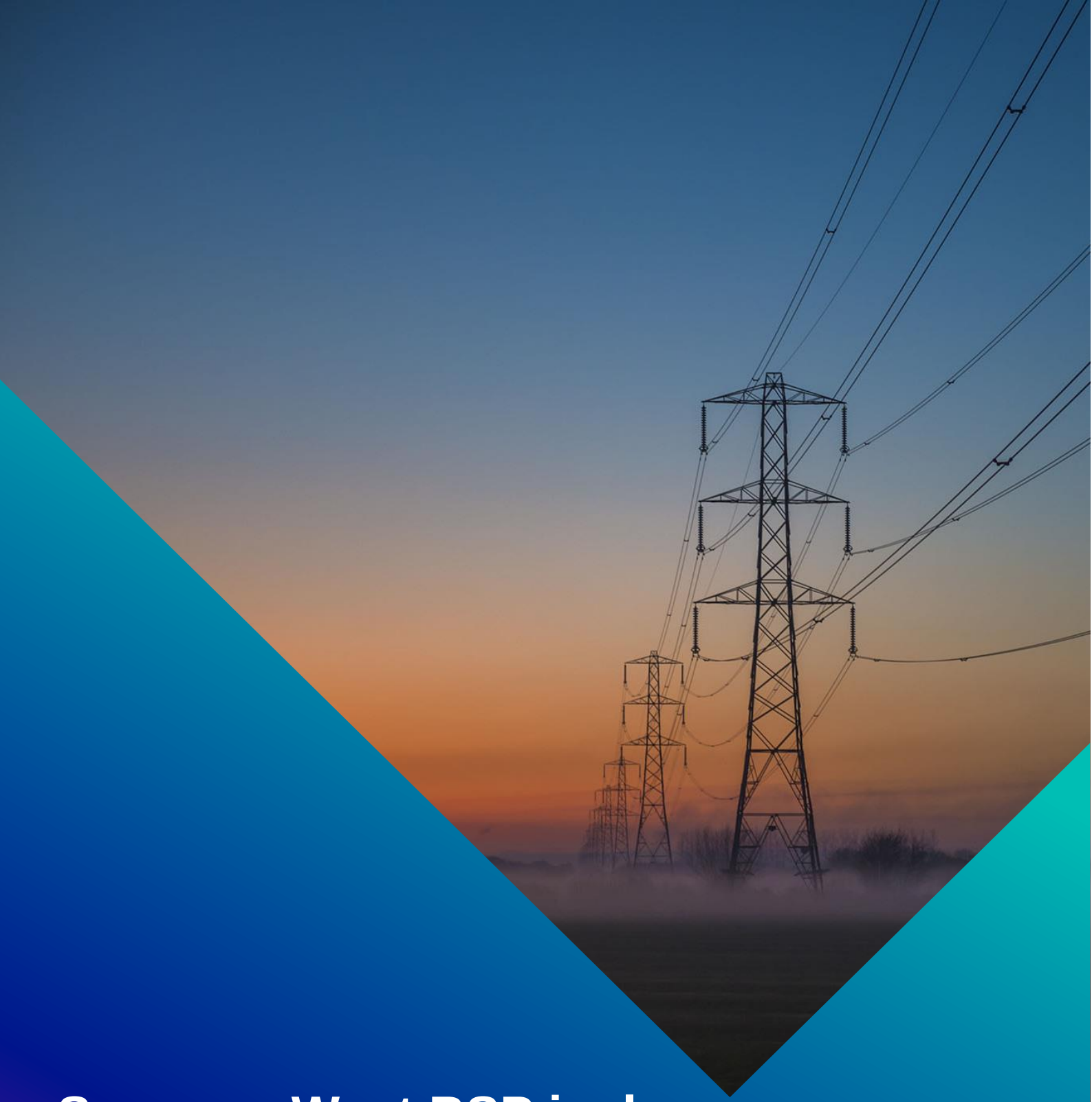

# Swansea West BSP incl. associated 33 kV network

Network Development Report – South Wales

**May 2024**

Electricity Distribution

nationalgrid

# Contents

# Swansea West BSP & Associated Network

## 1. Network Overview

Swansea West Bulk Supply Point (BSP) supplies an area of 33 kV network close to the Swansea Bay region. It is supplied by two 132/33 kV 90 MVA Grid Transformers (GTs) and fed via two 132 kV circuits from Swansea North GSP. The associated 33 kV network feeds a mostly urban area supplying over 50,000 customers that includes the following 33/11 kV Primary substations:

- Bishopston, Llanrhidian, Ravenhill, Sketty Park, Swansea Trading Estate, Uplands and West Cross.

