Port Ham (Walham) GSP Network

Network Development Report – West Midlands

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Electricity Distribution

nationalgrid

Contents

Port Ham (Walham) GSP Network

1. Network Overview

Port Ham (Walham) is a 132 kV Grid Supply Point (GSP) that supplies large parts of Gloucestershire and parts of Hereford area connecting over 229,000 customers. The network comprises several 132 kV circuits supplying nine Bulk Supply Points (BSPs) in total covering 132/66 kV, 132/33 kV and 132/11 kV sites.

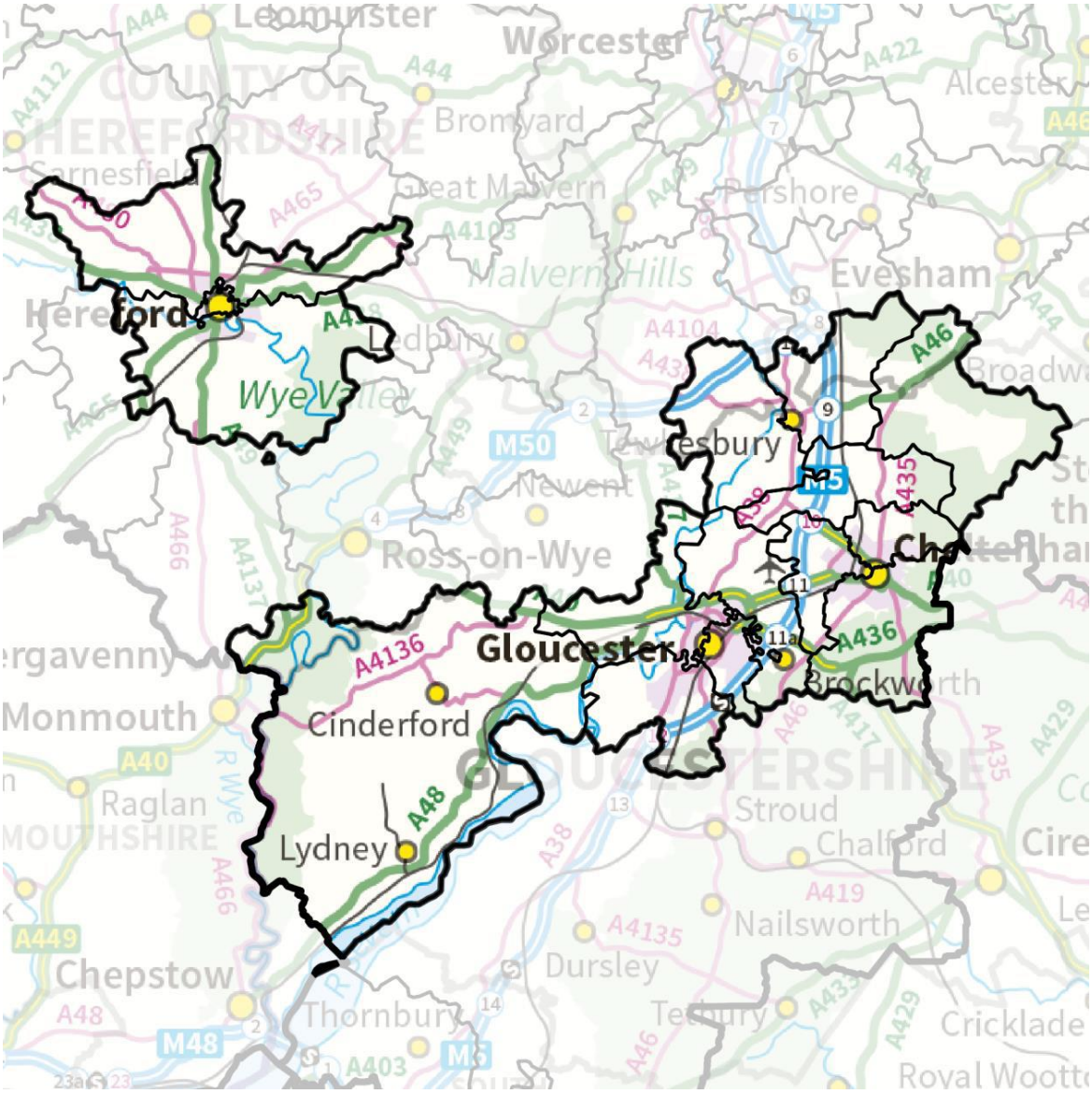

Figure 1.1 Port Ham GSP geographic network coverage

This report discusses existing and future network constraints over a 0-10 year horizon associated with Port Ham and its downstream network. It uses the methodology outlined in the Network Development Plan Methodology Report with Network Operability Modelling applied as outlined further below.

For the purposes of this analysis the NGED Best View Distribution Future Energy Scenario (DFES) has been used to study each year up to and including 2034. Representative days for each of the four seasons (Winter, Intermediate Cool, Intermediate Warm, and Summer) have been studied to cover the edge case scenarios for the network.

1.1 Network Topology

Port Ham GSP is 400/132 kV site fed via four 240 MVA Super Grid Transformers (SGTs), that normally runs solid through a 2-section double busbar configuration. It supplies nine BSPs most of which are 132/11 kV sites but they also include 132/33 kV BSPs (such as Lydney and Castle Meads) as well as 132/66 kV BSPs (such as Hereford and Cheltenham). The BSPs are listed below:

