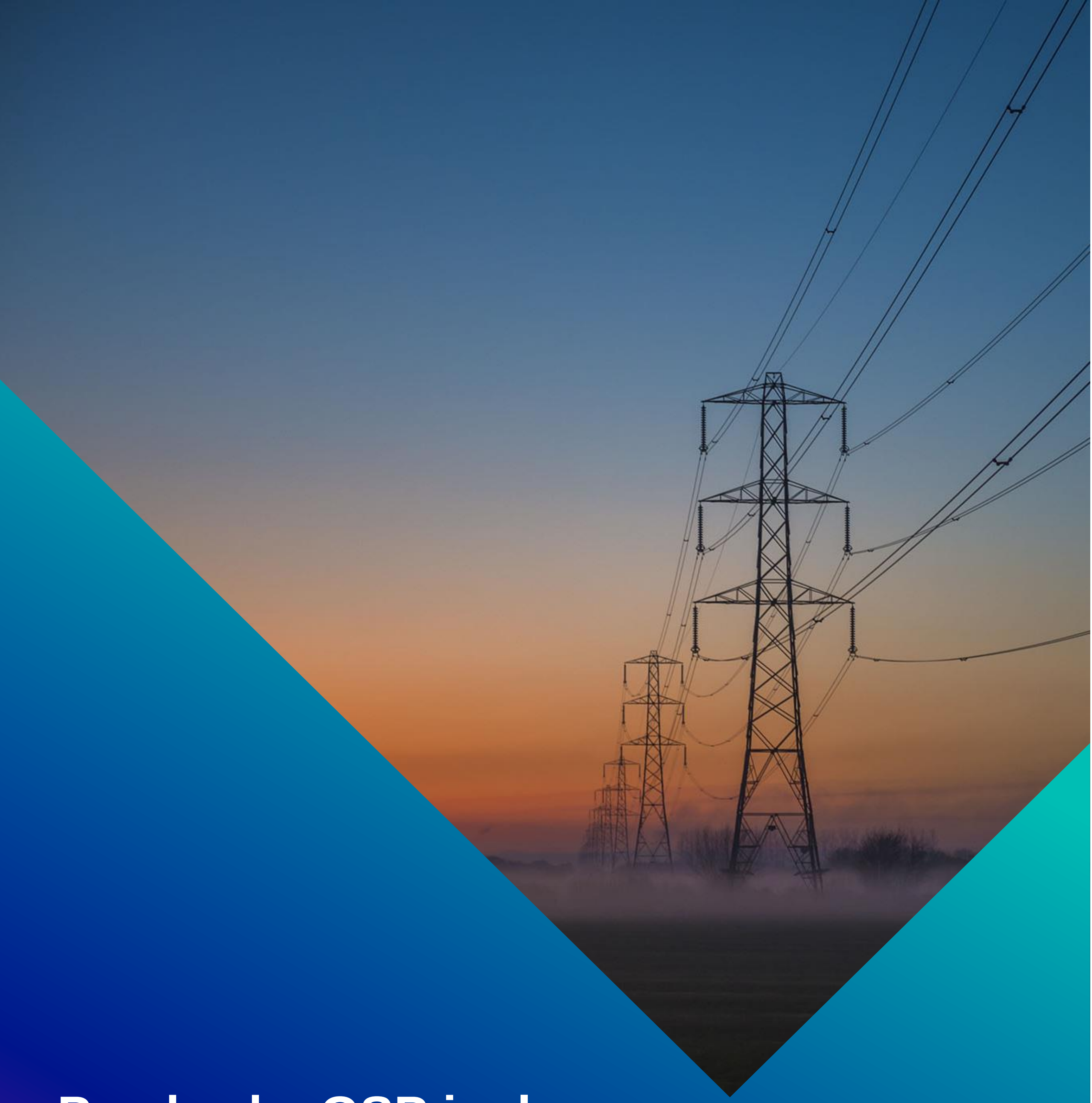

Pembroke GSP incl. associated 132 kV & 33 kV networks

Network Development Report – South Wales

May 2024

Electricity Distribution

nationalgrid

Contents

Pembroke GSP & Associated Network

1. Network Overview

Pembroke Grid Supply Point (GSP) feeds a large geographical area near to the coastal region of West Wales and is currently supplied by two 400/132 kV 240 MVA Super Grid Transformers (SGTs) from the interconnected 400 kV National Grid Transmission Network.

This group supplies over 66,000 customers which include several significant industrial connections. A large amount of distributed generation has also been connected to the network in recent times, due to the significant renewable energy potential seen across the area.

Pembroke GSP is normally run standalone as a network, however, the A-route 132 kV circuit can offer interconnection with Swansea North GSP under select network conditions.

The 132 kV network currently has three outgoing circuits between the double busbar arrangement at Pembroke GSP and Milford Haven's 132 kV closed mesh arrangement. Several Bulk Supply Point (BSPs) substations are supplied by this group, including both Golden Hill and Haverfordwest 132/33 kV BSPs that supply a sizable 33 kV network.

Pembroke GSP currently has a maximum demand of 189 MVA and under NGED's DFES Best View scenario this is projected to rise over 360 MVA by the year 2034.

Figure 1.1 Pembroke GSP geographic network coverage

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

For the purposes of this analysis the NGED Best View Distribution Future Energy Scenario (DFES) has been used to study the years 2022 (baseline), 2028 and 2034, with consideration given to how proposals could change under the other scenarios. The two most onerous half-hours have been studied for each of the five representative days considered: Winter Peak Demand, Intermediate Warm Peak Demand, Intermediate Cool Peak Demand, Summer Peak Demand and Summer Peak Generation.

1.1 Network Topology

The Pembroke 132 kV network is arranged as follows:

- Pembroke GSP is currently supplied by two 400/132 kV 240 MVA SGTs (SGT1 & SGT2) from the interconnected 400 kV National Grid Transmission Network.
- SGT1 & SGT2 supply a 132 kV double busbar arrangement that runs solid with both SGTs in service. SGT1 is normally selected to the Reserve 1 busbar and SGT2 is normally selected to the Main 2 busbar.
- Three outgoing 132 kV circuits from Pembroke GSP lead to closed mesh arrangement at Milford Haven 132 kV. This mesh is arranged as a ring of 8 section breakers with one transformer-incomer breaker supplying Milford Haven GT1 and subsequent 33 kV network.
- Golden Hill 132/33 kV BSP, supplied by the outgoing 132 kV circuits from Pembroke to Milford Haven, has two 60/90 MVA Grid Transformers (GT1 & GT2) and supplies a two-section 33 kV busbar. The 33 kV network is run in parallel with Haverfordwest and Milford Haven BSPs.
- Haverfordwest 132/33 kV BSP, supplied by 132 kV circuits from the Milford Haven 132 kV mesh, has two 60/90 MVA Grid Transformers (GT1 & GT2) and supplies a two-section 33 kV busbar. The 33 kV network is run in parallel with Golden Hill and Milford Haven BSPs.
- Milford Haven 132 kV also provides connection to a number of 132 kV connected customers at South Hook BSP, Robeston BSP and Waterston BSP.
- Pembroke GSP has two outgoing 132 kV circuits leading to a switching site at Rhoscrowther that supplies a 132 kV connected customer.

