Ironbridge and Shrewsbury GSP Group

Network Development Report – West Midlands

May 2024

Electricity Distribution

nationalgrid

Contents

Ironbridge / Shrewsbury GSP Group

1. Network Overview

Ironbridge is a 132 kV Grid Supply Point (GSP) that runs in parallel at 132 kV with Shrewsbury GSP. The group supplies the majority of Bridgnorth, Telford, and parts of Shropshire areas, connecting over 158,000 customers. The network comprises of a couple of 132 kV circuits that connect the two GSPs together including four Bulk Supply Points (BSPs) which in turn supply multiple primary substations and Extra High Voltage (EHV) customers.

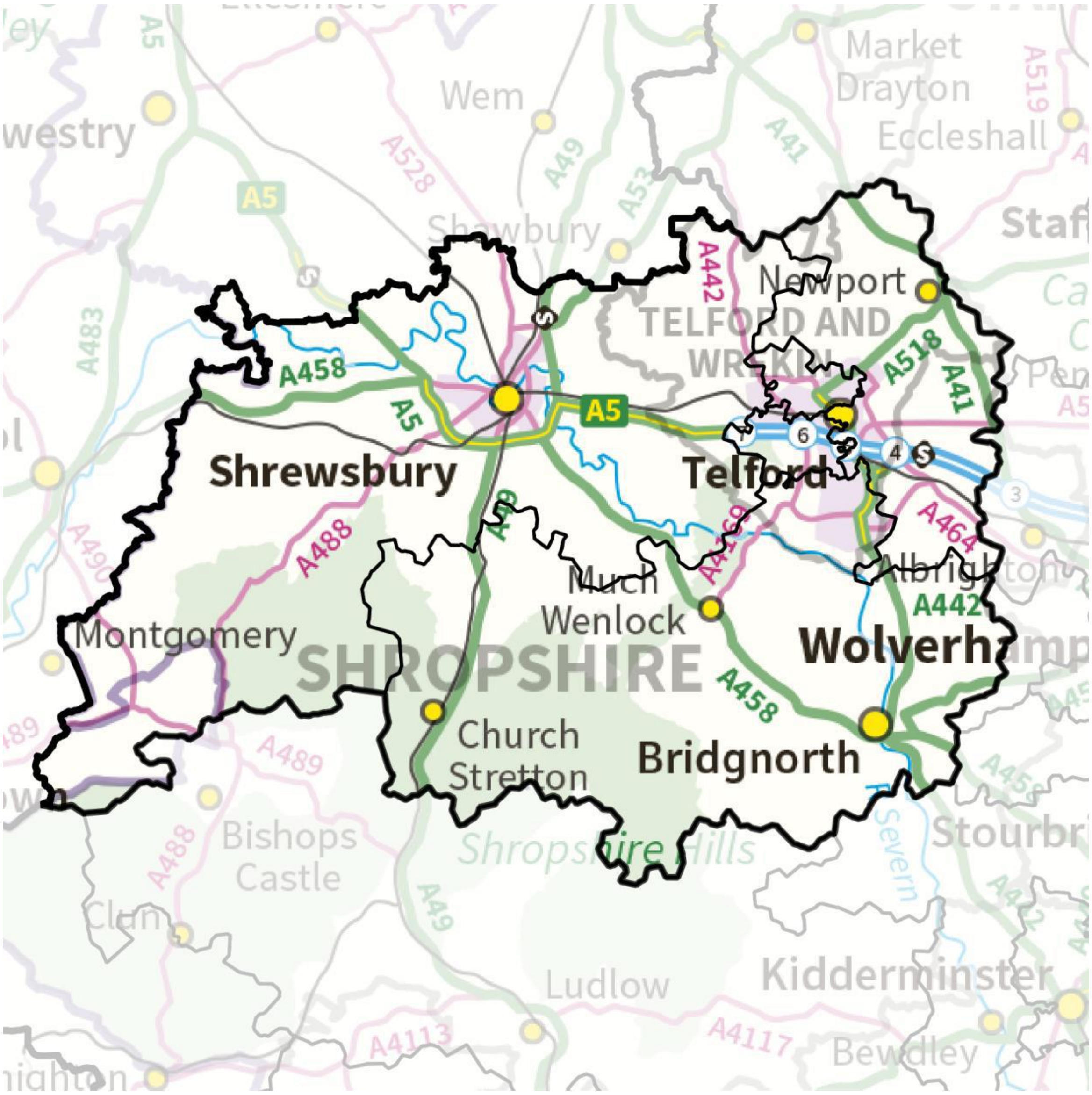

Figure 1.1 Ironbridge and Shrewsbury GSP geographic network coverage

This report discusses existing and future network constraints over a 0-10 year horizon associated with the Ironbridge and Shrewsbury GSP group 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

Ironbridge GSP is a 400/132 kV site fed via three 240 MVA Super Grid Transformers (SGTs), all running split through a two-section 132 kV double busbar arrangement.

Shrewsbury GSP is also a 400/132 kV site fed via a single 240 MVA SGT connected to a 4-section single busbar arrangement. It is interconnected with Ironbridge GSP via two 132 kV circuits, effectively creating a parallel between two of the SGTs at Ironbridge with the one at Shrewsbury.

The 132 kV interconnectors loop in via Ketley and Hortonwood BSPs.