There is distributed generation connected to both the 33 kV and 11 kV networks, in a variety of different technology types, including STOR and PV.

Swansea West BSP currently has a maximum demand of 58.85 MVA and under NGED's DFES Best View scenario this is projected to rise to 72.72 MVA by the year 2034.


*Figure 1.1 Swansea West BSP geographic network coverage*

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

For the purposes of this analysis the NGED Best View Distribution Future Energy Scenario (DFES) has been used to study the years 2022 (baseline), 2028 and 2034, with consideration given to how proposals could change under the other scenarios.

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 Swansea West 33 kV network is arranged as follows:

- Swansea West 132/33 kV BSP has two GTs (GT1 and GT2) both rated at 45/90 MVA and is currently run in parallel supplying a two-section indoor 33 kV switchboard. The outgoing 132 kV circuits are supplied from Swansea North GSP.
- Outgoing 33 kV circuits from Swansea West BSP supply the following eight 33/11 kV primary substations:
    - Bishopston: Two 5/6.25 MVA primary transformer substation (T1 & T2)
    - Llanrhidian: Two 5/6.25 MVA primary transformer substation (T1 & T2)
    - Ravenhill: Two primary transformer substation, with

      T1 (12/24 MVA) and T2 (10/14 MVA).
    - Swansea Trading Est: Two 12/24 MVA primary transformer substation (T1 & T2)
    - Sketty Park: Two 10/14 MVA primary transformer substation (T1 & T2)
    - Uplands: Two 15/21 MVA primary transformer substation (T1 & T2)
    - West Cross: Two 7.5/10 MVA primary transformer substation (T1 & T2)
- A 33 kV interconnection to Swansea North and Tir John is tee'd into the Ravenhill T1 to Swansea West 33 kV circuit. This circuit, which is normally run open at Ravenhill, can provide 33 kV interconnection between Swansea West, Swansea North and Tir John BSPs under select operating conditions.
- A 33 kV interconnection to Swansea North is also tee'd into the Llanrhidian T1 to Swansea West 33 kV circuit. This circuit, which is normally run open at Waunarlwydd, can provide 33 kV interconnection between Swansea West and Swansea North under select operating conditions.