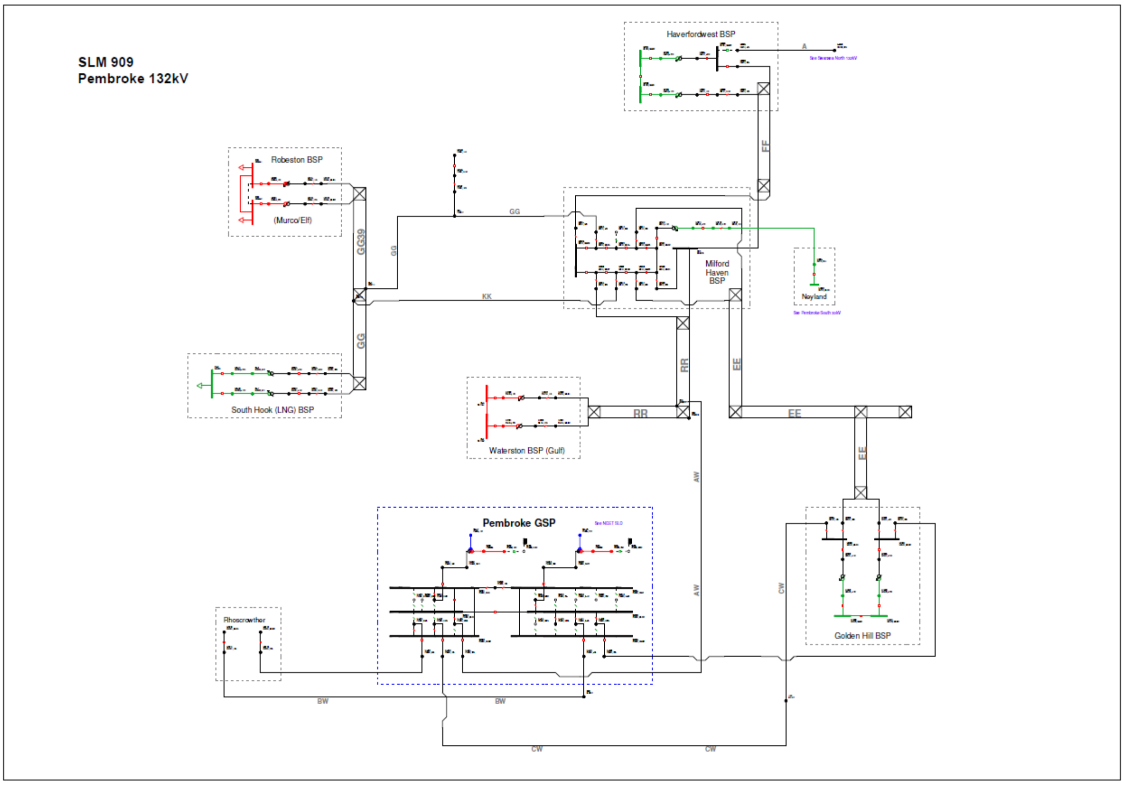

Figure 1.1.1 Pembroke 132 kV network single line diagram

The Pembroke 33 kV network is arranged as follows:

- The Haverfordwest BSP, Golden Hill BSP and Milford Haven BSP 33 kV networks all operate in parallel via several 33 kV circuits under intact network conditions. This 33 kV group is currently supplied by five 132/33 kV Grid Transformers (GTs):
    - Haverfordwest GT1 & GT2, 132/33 kV 60/90 MVA units
    - Golden Hill GT1 & GT2, 132/33 kV 60/90 MVA units
    - Milford Haven GT1, 132/33 kV 22.5/45 MVA unit
- In North Pembrokeshire, the associated 33 kV network feeds a similarly rural area that includes several outgoing 33 kV circuits at Haverfordwest BSP.
- A 33 kV ring is formed via two 33 kV overhead line circuits from Haverfordwest BSP that supply the following 33/11 kV Primary substations:
    - Brawdy: Two 7.5/15 MVA primary transformer substation (T1 & T2)
    - St Davids: Single 5/6.25 MVA primary transformer substation (T1)
    - Fishguard: Two 10/14 MVA primary transformer substation (T1 & T2)
    - Nevern: Two 5/6.25 MVA primary transformer substation (T1 & T2), only T2 is in-service under intact conditions.
- 33 kV circuits are connected directly from Haverfordwest BSP to Brawdy, directly from Haverfordwest to Fishguard and between Brawdy and Fishguard. St Davids and Nevern are fed via single 33 kV circuits from Brawdy and Fishguard respectively.
- 33 kV circuits are connected directly from Haverfordwest BSP to the following 33/11 kV Primary substations:
    - Haverfordwest Primary: Two 12/24 MVA primary transformer substation (T1 & T2)
    - Merlin's Bridge: Two 7.5/15 MVA primary transformer substation (T1 & T2)
    - Penblewin: Two 7.5/15 MVA primary transformer substation (T1 & T2), only a single 33 kV circuit from Haverfordwest BSP supplies this primary.

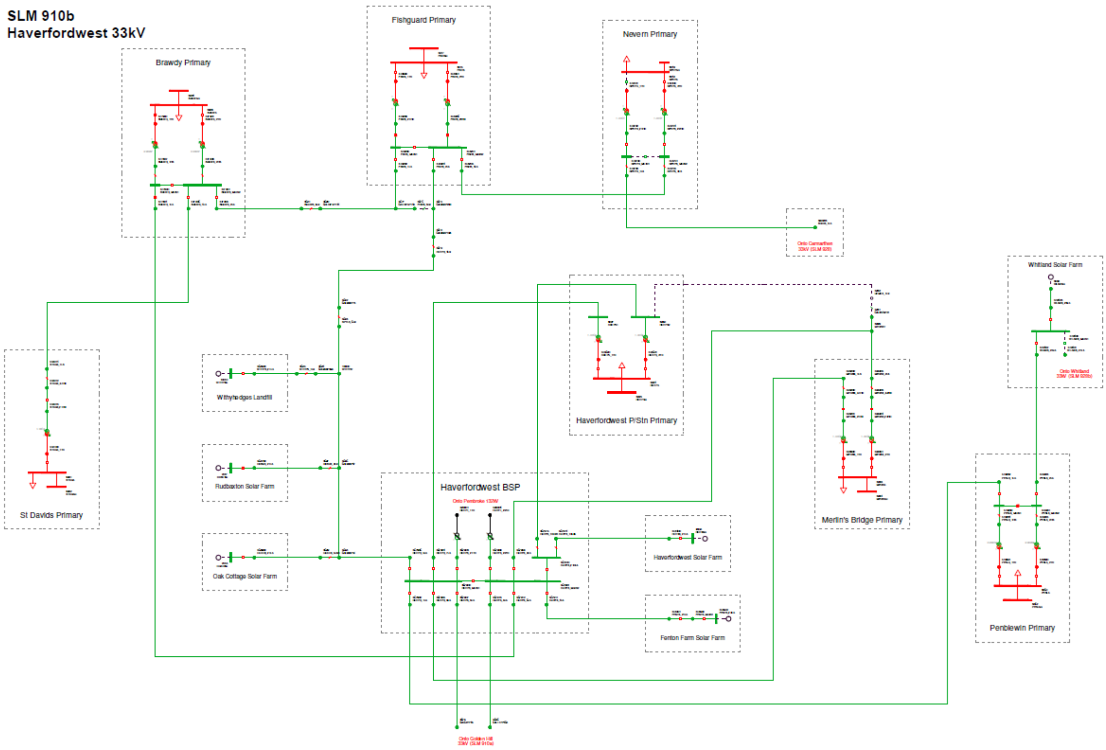

Figure 1.1.2 Haverfordwest (North Pembrokeshire) 33 kV network single line diagram

- In South Pembrokeshire, the associated 33 kV network feeds a mostly rural area that includes two outgoing 33 kV circuits from Golden Hill BSP that lead to the 33 kV busbar at Haverfordwest BSP.
- One of these outgoing 33 kV circuits from Golden Hill BSP supplies the following 33/11 kV Primary substations:
    - Neyland: Two 5/6.25 MVA primary transformer substation (T1 & T2). Neyland Primary also provides a 33 kV connection to Milford Haven BSP (GT1).
    - Steynton: Two 12/24 MVA primary transformer substation (T1 & T2)
    - Milford Haven Primary: Single 7.5/15 MVA primary transformer substation (T1)
- The second outgoing 33 kV circuit from Golden Hill BSP supplies the following 33/11 kV Primary substations:
    - St Florence: Single 5 MVA primary transformer substation (T1)
    - Tenby: Single 7.5/15 MVA primary transformer substation (T1)
    - Broadfield: Two 12/24 MVA primary transformer substation (T1 & T2)
- 33 kV circuits are also connected directly from Golden Hill BSP to the following 33/11 kV Primary substations:
    - Golden Hill Primary: Two 12/24 MVA primary transformer substation (T3 & T4) and is supplied by two 33 kV interplants from Golden Hill BSP (located within the same compound).
    - St Twynells: Two 5/6.25 MVA primary transformer substation (T1 & T2)