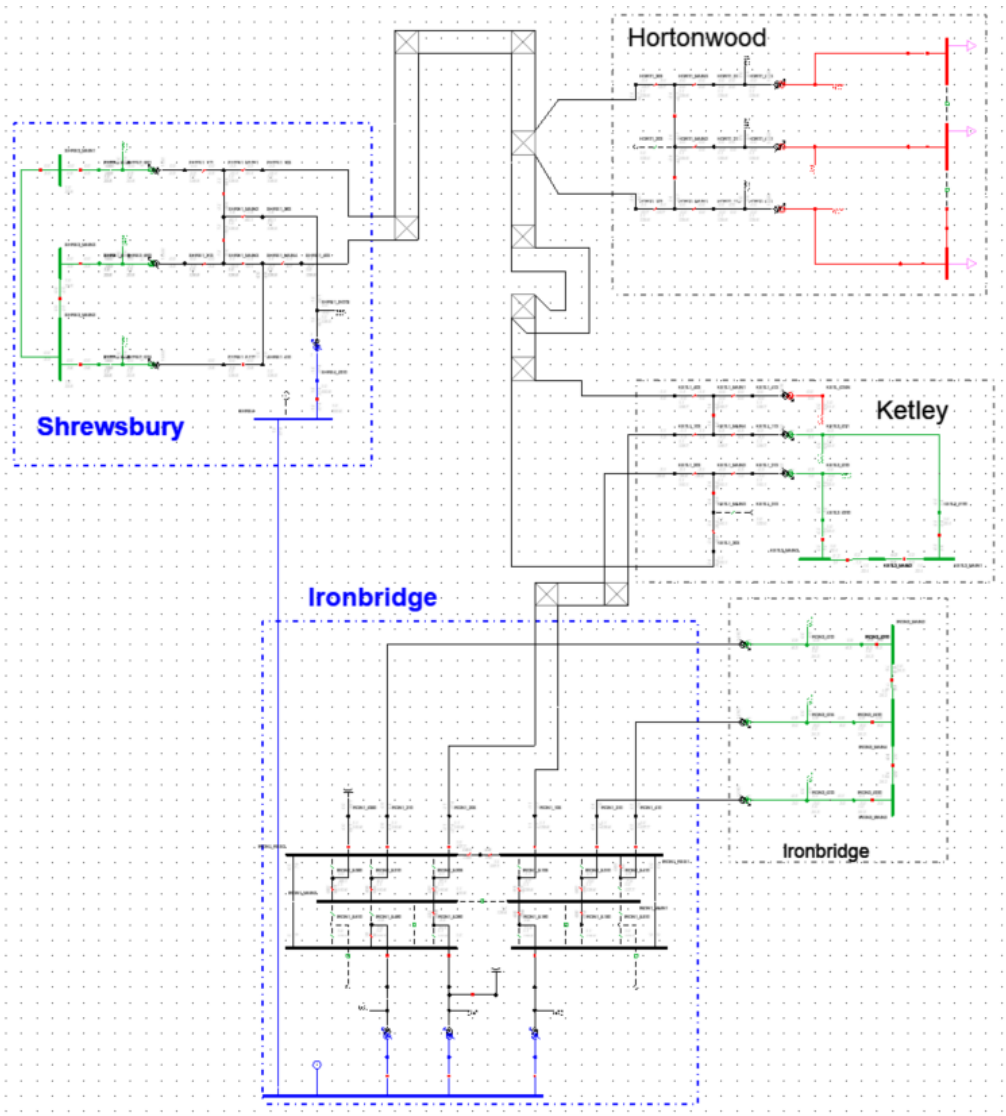

Figure 1.1.1 Ironbridge/Shrewsbury GSP schematic

A few of the BSPs within the group also have 33 kV networks downstream:

- Ironbridge BSP consists of 3x 132/33 kV Grid Transformers (GTs), suppling 8x primary substations; four of which are connected via radial circuits and four via three interconnected 33 kV circuits running as a mesh. Works to add a fourth GT are currently ongoing.
- Ketley BSP consists of a 2x 132/33 kV transformers plus a single of 132/11 kV transformer. Its 33 kV network supplies 8x primary substations most connected via radial 33 kV circuits.
- Shrewsbury BSP consists of 3x 132/33 kV GTs, supplying 11x primary substations; four of which are connected via radial circuits, and seven via several 33 kV circuits interconnected with each other running as closed ring, referred to as the Shrewsbury Ring network.

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.

Ironbridge and Shrewsbury 132 kV:

- Fault level restrictions do not permit Ironbridge GSP busbars from operating two SGTs on site in parallel with each other plus the SGT at Shrewsbury; however two SGTs can run in parallel if the Shrewsbury one is on outage. These tend to set the configuration limits when backfeeding during SGT or 132 kV busbar outages. As additional generation gets connected, further studies are required to assess the suitability of these limitations.
- Arranged outages at the SGT at Shrewsbury, or either of the 132 kV interconnectors results in the downstream network being split to avoid the other 132 kV circuit being overload following a fault outage.
- Arranged or fault outages leading to loss of a GT at Hortonwood BSP results in the 11 kV being closed in to backfeed.

Ironbridge BSP:

- Arranged outages affecting any of the GTs results in the network between the remaining two GTs in-service being run split.
- Arranged outages that split up the 33 kV busbars at Ironbridge results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged outages affecting any of the Ironbridge to Star Aluminium infeeds results in Quatt T2 being transferred to Stourport BSP, and the remaining network split to suit needs.
- Various arranged outages leading to a split of the two 132 kV circuits between the Ironbridge and Shrewsbury results is splitting of the 33 kV network to avoid back energisation for the next credible fault.
- An arranged outage of the Ironbridge to Leebotwood 33 kV circuit results in the primary being picked up from Ludlow BSP.
- Arranged or fault outages leading to loss of a primary transformer at Halesfield, Broseley, Star Aluminium, and Leebotwood results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

There is a New Connections driven scheme to add a 4th GT at Ironbridge and split the BSP into a 2+2 configuration. These are currently ongoing and would alter some of the operational behaviours listed above.

Ketley BSP:

- Arranged outages that split up the 33 kV busbars at Ketley results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged outages affecting any of the three circuits to Snedshill results in the network between the remaining two circuits being split to avoid thermal overload for a subsequent fault.
- Arranged or fault outages leading to loss of a primary transformer at Ketley 11 kV, Snedshill, Shifnal, Sankey, Donnington, Newport, and Dothill results in the 11 kV at these sites being closed in to backfeed from the other transformer(s).

Shrewsbury BSP:

- Arranged outages affecting any of the GTs results in the network between the remaining two GTs in-service being run split.
- Arranged outages that split up the 33 kV busbars at Shrewsbury results in the downstream 33 kV and 11 kV networks being split to avoid loose couples and back energisation.
- Arranged outages affecting the infeed to Leaton or Dothill results in the affected primary/primaries being picked up from Ketley BSP.
- Arranged outages affecting the infeed to Priestweston or Bishops Castle results in the affected primary/primaries being picked up from Ludlow BSP.
- Arranged outages affecting any of the four main infeeds to the Shrewsbury Ring results in the remaining circuit being split.
- Arranged or fault outages leading to loss of a primary transformer at Spring Gardens, Weir Hill, and Bishops Castle results in the 11 kV at these sites being closed in to backfeed.

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:

- Ironbridge to Ketley 132 kV circuit overload
- Halesfield transformer overload:
  - Halesfield T2 overload
  - Halesfield T1/T3 overload
- Ironbridge to Star Aluminium network:
  - Ironbridge to Broseley Tee 33 kV circuit overload
  - Star Aluminium 33 kV low volts
- Madeley transformer overload
- Snedshill transformer T1 overload
- Newport Tee 2 to Newport 2L3 33 kV circuit overload
- Rowton primary backfeed capacity
- Bayston Hill transformer overload
- Dothill transformer overload
- Spring Garden transformer overload
- Shrewsbury 33 kV ring
  - Weir Hill to Bayston Hill Tee 33 kV circuit overload
  - Voltages at 33 kV falling below limits
  - Voltages at 33 kV rising above limits
  - Voltage step change at 33 kV exceeding limits

Transmission-Distribution interface

Ironbridge and Shrewsbury GSPs are both 400/132 kV sites and the boundaries 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, switchgear fault level capability, and 400 kV circuit ratings. Proposals to mitigate are being considered including uprating the existing assets at Ironbridge GSP or establishing another GSP at a location suitable for the region.

3. Network Constraints and Solution Options

3.1 Ironbridge to Ketley 132 kV circuit overload

Constraint Overview

Generation | **Demand**

As discussed earlier in the report, Ironbridge and Shrewsbury GSP run in parallel through two 132 kV circuits. Arranged outage of the Shrewsbury SGT followed by a fault on either circuit could see the group demand consisting of Ketley, Hortonwood, and Shrewsbury picked up by the other circuit.

The group is currently Class D under Engineering Recommendation P2, anticipated to become Class E by 2032.

The table below outlines the constraints identified for Best View, the conditions they occur 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
Ironbridge to Ketley 132 kV circuit overload	N-2: Arranged outage of the SGT at Shrewsbury followed by a fault on either circuit from Ironbridge overloads the other. Group demand is also approaching Class E, by 2032, under P2	2025	2025	2026	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 3.1.2 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	Reinforcing existing 132 kV circuits	✓	✓	×	Discounted
3	Adding an Ironbridge-Ketley 132 kV circuit	✓	✓	×	Viable
4	Installing a second Shrewsbury SGT	✓	✓	✓	Viable
Operational mitigation					
5	Load transfers and split schemes	✓	✓	×	Discounted
Load Management Schemes					
6	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
7	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, as described above, and to the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Existing 132 kV circuit ratings as detailed earlier above

Option 2 – Reinforcing existing 132 kV circuits

Estimated capacity released: 100 MVA

Discounted

Detailed description: Uprating the existing 132 kV circuits between Ironbridge and Ketley.