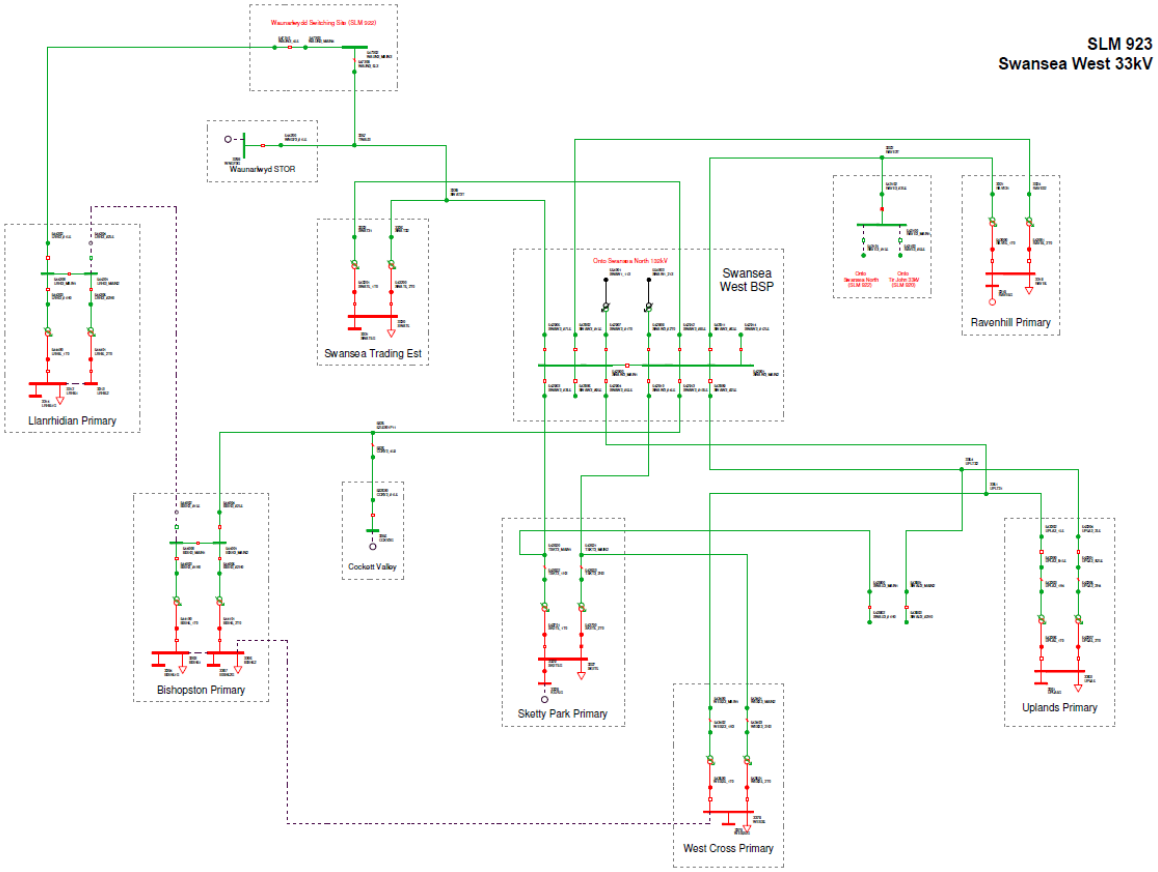


*Figure 1.1.1 Swansea West 33 kV network single line diagram*

## 1.2 Network Operability Modelling

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

- For an arranged outage impacting either 33 kV circuit supplying Llanrhidian or Bishopston from Swansea West BSP, the 33 kV circuit installed between Bishopston and Llanrhidian which is normally run open at Llanrhidian 2L5, can be closed into service to provide support to either primary depending on the outage.
- Bishopston has an 11 kV interconnection with West Cross which is typically run split under intact network conditions. This interconnector can be closed into service to restore load from either primary depending on the outage.
- The 33 kV circuit to Ravenhill Primary that can provide interconnection between Swansea West, Swansea North and Tir John BSPs is primarily utilised to support either BSP following Second Circuit Outage (SCO) conditions. From a Swansea West 33 kV standpoint, this could be in the event of both GTs being out of service.
- The 33 kV circuit to Ravenhill Primary that can provide interconnection between Swansea West and Swansea North BSPs is also utilised to support either BSP following SCO conditions, in a similar manner as above.
- For the loss of an infeed to a transformer at any of the primaries fed from within the Swansea West 33 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.
- 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:

- Swansea West 33 kV Constraints:
    - Ravenhill 33/11 kV Primary Transformer overload
    - Llanrhidian – Waunarlwydd 33 kV circuit overload

# 3. Network Constraint Details and Solution Options

## 3.1 Swansea West 33 kV Group

The table below summarises the scale of the demand and generation forecast to connect to the Swansea West 33 kV network up to 2034 under NGEDs DFES Best View scenario.

*Table 3.1.1 Maximum demand forecast to connect to the Swansea West 33 kV network*

| DFES Scenario | Demand | | |
|---|---|---|---|
| | Baseline | 2028 | 2034 |
| Best View | 58.85 MW | 63.47 MW | 72.72 MW |

By 2034, this figure takes into account an additional 2.74 MW due to the anticipation of hydrogen electrolysis projected to connect in this area.

*Table 3.1.2 Maximum generation forecast to connect to the Swansea West 33 kV network*

| DFES Scenario | Generation | | |
|---|---|---|---|
| | Baseline | 2028 | 2034 |
| Best View | 33.03 MW | 40.40 MW | 52.46 MW |

With new developments proposed to connect within the group at 11 kV and at 33 kV in the near future, the demand and generation forecast is expected to increase. However, this will vary depending if such developments materialise.

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.

## 3.2 Ravenhill 33/11 kV Primary Substation

### Constraint Overview

Generation **Demand**

Ravenhill Primary Substation is a two 33/11 kV transformer site and is supplied by two 33 kV circuits from Swansea West BSP. The primary currently has a pair of mismatched transformers and the firm capacity of the substation is limited by the smaller of the two transformers, T2 which is rated at 10/14 MVA.

For a First Circuit Outage (FCO) (arranged or fault) which results in the loss of Ravenhill T1, the lower rated transformer T2 in service begins to overload in-line with future load growth projections.

Ravenhill group demand is projected to reach 14.5 MVA by 2028 and rise over 18.8 MVA by 2034.