SLM 910a
Golden Hill 33kV

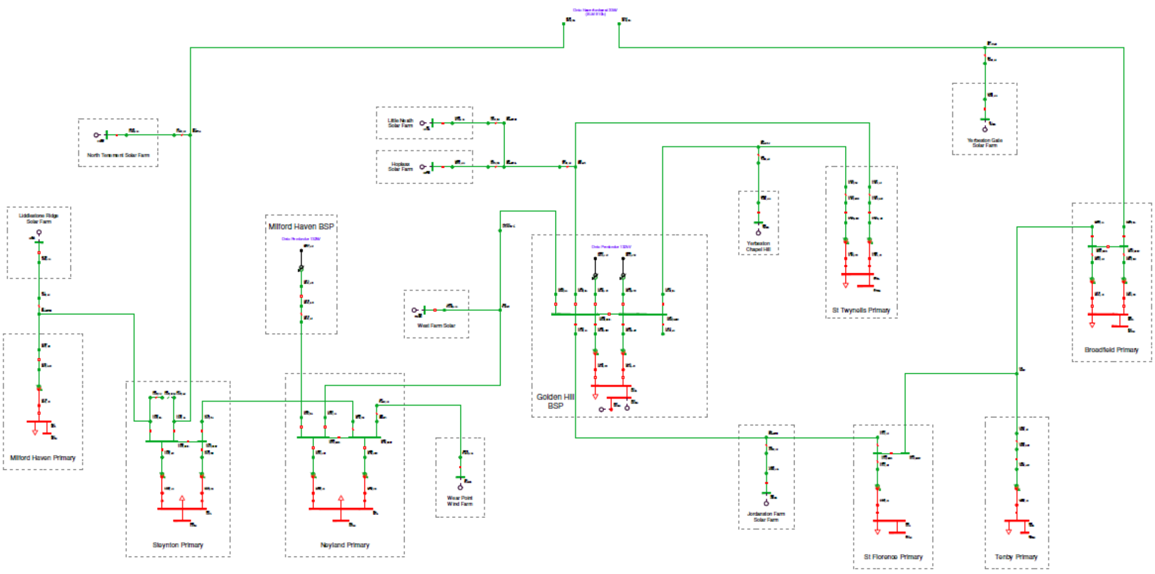

Figure 1.1.2 Golden Hill & Milford Haven (South Pembrokeshire) 33 kV network single line diagram

1.2 Network Operability Modelling

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

- Pembroke GSP and Swansea North GSP are run independently at 132 kV, with the A-route circuit offering interconnection between the two GSPs, which is held normally open on line breaker 405 at Haverfordwest BSP.
- For an arranged outage of an SGT at Pembroke or for the loss of two of the three 132 kV circuits between Pembroke GSP and Milford Haven 132 kV, this interconnecting circuit (between Haverfordwest 405 and Carmarthen 805) is switched in to parallel Swansea North and Pembroke at 132 kV. The circuit breaker at Haverfordwest is fitted with overload protection, which is intended to operate when the circuit loading is above 500 A (Definite Time (DT), 3 seconds), a condition which could happen for a double SGT outage Second Circuit Outage (SCO) condition.
- Due to the 132 kV interconnection afforded between both GSPs, in a similar manner, for an arranged outage of the circuit between Swansea North-Carmarthen-Rhos (which is carried on numerous 132 kV circuits), the normally open A-route circuit between Carmarthen and Haverfordwest is switched in to provide support to the Carmarthenshire network from Pembroke. When this arranged outage is followed by a circuit fault between Carmarthen and Llanelli, both of the 132 kV circuits from Swansea North to Carmarthen are lost and the group is entirely fed via Pembroke at 132 kV.
- For an arranged outage of either Haverfordwest GT (GT1 or GT2), the Pembroke 33 kV network is split to run Haverfordwest 33 kV independently from the Golden Hill and Milford Haven 33 kV network. These splits occur at Steynton 33 kV 2L5 and Broadfield 33 kV 2L5.
- For an arranged outage of either Golden Hill GT (GT1 or GT2), the Pembroke 33 kV network can either remain intact or be split to run Golden Hill independently from Milford Haven and Haverfordwest. These splits occur at Neyland 33 kV 1L5 and Broadfield 33 kV 2L5. This split is typically based on network loading at the time.
- The Pembroke 33 kV network remains intact for a Milford Haven GT1 outage.
- Nevern Primary has a point of interconnection with the Rhos 33 kV network. A sequential control (SQC) scheme is in place to transfer Nevern across into the Rhos 33 kV network. This is to support the Haverfordwest group by reducing the group demand in line with outage conditions.
- Penblewin Primary has a point of interconnection with the Carmarthen 33 kV network. An auto-changeover scheme is in place to transfer Penblewin onto Carmarthen in line with any outage impacting the single 33 kV circuit supplying the Primary. Additionally this transfer could be made to support the Haverfordwest group if a reduction in demand is required.
- For the loss of an infeed to a transformer at any of the primaries fed from within the Pembroke 33 kV network under arranged outages, the lower voltage side circuit breaker is opened to prevent back-energisation.
- Curtailment of all connected load management schemes within the group are modelled at a variety of outage conditions, as outlined in customer connection agreements.
- Various winter arranged outages not permitted due to SCO overloads.
- Various SCO overloads solved by network reconfiguration for arranged outages.

2. Summary of Network Constraints

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

- North Pembrokeshire 33 kV Constraints:
  - Haverfordwest BSP Grid Transformer overloads
  - St Davids 33/11 kV Single Primary Transformer overloads
  - Fishguard 33/11 kV Primary Transformer overloads
  - Haverfordwest - Brawdy/Fishguard/Nevern/St Davids 33 kV circuit overloads
  - Haverfordwest - Brawdy/Fishguard/Nevern/St Davids 33 kV voltage issues
  - Penblewin 33/11 kV Primary Transformer and 33 kV circuit overloads
  - Haverfordwest Primary 33/11 kV Transformer and 33 kV circuit overloads
  - Merlin's Bridge 33/11 kV Primary Transformer overloads

- South Pembrokeshire 33 kV Constraints:
  - Milford Haven BSP Grid Transformer and 33 kV circuit overloads
  - Steynton 33/11 kV Primary Transformer and 33 kV circuit overloads
  - Neyland 33/11 kV Primary Transformer overloads
  - Golden Hill BSP Grid Transformer overloads
  - Golden Hill Primary 33/11 kV Transformer overloads
  - St Twynells 33/11 kV Primary Transformer and 33 kV circuit overloads
  - Golden Hill to St Florence 33 kV circuit overload
  - St Florence to Tenby Tee 33 kV circuit overload

- Pembrokeshire 33 kV Parallel Group Constraints:
  - Haverfordwest / Golden Hill / Milford Haven BSP reconfiguration
  - Thermal overloads due to the amount of hydrogen electrolysis forecast to connect to this network up to 2034

- Pembrokeshire 132 kV Constraints:
  - SGT Capacity
  - Pembroke to Milford Haven 132 kV circuit overloads

3. EHV Reinforcement Schemes Progressing

The following list contains the EHV reinforcement schemes that are currently in active development in this area to overcome a number of constraints facing the network, these include:

- Installation of a new 33 kV circuit between Haverfordwest BSP and Brawdy Primary (including the replacement of both outdoor 33 kV arrangements at Brawdy and Haverfordwest to new indoor GIS 33 kV switchboards).
    - Please see Network Constraint 4.5 for further information.
- Installation of a new 33 kV circuit between Golden Hill BSP and Broadfield Primary.
    - Please see Network Constraint 4.15 for further information.
- Installation of a fourth 132 kV circuit between Pembroke GSP and Milford Haven 132 kV including the extension of the 132 kV closed mesh arrangement at Milford Haven.
    - Please see Network Constraint 4.18 for further information.
- Installation of a 230 bus coupler 132 kV circuit breaker at Pembroke GSP.