The existing circuits consist of twin 0.175 in Aluminium Conductor Steel Reinforced (ACSR) on a double circuit tower line that is close to its theoretical maximum rating (based on its construction).

To uprate them beyond this would require a rebuild of the tower line to achieve summer ratings above 270 MVA (in order to resolve the overload constraints and meet the future compliance needs of a Class E group, requiring the group access period demand to be fully picked up during N-2 conditions).

Such construction is not standard for NGED nor DNOs in general; and in any case, would not future proof the network.

New limiting factor: Rating of the new 132 kV circuits

Option 3 – Adding an Ironbridge-Ketley 132 kV circuit

Estimated capacity released: 200 MVA

Viable

Detailed description: Adding a third circuit, the works include:

- Establishing a new 132 kV bay at Ironbridge GSP
- Installing a three-section 132 kV single busbar arrangement at Ketley with the bus-section circuit breakers normally run open.
- Reconfiguring Hortonwood's existing 132 kV loop connection to a double tee'd connection via the existing double circuit tower line, and running Hortonwood 132 kV split. The tower on site may need modification works to facilitate this.
- Reconfigure the Shrewsbury 33 kV busbars to run 2+1, with the single running GT picking up the radial feeders to Leaton/Dothill, one of the Spring Gardens transformers, and one of the Roushill transformers (on the assumption Roushill 11 kV could be run split with a sequence scheme in place).
- Installing a new 10 km 132 kV circuit between Ironbridge and Ketley (with a minimum summer sustained rating of 200 MVA).
- Extending Ketley 132 kV busbars to become a 3-section single busbar configuration with the two bus-section circuit breakers running open. The network to be configured such that:
    - The existing tower lines run in parallel with the SGT at Shrewsbury, picking up the 132/33 kV GTs at Ketley, a 132/11 kV GT at Hortonwood, and two 132/33 kV GTs at Shrewsbury.
    - The new circuit (assumed to be cable) picks up the 132/11 kV GT at Ketley, two 132/11 kV GTs at Hortonwood, and a 132/11 kV GT at Shrewsbury.
- Assessing fault levels at Ironbridge.

New limiting factor: Rating of the 132 kV circuits within the group

Option 4 – Installing a second Shrewsbury SGT

Estimated capacity released: 240 MVA

Viable

Detailed description: Adding a second SGT at Shrewsbury, the works include:

- Applying for the establishment of a second 240 MVA 400/132 kV SGT at Shrewsbury from the transmission owner.
- Reconfigure the existing 132 kV busbars at Shrewsbury to accommodate the new SGT. This may involve extending the compound to establish a new 132 kV busbar configuration to facilitate the connection.
- Creating normal 132 kV open points at Hortonwood and Ketley to effectively split the Ironbridge / Shrewsbury group.

New limiting factor: Rating of the SGTs

Option 5 – Operational mitigation: Load transfers and split schemes

Estimated capacity released: 10 MVA+

Discounted

Detailed description: This is split into two parts:

- Load transfers:

  The group has some interconnection at 33 kV at Shrewsbury BSP via the transfer of Priestweston and Bishops Castle to Ludlow, and some very limited transfers to Ironbridge BSP. These transfers ease the constraint slightly but are not sufficient as a long term solution; at least not without substantially upgrading the 33 kV interconnections.

- Network split schemes:

  This involves splitting the network during the arranged outage to avoid a thermal overload following a fault. It is already being implemented at times where the demand is close to the rating of the circuit, but it requires several switching operations (at multiple sites, and across different voltage levels) which sterilises the network and is prone to human oversights which can put the network at risk.

These measure are only viable (partially) until the group demand exceeds 300MW (anticipated by 2032) making it Class E under Engineering Recommendation P2; at which point the entire access period demand would need to be restored for an N-2 condition.

New limiting factor: Rating of the existing 132 kV circuits and P2 non-compliance

Option 6 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA

Discounted

Detailed description: The group is currently Class D under Engineering Recommendation P2, anticipated to become Class E by 2032 which requires full restoration of the demand under N-2 during the access period, therefore demand disconnection schemes (or similar) would make the network non-compliant.

New limiting factor: Engineering Recommendation P2 non-compliance

Option 7 – Flexibility service procurement

Estimated Flexibility Required (MW): 42 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, including all necessary sufficiency checks.

New limiting factor: Rating of the existing 132 kV circuits

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 4 above (adding a second SGT at Shrewsbury) as it is likely to be the most economical in the long run, and has a wider benefit of simplifying the network and reducing fault levels.

It is worth noting that option 5 can be utilised in certain conditions to manage the constraints, but it is not an enduring solution as described above, especially when the group becomes Class E.

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. Due to the timescales involved with any of the build options described above, the scheme has already been through this process but has not secured sufficient flexibility for deferment; as a result reinforcement is being progressed.

3.2 Halesfield transformer overload

Constraint Overview

Generation Demand

Halesfield is a 33/11 kV primary substation fed out of Ironbridge BSP via three circuits. The site has three transformers that normally run 2+1, where T1 and T3 run in parallel, and T2 is split. The site is Class C under Engineering Recommendation P2.

The table below outlines the constraints identified for Best View, the conditions they occur 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
Halesfield T2 overload	Intact	-	Baseline	2028	-
Halesfield T1/T3 overload	N-2: Arranged outage of T2 resulting in its demand being picked up on T1 and T3, followed by a fault of either T1 or T3	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 3.2.2 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	Adding a fourth transformer	✓	✓	×	Viable
3	Uprating the existing transformers	✓	✓	×	Viable
Operational mitigation					
4	Load transfers and split schemes	✓	✓	×	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 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: Some of the constraints are imminent with the demand projected to continue increasing. Doing nothing could therefore lead to thermal overloads and safety implications.

New limiting factor: Rating of existing transformers

Option 2 – Adding a fourth transformer

Estimated capacity released: 18 MVA **Viable**

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

- Extending the 33 kV busbars to include an additional bus-section circuit breaker and a new 33 kV transformer bay
- Installing a fourth 33/11 kV 12/24 MVA transformer
- Installing an additional 11 kV 2-section board interconnected with the existing but configured such that Halesfield runs 2+2

New limiting factor: Rating of the 33 kV incoming circuits

Option 3 – Uprating the existing transformers

Estimated capacity released: 24 MVA **Viable**

Detailed description: Uprating the existing three 12/24 MVA primary transformers with 20/40 MVA units. The existing 11 kV board is already 2000 amp rated and would therefore not need replacing.

New limiting factor: Rating of the incoming 33 kV circuits

Option 4 – Operational mitigation: Load transfers and split schemes

Estimated capacity released: Up to 18 MVA

Viable

Detailed description: There are two considerations:

- With regards to Halesfield T2 intact constraint: the mitigation is to permanently move some demand, via the 11 kV network, from T2 to T1/T3.
- With regards to the N-2 constraint for Halesfield T1/T3, the mitigation is to split the network between T1 and T3 during the arranged outage of T2.

New limiting factor: Rating of existing transformers

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

Estimated capacity released: 0 MVA

Discounted

Detailed description: Halesfield primary is Class C under Engineering Recommendation P2 which would require restoration of the group 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): 3 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 existing transformers

Solution Recommendation

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

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 DNOA process. The flexibility option however, although may be technically viable, is not likely to be as cost-effective as the Operational mitigation option.