- Hereford BSP consisting of three 132/66 kV Grid Transformers (GTs) fed via two circuits from Port Ham. The GTs run in parallel and supply three primary substations: Hereford North, Hereford Central, and Hereford South.
- Castle Meads BSP consisting of three 132/33 kV transformers fed via three circuits from the GSP. The BSP then supplies five primary substations and 33 kV connected customers via its downstream 33 kV network.
- Lydney BSP consisting of two 132/33 kV transformers fed via two circuits from the GSP, one of which loops through Cambridge Arms switching station. The BSP then supplies nine primary substations and a 33 kV customer via its downstream 33 kV network.
- Cheltenham BSP consisting of a single 132/66 kV GT that feeds a couple of primary substations, and three 132/11 kV GTs supplying the local demand; all fed via three 132 kV circuits from the GSP.
- Tewkesbury BSP consisting of three 132/11 kV transformers fed via two 132 kV circuits. The transformers are connected to three sections of 11 kV busbars, and normally run split with each other.
- Montpellier BSP consisting of two three-winding 132/11/11 kV transformers fed via two 132 kV circuits from the GSP (via Cheltenham). The transformers are connected to two 11 kV double busbars and normally run split with each other.
- Marle Hill BSP consisting of a single three-winding 132/11/11 kV transformer fed out of the GSP, and two 66/11 kV transformers supplied from Cheltenham 66 kV network. The site's demand is normally picked up via the three-winding transformer, with the primary transformers on hot-standby.
- Commercial Road BSP consisting of a single three-winding 132/11/11 kV transformer fed from a 132 kV circuit via Castle Meads, and two 33/11 kV transformers supplied from Castle Meads 33 kV network. All three transformers are connected to five section of 11 kV busbars, normally run split with each other.
- Eastern Avenue BSP consisting of two three-winding 132/11/11 kV transformers, each banked with a two-winding 132/11 kV transformer, all fed via two 132 kV circuits via Castle Meads. The two three-winding transformers run in parallel with each other, and similarly for the two two-winding transformers; but both pairs normally run split with one another.

1.2 Network Operability Modelling

The analysis modelling covers automation and manual switching schemes that represent how the network is generally operated. Some of the main ones are listed below.

Port Ham 132 kV:

- Arranged outages at the GSP busbars causing a split configuration results in the reserve busbars being closed in to maintain parallels; this may often include re-selecting SGTs and feeders to avoid constraints following a second outage.
- Arranged or fault outages leading to loss of a 132/11 kV GT at Commercial Road, Cheltenham, Montpellier, Marle Hill, and Tewkesbury BSPs results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

Hereford BSP:

- Arranged outages that split up the 66 kV network at Hereford results in the downstream 66 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged or fault outages leading to loss of a primary transformer at Hereford North and Hereford South results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

Cheltenham BSP:

- Arranged outages leading to loss of the 132/66 kV grid transformer at Cheltenham BSP results in the 66 kV network it supplies being picked up from Feckenham GSP via Wormington primary.

Castle Meads BSP:

- Outages of any of the 132/33 kV transformers results in the network between the remaining two 132/33 kV transformers in-service being run split.
- Arranged outages that split up the 33 kV network at Castle Meads results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Rotol and Brockworth are supplied via four circuits from Castle Meads (two each) with an interconnector between them forming a closed 33 kV ring. Outages at Castle Meads 33 kV busbars (or any of the infeeds to the ring) results in the rest of it being run split; typically at Brockworth S628, but this would depend on the infeed being on outage. As the demand of the group grows, the network would need to be reviewed periodically to determine the best location for splitting the ring to avoid thermal overloads.
- Arranged or fault outages leading to loss of a primary transformer at Brockworth or Tuffley results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

Lydney BSP:

- Arranged outages that split up the 33 kV network at Lydney results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged or fault outages leading to loss of a primary transformer at Lydney or Mead Lane results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

2. Summary of Network Constraints

The following constraints were identified for the Best View Scenario, for which mitigation options are covered further down in the report:

- Alderton primary transformer overload
- Bishops Cleeve primary transformer T1 overload
- Hereford South primary transformer overload
- Hereford North primary transformer overload
- Hereford_7L0 to Hereford North_2H3 66 kV circuit overload
- Brockworth primary transformer T1 overload
- Rotol primary transformer overload
- Tuffley transformer T1B and T2B overload
- Castle Meads to Tuffley circuits:
    - Castle Meads to Tuffley_3L5 33 kV circuit overload
    - Castle Meads to Tuffley_T2A/T2B 33 kV circuit overload
- Lydney primary transformer overload
- Bilson primary transformer overload
- Princess Royal primary transformer overload
- Lydney group constraints
    - Port Ham to Lydney 132 kV circuit overload
    - Cambridge Arms to Lydney 132 kV circuit overload
    - Lydney grid transformer overload
    - Lydney BSP N-2 group compliance
    - Lydney to Princess Royal 33 kV circuit overload
    - Bixhead to Stowfield tee 33 kV circuit overload
    - Lydney to Bilson_1L3 33 kV circuit overload
    - Lydney to Yorkley tee 33 kV circuit overload
    - Yorkley tee to Bilson 33 kV circuit overload

Transmission-Distribution interface

Port Ham (Walham) GSP is a 400/132 kV site and the boundary between the transmission and distribution network for that area. New Connection activity at the distribution network, both demand and generation, have triggered constraint at the transmission network with regards to SGT capacity, 132 kV circuit breaker ratings, and 400 kV circuit ratings. Proposals to mitigate are being considered including the installation of an additional SGT, circuit breaker replacement, and 400 kV circuit upgrade works.

3. Network Constraints and Solution Options

3.1 Alderton primary transformer overload

Constraint Overview

Generation Demand

Alderton primary is a 66/11 kV site, fed from Cheltenham BSP, and consists of two primary transformers:

- T1 which is rated 10/13 MVA (commissioned in 1994), and
- T2 which is 7.5/15 MVA (commissioned in 2016).

The primary is a Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.1.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Alderton transformer overload	N-1: Outage of either of the two transformers at Alderton	2025	Baseline	Baseline	2026

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 3.1.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformers	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is imminent and the demand is projected to continue increasing. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 20 MVA

Viable

Detailed description: Uprating the existing transformers with 20/40 MVA units (as 12/24 MVA rated units would run out of capacity by 2040).

The existing 11 kV board is 1250 amp rated (commissioned in 2003) and therefore would not need to be uprated yet.

New limiting factor: Rating of 11 kV board

Option 3 – Adding a third transformer

Estimated capacity released: 11 MVA

Viable

Detailed description: Adding a third transformer on site, the works include the following:

- Undergrounding the last span of the 66 kV circuit from Bishops Cleeve to create more space on site
- Extending the 66 kV busbars by installing an additional 66 kV bus-section circuit breaker and a new transformer bay; the feeder to Bishops Cleeve would also need to be relocated to the end busbar
- Installing a third 66/11 kV transformer, rated 12/24 MVA, at Ledbury
- Installing an additional 11 kV 2-section board suitably interconnected with the existing
- Purchasing additional land may be required to accommodate the new assets above

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A couple of MVAs

Discounted

Detailed description: Alderton primary has limited 11 kV interconnection to other sites, which is insufficient to mitigate the constraints above.