From 2028, an additional two SGTs are anticipated at Pembroke GSP, aligned to the latest compliance report received as part of the annual data exchange between DNOs and National Grid Electricity Transmission.

4. Network Constraint Details and Solution Options

4.1 Pembrokeshire 33 kV Parallel Group

Currently Haverfordwest BSP, Golden Hill BSP and Milford Haven BSP supply the entire Pembrokeshire 33 kV network and operate in parallel under intact network conditions.

The table below summarises the scale of the demand and generation forecast to connect to the Pembrokeshire 33 kV network up to 2034 under NGED's DFES Best View scenario.

Table 4.1.1 Maximum demand forecast to connect to the Pembrokeshire 33 kV network

DFES Scenario	Demand		
	Baseline	**2028**	**2034**
Best View	83.81 MW	169.98 MW	257.35 MW

By 2034, this figure takes into account an additional 46.59 MW due to the anticipation of hydrogen electrolysis projected to connect in this area.

Table 4.1.2 Maximum generation forecast to connect to the Pembrokeshire 33 kV network

DFES Scenario	Generation		
	Baseline	**2028**	**2034**
Best View	133.27 MW	209.52 MW	304.80 MW

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

This group becomes vulnerable to intact, First Circuit Outage (FCO) and SCO conditions throughout the 0-10 year horizon period as a result of the load growth projections. These limitations are highlighted below.

North Pembrokeshire 33 kV Network

4.2 Haverfordwest 132/33 kV BSP Substation

For a first circuit outage (arranged or fault) which results in the loss of either Haverfordwest 132/33 kV GT (GT1 or GT2), the remaining GT in service will soon overload.

Overloads are also observed under SCO conditions when an arranged outage of Milford Haven GT1 is followed by a fault to either Haverfordwest GT. The remaining Haverfordwest GT in service is left to supply the Pembrokeshire 33 kV network alongside both Golden Hill GTs.

These SCO overloads occur even with operational outage windows restricted to intermediate warm and summer demand periods only.

Constraint Overview

Generation | Demand

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

Table 4.2.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Haverfordwest GT1 or GT2 overload	Arranged or Fault outage to either GT/ 132 kV circuit	None	2028	2028	2028	2028
Haverfordwest GT1 or GT2 overload	Arranged outage to Milford Haven GT/ 132 kV circuit	Haverfordwest GT fault/ 132 kV circuit fault	N/A	N/A	2028	2030

Solution Options

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

Table 4.2.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate Haverfordwest GTs by use of cyclic ratings	✓	✓	✓	Viable
2	Install a third GT and new 132 kV circuit to Milford Haven	✓	✓	×	Discounted
Operational Mitigation					
3	Review Seasonal Ratings	×	✓	✓	Viable
Load Management Schemes					
4	Active Network Management schemes	×	✓	✓	Viable
Flexibility services					
5	Procure flexibility at Haverfordwest BSP	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Based on the long term DFES projections, constraints are observed from 2028 onwards under Leading the Way, Consumer Transformation and Best View scenarios. Under System Transformation and Falling Short, constraints are observed from 2030 and 2032 respectively.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

Detailed description: Doing nothing to mitigate the constraint would result in GT overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would risk damaging the transformers.

Existing limiting factor for constraint(s) considered:

Existing Haverfordwest 90 MVA GT Rating

Option 1 – Uprate Haverfordwest GTs by use of cyclic ratings

Capacity Released for constraint(s) considered:

Viable

27 MVA (winter cyclic increase) and 9 MVA (summer cyclic increase)

Detailed description: Uprating the existing GTs by use of cyclic ratings in accordance with British Standard 171/IEC60076 and NGED Standard Technique SD8C will provide additional capacity for the network. This requires a capability assessment of all transformer ancillaries. In addition, an assessment of the cyclic profile of the load will be required to determine if transformer temperature and ageing is within acceptable limits.

These works can increase the winter cyclic rating to 117 MVA and summer cyclic to 99 MVA if the assessment permits the use of cyclic ratings.

It is also suggested that a review of the load share across the Pembrokeshire 33 kV network under arranged Haverfordwest GT outages is carried out. If Steynton and Milford Haven Primary can remain in the Milford Haven & Golden Hill 33 kV group under split network conditions then (with these increased cyclic ratings) Haverfordwest GT overloads can be alleviated up to 2034. The Haverfordwest group demand minus both primaries is projected to reach 113.8 MVA by 2034.

SCO overloads however will re-emerge from 2030 under intermediate cool and intermediate warm conditions. Summer demand ratings are exceeded further from 2032. Significant 33 kV circuit overloads are also observed across the group alongside the GT constraints.

A reinforcement strategy has been proposed in Network Constraint 4.11 that recommends the reconfiguration of Milford Haven BSP that could enable Haverfordwest, Milford Haven and Golden Hill to be run independently, alleviating constraints across the 0-10 year horizon period and beyond.

New limiting factor for constraint(s) considered:

Haverfordwest GT1/GT2 with a 117 MVA (winter cyclic) and 99 MVA (summer cyclic) rating.

Option 2 – Install third GT at Haverfordwest BSP and 132 kV circuit to Milford Haven

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

Detailed description: Installing a third 90 MVA Grid Transformer at Haverfordwest BSP would ensure two transformers remain in-service for any first circuit outage event while reducing the risk of a subsequent SCO fault that previously led to a sizeable lost load.

A three section 33 kV indoor GIS switchboard is anticipated to be installed at Haverfordwest BSP by 2028 which could facilitate a GT connection to each 33 kV busbar. A new 9 km 132 kV circuit to the closed mesh 132 kV arrangement at Milford Haven would be also be proposed. An EHV reinforcement scheme has planned for the extension of the 132 kV mesh to accommodate a fourth 132 kV circuit from Pembroke GSP, see Network Constraint 4.21. If the existing layout permits further extension, it is recommended that this EHV reinforcement scheme is re-visited to facilitate an additional connection if this option is to proceed.

Fault level across the network would increase with the addition of a third GT at Haverfordwest BSP and as such an assessment would be required to determine if switchgear is rated sufficiently.

This option has the potential to release a significant level of capacity for the North Pembrokeshire area, however it is to be discounted as it would be a prohibitively expensive scheme and unlikely to be viewed as a cost-effective solution.

New limiting factor for constraint(s) considered:

Combination of the remaining Haverfordwest GTs in-service during FCO conditions

Option 3 – Review Seasonal Ratings

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

Detailed description: Overloads are observed under intermediate cool and intermediate warm demands notably from 2028 onwards. An internal review of the transformer seasonal ratings may conclude that these constraints are not present as early as estimated. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating.

This could defer the overloads by a number of years.

New limiting factor for constraint(s) considered:

Existing Haverfordwest 90 MVA GT rating

Option 4 – Active Network Management schemes

Capacity Released for constraint(s) considered: Dependent on ANM scheme **Viable**

Detailed description: Any additional connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.

New limiting factor for constraint(s) considered:

Existing Haverfordwest 90 MVA GT rating

Option 5 – Procure flexibility at Haverfordwest BSP

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured throughout the North Pembrokeshire 33 kV network to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a CBA and confirmation through the DNOA process. An assessment of cyclic ratings should be carried out alongside an internal review of the transformer seasonal ratings, to help address the overloads observed at Haverfordwest BSP.