3.3 Ironbridge to Star Aluminium network

Constraint Overview

Generation | Demand

Broseley, Worfield, Star Aluminium, and Quatt T2 are 33/11 kV primary substations fed out of Ironbridge BSP via three 33 kV interconnected circuits, all running in parallel via Star Aluminium 33 kV busbars. The network also includes 33 kV connected customers.

The group is currently 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
Ironbridge to Broseley Tee 33 kV circuit overload	N-1: Outage of the direct 33 kV circuit between Ironbridge and Star Aluminium	2029	2029	2028	2030
Star Aluminium 33 kV low volts	N-1: Outage of the direct 33 kV circuit between Ironbridge and Star Aluminium	2026	2026	2028	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 3.3.2 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	Uprating the existing circuits	✓	✓	×	Viable
3	Installing a 33 kV circuit to Star Aluminium	✓	✓	✓	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 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 2026 with the demand projected to continue increasing thereafter. Doing nothing could therefore lead to thermal overloads, voltages dropping below statutory limits, and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Low volts and rating of the existing circuit

Option 2 – Uprating the existing circuits

Estimated capacity released: 5-10 MVA — Viable

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

- Ironbridge to Broseley Tee 1 circuit: 4 km tower line
- Broseley Tee 1 to Star Aluminium circuit: 13 km OHL
- Ironbridge to Broseley Tee 2 circuit: 4 km tower line
- Broseley Tee 2 to Worfield: 11.5 km OHL

The circuit works above would need to include a substantial amount of undergrounding to achieve the desired rating and to reduce the impedance of the network to improve the 33 kV voltages. This would unlock some capacity but the further undergrounding work would be necessary again in the medium term to release more capacity.

New limiting factor: Low volts at 33 kV

Option 3 – Installing a 33 kV circuit to Star Aluminium

Estimated capacity released: 37 MVA — Viable

Detailed description: Installing a new 13 km 33 kV circuit between Ironbridge and Star Aluminium, utilising existing panels where possible. Reconfiguration at Ironbridge may be necessary to best fit with the existing works of adding a fourth GT.

New limiting factor: Rating of the existing 33 kV circuits within the group

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: 5-10 MVA — Discounted

Detailed description: The group has interconnection at 33 kV to transfers Quatt T2 over to Stourport BSP which could be utilised for some arranged outages to limit the constraint (not fully mitigate), but not under fault outages.

Furthermore, 11 kV transfers out of the group are extremely limited due to the primaries being rural, and therefore not sufficient to mitigate the anticipated constraints.

New limiting factor: Low volts and rating of existing circuits

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

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The group 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): 30 MW+ **Discounted**

Detailed description: Flexibility services through generation turn up and/or demand turn down may help reduce some of the constraints but MW procurement only would not be sufficient to resolve the voltage constraints without hindering the Power Quality of the network.

New limiting factor: Power Quality

Solution Recommendation

It is recommended to pursue option 3 above (installing a new 33 kV circuit to Star Aluminium) as it is likely to be the most cost-effective, deliverable, and long lasting solution, allowing the network to be operated in a more efficient and secure manner.

3.4 Madeley transformer overload

Constraint Overview

Generation Demand

Madeley primary is 33/11 kV site consisting of two transformers fed from Ironbridge BSP via two 33 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
Madeley transformer overload	N-1: Outage of either of the two transformers at Madeley	2027	Baseline	Baseline	-

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	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 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: 12 MVA **Viable**

Detailed description: Uprating the existing transformers, the works can be split into two phases:

Phase 1: Transformer works

- Replacing the existing two 12/24 MVA transformers (commissioned in 1962) with 20/40 MVA units
- Replacing the existing 1250 amp 11 kV board (commissioned in 1990) with a 2000 amp board
- Allowing space for a future 33/11 kV transformer on site

Phase 2: Circuit works

There are two sub-options for the circuit works:

Option a:

- Installing a new 3-section 33 kV indoor switchgear board consisting of minimum of 9x panels to include three transformers (one being a future spare), two bus-sections, three incoming circuits, and one outgoing circuit.
- One of the exiting 33 kV circuits between Ironbridge and Halesfield is a 40 MVA cable circuit that runs very close to Madeley primary; so the works would be to loop this circuit into Madeley via the new 33 kV switchboard.

Option b:

- Uprating the existing two circuits between Ironbridge and Madeley, each consisting of:
    - 5 km of 0.15 in ACSR to be uprated to 200 mm All Aluminium Alloy conductor (AAAC) designed to 75 degrees.
    - 1.3 km of underground cable (mixture of Al cable and 0.5 in copper cable) to a minimum of 400 mm copper cable to achieve a 40 MVA winter cyclic rating.

It is worth noting that phase 1 would increase capacity by a few MVAs, enough to secure the site until RIIO-ED4, beyond which the circuit works would need to be considered.

New limiting factor: Rating of transformers and circuits

Option 3 – Adding a third transformer

Estimated capacity released: 18 MVA **Viable**

Detailed description: Adding a third transformer on site, the works can be split into two phases:

Phase 1: Transformer works

- Installing a new 3-section 33 kV indoor switchgear board consisting of minimum of 9x panels to include three transformers, two bus-sections, three incoming circuits (one spare), and one outgoing circuit (also a spare).
- Installing a third 12/24 MVA 33/11 kV transformer.
- Installing an additional 2-section 11 kV board suitably interconnected with the existing.

Phase 2: Circuit works

There are two sub options for the circuit works:

Option a:

- One of the exiting 33 kV circuits between Ironbridge and Halesfield is a 40 MVA cable circuit that runs very close to Madeley primary; so the works would be to loop this circuit into Madeley via the new 33 kV switchboard.

Option b:

- Uprating the existing two circuits between Ironbridge and Madeley, each consisting of:
    - 5 km of 0.15 in ACSR to be uprated to 200 mm AAAC designed to 75 degrees.
    - 1.3 km of underground cable (mixture of Aluminium cable and 0.5 in copper cable) to a minimum of 400 mm copper cable to achieve a 40 MVA winter cyclic rating.

It is worth noting that phase 1 would increase capacity by a few MVAs, enough to secure the site until RIIO-ED4, beyond which the circuit works would need to be considered.

New limiting factor: Rating of the transformers and circuits

Option 4 – Operational mitigation: Load transfers

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

Detailed description: Madeley primary has 11 kV interconnection to Halesfield primary which could help alleviate the Baseline constraints in the interim, but not sufficient enough to secure the site in the long run.

New limiting factor: Rating of the transformers

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

Estimated capacity released: 0 MVA **Discounted**

Detailed description: Madeley 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): 5.5 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 will likely be more cost-effective especially when considering the age of the existing assets.

As mentioned above, option 4 (operational mitigation) can also be implemented in the interim to manage the baseline constraints but it would not be 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 DNOA process.

3.5 Snedshill transformer T1 overload

Constraint Overview

Generation | **Demand**

Snedshill is a 33/11 kV primary substation fed out of Ketley BSP via three circuits connected to Snedshill 33 kV indoor board that runs solid. The site has three transformers that normally run 2+1, where T1 and T3 run in parallel and therefore backfeed each other, and T2 is run split.

T1 and T2 are 20 MVA transformers, while T3 is a 20/40 MVA unit.

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 3.5.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Snedshill transformer T1 overload	N-1: Outage of transformer T3	Baseline	Baseline	Baseline	2028

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

Solution Options

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

Table 3.5.2 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	Upgrading transformer T1	✓	✓	×	Viable
3	Adding a fourth 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 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 the existing transformer

Option 2 – Upgrading transformer T1

Estimated capacity released: 18 MVA

Viable

Detailed description: Uprating the existing 20 MVA transformer T1 (commissioned in 1965) with a 20/40 MVA unit.