The interconnections however could help manage the Baseline constraints in the interim, but would not be a viable long term solution.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Alderton primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 6 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (replacing the existing transformers) as it will likely have a lower deliverability risk, and be more cost-effective.

As mentioned above, option 4 (operational mitigation) can also be implemented in the interim to manage the baseline constraints but it is not a viable long term solution.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.2 Bishops Cleeve primary transformer T2 overload

Constraint Overview

Generation | **Demand**

Bishops Cleeve primary is 66/11 kV site consisting of two primary transformer fed from Cheltenham BSP. T1 is a 15 MVA transformer commissioned in 1991; and T2 is a 12/24 MVA transformer commissioned in 2015. The 11 kV board is 1250 amp rated that was commissioned in 2003.

The primary is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.2.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Bishops Cleeve transformer T1 overload	N-1: Outage of transformer T2	-	2032	-	-

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 3.2.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformer	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2032 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of transformer T2

Option 2 – Uprating the existing transformer

Estimated capacity released: 8 MVA

Viable

Detailed description: Replacing the existing transformer T1 with a 20/40 MVA unit (as a 12/24 MVA transformer would not be as long-lasting).

Transformer T2 and the existing 11 kV board would not need to be replaced yet, lasting until about 2040.

New limiting factor: Rating of transformer T2 which is 12/24 MVA rated

Option 3 – Adding a third transformer

Estimated capacity released: 15 MVA

Viable

Detailed description: Adding a third transformer on site, the works include:

- Extending the 66 kV busbars to create 3x sections with 2x bus-section circuit breakers, 3x transformer bays, and 2x circuit incomers.
- Installing a third 12/24 MVA 66/11 kV transformer.
- Installing a new 2-section 11 kV board suitably interconnected with the existing.
- Purchasing additional land may be needed to accommodate the new assets above.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs — **Discounted**

Detailed description: Bishops Cleeve primary has limited 11 kV interconnection to other primary substations which is insufficient to alleviate all the constraint.

New limiting factor: Rating of transformer T1

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA — **Discounted**

Detailed description: Bishops Cleeve primary is currently Class C under Engineering Recommendation P2, which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 6 MW+ — **Viable**

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of transformer T1

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (replacing the existing transformer) as it will likely be a more deliverable and cost-effective solution.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.3 Hereford South primary transformer overload

Constraint Overview

Generation | Demand

Hereford South primary is a 66/11 kV site consisting of two 20/32/40 MVA transformers (commissioned in 1983) fed from Hereford BSP. The primary is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.3.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Hereford South transformer overload	N-1: Outage of either of the two transformers at Hereford South	-	2031	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 3.3.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the 11 kV interconnection	✓	✓	✓	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	✓	✓	×	Viable
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2031 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Upgrading the 11 kV interconnection

Estimated capacity released: 5-10 MVA

Viable

Detailed description: Upgrading the 11 kV network between Hereford South and its neighbouring primary substations such as Hereford Central (approximately 3.5 km away), Hereford North (approximately 5 km away), and Madley (approximately 9 km away) to add 5-10 MVA of additional transfer capacity, securing the site longer term.

New limiting factor: Rating of transformers

Option 3 – Adding a third transformer

Estimated capacity released: 30 MVA

Viable

Detailed description: Adding a third transformer on site, the works include the following:

- Extending the 66 kV busbars and installing two bus-section circuit breakers and an additional transformer bay.
- Installing a third 66/11 kV transformer rated 20/40 MVA.
- Installing an additional 11 kV 2-section board suitably interconnected with the existing.
- Assessing the need for any additional land to accommodate the new assets.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Viable

Detailed description: Hereford South has existing 11 kV interconnections to Hereford Central and Hereford North primary substations, sufficient enough to mitigate the constraint above which is anticipated to be less than 1 MVA by 2034.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Hereford South primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 1 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (upgrading the 11 kV network to neighbouring primaries) as it will likely be more cost-effective, especially when considering the marginal shortfall. This would also have the wider benefit of improving the security of supply for the neighbouring primaries affected.

Furthermore, given the constraints are observed in the intermediate cool and intermediate warm seasons only, and that the demand is not dominated by commercial nor industrial load, it will be worth re-assessing the seasonal ratings of these transformers prior to commencing physical works.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.4 Hereford North primary transformer overload

Constraint Overview

Generation Demand

Hereford North primary is a 66/11 kV site consisting of three 20/40 MVA transformers (commissioned in 2016) fed from Hereford BSP via three 66 kV circuits. The primary is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.4.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Hereford North transformer overload	N-1: Outage of either of the two transformers at Hereford North	2030	Baseline	2027	2031

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 3.4.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the 11 kV interconnection	✓	✓	×	Viable
3	Adding a fourth transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	✓	✓	×	Viable
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is imminent and the demand is projected to continue increasing. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Upgrading the 11 kV interconnection

Estimated capacity released: 5-10 MVA

Viable

Detailed description: Upgrading the 11 kV network between Hereford North and its neighbouring primary substations such as Hereford Central (approximately 2 km away), Hereford South (approximately 5 km away), and Bodenham (approximately 8.5 km away) to add at least 5-10 MVA of additional transfer capacity, securing the site longer term.

New limiting factor: Rating of transformers

Option 3 – Adding a fourth transformer

Estimated capacity released: 30 MVA

Viable

Detailed description: Adding a third transformer on site, the works include the following:

- Extending the 66 kV busbars and installing a bus-section circuit breakers and an additional transformer bay
- Installing a fourth 66/11 kV transformer rated 20/40 MVA
- Extending the 11 kV board to include a 2000 amp transformer circuit breaker

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: 10-15 MVA

Viable

Detailed description: Hereford North has sufficient 11 kV transfer capacity to mitigate the constraint above, this is in two-fold:

- Hereford North T1 and T2 run closed at 11 kV and backfeed each other during an outage, the proposal is therefore to move some demand onto T3 to avoid an overload following a first circuit outage.
- The primary has existing 11 kV interconnections to Hereford Central primary, which could be utilised to further ease off the demand on the existing transformers.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Hereford North primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) could make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 10 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

It would be recommended to pursue option 4 above (operational mitigation) as it would be the most cost effective solution and would allow for better utilisation of the existing assets.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process. The flexibility option however, although may be technically viable, is not likely to be as cost-effective as the operational mitigation option above.