Following this and in-line with the high demand/generation growth forecast and constraints observed up to 2034, it is recommended that detailed studies (also 33 kV reinforcement as necessary) are carried out to be able to run Haverfordwest, Milford Haven and Golden Hill independently.

Please see Network Constraints 4.11 and 4.14 for proposals associated to both Milford Haven and Golden Hill BSPs to facilitate the network split.

This allows for future load growth within the Pembrokeshire area, alleviating constraints observed across this assessed period and ensures compliance with P2/8 throughout the forecasted load growth period and beyond.

4.3 St Davids 33/11 kV Single Transformer Primary Substation

Constraint Overview

Generation | Demand

St Davids Primary substation is a single 33/11 kV transformer site supplying a relatively rural area. There is one 33 kV infeed into the site from Brawdy Primary substation. The site relies on 11 kV interconnections for the loss of supply to its transformer, which is a 5/6.25 MVA unit. Approximately 1.8 MVA of 11 kV backfeed capacity is available to support St Davids and in the upcoming years this will soon be exceeded.

The St Davids group demand is projected to rise over 3 MVA by 2028 and reach 3.6 MVA by 2034. By 2034, it is forecast that 13.8 MVA of generation will connect to the primary.

St Davids is located on a peninsula and in the load growth projections, a large amount of marine generation is expected to connect within the area. If the expected generation is to connect at 11 kV, additional primary capacity would be required. However, a 33 kV connection may be more suitable for the expected developments. This would alleviate generation driven 11 kV constraints in the area.

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

Table 4.3.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
St Davids 11 kV backfeed capability	Arranged or fault outage of St Davids T1 or 33 kV incoming circuit	None	2028	2030	2034	2034
St Davids 33/11 kV T1 Rating	Intact condition	None	-	-	-	2034

Solution Options

A list of each of the options considered for these constraints are given in the table below.

Table 4.3.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install a second 33/11 kV transformer and a second 33 kV circuit to Brawdy	✓	✓	✓	Viable
2	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
3	Procure flexibility at St Davids Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: From a demand perspective, this constraint is not an issue under the current baseline scenario. It first becomes present under Leading the Way, Best View, Consumer Transformation and System Transformation by 2028. The constraint does not appear in Falling Short until 2034. From a generation standpoint, assuming the expected generation does connect at 11 kV, intact constraints become an issue by 2034 under all scenarios except Falling Short.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in 11 kV circuit overloads for the conditions described above. The 11 kV network also be susceptible to voltages outside of statutory limits under the same conditions outlined. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for St Davids Primary.

Existing limiting factor for constraint(s) considered: 1.8 MVA

Option 1 – Install a second 33/11 kV transformer and a second 33 kV circuit

Capacity Released for constraint(s) considered: Viable

St Davids T1 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Detailed description: Installing a second 33/11 kV transformer at St Davids (T2) and a new 33 kV circuit to Brawdy Primary would alleviate this constraint and will release capacity for future growth. This option will improve network resilience and reduces the dependency on 11 kV interconnectivity under FCO conditions, which is forecast to be insufficient in the near future.

A new 33 kV circuit of approximately 13 km to Brawdy Primary will be required. Assumed as a combination of both overhead line construction (100mm^2 HDC conductor or similar) with underground cable sections (185mm^2 copper EPR cable or similar).

To facilitate this new 33 kV connection it would be necessary to replace the existing outdoor arrangement at Brawdy Primary with an indoor Gas-Insulated Switchgear (GIS) 33 kV switchboard, as there are currently no options for additional circuit breaker bays within the existing design. These works however have already been initiated due to the requirements of an EHV reinforcement scheme in the area that is currently in active development.

It is proposed that T2 will be installed as a 7.5/15 MVA rated unit. Due to the recent installation of T1 and in-line with the load growth projections it is not anticipated that T1 (5/6.25 MVA) will require uprating to match the proposed rating of T2 (7.5/15 MVA) initially.

New limiting factor for constraint(s) considered:

St Davids T1 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

If St Davids T1 is uprated to match T2 at a later date then the new limiting factor will increase to the 7.5/15 MVA rating of the new transformer. This could be a possibility if the level of marine generation forecasted does in fact connect at 11 kV. By 2034, the generation capacity is projected to exceed the new limiting factor of St Davids. To alleviate this limitation, T1 would need to be uprated to match the rating of T2.

Option 2 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Minimal Discounted

Detailed description: To release additional capacity available at St Davids Primary, new 11 kV circuits would need to be installed (or existing circuits reinforced) to provide greater interconnectivity towards Brawdy Primary. Brawdy is located over 12 km away from St Davids and is the only realistic option for support.

This may only offer marginal benefit in the short term and will limit potential future growth as additional reinforcement at St Davids may still be required at a later date to release additional capacity in the long-term.

The 11 kV interconnection has not been studied in detail, further analysis of the 11 kV network in St Davids and Brawdy would be required to fully analyse any potential transfer capability. However, it is anticipated that due to the considerable 11 kV circuit lengths towards Brawdy, reinforcing this 11 kV network sufficiently to meet the projected load growth may result in voltage / power quality issues, restricting the level of capacity that could be released.

New limiting factor for constraint(s) considered: 11 kV circuit capacity

Option 3 – Procure flexibility at St Davids Primary

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

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

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

Solution Recommendation

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

Following this, Option 1 is likely to provide the most network benefit in the long term and has the potential to release further capacity in the future by uprating St Davids T1 if required. This option will also ensure compliance with statutory voltage limits and P2/8 throughout the forecasted load growth period and beyond.

4.4 Fishguard 33/11 kV Primary Substation

Constraint Overview

Generation | **Demand**

For a first circuit outage (arranged or fault) which results in the loss of either Fishguard 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with future load growth projections.

The Fishguard group demand is projected to reach 18 MVA by 2028 and rise over 30 MVA by 2034.

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

Table 4.4.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Fishguard T1 or T2 remaining in-service	Outage to either Fishguard T1 or T2 (arranged or fault)	None	2028	2028	2028	2028

Solution Options

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

Table 4.4.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Fishguard	✓	✓	✓	Viable
2	Install a third transformer at Fishguard	✓	✓	×	Viable
3	Build a new 33/11 kV Primary Substation	✓	✓	×	Discounted
4	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
5	Procure flexibility at Fishguard Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present by 2028 under Leading the Way, Consumer Transformation and Best View scenarios. Under System Transformation and Falling Short, the constraint is not observed until 2030 and 2034 respectively.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

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

New limiting factor for constraint(s) considered:

Existing Fishguard T1/T2 with a 15.24 MVA (winter cyclic) and 14.5 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers

Capacity Released for constraint(s) considered: 22.76 MVA

Viable

Detailed description: Uprating the 33/11 kV transformers at Fishguard Primary to 12/24 MVA units (including removal of any ancillary rating limitations) would alleviate the overloads identified in 2028. However, with the Fishguard group demand predicated to rise over 30 MVA by 2034 and based on the anticipation of hydrogen electrolysis projected to connect in this area, it is proposed that Fishguard Primary Transformers are uprated to 20/40 MVA units.

This will alleviate the overloads observed at Fishguard across this assessed period.

New limiting factor for constraint(s) considered:

Fishguard T1/T2 with a 38 MVA (winter cyclic) and 30 MVA (summer cyclic) rating.

Option 2 – Install a third 33/11 kV transformer

Capacity Released for constraint(s) considered: 30.76 MVA Viable

Detailed description: Installing a new 12/24 MVA primary transformer alongside the existing units at Fishguard (including removal of any ancillary rating limitations) would alleviate the overloads identified in 2028 however greater reinforcement would be required by 2034.

If both existing transformers were replaced with 12/24 MVA units to match the new transformer proposed, this will remove the overloads observed at Fishguard under all scenarios. Given the age of the existing transformers this would have a dual benefit in terms of releasing capacity and replacing aging assets in-line with this proposed scheme.