New limiting factor: Rating of transformer T2

Option 3 – Adding a fourth transformer

Estimated capacity released: 18 MVA

Viable

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

- Installing a second 33 kV switchgear board at Snedshill interconnected and run in parallel with the existing board.
- Installing a new 33/11 kV transformer rated 20/40 MVA, and reconfiguring the 11 kV such that the pair of 20/40 MVA units run in parallel, and the other pair of 20 MVA units run together, with suitable 11 kV interconnection between the two sides

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

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: There are two transfers here:

- Transferring demand to transformer T2 (under normally running arrangement) would mitigate temporarily before starting to thermally overload T2.
- Transferring demand to other primary substations such as Madeley or Halesfield primaries (under normal running arrangements) but this would also start triggering constraints at these primaries in the short-medium term.

In summary, these transfers can be utilised to carefully manage the baseline constraints in the interim, but are not viable as long term solutions.

New limiting factor: Rating of transformer T1

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

Estimated capacity released: 0 MVA

Discounted

Detailed description: The primary substation is Class C under Engineering Recommendation P2 which would require restoration of the group 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): 2 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 2 above (uprating transformer T1) as it is likely to be the most deliverable and cost-effective solution especially when considering the age of the transformer.

As mentioned above, option 4 (operational mitigation) can also be implemented in the interim to manage 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 may be tested against the flexibility market as part of the DNOA process.

3.6 Newport Tee 2 to Newport 2L3 33 kV circuit overload

Constraint Overview

Generation Demand

Newport primary is a 33/11 kV site consisting of two 12/24 MVA transformers fed via two circuits from Ketley BSP, with tee points to Sankey/Donnington on one side (Newport Tee 2), and Dothill on the other (Newport Tee 1).

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
Newport Tee 2 to Newport 2L3 33 kV circuit overload	N-1: Outage of the other 33 kV circuit into Newport from Ketley BSP	2031	2032	2033	-

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 the existing circuit	✓	✓	×	Viable
3	Installing a new 33 kV circuit from Ketley	✓	✓	×	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 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 the existing circuit

Option 2 – Upgrading the existing circuit

Estimated capacity released: 15 MVA

Viable

Detailed description: Uprating the existing OHL circuit (mainly consisting of 5.4 km of 0.15 in ACSR OHL conductor) to 34 MVA winter cyclic rating (anticipated to be 200 mm AAAC).

New limiting factor: Rating of the transformers

Option 3 – Installing a new 33 kV circuit from Ketley

Estimated capacity released: 40 MVA

Viable

Detailed description: Adding a circuit between Ketley and Newport, the works include:

- Extending the 33 kV switchgear board at Ketley (on the GT1 side) to allow for a new CB; where there is no room to extend, consideration is to be given to installing a 3-panel board on site and using this to reconfigure and make provision for a new panel.
- Extending the 33 kV busbars at Newport to allow for a new incoming circuit and a bus-section circuit breaker.
- Installing approximately 13 km of 33 kV circuit from Ketley to Newport.

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: Limited

Discounted

Detailed description: The substation is relatively rural with very limited transfer capacity at 11 kV, and therefore insufficient to mitigate the constraint.

New limiting factor: Rating of the existing circuit

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

Estimated capacity released: 0 MVA

Discounted

Detailed description: The primary is Class C under Engineering Recommendation P2 which would require restoration of the group 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): 3 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 existing circuit

Solution Recommendation

With regards to reinforcement build options, it would be recommended to pursue option 2 above (uprating the existing circuit) as it is more likely to be a cost-effective and deliverable solution that avoids complicating the network further.

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 DNOA process.

3.7 Rowton primary backfeed capacity

Constraint Overview

Generation | **Demand**

Rowton is a single 33/11 kV transformer site that relies on 11 kV interconnection to other primary substations for security of supply. The site is Class B 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
Rowton primary backfeed capacity	N-1: Outage of the primary transformer at Rowton	Baseline	Baseline	Baseline	-

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 backfeed capacity	✓	✓	×	Viable
3	Adding a second 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 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: 11 kV backfeed capacity

Option 2 – Upgrading the 11 kV backfeed capacity

Estimated capacity released: A couple of MVAs **Viable**

Detailed description: Upgrading the 11 kV interconnections to other primary substations such as Malehurst (5.5 km away) and Spring Gardens (13 km away), especially since the shortfall is relatively small (less than 1 MVA).

[The current capacity is assumed to be approximately 3 MVA, it would be worth carrying out a re-assessment of this existing capacity before commencing any physical works.]

New limiting factor: 11 kV backfeed capacity

Option 3 – Adding a second transformer at Rowton

Estimated capacity released: 11 MVA **Viable**

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

- Extending the 33 kV busbars to include a bus-section circuit breaker and an additional transformer bay
- Extending the 11 kV busbars to include a transformer incomer
- Installing a second 33/11 kV transformer rated 7.5/15 MVA

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: 0 MW **Discounted**

Detailed description: The substation already relies on 11 kV backfeed for security of supply, which is the existing limiting factor.

New limiting factor: 11 kV backfeed capacity

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

Estimated capacity released: 0 MW **Discounted**

Detailed description: The primary is Class B under Engineering Recommendation P2 which would require restoration of the group demand minus 1 MW within 3 hours for a circuit outage; therefore demand disconnection schemes (or similar) would make the site non-compliant in the foreseeable future as the shortfall exceeds 1 MW.

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: 11 kV backfeed capacity

Solution Recommendation

With regards to reinforcement build options, both option 2 (upgrading the 11 kV backfeed) and option 3 (adding a second transformer) have merit and would therefore be subject to a more detailed assessment.

However given that the shortfall by 2034 is relatively small (less than 1 MVA), and the trigger is fairly imminent, it would be worth pursuing option 2 in the first instance, re-assessing the 11 kV network and identifying the upgrades necessary to maintain security of supply for the site.

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 DNOA process.

3.8 Bayston Hill transformer overload

Constraint Overview

Generation | **Demand**

Bayston Hill primary is a 33/11 kV site consisting of a 3-section 33 kV air-insulated busbars supplying two 12/24 MVA transformers (commissioned in 2012) that normally run in parallel. It is fed from the Shrewsbury ring, and 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 3.8.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Bayston Hill transformer overload	N-1: Arranged or fault outage of either primary transformer	-	2030	2033	-

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	Adding a third transformer	✓	✓	×	Viable
3	Uprating the existing transformers	✓	✓	×	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 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 the existing transformers

Option 2 – Adding a third transformer

Estimated capacity released: 18 MVA

Viable

Detailed description: Adding a third transformer, the work include:

- Installing a third 12/24 MVA 33/11 kV transformer; additional land, possibly to the south of the existing boundary, may need to be sought
- Extending the 33 kV busbars, where the new Bayston Hill-Malehurst circuit would be connected to, and installing a disconnector and a sealing end structure allowing for a suitable cable connection to the new transformer.

  [These 33 kV busbar extension works rely on the reinforcement works proposed for the Shrewsbury Ring, otherwise the busbars connecting the existing Bayston Hill-Malehurst circuit would need to be extended instead. This would involve undergrounding that first section of the circuit to create enough space for the busbar extension works.]
- Installing a new 2-section 2000 amp 11 kV board in a new building. The new transformer would be connected to this new 11 kV board, which would also have two interconnectors to either side of the existing board.