3.5 Hereford_7L0 to Hereford North_2H3 66 kV circuit overload

Constraint Overview

Generation Demand

Hereford North and Hereford South primary substations are fed via four 66 kV circuits in total from Hereford BSP:

- Two directly to Hereford North.
- One directly to Hereford South.
- One to a tee point which then connects to Hereford North and to Hereford South.

For an arranged busbar outage at Hereford BSP, one of the direct circuits between Hereford BSP and Hereford North primary could overload, as it picks up parts of Hereford North demand and approximately half of Hereford South. The group supplied from the circuit is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.5.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Hereford_7L0 to Hereford North_2H3 66 kV circuit	N-1: Arranged busbar outage affecting the Hereford to Hereford North/Hereford South tee 66 kV circuit	2030	2031	2031	-

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 3.5.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing circuit	✓	✓	×	Viable
3	Installing a new circuit to unstitch the tee	✓	✓	×	Viable
Operational mitigation					
4	Load transfers and outage restrictions	✓	✓	×	Viable
Load Management Schemes					
5	Demand disconnection	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2030 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads which could subsequently have health and safety implications.

New limiting factor: Rating of the existing circuit

Option 2 – Uprating the existing circuit

Estimated capacity released: 18 MVA

Viable

Detailed description: Uprating the existing 66 kV circuit between Hereford_7L0 and Hereford North_2H3, the works include:

- Replacing the 400 amp current transformers (CTs) along the circuit.
- Restringing/rebuilding approximately 5 km of existing sections of 0.1 in Aluminium Conductor Steel Reinforced (ACSR) overhead line wood pole circuit with 200 mm All Aluminium Alloy conductor (AAAC) designed to 75 degrees.

New limiting factor: Rating of other parts of the circuit

Option 3 – Installing a new circuit to unstitch the tee

Estimated capacity released: 35 MVA

Viable

Detailed description: Adding a new circuit to unstitch the tee point between Hereford BSP and Hereford North/Hereford South tee circuit, the works include:

- Extending the 66 kV busbars at Hereford BSP (GT4 side) to establish a new feeder bay.
- Installing approximately 4 km of 66 kV circuit from the new bay at Hereford BSP to the existing Hereford North/Hereford South 66 kV tee point, to pick the circuit heading towards Hereford South. The circuit is to have a minimum rating of 70 MVA winter cyclic to future proof Hereford South; this is anticipated to require 630 mm copper cable or 200 mm AAAC overhead line designed to 75 degrees.

This would effectively result in two direct feeders to Hereford South, and three direct feeders to Hereford North.

New limiting factor: Rating of the existing circuit

Option 4 – Operational mitigation: Load transfers and outage restrictions

Estimated capacity released: 10 MVA+

Viable

Detailed description: This option can be subdivided into two sections as per below:

- Limiting the arranged outages to the summer months only:
- Transferring demand out of the group for the duration of the arranged outages; this could include:
  - Transfers within Hereford North to put more demand on T1 which is fed from a different circuit.
  - Transfers within Hereford South to put more demand on T2 which is being fed from its other circuit.
  - Transfers from Hereford North and Hereford South onto Hereford Central (via the 11 kV network (to reduce demand on the affected 66 kV circuit).

Any of the above could resolve the constraint but the first section (limiting the outage window) could be quite restrictive with maintenance programmes and other outages in the area, therefore it would be more viable to utilise a combination of the measures listed above to manage the constraint much more effectively.

New limiting factor: Rating of the circuits

Option 5 – Load Management Schemes: Demand disconnection

Estimated capacity released: 0 MVA

Discounted

Detailed description: Installing a load management schemes could be quite complex to implement and manage given the busbar arrangements and interconnectivity between the primaries. It will also have a detrimental impact on Customer Interruptions (CIs) and Customer Minutes Losses (CMLs).

Furthermore, considering the group is Class C under Engineering Recommendation P2, keeping customers off supply for arranged outages could have security of supply implications.

New limiting factor: Impact on CIs and CMLs, and risk of security of supply compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 4 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down (at Hereford North and Hereford South primaries) could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the circuit.

Solution Recommendation

It would be recommended to pursue option 4 above (operational mitigation) as it would be the most cost effective solution and would allow for better utilisation of the existing assets.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process. The flexibility option however, although may be technically viable, is not likely to be as cost-effective as the operational mitigation option above.

3.6 Brockworth primary transformer T1 overload

Constraint Overview

Generation Demand

Brockworth is a 33/11 kV primary substation fed out of Castle Meads BSP via three circuits; two direct and one via Rotol primary. It consists of three transformers:

- T1 and T2 each being 12/24 MVA rated (commissioned in 2018) are run in parallel with each other; and
- T3 which is rated 15/18.75 MVA, summer/winter, commissioned in 1964 and normally runs split at 11 kV from the other two transformers.

The 33 kV busbars are air-insulted with no bus-section circuit breakers, but each transformer and each circuit is connected to a circuit breaker.

The site is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.6.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Brockworth transformer T1 overload	N-1: Arranged outage of isolator S628 resulting in both T2 and T3 being on outage	2031	2025	2031	-

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 3.6.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading transformer T1	✓	✓	×	Viable
3	Adding a 33 kV disconnector	✓	✓	×	Viable
Operational mitigation					
4	Load transfers and outage restrictions	×	✓	×	Viable
Load Management Schemes					
5	Demand disconnection	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	×	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2025 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of the existing transformer

Option 2 – Upgrading transformer T1

Estimated capacity released: 12 MVA

Viable

Detailed description: Uprating the existing assets, the works include:

- Replacing the transformer T1 with a 20/40 MVA unit
- Replacing the existing 1250 amp 11 kV board (commissioned in 2018) with a 2000 amp board

New limiting factor: Rating of the transformers

Option 3 – Adding a 33 kV disconnector

Estimated capacity released: 18 MVA

Viable

Detailed description: Installing a second 33 kV disconnector anywhere between the existing S628 disconnector and T3's 33 kV busbar connection.

This prevents both T2 and T3 being on outage when S628 disconnector is on an arranged outage.