It is worth noting that this third primary transformer would need to be connected to a different 33 kV busbar than the existing two transformers to avoid losing two transformers for an outage on a single busbar. This option would necessitate the installation of a third 33 kV busbar to facilitate the installation of Fishguard T3.

Fishguard is currently supplied by two 33 kV circuits from the North Pembrokeshire 33 kV network with a third 33 kV circuit supplying Nevern. It would be recommended to modify the 33 kV arrangement at Fishguard to ensure each 33 kV busbar is supplied by an infeed from the 33 kV network. To achieve this, a third circuit from the North Pembrokeshire 33 kV network would be required.

This proposal could be carried out in conjunction with Network Constraint 4.6 that proposes a second 33 kV circuit from Haverfordwest to Fishguard.

New limiting factor for constraint(s) considered:

Fishguard T1/T2/T3 with a 46 MVA (winter cyclic) and 36 MVA (summer cyclic) rating.

Option 3 – Build a new 33/11 kV Primary Substation

Capacity Released for constraint(s) considered: 23 MVA Discounted

Detailed description: This constraint could be resolved by building a new two 12/24 MVA transformer 33/11 kV primary substation and transferring some of the load projected from Fishguard to the new substation. The level of load growth projected at Fishguard may necessitate this level of investment, likewise if the expected level of load projected does in fact connect in the wider area then the primaries in close enough proximity could also benefit from a new primary to shift load to (the closest other primaries are Brawdy, which is around 14 km away and St Davids, which is around 22 km away).

This option would be more expensive than the options discussed above but could offer a solution to a number of primaries in the area with the aim to de-load each sufficiently based on the longer term load projections facing this area.

This option has been discounted as it would be prohibitively expensive for the overall network benefit it would provide.

New limiting factor for constraint(s) considered:

Existing Fishguard T1/T2 with a 15.24 MVA (winter cyclic) and 14.5 MVA (summer cyclic) rating.

Option 4 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Minimal (unless used in conjunction with alternative options discussed)

Discounted

Detailed description: To release additional capacity available at Fishguard Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries. Similar to St Davids, considerable 11 kV circuit lengths would be needed to reach supporting primaries. Reinforcing this 11 kV network sufficiently to meet a transfer capacity in excess of 15 MVA is likely to result in voltage / power quality issues, restricting the level of capacity that could be released.

This may only offer marginal benefit in the short term and will limit potential future growth as additional reinforcement at Fishguard may still be required at a later date to release additional capacity in the long-term.

New limiting factor for constraint(s) considered:

Existing Fishguard T1/T2 with a 15.24 MVA (winter cyclic) and 14.5 MVA (summer cyclic) rating.

Option 5 – Procure flexibility at Fishguard Primary

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Fishguard to help alleviate the projected overloads. This could rise up to 15 MVA by 2034. It is unlikely that sufficient flexibility could be procured as a long-term solution due to the rural nature of the area. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement in the short-term, subject to a CBA and confirmation through the DNOA process. Following this, a technical comparison should be made between uprating the existing 33/11 kV transformers at Fishguard (Option 1) or installing a third primary transformer at Fishguard (Option 2).

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

It is worth noting that additional 33 kV circuit capacity will be required to accommodate this level of load growth by 2034. Please see Network Constraint 4.6 for proposals associated to the 33 kV network.

4.5 North Pembrokeshire 33 kV Ring Network Haverfordwest - Brawdy / Fishguard / Nevern / St Davids 33 kV Group

Constraint Overview

Generation | **Demand**

Currently this North Pembrokeshire 33 kV ring, with Haverfordwest BSP supplying Brawdy, Fishguard, Nevern and St Davids has a maximum demand of 14.18 MVA. The table below summarises the scale of the demand forecast to connect to this group up to 2034.

Table 4.5.1 constraint(s) and condition under which constraint occurs

DFES Scenario	Demand		
	Baseline	2028	2034
Best View	14.18 MW	26.67 MW	41.60 MW

An EHV reinforcement scheme to install a second 33 kV circuit from Haverfordwest BSP to Brawdy Primary is currently in active development and it is expected to be completed by 2028. This scheme, alongside the associated works to replace the existing outdoor arrangement at both Haverfordwest BSP and Brawdy Primary with indoor GIS 33 kV switchboards, have been included in all studies from 2028 onwards.

In-line with the high load growth forecast, from 2028 onwards, this network becomes vulnerable to FCO overloads for the loss of the Haverfordwest to Fishguard 33 kV circuit. The Brawdy to Fishguard 33 kV circuit is left to supply a sizable demand from Fishguard. This network will also become susceptible to SCO conditions from 2028. A combination resulting in the loss of both Haverfordwest to Brawdy 33 kV circuits, even with operational outage windows restricted to intermediate warm and summer demand periods only, lead to both thermal overloads and voltages at the remote ends of the circuit to fall below statutory limits.

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

Table 4.5.2 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Brawdy - Fishguard 33 kV circuit overload	Haverfordwest – Fishguard 33 kV circuit out of service (arranged or fault outage)	None	2030	2030	2032	2032
Haverfordwest – Fishguard 33 kV circuit overload and low voltages observed	Haverfordwest – Brawdy 33 kV circuit out of service (arranged outage)	Fault to the second Haverfordwest – Brawdy 33 kV circuit	N/A	N/A	2028	2028

Solution Options

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

Table 4.5.3 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install a second 33 kV circuit from Haverfordwest to Fishguard, re-conductor the existing 33 kV circuit and split the 33 kV group	✓	✓	✓	Viable
2	Extend the 132 kV network from Haverfordwest BSP to Fishguard	✓	✓	×	Discounted
3	Reinforce 11 kV circuits to transfer demand to other Primaries	×	×	×	Discounted
Operational Mitigation					
-	Nevern auto-changeover scheme	×	✓	✓	Viable
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility within the group	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: These constraints are initially alleviated through the EHV reinforcement scheme. Based on the long term DFES projections, greater thermal and voltage constraints are observed from 2028 onwards across this 33 kV group under all scenarios except Falling Short.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in excessive thermal overloads for the conditions described above. The network would still be susceptible to voltages outside of statutory limits under the same conditions outlined.

Existing limiting factor for constraint(s) considered:

Brawdy to Fishguard & Haverfordwest to Fishguard 33 kV circuit ratings:

19.1 MVA (winter variable pre-fault) and 20.9 MVA (post fault)

Option 1 – Install a second Haverfordwest to Fishguard 33 kV circuit, re-conductor the existing Haverfordwest to Fishguard 33 kV circuit and split the 33 kV ring network

Capacity Released for constraint(s) considered: 30.3 MVA **Viable**

Detailed description: Installing a second Haverfordwest to Fishguard 33 kV circuit and re-conductoring the existing circuit between both substations would alleviate the constraints identified for all scenarios across this assessed period. Additional capacity will be released for future growth particularly in the anticipation that hydrogen electrolysis may in the future connect in this area.

A new circuit of approximately 20 km would be required from Haverfordwest to Fishguard which would be assumed predominantly as overhead line construction with underground cable sections. It would be proposed that the 33 kV circuit would be 200mm^2 AAAC or similar construction to provide a winter variable pre-fault rating of 30.3 MVA. It is also be proposed to re-conductor the existing Haverfordwest to Fishguard 33 kV circuit to match this new circuit construction.

Following these works, it is recommended that this North Pembrokeshire 33 kV ring is split at the Brawdy end of the Fishguard 33 kV circuit under intact network conditions. An arranged FCO to one of the Haverfordwest to Fishguard 33 kV circuits would leave Fishguard (assuming Nevern can be transferred out of the group) at single circuit risk, but the group would remain fully P2/8 compliant while reducing the risk of a subsequent SCO fault leading to further assets overloading.

This solution would help improve network security and resilience under SCO conditions.