New limiting factor: Rating of the transformers

Option 3 – Uprating the existing transformers

Estimated capacity released: 12 MVA

Viable

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

- Replacing the existing two 12/24 MVA transformers with two 20/40 MVA units
- Replacing the existing 2-section 1250 amp 11 kV switchgear board with a 2000 amp board

New limiting factor: Rating of the incoming 33 kV circuits

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs

Discounted

Detailed description: Bayston Hill primary has 11 kV interconnections to Berrington and Weir Hill:

- Transfers to Berrington are almost nil due to the size of its primary transformer; the 11 kV interconnections there are generally for the benefit of Berrington and not Bayston Hill.
- Transfers to Weir Hill are limited to a couple of MVAs to avoid overloading the transformers there.

These transfers are therefore not sufficient to mitigate the constraint longer term.

New limiting factor: Rating of the existing transformers

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

Estimated capacity released: 0 MVA

Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group 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): 3 MW+

Viable

Detailed description: Flexibility services through generation turn up and/or demand turn down could help alleviate the constraint. 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 existing transformers

Solution Recommendation

Both option 2 (adding a third transformer) and option 3 (uprating the existing transformers) have merit and are closely matched in terms of a technical solution; further detailed assessment may be needed to affirm the best option which could depend on the progress of the existing proposals for the Shrewsbury Ring and how quickly the demand projections materialise.

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 before commencing any physical works.

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 DNOA process.

3.9 Dothill transformer overload

Constraint Overview

Generation | **Demand**

Dothill primary is a 33/11 kV site consisting of two 33/11 kV transformers (commissioned in 2016) fed out of two 33 kV circuits; one from Shrewsbury BSP and one from Ketley BSP, with the site normally running split at 33 kV and 11 kV. The group is currently Class B under Engineering Recommendation P2, anticipated 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 3.9.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Dothill transformer overload	N-1: Arranged or fault outage of either of the transformers	2032	2030	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 3.9.2 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 transformers	✓	✓	×	Viable
3	Adding a third transformers	✓	✓	×	Viable
4	Uprating the Leaton transformers and 11 kV backfeed to Dothill	✓	✓	✓	Viable
Operational mitigation					
5	Load transfers	×	✓	×	Discounted
Load Management Schemes					
6	Post-fault inter-trips	×	✓	×	Discounted
Flexibility services					
7	Flexibility service procurement	✓	✓	×	Viable

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed 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 the Forsbrook to Simplex 33 kV circuit

Option 2 – Uprating the existing transformers

Estimated capacity released: 9 MVA

Viable

Detailed description: Uprating the existing 7.5/15 MVA 33/11 kV transformers (commissioned in 2016) with 20/40 MVA units.

[The existing 11 kV board is 1250 amp (commissioned in 2016) and not expected to overload until after 2035, and therefore would not need to be uprated yet.]

New limiting factor: Rating of the 11 kV switchgear board

Option 3 – Adding a third transformer

Estimated capacity released: 14 MVA

Viable

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

- Extending the 33 kV AIS busbars to the West of the compound
- Installing an additional bus-section CB and two new bays; one for the new transformer, and the other for relocating the Leaton circuit
- Installing a third 33/11 kV transformer rated 12/24 MVA
- Installing a new 2-section 11 kV switchgear board in a newly constructed building, and suitably interconnecting it to the existing board

New limiting factor: Rating of the 33 kV incoming circuits

Option 4 – Uprating the Leaton transformers and 11 kV backfeed to Dothill

Estimated capacity released: 24 MVA

Viable

Detailed description: Uprating the transformers at Leaton and the 11 kV backfeed to Dothill, the works include:

- Replacing the two 33/11 kV transformers at Leaton (commissioned in 1962 and rated 7.5 MVA) with 12/24 MVA units.
- Upgrading the 11 kV network between Leaton and Dothill to add about 12 MVA of transfer capability. Two 3.5 km cable circuits, anticipated to be no less than 300 mm copper conductor, could achieve this but the works would more likely involve a mixture of upgrading various overhead lines and underground cable to best utilise the network.
- Existing circuit breakers to be utilised but where space permits, additional 11 kV switchgear could be installed. The projected demand growth at Dothill could then be moved onto Leaton primary via the upgraded 11 kV network.

[The 11 kV board at Leaton is rated 1200 amp which is currently suitable for the network needs.]

New limiting factor: Rating of the 11 kV switchgear board.

Option 5 – Operational mitigation: Load transfers

Estimated capacity released: A couple of MVAs **Discounted**

Detailed description: Load transfers out of Dothill are limited and would be insufficient to secure the site for the projected load growth.

New limiting factor: Rating of the existing transformers

Option 6 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The site is Class B under Engineering Recommendation P2, anticipated to become Class C by 2030, which would require restoration of the group 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 7 – 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 existing transformers

Solution Recommendation

It is recommended to pursue option 4 above (replacing the transformers at Leaton and upgrading the 11 kV backfeed to Dothill) as it is likely to be the most cost-effective option considering the age of the assets at Dothill (2016) and Leaton (1962). It also has the wider benefit of improving the 11 kV interconnection between these sites, increasing their security of supply even for N-2 conditions.

- Allow for the aggressive demand growth at Dothill
- Improve the 11 kV network and its interconnectivity
- Provide a wider benefit at Leaton especially since the existing transformers are over 60 years old. [Note: The 11 kV board at Leaton is of similar age but its 1200 amp rating is suitable; when this gets replaced on asset condition, it would be recommended to add extra CBs to allow better transfers with Dothill primary.]

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 DNOA process.

3.10 Spring Gardens transformer overload

Constraint Overview

Generation | **Demand**

Spring Gardens is a 33/11 kV primary substation consisting of two 20/40 MVA transformers that are supplied from Shrewsbury BSP via a pair of 33 kV circuits. 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 3.10.1 overview of constraint

Constraint	Condition	Trigger year per season			
		Winter	Inter Cool	Inter Warm	Summer
Spring Gardens transformer overload	N-1: Outage of either of the two 33/11 kV transformers	-	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 3.10.2 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	Installing a third circuit and transformer	✓	✓	×	Viable
3	Establishing of a new primary at Shelton	✓	✓	✓	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 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 2034, 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 transformers

Option 2 – Installing a third circuit and transformer

Estimated capacity released: 30 MVA — Viable

Detailed description: Adding a third transformer and incomer, the works include:

- Purchasing additional land at Spring Gardens to accommodate the additional assets (this comes with risk to delivery due to the existing site being located in a residential area)
- Installing approximately 5 km of 33 kV cable circuit from Shrewsbury BSP to Spring Gardens
- Installing a 3-section 8-panel 33 kV switchgear board in a newly constructed building
- Installing an additional 2-section 11 kV board, interconnected to the existing board

New limiting factor: Rating of the new transformers

Option 3 – Establishing of a new primary at Shelton

Estimated capacity released: 14 MVA — Viable

Detailed description: Establishing a new primary at Shelton, the works include:

- Establishing a new 33/11 kV primary at an existing site owned by NGED (called Shelton), comprising two 20/40 MVA transformers and an 11 kV switchgear board
- Laying approximately 8 km of two 33 kV cable circuits, each being 630 mm copper EPR, between Shrewsbury BSP and the new primary site, to at least match the transformer ratings
- Constructing the site to allow for a future 33 kV switchgear board to potentially loop in the Harlescott-Rowton 33 kV circuit which is less than 100 m away from the new site
- Transferring in demand at 11 kV from Spring Gardens and Roushill primary substations

New limiting factor: Rating of the transformers

Option 4 – Operational mitigation: Load transfers

Estimated capacity released: A few MVAs — Discounted

Detailed description: Spring Gardens primary has some 11 kV interconnection to Roushill and Harlescott primary substations. The transfers are limited to a few MVAs to avoid overloading the other substations; therefore this solution on its own is discounted but it can be partially implemented to delay reinforcement, or relieve Spring Gardens during the works.