New limiting factor: Rating of the Ketley-Snedshill 33 kV circuits

Option 4 – Operational mitigation: Load transfers and outage restrictions

Estimated capacity released: A few MVAs — **Viable**

Detailed description: This option can be subdivided into two sections as per below:

- Limiting the arranged outages to the summer months only; but this could be quite restrictive with regards to the maintenance programme.
- Transferring sufficient demand to neighbouring primary substations for the duration of the arranged outage; but this is restricted by the limited 11 kV interconnections which are not sufficient to fully mitigate the constraints.

Both of the above could help manage the constraint in the short term but may not be a practical solution longer term.

New limiting factor: Rating of transformer T1

Option 5 – Load Management Schemes: Demand disconnection

Estimated capacity released: 0 MVA — **Discounted**

Detailed description: Installing a load management scheme could be quite complex to implement and will likely have a detrimental impact on CIs and CMLs.

Furthermore, considering the site is Class C under Engineering Recommendation P2, keeping customers off supply for arranged outages could have security of supply implications.

New limiting factor: Impact on CIs and CMLs, and risk of security of supply compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 5 MW+ — **Viable**

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of transformer T1

Solution Recommendation

It is recommended to pursue option 4 above (operational mitigation) as it is likely to be the most and cost-effective allows for better utilisation of the existing network.

Longer term, and where the option above has been exhausted, option 3 (adding a 33 kV disconnector) would be the next viable solution to mitigate the constraint above.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it may be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.7 Rotol primary transformer overload

Constraint Overview

Generation Demand

Rotol primary is 33/11 kV site consisting of two transformers fed from Castle Meads BSP via two 33 kV circuits, with a third circuit (interconnector) to Brockworth primary.

The transformer are 20/32/40 MVA rated (commissioned in 2015), and connected to a 2000 amp 11 kV switchgear board.

The primary is Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.7.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Rotol transformer overload	N-1: Outage of either of the two transformers at Rotol	2032	2028	2030	2032

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 identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Upgrading the 11 kV interconnection	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated by 2028, with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 8-10 MVA

Viable

Detailed description: Upgrading the 11 kV interconnection between Rotol and its neighbouring substations such as Montpellier (approximately 6.5 km away), Marle Hill (approximately 7 km away) and Brockworth (approximately 6 km away). The upgrade work would need to add 8-10 MVA of capacity to ensure this becomes an enduring solution.

New limiting factor: Rating of the transformers

Option 3 – Adding a third transformer

Estimated capacity released: 30 MVA

Viable

Detailed description: Adding a third transformer on site, the works include:

- Extending the 33 kV busbars to allow for a transformer panel connected to the middle section of the existing board. Where space may be restricted, consideration to be given to installing a 3-panel board on site and using this to reconfigure and make provision for the new panel.
- Installing a third 33/11 kV transformer rated 20/40 MVA.
- Installing an additional 2-section 11 kV board suitably interconnected with the existing; it is anticipated to run this new transformer split from the other two to keep fault levels within equipment rating.

The additional assets above are expected to fit within the existing substation compound.

New limiting factor: Rating of the transformers and circuits

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A couple of MVAs

Discounted

Detailed description: Rotol has limited 11 kV interconnection to other primary substations, which may help manage the early stages of the constraint but would not be sufficient to fully mitigate or to become a long term viable solution.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Rotol primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 6 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 3 above (adding a third transformer) as it will likely be a more enduring solution and more cost-effective in the long run.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.8 Tuffley transformer T1B and T2B overload

Constraint Overview

Generation | **Demand**

Tuffley primary is a 33/11 kV site, fed via two circuits from Castle Meads BSP. It consists of four transformers on site:

- T1A and T2A: each rated 30 MVA, commissioned in 1965, and backfeed each other at 11 kV
- T1B and T2B: each rated 15/19.5 MVA (summer/winter), commissioned in 1958, and backfeed each other at 11 kV

At 33 kV, T1A is banked with T1B, and similarly, T2A is banked with T2B. Each pair is supplied via a circuit from Castle Meads BSP, with no 33 kV busbar link at Tuffley. The 11 kV switchgear board is currently 2000 amp rated.

The primary is a Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.8.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Tuffley transformer overload (T1B and T2B)	N-1: Outage of either of the two transformers at Tuffley	2028	2029	2030	2032

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 3.8.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformers	✓	✓	×	Viable
3	Installing 33 kV switchgear to unbank	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated by 2025 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 15 MVA

Viable

Detailed description: Uprating the existing two 15 MVA transformers (T1B and T2B) with 20/40 MVA units.

New limiting factor: Rating of the transformers

Option 3 – Installing 33 kV switchgear to unbank

Estimated capacity released: 15 MVA

Viable

Detailed description: Unbanking the transformers, the works include:

- Installing a 4-section 33 kV indoor switchgear board, configured such that each transformer connects to one section, and the circuits from Castle Meads connect to the end busbars of the switchgear board.
- Running the new 33 kV board solid.
- Carrying out a fault level assessment to establish any potential overstress; where these may be present, then consideration to be given to running the 33 kV board split (effectively mimicking the existing configurations) and implementing a backfeed arrangement via the normally open 33 kV bus-section circuit breaker.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited

Discounted

Detailed description: Tuffley primary has limited 11 kV interconnection to other primary sites, which is insufficient to mitigate the constraints above.

The interconnections however could help manage some of the early stages of the constraint, but would not be a viable long term solution.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Tuffley primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 4 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (replacing the existing transformers) as it will likely be the most cost-effective solution longer term, especially when considering the age of the transformers.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.9 Castle Meads to Tuffley circuits

Constraint Overview

Generation Demand

Tuffley primary is a 33/11 kV site, consisting of four transformers fed via two circuits from Castle Meads BSP. An outage on either circuit takes out two transformers but puts the demand on the other circuit (via the remaining two transformers in-service).