New limiting factor for constraint(s) considered:

Haverfordwest to Fishguard 33 kV circuits:

30.3 MVA (winter variable pre-fault) and 33.09 MVA (post fault)

Haverfordwest to Brawdy 33 kV circuits:

17.6 MVA (winter variable pre-fault) and 19.3 MVA (post fault)

Option 2 – Extend the 132 kV network from Haverfordwest BSP to Fishguard

Capacity Released for constraint(s) considered: Dependent on GT Rating **Discounted**

Detailed description: An alternative option at this stage if this level of growth, notably at Fishguard, does materialise as expected could be to consider converting Fishguard Primary into a 132/33 kV Bulk Supply Point and extend the 132 kV network from Haverfordwest BSP.

This North Pembrokeshire 33 kV ring is projected to rise to 41.60 MVA by the year 2034 with Fishguard primary forecast to rise over 30 MVA.

Considering the large geographic area supplied and extensive 33 kV reinforcement required to overcome longer-term constraints, it may be a possibility to establish a 132/33 kV bulk supply point at Fishguard to support the load forecast instead of expanding the 33 kV network further.

This solution will eliminate both thermal and voltage constraints and will ensure compliance with P2/8 throughout this 0-10 year horizon and beyond.

This area has significant renewable energy potential and this option will release a sizeable level of capacity for the area however would be a prohibitively expensive scheme.

New limiting factor for constraint(s) considered: Dependent on GT Rating

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

Capacity Released for constraint(s) considered: Minimal **Discounted**

Detailed description: Any 11 kV demand transfers would have to be made to primaries supplied outside of this group. Unfortunately due to the location of Brawdy, Fishguard, Nevern and St Davids, no primary is in close enough proximity to be able to transfer the sufficient level of demand required in order to alleviate this constraint.

New limiting factor for constraint(s) considered:

Existing Brawdy to Fishguard & Haverfordwest to Fishguard 33 kV circuit ratings:

19.1 MVA (winter variable pre-fault) and 20.9 MVA (post fault)

Operational Mitigation – Nevern auto-changeover scheme

Capacity Released for constraint(s) considered: 2-3 MVA **Viable**

Detailed description: Nevern Primary has a point of interconnection with the Rhos 33 kV network. A sequential control (SQC) scheme is in place to transfer Nevern across into the Rhos 33 kV network. This is to support the Haverfordwest group by reducing the group demand in line with select outage conditions. Post fault switching may also lead to Nevern being supplied by Rhos BSP depending on the fault that has occurred.

Installing an auto-changeover scheme at Nevern would allow the primary to be transferred into the Rhos 33 kV network in line with any fault/outage impacting the single 33 kV circuit supplying the Primary. Additionally this transfer could be made to support the Haverfordwest group if a reduction in demand is required for any outage condition within the group.

This option will not solely alleviate the constraints, however, these works could be carried out in conjunction with the longer-term plan to provide greater network operability for the Pembrokeshire 33 kV network.

Option 4 – Procure flexibility within the North Pembrokeshire 33 kV ring

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

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

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

Solution Recommendation

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

Following this, a technical review of installing a second Haverfordwest to Fishguard 33 kV circuit and associated works (Option 1) should be carried out. This option is likely to prove to be the most cost-effective long term option and will be more compatible with the existing site layout at Fishguard Primary.

This option will also improve network security and resilience under SCO conditions particularly by splitting this 33 kV network moving forward. This option will also ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

4.6 Penblewin 33/11 kV Primary Substation

Constraint Overview

Generation | Demand

Penblewin 33/11 kV primary substation is supplied by a single 33 kV circuit from Haverfordwest BSP. This site relies on an auto-changeover scheme to transfer the substation onto Carmarthen BSP for any fault/outage impacting the single 33 kV circuit supplying the primary.

For a first circuit outage (arranged or fault) which results in the loss of either Penblewin 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with the load growth projections. Future years will also lead to the 33 kV circuit supplying the primary to overload under intact network conditions.

The Penblewin group demand is projected to reach 15 MVA by 2028 and rise over 20 MVA by 2034. A steady increase of distributed generation is projected to connect to the primary by 2028. By 2034, a large amount of wind and solar generation is expected to connect, rising to 14.92 MVA.

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

Table 4.6.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Penblewin T1 or T2 remaining in-service	Outage to either Penblewin T1 or T2 (arranged or fault)	None	2028	2028	2028	2028
Penblewin to Haverfordwest 33 kV circuit	Intact	None	2029	2030	2030	2032

Solution Options

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

Table 4.6.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the Penblewin transformers and re-conductor the existing Penblewin to Haverfordwest and Penblewin into Carmarthen 33 kV circuits	✓	×	×	Discounted
2	Uprate the Penblewin transformers, install a second 33 kV circuit and re-conductor the existing 33 kV circuit from Haverfordwest BSP	✓	✓	✓	Viable
3	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility at Penblewin Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present from 2028 onwards under Leading the Way, Consumer Transformation, Best View and System Transformation scenarios. Under Falling Short, the constraint is not observed until 2030.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in both circuit and transformer overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Penblewin Primary.

Existing limiting factor for constraint(s) considered:

Penblewin T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers and re-conductor the existing Penblewin to Haverfordwest and Penblewin into Carmarthen 33 kV circuits

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

Detailed description: Uprating the 33/11 kV transformers at Penblewin Primary to 12/24 MVA units will alleviate the constraints observed at the primary across this assessed period. The next limiting factor following replacement of the primary transformers will be the 33 kV circuit supplied from Haverfordwest BSP which has a winter variable pre-fault rating of 17.6 MVA.

This rating is expected to be reached by 2029. Reprofiling the existing 0.1 sq.in. HDC conductor for operation at 75°C would resolve this overload up until 2032.

To alleviate this circuit overload, it would be proposed to reconductor the Haverfordwest to Penblewin 33 kV circuit to 0.2 sq.in. HDC conductor or similar to provide a winter variable pre-fault rating of 27.4 MVA.

As the dependency on the auto-changeover scheme under FCO conditions would still remain, it would also be a requirement to reconductor and/or reprofile extensive 33 kV circuit sections that have the potential to supply Penblewin from the Carmarthen BSP group. This could be in the order of 24 km based on the construction type of these 33 kV circuits. In addition, voltages at the Penblewin end supplied by the Carmarthen 33 kV network begin to fall considerably below statutory limits with increasing load observed at the primary.

New limiting factor for constraint(s) considered:

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

Option 2 – Uprate the 33/11 kV transformers, install a second 33 kV circuit and re-conductor the existing 33 kV circuit from Haverfordwest BSP

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

Detailed description: Similar to the option above, it would be proposed to uprate the primary transformers to 12/24 MVA units, alleviating the constraints observed at the primary up to 2034.

To overcome the 33 kV circuit limitation, as discussed, this rating is expected to be reached by 2029. Reprofiling the existing 0.1 sq.in. HDC conductor for operation at 75°C would only resolve this overload up until 2032. It would be proposed to reconductor the Haverfordwest to Penblewin 33 kV circuit to 0.2 sq.in. HDC conductor or similar to alleviate this circuit overload.

To reduce the level of dependency on the auto-changeover scheme under FCO conditions and to avoid the extensive level of 33 kV reconductoring and/or reprofiling into Carmarthen, it is proposed that a second 33 kV circuit is installed between Haverfordwest BSP and Penblewin Primary. A 33 kV circuit length of approximately 15 km would be required, built predominantly as overhead line construction with underground cable sections, with an assumed 0.2 sq.in. HDC conductor or similar construction to match the existing circuit.

This alleviates the projected overloads up to 2034 and beyond the period covered by this analysis.

New limiting factor for constraint(s) considered:

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

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

Capacity Released for constraint(s) considered: Minimal

Discounted

Detailed description: Unfortunately due to the location of Penblewin, no primary is in close enough proximity to be able to transfer the sufficient level of 11 kV demand required in order to alleviate this constraint.