New limiting factor: Rating of the exiting transformers

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

Estimated capacity released: 0 MVA — Discounted

Detailed description: The site is Class C under Engineering Recommendation P2 which would require restoration of the group 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

It would be recommended to pursue option 3 above (establishment of a new Shelton primary), as it is likely to be the most deliverable and economical solution longer term. The option also has the following wider benefits:

- easing the pressure off Roushill primary which has accessibility restrictions and 11 kV network limitations
- increasing interconnectivity with other substations such as Harlescott primary
- creating an opportunity in the future to loop in the Harlescott-Rowton 33 kV circuit, providing additional support for the Shrewsbury Ring 33 kV network

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 before commencing any 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 DNOA process.

3.11 Shrewsbury 33 kV Ring

Generation | Demand

Constraint Overview

Shrewsbury ring supplies eight 33/11 kV primary substations (Weir Hill, Bayston Hill, Malehurst, Rowton, Harlescott, and Bishops Castle T2), all fed via four main 33 kV infeeds (two either side), normally running in parallel. The group is currently Class C under Engineering Recommendation P2, expected to become Class D in RIIO-ED3.

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
Weir Hill to Bayston Hill Tee 33 kV circuit overload	N-1: Arranged or fault outages of the Shrewsbury-Weir Hill L1 33 kV circuit	2034	2034	2034	-
Voltages at 33 kV falling below limits	Intact; N-1: Arranged or fault outages of the Bayston Hill-Malehurst circuit	Baseline	Baseline	Baseline	-
Voltages at 33 kV rising above limits	N-1: Arranged or fault outages of the Bayston Hill-Malehurst circuit, or the Harlescott-Rowton circuit	-	-	-	Baseline
Voltage step change at 33 kV exceeding limits	Intact, where battery storage connections go from full import to full export, and vice versa	2028	2028	2028	2028

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

Solution Options

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

Table 3.11.2 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	Adding a Bayston Hill-Malehurst circuit	✓	✓	×	Viable
3	Installing a Statcom at Priestweston 33 kV	✓	✓	×	Viable
4	Establishing a new primary at Shelton	×	✓	✓	Discounted
5	Uprating circuits within the ring	×	✓	✓	Discounted
Operational mitigation					
6	Network split and demand transfers	×	✓	×	Discounted
Load Management Schemes					
7	Post-fault inter-trips and ANM	×	✓	×	Discounted
Flexibility services					
8	Flexibility service procurement	×	✓	×	Discounted

Solution Development

These options have been assessed on their technical viability and cost-effectiveness pending a more detailed 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: Some of the constraints are imminent with the demand projected to continue increasing. Doing nothing could therefore lead to thermal overloads, voltage levels out of statutory limits, power quality restrictions, and the inability to meet security of supply compliance with Engineering Recommendation P2.

New limiting factor: Rating of existing circuits and 33 kV network volts

Option 2 – Adding a Bayston Hill-Malehurst circuit

Estimated capacity released: 16 MVA

Viable

Detailed description: Installing an additional 33 kV circuit between Bayston Hill and Malehurst, connected to the existing AIS structures, and uprating some of the existing network. The works are split into the following parts for clarity:

Part 1: Weir Hill-Bayston Hill Tee (Cronkhill) 33 kV circuit:

The circuit is a mixture of 400 mm copper cable and 0.15 in ACSR OHL, with some sections of 300 mm copper cable. The proposal is as follows:

- Uprating the 300 mm copper sections (totalling 400m in length) to 400 mm or 630 mm copper EPR
- Installing approximately 5 km of 400 mm copper EPR cable from pole 84ZYPB23 to Bayston Hill primary, connecting onto line isolator L2 and replacing the existing Ironbridge Tee/Weir Hill connection.
- To enable the new cable section above, pole 84ZYPB23 may need modification works to allow for a tee connection (comprising two cable circuits and one OHL); and a new sealing end structure would be required at Bayston Hill for the new termination.

- Removing the existing tee connection at pole 84ZYPB42 such that the circuit from Ironbridge/Condover now extends to the pole 84ZYPB23, which becomes the new Ironbridge/Bayston Hill tee.
- The resultant disconnected circuit section (from pole 84ZYPB42 to Bayston Hill L2) becomes redundant at 33 kV. Proposal would therefore be to operate this at 11 kV as an interconnector, normally run open, between Bayston Hill and Berrington primary substations. Suitable 11 kV CBs or ring main units either end, and 11 kV cable sections (approximately 1.3 km) may be required to facilitate this.

Part 2: Weir Hill-Berrington Tee 33 kV circuit:

The circuit is mostly 400 mm copper cable, with one section of 300 mm copper. Proposal would therefore be to uprate the 300 mm copper section (approximately 80m in length) to 400 mm or 630 mm copper cable.

Part 3: Berrington Tee-Bayston Hill 33 kV circuit:

The circuit is a mixture of cable (400 mm, 240 mm, and 185 mm copper sections), and overhead line (0.175 in ACSR and 200 AAAC). The proposal is as follows:

- Uprating/undergrounding the entire 6 km circuit to 400 mm copper EPR cable.
- Installing a new sealing end structure at Bayston Hill to allow for a cable connection from Berrington Tee instead of an overhead one. This includes positioning the new sealing end in a suitable location to remove the existing 33 kV busbar cross-over. The existing liquid neutral earthing resistor may also need to be re-located.

Part 4: Additional Bayston Hill-Malehurst circuit:

There is an existing Bayston-Malehurst 33 kV circuit, so this will be installing a second circuit run in parallel with the existing. The proposal is as follows:

- At Bayston Hill:
    - Installing an additional 33 kV AIS bus-section CB between CB S2 and disconnector S2C
    - Establishing a new 33 kV bay between this new bus-section CB and existing CB S2
    - Furnishing the new bay and assets with disconnectors to suit, including a sealing end structure for a new additional circuit to Malehurst primary
- At Malehurst, extending the 33 kV busbars between disconnectors S1B and S2A by installing a disconnector and a sealing end structure for a new circuit from Bayston Hill.
- Installing a new 13 km 33 kV circuit between Bayston Hill and Malehurst:
    - construction is assumed to be a mix of OHL and underground cable (50/50 split)
    - Overhead line sections proposed to be of 200 mm AAAC designed to 75 degrees
    - cable sections proposed to be 400 mm copper cable
    - it is anticipated that cable sections would terminate at both substations, hence the sealing end structures proposed earlier above
- At Ludlow BSP, raising the 33 kV target volts to 1.027 per unit (pu), aligning with that at Shrewsbury BSP, to improve the volts during transfers of Priestweston and Bishops Castle T2.

New limiting factor: Rating of the 33 kV incomers

The schematic diagram below shows the Shrewsbury Ring network and the proposals as parts of option 2 above.