The primary is a Class C under Engineering Recommendation P2.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.9.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Castle Meads to Tuffley_3L5 33 kV circuit	N-1: Outage of the Castle Meads-Tuffley_T2A/T2B 33 kV circuit	2029	2025	2030	-
Castle Meads to Tuffley_T2A/T2B 33 kV circuit	N-1: Outage of the Castle Meads-Tuffley_3L5 33 kV circuit	2029	2025	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 3.9.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing circuits	✓	✓	×	Viable
3	Installing a third circuit to Tuffley	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated by 2025 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing circuits

Estimated capacity released: 10 MVA

Viable

Detailed description: Uprating the existing 33 kV circuits, the works include:

- For the Castle Meads to Tuffley_3L5 circuit: Replacing approximately 90 m of 0.5 in copper solid cable with a conductor having a minimum rating of 46 MVA winter cyclic, anticipated to be 630 mm copper cable.
- For the Castle Meads to Tuffley_T2A/T2B circuit: Replacing approximately 300 m of 0.5 in copper solid cable with a conductor having a minimum rating of 46 MVA winter cyclic, anticipated to be 630 mm copper cable.

New limiting factor: Rating of the circuits

Option 3 – Installing a third circuit to Tuffley

Estimated capacity released: 30 MVA

Viable

Detailed description: Adding a third 33 kV circuit to Tuffley, the works include:

- Extending the 33 kV switchgear board at Castle Meads (on the GT3 side) to include a new feeder circuit breaker; where space may be restricted, consideration to be given to installing a 3-panel board on site and using this to reconfigure and make provision for the new panel.
- Extending the 33 kV busbars at Tuffley to include a new feeder bay; where space may be restricted, consideration to be given to installing a 4-section 33 kV indoor switchgear board with provisions for three incoming circuits.
- Running the 33 kV busbars at Tuffley solid.
- Carrying out a fault level assessment to establish any potential overstress; where these may be present, then consideration to be given to uprating the affected assets or splitting the busbars and implementing a backfeed arrangement to restore supplies following an outage.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: Tuffley primary has limited 11 kV interconnection to other primary sites, which is insufficient to mitigate the constraints above.

The interconnections however could help manage some of the early stages of the constraint, but would not be a viable long term solution.

New limiting factor: Rating of the circuits

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Tuffley primary is Class C under Engineering Recommendation P2 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 7.4 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the circuits

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (uprating the existing circuits) as it will likely be the most deliverable and cost-effective solution.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.10 Lydney primary transformer overload

Constraint Overview

Generation Demand

Lydney primary is a 33/11 kV site consisting of two 6/12 MVA primary transformers (commissioned in 2009), fed from Lydney BSP. They connect to an 11 kV board that is 2000 amp rated.

The primary is currently Class B under Engineering Recommendation P2, expected to become Class C by 2030.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.10.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Lydney primary transformer overload	N-1: Outage of either of the two primary transformers at Lydney	2030	2030	2031	2031

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 3.10.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformers	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2030 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 26 MVA

Viable

Detailed description: Uprating the existing transformers with 20/40 MVA units (as 12/24 MVA rated units would run out of capacity by 2040).

The existing 11 kV board is 2000 amp rated and therefore would not need to be uprated.

New limiting factor: Rating of transformers

Option 3 – Adding a third transformer

Estimated capacity released: 11 MVA

Viable

Detailed description: Adding a third transformer on site, the works include the following:

- Extending the 33 kV busbars at Lydney to allow for a third section and an additional primary transformer circuit breaker; where space may be restricted, consideration to be given to installing a third section of gas-insulated switchgear board on site, suitably interconnected with the existing.
- Installing a third 33/11 kV transformer, rated 12/24 MVA.
- Installing an additional 2-section 11 kV board suitably interconnected with the existing.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited

Discounted

Detailed description: Lydney primary has some 11 kV interconnection to other sites such as Mead Lane (approximately 2.5 km away) and Princess Royal (approximately 3 km away), but these are not sufficient to mitigate the constraints above.

The interconnections however could help manage the early stages of the constraint but would not be a viable long term solution.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Lydney primary is currently Class B under Engineering Recommendation P2, expected to become Class C by 2030 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 4.5 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (replacing the existing transformers) as it is likely to have a lower deliverability risk, and be more cost-effective.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.11 Princess Royal primary transformer overload

Constraint Overview

Generation Demand

Princess Royal primary is a 33/11 kV site consisting of two 10 MVA primary transformers (commissioned in 1996), fed from Lydney BSP. They connect to an 11 kV board that is 1200 amp rated.

The primary is currently Class B under Engineering Recommendation P2, expected to become Class C by 2033.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.11.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Princess Royal primary transformer overload	N-1: Outage of either of the two primary transformers at Princess Royal	2031	2030	2031	-

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 identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformers	✓	✓	×	Viable
3	Adding a third transformer	✓	✓	×	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2030 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 10 MVA

Viable

Detailed description: Uprating the existing transformers with 12/24 MVA units.

The existing 11 kV board is 1200 amp rated and therefore would not need to be uprated yet.

New limiting factor: Rating of the 11 kV circuit breakers

Option 3 – Adding a third transformer

Estimated capacity released: 11 MVA

Viable

Detailed description: Adding a third transformer on site, the works include the following:

- Extending the 33 kV busbars at Princess Royal to include an additional bus-section circuit breaker and a transformer bay; the circuit to Bixhead would also need to be relocated to the new section of bar to cover the busbar ends.
- Installing a third 33/11 kV transformer, rated 7.5/15 MVA.
- Installing an additional 2-section 11 kV board suitably interconnected with the existing.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited

Discounted

Detailed description: Princess Royal primary has limited 11 kV interconnection to other sites such as Mead Lane (approximately 5 km away) and Lydney primary (approximately 3 km away), but these are not sufficient to mitigate the constraints above.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Princess Royal primary is currently Class B under Engineering Recommendation P2, expected to become Class C by 2033 which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 1 MW+ Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (replacing the existing transformers) as it is likely to be more cost-effective especially when considering the age of the transformers.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.12 Bilson primary transformer overload

Constraint Overview

Generation Demand

Bilson primary is a 33/11 kV site fed out of three circuits from the BSP, and consists of three primary transformers that run in parallel:

- TA and TB: each rated 5 MVA, commissioned in 1956
- TC: rated 7.5 MVA, commissioned in 1966

The 11 kV board is 1250 amp rated, commissioned in 2021.

The primary is currently Class C under Engineering Recommendation P2, expected to become Class D by 2033 following a very steep increase in demand, mostly due to a few significant developments.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season although this would be heavily dependent on the new developments in the area.