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

*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 |
| Ravenhill T2 remaining in-service | Outage to Ravenhill T1 (arranged or fault) | None | 2028 | 2029 | 2031 | 2032 |

### Solution Options

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

*Table 3.2.1 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 | Uprate transformer T2 at Ravenhill | ✓ | ✓ | ✓ | Viable |
| 2 | Install a third transformer T3 at Ravenhill | ✓ | ✓ | × | Viable |
| 3 | Reinforce 11 kV circuits to transfer demand to other Primaries | ✓ | × | × | Discounted |
| **Operational Mitigation** | | | | | |
| - | *None Identified* | - | - | - | - |
| **Load Management Schemes** | | | | | |
| - | *None Identified* | - | - | - | - |
| **Flexibility services** | | | | | |
| 4 | Procure flexibility at Ravenhill Primary | × | ✓ | ✓ | Viable |

**Uncertainty under other Distribution Future Energy Scenarios:** This constraint is not an issue under the current baseline scenario. It first becomes present by 2026 under Leading the Way. Under Consumer Transformation and Best View, the constraint is observed by 2028. Under System Transformation and Falling Short, the constraint is not observed until 2032 and 2034 respectively.

### 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 transformer overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Ravenhill Primary.

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

Ravenhill T2 with a CMR value of 14 MVA.

## Option 1 – Uprate transformer T2 at Ravenhill

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

**Viable**

**Detailed description:** Uprating the T2 transformer at Ravenhill to a 12/24 MVA unit to match T1 (including works to remove associated ancillary rating limitations) would alleviate all the overloads observed at the primary up to 2034 and beyond.

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

Ravenhill T1/T2 with a 23 MVA (winter cyclic) and 18 MVA (summer cyclic) rating.

## Option 2 – Install a third transformer T3 at Ravenhill

**Capacity Released for constraint(s) considered:** 27.2 MVA

**Discounted**

**Detailed description:** Installing a new 12/24 MVA primary transformer alongside the existing units at Ravenhill (including works to remove associated ancillary rating limitations) would alleviate all the overloads observed at the primary up to 2034 and beyond.

This may prove difficult to achieve due to the existing substation footprint and lack of space available that would be required to install this unit alongside the extension of the 11 kV switchboard that would be needed to facilitate this work.

If achievable however, a third 33 kV circuit from Ravenhill to Swansea West BSP would be required to facilitate this proposal. A circuit length of approximately 2.5 km would be needed, constructed to 185 $mm^2$ copper EPR cable or similar.

This option has been discounted based on the overall network benefit it would provide, in-line with the load growth anticipated and is unlikely to be viewed as a cost-effective solution.

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

Combination of the either T1 & T2 or T2 & T3 in-service during FCO conditions:

41.2 MVA (winter cyclic) and 32.5 MVA (summer cyclic) rating.

## Option 3 – Reinforce 11 kV circuits to transfer demand to other Primaries

**Capacity Released for constraint(s) considered:** 5 MVA by 2034

**Discounted**

**Detailed description:** To release additional capacity available at Ravenhill Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries. Swansea Trading Estate Primary is located within 1.5 km of Ravenhill and is the only realistic option for support.

Approximately 5 MVA would need to be transferred away from Ravenhill to alleviate the overloads observed up to 2034.

The 11 kV interconnection has not been studied in detail, further analysis of the 11 kV network surrounding Ravenhill would be required to fully analyse any potential transfer capability. However

there may not be enough spare capacity available to transfer such a substantial load to resolve the constraints without causing further issues.

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

Existing Ravenhill T2 with a CMR value of 14 MVA.

**Option 4 – Procure flexibility at Fishguard Primary**

**Flexibility service type:** Demand turn down or generation turn up

Viable

**Detailed description:** Flexibility services could be procured at Ravenhill to help alleviate the projected overloads. 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 up to 5 MVA by 2034.

### 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. Following this, it is recommended that the existing 33/11 kV transformer T2 at Ravenhill (Option 1) is uprated to a 12/24 MVA unit to match T1.

Option 1 may prove to be the most cost-effective long term option and would also be compatible with the existing site layout at Ravenhill Primary. This option will also ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

## 3.3 Llanrhidian to Waunarlwydd 33 kV Circuit

Generation Demand

### Constraint Overview

For an arranged FCO which results in the loss of the 33 kV circuit supplying Bishopston from Swansea West BSP, the 33 kV circuit between Bishopston and Llanrhidian which is normally run open at Llanrhidian 2L5, can be closed into service to provide support to Bishopston.