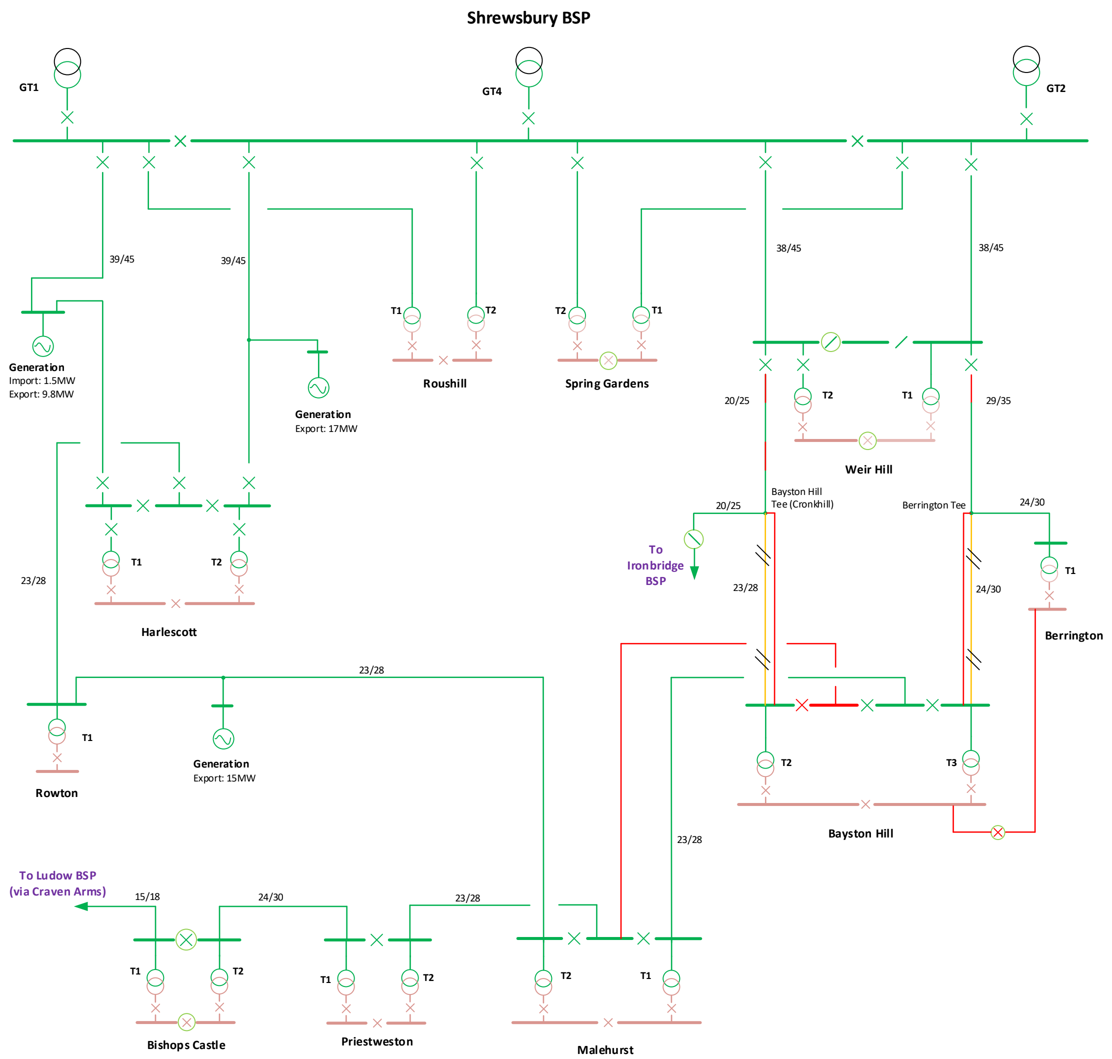

Figure 3.11.1 Shrewsbury ring schematic

Option 3 – Installing a Statcom at Priestweston 33 kV

Estimated capacity released: 14 MVA

Viable

Detailed description: Installing a 33 kV Statcom at Priestweston primary substation, in addition to uprating and reconfiguring parts of the existing circuits. The works are split into the following parts for clarity:

Part 1 to Part 3 is identical to those of option 2 above.

Part 4: Installing a Statcom at Priestweston 33 kV:

The works include the following:

- Purchasing additional land on the south eastern side of the existing Priestweston compound.
- Extending the AIS busbars on the T1 side by installing an additional 33 kV bus-section circuit breaker.
- Moving the connections for T1 and for Bishops Castle 33 kV circuit to the newly extended busbars.
- Installing a minimum of 10 MVAr Statcom and connecting it at 33 kV between the existing and new bus-section circuit breakers.

New limiting factor: 33 kV network volts

Option 4 – Establishing a new primary at Shelton

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

Detailed description: Establishing a new 33/11 kV primary substation at a site in Shelton already owned by NGED. The works include:

- Establishing a new 33/11 kV primary site at Shelton, comprising two 20/40 MVA transformers, and an 11 kV switchgear board.
- Laying approximately 8 km of two 33 kV cable circuits, each being 630 mm copper EPR, between Shrewsbury BSP and the new primary site, to at least match the transformer ratings.
- Constructing the site to allow for a future 33 kV switchgear board to potentially loop in the Harlescott-Rowton 33 kV circuit which is less than 100m away from the new site.
- Transferring in demand at 11 kV from primaries within the Shrewsbury ring, in order to reduce the loading and improve network volts.

New limiting factor: The 33 kV network volts

Option 5 – Uprating circuits within the ring

Estimated capacity released: 14 MVA **Discounted**

Detailed description: Uprating the existing circuit within the ring to add capacity and improve volts, the works include:

- Uprating the two Weir Hill-Bayston Hill 33 kV circuits – similar to parts 1-3 from reinforcement option 2 above.
- Uprating a total of about 23 km of 0.175 ACSR OHL along the Harlescott-Rowton-Malehurst 33 kV route, to a larger conductor (200 or 300 AAAC) or underground cable (400 mm Cu).

None of the conductor sizes above will fully resolve the constraints, and the cable option will most likely be uneconomic.

New limiting factor: The 33 kV network volts

Option 6 – Operational mitigation: Load transfers

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

Detailed description: There are a few transfers between Shrewsbury ring other areas (including transfers to Ludlow BSP) but these are not sufficient to resolve the constraints, and do not mitigate those under intact conditions.

Such transfers can however be utilised in the interim to manage some of the baseline constraints and network risks, but are not viable as a long term solution.

New limiting factor: The 33 kV network volts

Option 7 – Load Management Schemes: Post-fault inter-trips

Estimated capacity released: 0 MVA **Discounted**

Detailed description: The group 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 8 – Flexibility service procurement

Estimated Flexibility Required (MW): A few MWs (for thermal constraints) **Discounted**

Detailed description: Flexibility services through generation turn up and/or demand turn down may reduce some risk on specific thermal overload scenarios, but it could be more detrimental to the network if different fault outages occur, considering the parallel ring configuration. It is also not effective for the voltage constraints, nor for the generation triggered ones.

New limiting factor: Rating of the existing transformers

Solution Recommendation

It would be recommended to pursue option 2 above (adding a Bayston Hill-Malehurst circuit) as it best mitigates the identified constraints and provides a better path for simplifying, operating, and building out the network in the future.

It is worth noting however that installing a Statcom as per option 3 above has some merit and is closely matched to option 2, but comes with the following concerns;

- Cost effectiveness,
- deliverability risks especially with the size of the additional land needed,
- ongoing maintenance requirements,
- failure risks.

It is anticipated however that during the RIIO-ED4 price control period and beyond, a form of voltage control at Priestweston would be required to support the 33 kV network volts, even with the additional new circuit. By then certain technologies may have evolved further and any subsequent solution would need to be assessed again.

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Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB
nationalgrid.co.uk