Table 3.12.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Bilson primary transformer overload	N-1: Outage of any of the primary transformers at Bilson	2025	2025	2025	2025

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 identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing transformers	✓	✓	×	Viable
3	Establishing a new primary substation	✓	✓	✓	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The constraint is anticipated to trigger by 2025 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing transformers

Option 2 – Uprating the existing transformers

Estimated capacity released: 50 MVA

Viable

Detailed description: Uprating the existing transformers, the works include:

- Replacing all three 33/11 kV transformers with 20/40 MVA units.
- Replacing the existing 11 kV switchgear board with a 2000 amp rated one.
- Carrying out a fault level assessment of the 11 kV network to identify any potential overstress, where these may be present, consideration to be given to running the new transformers split at 11 kV, with suitable switching schemes put in place.

New limiting factor: Rating of the circuits

Option 3 – Establishing a new primary substation

Estimated capacity released: 60 MVA

Viable

Detailed description: Establishing a new primary substations, the works include:

- Purchasing land in a suitable location and within close proximity to the anticipated significant developments.
- Depending on the location of the new site, laying two 33 kV circuits to the site, rated and sized sufficiently for the new developments.
- Installing a minimum of two 20/40 MVA transformers at the new site; where the developments require more capacity, consideration to be given to installing a third transformer via a 33 kV switchgear board.
- Installing suitable 11 kV switchgear board, with the number of busbar sections, circuit breakers, and 11 kV feeders, set to fulfil the size of the developments while utilising the full ratings of the transformers.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: Bilson primary has some 11 kV interconnection to other sites but these are not sufficient to mitigate the constraints above.

New limiting factor: Rating of the transformers

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Bilson primary is currently Class C under Engineering Recommendation P2, which would require restoration of the demand within 15 minutes for a first circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant. It is also expected to become Class D by 2033, making the requirements more onerous, and therefore this option becoming less viable.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 1 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint and defer reinforcement. This option would be subject to a cost benefit analysis closer to the time, including all necessary sufficiency checks.

New limiting factor: Rating of the transformers

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 3 above (establishing a new primary substation for the future developments) as this is an enduring solution that avoid complicating the existing 33 kV network configuration.

The timing and trigger of such works would be heavily reliant on the new developments materialising, and in some cases, contributing to the works.

Any reinforcement solution however would be subject to a CBA by the DNO, and in this case, it would then be tested against the flexibility market as part of the Distribution Network Options Assessment (DNOA) process.

3.13 Lydney group constraints

Constraint Overview

Generation | **Demand**

Lydney BSP is a 132/33 kV site consisting of two 90 MVA grid transformers that are fed out of two 132 kV circuits from Port Ham GSP (one direct and another via Cambridge Arms switching station).

The 33 kV runs solid and supplies several primary substations, most of which are connected via a closed ring, with main infeed via Elton, Princess Royal, and Bilson primaries.

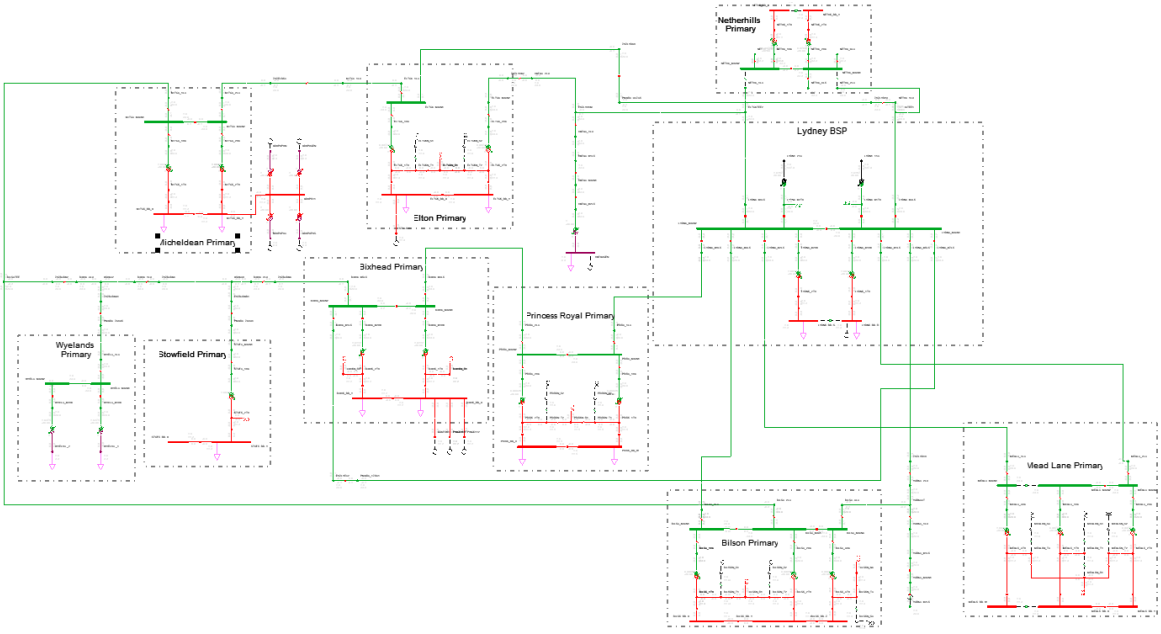

Figure 3.13.1 Lydney BSP schematic network diagram

The group is class D under Engineering Recommendation P2, with a group demand expected to exceed 100 MW by 2027.

The table below outlines the constraint identified for Best View, the conditions it occurs under, and the triggering year per season.

Table 3.13.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Port Ham to Lydney 132 kV circuit overload	N-1: Outage of the 132 kV infeed from Port Ham to Lydney (via Cambridge Arms)	2027	2027	2027	2027
Cambridge Arms to Lydney 132 kV circuit overload	N-1: Outage of the Port Ham to Lydney 132 kV circuit	2028	2028	2028	2029
Lydney grid transformer overload	N-1: Outage of either of the GTs at Lydney	2025	2025	2026	2027
Lydney BSP N-2 group compliance	N-2: Arranged outage of one infeed to Lydney, followed by a fault of the other; where group demand exceeds 100 MW	2029	2029	2030	2031
Lydney to Princess Royal 33 kV circuit overload	N-1: Busbar outage at Lydney 33 kV main 2 taking out two infeeds to the ring	2028	2028	2028	2030
Bixhead to Stowfield tee 33 kV circuit overload	N-1: Outage of the Lydney-Bilson_3L3 33 kV circuit	2029	2029	2029	2029
Lydney to Bilson_1L3 33 kV circuit overload	N-1: Outage of one of the other 33 kV infeeds to Bilson primary	2030	2031	2031	2031
Lydney to Yorkley tee 33 kV circuit overload	N-1: Outage of the direct 33 kV circuit between Lydney and Bilson	2028	2027	2027	2028
Yorkley tee to Bilson 33 kV circuit overload	N-1: Outage of the direct 33 kV circuit between Lydney and Bilson	2030	2029	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 3.13.2 solution options to identified constraint(s)

