 132 kV group is developed, to facilitate the most economical network split, to include either:

Option A:

- Installation of a 132 kV circuit from the end of the dual circuit tower line on the MM route to Cardiff North BSP with split points proposed at Cardiff West 220 and Cardiff East 705.

This option will require the return to service off the non-energised 132 kV circuit on one side of the MM route between Barry/Brynhill BSP and Cardiff North BSP, with additional works required to facilitate this restoration.

#### Option B:

- Installation of 132kV circuits from Cardiff East GSP to Cardiff North BSP and from Cardiff East GSP to Rover Way BSP with split points proposed the Aberthaw side of both BSPs.

These splits allow for transfer capacity between Aberthaw and Cardiff East GSPs under second circuit outage conditions. Transferring load between groups under arranged outages can be used to ensure high levels of demand resilience, however this needs to be managed against existing circuit and SGT loadings in the adjacent group.

It is suggested that a review of the load share across the Aberthaw and Cardiff East 132 kV group is carried out in conjunction with a continual review and assessment of the projected load growth to determine the most credible points to split the network, ensuring demand security compliance throughout the forecasted load growth period and beyond

#### New limiting factor for constraint(s) considered:

Aberthaw to Cardiff East 132 kV circuit capacity under outage conditions

### Option 5 – Establish a new Grid Supply Point

**Capacity Released for constraint(s) considered:** Up to 360 MVA

 **Discounted**

**Detailed description:** Given the geographic area supplied, it may be a possibility to transfer load away from the Aberthaw and Cardiff East group by establishing a new GSP, north of Aberthaw, instead of expanding this group further.

Furthermore, in conjunction with option 4, establishing an SGT infeed within the Cardiff East group would allow for the greater transfer of load from Aberthaw/Cardiff East, particularly with a third SGT in the group. Cardiff East would also be less susceptible to SCO SGT overloads.

**New limiting factor for constraint(s) considered:** 132 kV circuits in Cardiff East/Aberthaw GSP

### Option 6 – Procure flexibility across the Aberthaw and Cardiff East group

**Estimated Flexibility Required (MVA):** 90+ MVA by 2034 (Best View)

 **Viable**

**Detailed description:** Flexibility services could be procured throughout the Aberthaw and Cardiff East network to help alleviate the projected overloads. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement and may not be a viable permanent solution

Given the flexibility of the 132kV network in transferring large tranches of load and the possibility that the timing in the deployment of large new connections might vary in both this and adjacent groups, it should be investigated what quantity of Flexibility Services might be available to call on.

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

## Solution Recommendation

The timing and trigger of such works would be heavily reliant on the new developments materialising, and in some cases, contributing to the works. The modelling of such reinforcement may mask the impact of other demand growth in the Cardiff area.

It is recommended that the projected load growth is continually assessed and reviewed to ensure that the solutions proposed encompass a credible future.

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 assessment of available demand transfers in conjunction with short-term ratings should be reviewed to help with the initial overloads observed at Aberthaw/Cardiff East GSP.

Following this, a technical review of reinforcement strategies should be carried out.

Detailed network design will be required to assess the proposed reinforcement strategies against the projected demand and generation growth, including but not limited to:

- Running arrangements for outage management, particularly for transmission network outages
- Protection and fault level studies

Option 4 is likely to provide greater network operability while also improving network security and resilience, particularly by splitting this 132 kV network moving forward. This option allows for future load growth within the Cardiff and Aberthaw area, alleviating the load imbalance observed across this assessed period while ensuring demand security compliance throughout the forecasted load growth period and beyond.



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