In-line with the future load growth, the 33 kV circuit from Llanrhidian to Waunarlwydd will overload towards the end of this assessed period when required to support both primaries. Furthermore, voltages at the remote ends of the circuit begin fall below statutory limits when Bishopston is supplied entirely from Llanrhidian.

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/warm 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 |
| Llanrhidian to Waunarlwydd 33 kV circuit overload and low voltages observed | Arranged outage of Bishopston to Swansea West 33 kV circuit | None | 2033 | 2033 | 2033 | 2034 |

### 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 | Reprofile the Llanrhidian to Bishopston 33 kV circuit | ✓ | ✓ | ✓ | **Viable** |
| 2 | Reconductor the Llanrhidian to Bishopston 33 kV circuit | ✓ | ✓ | ✓ | **Viable** |
| **Operational Mitigation** | | | | | |
| 3 | Transfer load to nearby primaries | ✓ | ✓ | ✓ | **Viable** |
| **Load Management Schemes** | | | | | |
| - | *None Identified* | - | - | - | - |
| **Flexibility services** | | | | | |
| 4 | Procure flexibility at both primaries | × | ✓ | ✓ | **Viable** |

**Uncertainty under other Distribution Future Energy Scenarios:** This constraint is not an issue under the current baseline scenario. It first becomes present by 2030 under Leading the Way and Consumer Transformation. Under Best View and System Transformation, the constraint is not observed until 2033. Falling Short is observed by 2034.

## Solution Development

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

### Option 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. The network would still be susceptible to voltages outside of statutory limits under the same conditions outlined.

This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for this group.

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

Llanrhidian to Waunarlwydd 33 kV circuit: 11.5 MVA (winter variable pre-fault)

### Option 1 – Reprofile the Llanrhidian to Bishopston 33 kV circuit

**Capacity Released for constraint(s) considered:** 2.5 MVA ⬆ **Viable**

**Detailed description:** The Llanrhidian to Waunarlwydd 33 kV circuit rating is expected to be reached by 2033 under winter peak, intermediate cool and intermediate warm demand conditions. Reprofiling approximately 13.7 km of the limiting 0.05 sq.in. HDC conductor for operation at 75°C would resolve this overload.

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

Llanrhidian to Waunarlwydd 33 kV circuit: 14 MVA (winter variable pre-fault)

### Option 2 – Reconductor the Llanrhidian to Bishopston 33 kV circuit

**Capacity Released for constraint(s) considered:** 6.1 MVA ⬆ **Viable**

**Detailed description:** Reprofiling the existing circuit, in accordance with the option above, will release an additional 2.5 MVA in capacity which will alleviate the overloads observed, however only for a number of years beyond 2034. If the limiting overhead line sections are reconductored to 0.1 sq.in. HDC conductor or similar, this will further extend the support that can be provided by this circuit.

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

Llanrhidian to Waunarlwydd 33 kV circuit: 17.6 MVA (winter variable pre-fault)

### Option 3 – Transfer load to nearby primaries

**Capacity Released for constraint(s) considered:** 3 MVA by 2034 **Viable**

**Detailed description:** Bishopston has an 11 kV interconnection with West Cross which is typically run split under intact network conditions. This interconnector can be closed into service to restore load from either primary depending on the outage.

The 11 kV interconnection has not been studied in detail, further analysis of the 11 kV network between Bishopston and West Cross would be required to fully analyse any potential transfer capability. However if a transfer in the order of 3 MVA is achievable from Bishopston to West Cross under this FCO condition then this would alleviate the constraints observed across this assessed period.

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

Existing Llanrhidian to Waunarlwydd 33 kV circuit: 11.5 MVA (winter variable pre-fault)

### Option 4 – Procure flexibility at both primaries

**Flexibility service type:** Demand turn down or generation turn up **Viable**

**Detailed description:** Flexibility services could be procured at both Bishopston and Llanrhidian to help alleviate the projected overloads. 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 up to 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.

Following this, a technical review of reprofiling and/or reconductoring the existing 33 kV circuit sections between Llanrhidian to Waunarlwydd should be made (Option 1 or 2). It is recommended that the 11 kV interconnection to West Cross is maintained and used to support Bishopston in conjunction with either Option above to avoid Bishopston being supplied entirely from Llanrhidian, notably to overcome the low voltage concerns.

An assessment of the available 11 kV transfers between Bishopston and West Cross should be carried out initially as possible mitigation to manage the constraints observed.

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Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB
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