Option	Description	Solves constraint	Potentially economic	Wider benefit	Viable or Discounted
1	No Intervention	×	✓	×	Discounted
Reinforcement (build) options					
2	Uprating the existing network	✓	✓	×	Viable
3	Establishing a new BSP near Bilson	✓	✓	✓	Viable
Operational mitigation					
4	Load transfers	×	✓	×	Discounted
Load Management Schemes					
5	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
6	Flexibility service procurement	✓	✓	×	Discounted

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed cost benefit analysis (CBA) by the DNO. The section below covers more detail on these options.

Option 1 – No Intervention

Estimated capacity released: 0 MVA

Discounted

Detailed description: The earliest constraint is anticipated by 2025 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing circuits and P2 compliance

Option 2 – Uprating the existing network

Estimated capacity released: 90 MVA

Viable

Detailed description: Uprating the existing network, the works include:

- Establishing a new 132 kV bay at Port Ham GSP; where there may be space restrictions then consideration to be given to creating a switching station within close proximity to the existing site (this would include utilising existing bays and circuits as interconnectors, and re-connecting them from the new site).
- Installing over 25 km of 132 kV circuit from the new bay at Port Ham (or the new switching site) to Lydney BSP to create a third infeed.
- Installing a third 132/33 kV grid transformer at Lydney BSP, including a new 33 kV switchboard, suitably interconnected with the existing.
- Uprating the Lydney to Princess Royal 33 kV circuit to achieve a minimum rating of 51 MVA winter cyclic. This would involve undergrounding approximately 3 km of existing 241 mm BLL aluminium conductor with a minimum of 630 mm copper or 800 mm copper cable.
- Uprating the Bixhead to Stowfield 33 kV circuit to achieve a minimum rating of 36 MVA winter cyclic. This would involve uprating the 500 amp current transformers (CTs) and approximately 5.5 km of 0.1 in hard drawn copper (HDC) overhead line conductor with 200 mm AAAC; where underground cable is necessary it is anticipated 400 mm copper would be required as a minimum.
- Uprating the Lydney to Bilson_1L3 33 kV circuit to achieve a minimum rating of 36 MVA winter cyclic. This would involve uprating approximately 11 km of 0.175 in ACSR overhead line conductor with 200 mm AAAC designed to 75 degrees; where underground cable is necessary it is anticipated 400 mm copper would be required as a minimum.
- Uprating the Lydney to Yorkley tee 33 kV circuit to achieve a minimum rating of 35 MVA winter cyclic. This would involve uprating approximately 80 m of a mixture of 0.2 in and 0.5 in cable sections with 400 mm copper conductor.
- Uprating the Yorkley tee to Bilson 33 kV circuit to achieve a minimum rating of 35 MVA winter cyclic. This would involve uprating approximately 550 metres of 185 mm copper cable sections with 400 mm copper conductor.

New limiting factor: Rating of the circuits

Option 3 – Establishing a new BSP near Bilson

Estimated capacity released: 100 MVA+

Viable

Detailed description: Establishing a new BSP to pick up the bulk of the demand growth, the works include:

- Establishing two new 132 kV bays at Port Ham GSP; where there may be space restrictions then consideration to be given to creating a switching station within close proximity to the existing site (this would include utilising existing bays and circuits as interconnectors, and re-connecting them from the new site).
- Procuring a new BSP site around the area between Elton primary and Bilson primary.
- Installing approximately 12 km of 132 kV double circuit from the new bays at Port Ham (or the new switching station) to the new BSP site.
- Installing two 90 MVA 132/33 kV transformers at the new BSP, including a two section 33 kV switchgear board.
- Installing 33 kV circuits from the new BSP to pick up Elton, Bilson and possibly Mitcheldean primary substations (as a minimum) with open points at 33 kV and 11 kV to create a normally split configuration with Lydney BSP.

  The level of circuit works (and modifications at existing primary substations) will depend on the location of the new BSP which is subject to planning and consents.
- Carrying out site checks allowing the existing transformers at Lydney BSP to utilise their cyclic ratings.

New limiting factor: Rating of the circuits

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: Lydney BSP has a 33 kV transfer capacity to Ryeford BSP (via Netherhills) and very limited 11 kV interconnection to Hereford BSP.

The interconnections however could help manage some of the early stages of the constraint, but would not be a viable long term solution.

New limiting factor: Rating of existing circuits and P2 compliance

Option 5 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: Lydney BSP is Class D under Engineering Recommendation P2 which would require the immediate restoration of the group demand minus 20 MW following a first circuit outage, with restoration of the full demand within 3 hours; therefore demand disconnection schemes (or similar) would make the site non-compliant.

As the group demand exceeds 100 MW, a third infeed would become necessary making this option less viable.

New limiting factor: Rating of existing circuits and P2 compliance

Option 6 – Flexibility service procurement

Estimated Flexibility Required (MW): 7.4 MW+ **Discounted**

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate some thermal constraints for specific outage conditions but it could be more detrimental to the network if different fault outages occur, considering the parallel ring configuration of the network. It would also not resolve the N-2 group compliance constraints.

New limiting factor: Rating of existing circuits and P2 compliance

Solution Recommendation

It would be recommended to pursue option 3 above (establishing a new BSP) as it will likely be a more enduring solution than the alternative viable option, and more cost-effective in the long run. It also provides a wider benefit of enabling a simpler network configuration and keeping the fault levels in check.

As the demand progresses, there may be merit in implementing a hybrid solution between both option 2 and option 3, with the overall focus being a new BSP in the area.

The significant load growth observed within the BSP is related to these observed for Bilson primary substation and can be traced to a few large developments; as a result, the timing and trigger of any works would be heavily reliant on these new developments materialising, and in some cases, contributing to the works.

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