New limiting factor for constraint(s) considered:

Penblewin T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 4 – Procure flexibility at Penblewin Primary

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Penblewin to help alleviate the projected overloads. This could rise up to 6 MVA by 2034. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

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

Following this, it is recommended that uprating the 33/11 kV transformers to 12/24 MVA units, installing a second 33 kV circuit to Haverfordwest and re-conductoring the existing circuit (Option 2) will provide the most network benefit for this area in the long-term.

This option will improve network resilience by reducing the dependency on the auto-changeover scheme under FCO conditions and will ensure compliance with statutory voltage limits and P2/8 throughout the forecasted load growth period and beyond.

4.7 Haverfordwest 33/11 kV Primary Substation

Constraint Overview

Generation **Demand**

For a first circuit outage (arranged or fault) which results in the loss of either Haverfordwest 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service and associated 33 kV circuits begin to overload in-line with future load growth projections.

Haverfordwest Primary group demand is projected to reach 19.87 MVA by 2028 and rise up to 33.31 MVA by 2034. These figures take into account significant load connection activity from commercial developments within the area with a scaled capacity increase modelled year on year.

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

Table 4.7.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Haverfordwest Primary T1 or T2 remaining in-service	Outage to either Haverfordwest Primary T1 or T2 (arranged or fault)	None	2030	2028	2028	2030
Haverfordwest Primary to Haverfordwest BSP 33 kV circuit overloads	Outage to Haverfordwest Primary T1 or T2 (arranged or fault)	None	2030	2030	2030	2032

Solution Options

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

Table 4.7.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Haverfordwest Primary	✓	✓	×	Discounted
2	Install a third transformer at Haverfordwest Primary	✓	✓	×	Discounted
4	Build a new 33/11 kV Primary Substation	✓	✓	✓	Viable
5	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	✓	✓	Viable
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
6	Procure flexibility at Haverfordwest Primary	×	✓	✓	Viable

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

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in transformer and circuit overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Haverfordwest Primary.

Existing limiting factor for constraint(s) considered:

Haverfordwest Primary T1/T2 with a 22.86 MVA (winter cyclic) and 18 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers

Capacity Released for constraint(s) considered: 15.14 MVA **Discounted**

Detailed description: Installing new 20/40 MVA primary transformers at Haverfordwest Primary would alleviate the transformer overloads up to 2034 and beyond. Transformer overloads are observed from 2028 under intermediate cool / warm conditions.

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

If achievable however, the next limiting factor will be the 33 kV circuits supplied from Haverfordwest BSP which have a winter cyclic rating of 24.9 MVA and 26.6 MVA. These circuits are expected to exceed their ratings by 2030 and 2031 respectively.

To alleviate these circuit overloads, it would be proposed to overlay both Haverfordwest BSP to Haverfordwest Primary 33 kV circuits to 300mm^2 copper EPR cable or similar.

New limiting factor for constraint(s) considered:

Haverfordwest Primary T1/T2 with a 38 MVA (winter cyclic) and 30 MVA (summer cyclic) rating.

Option 2 – Install a third 33/11 kV transformer

Capacity Released for constraint(s) considered: 23 MVA **Discounted**

Detailed description: Installing a third 12/24 MVA primary transformer alongside the existing units at Haverfordwest Primary (including removal of any ancillary rating limitations) would alleviate the transformer overloads up to 2034 and beyond.

As above, this may prove difficult based on the lack of space available at the primary to accommodate these works.

Additional 33 kV circuit capacity will be required in-line with the proposals of option 1 to accommodate this level of load growth from 2030.

New limiting factor for constraint(s) considered:

Haverfordwest Primary T1/T2/T3 with a 46 MVA (winter cyclic) and 36 MVA (summer cyclic) rating.

Option 3 – Build a new 33/11 kV Primary Substation

Capacity Released for constraint(s) considered: 23 MVA **Viable**

Detailed description: With the group demand predicted to rise over 33 MVA by 2034 and based on the anticipation of both hydrogen electrolysis and commercial developments projected to connect in this area, this option proposes building a new two 12/24 MVA transformer 33/11 kV primary substation in the nearby area and transferring some of the load projected from Haverfordwest Primary to the new substation.

The level of load growth projected at Haverfordwest Primary may necessitate this level of investment, likewise if the expected level of load projected does in fact connect in the wider area then the primaries in close enough proximity could also benefit from a new primary to shift load to (the closest other primary is Merlin's Bridge which is around 2 km away).

This option would be more expensive than the previous options discussed but could offer a solution to both existing primaries in the area with the aim to de-load each sufficiently based on the longer term load projections facing Haverfordwest Primary and Merlin's Bridge.

New limiting factor for constraint(s) considered:

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

Option 4 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Up to 11 MVA

Viable

Detailed description: To release additional capacity available at Haverfordwest Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries. Merlin's Bridge is located approximately 2 km away.

Approximately 11 MVA would need to be transferred away from Haverfordwest Primary to solve the constraint. It is recommended that this option is used in conjunction with Option 3 that proposes a new 33/11 kV primary substation in the vicinity of both Haverfordwest Primary and Merlin's Bridge.

The 11 kV interconnections have not been studied in detail, further analysis of the 11 kV network surrounding Haverfordwest Primary would be required to fully analyse any potential transfer capability. However if a transfer in the order of 11 MVA is achievable to the new primary then this would alleviate the constraints across this assessed period.

New limiting factor for constraint(s) considered:

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

Option 5 – Procure flexibility at Haverfordwest Primary

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Haverfordwest Primary to help alleviate the projected overloads. This could rise up to 11 MVA by 2034. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement in the short-term, subject to a CBA and confirmation through the DNOA process. Following this, a technical comparison should be made between uprating the existing 33/11 kV transformers at Haverfordwest Primary (Option 1) against building a new 33/11 kV primary in the nearby area (Option 3) in conjunction with de-loading sufficient demand by 11 kV transfers (Option 4).

Option 3 is likely to provide the most network benefit for this area in the long-term and will ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

Furthermore, this option could be used in conjunction with the limitations facing Merlin's Bridge Primary, please see Network Constraint 4.9 for the constraints associated to this substation.

4.8 Merlin's Bridge 33/11 kV Primary Substation

Constraint Overview

Generation | Demand

For a first circuit outage (arranged or fault) which results in the loss of either Merlin's Bridge 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with future load growth projections.

The Merlin's Bridge group demand is projected to reach 11.8 MVA by 2028 and rise to 18.3 MVA by 2034.

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

Table 4.8.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Merlin's Bridge T1 or T2 remaining in-service	Outage to either Merlin's Bridge T1 or T2 (arranged or fault)	None	2030	2028	2028	2030

Solution Options

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

Table 4.8.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Merlin's Bridge	✓	✓	✓	Viable
2	Reinforce existing CER transformers to CMR units	×	×	×	Discounted
3	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	✓	✓	Viable
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility at Merlin's Bridge Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present from 2028 under Leading the Way and Best View and 2030 under Consumer Transformation and System Transformation. No overloads are observed under Falling Short up to 2034.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in transformer overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Merlin's Bridge Primary.

Existing limiting factor for constraint(s) considered:

Merlin's Bridge T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers

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

Detailed description: It is proposed that Merlin's Bridge Primary Transformers are uprated to 12/24 MVA units. Merlin's Bridge group demand is projected to rise to 18.3 MVA by 2034 and based on this load growth this option would alleviate the overloads observed at the primary up to 2034 and beyond the period covered by this analysis.

New limiting factor for constraint(s) considered:

Merlin's Bridge T1/T2 with a 23 MVA (winter cyclic) and 18 MVA (summer cyclic) rating.

Option 2 – Reinforce existing CER transformers to CMR units

Capacity Released for constraint(s) considered: Between 1 MVA and 4 MVA **Discounted**

Detailed description: The 7.5/15 MVA CER transformers could be replaced by 7.5/15 MVA CMR units. This however, would not solve the constraint on its own but would defer constraints by a number of years. Transformer overloads are first observed under intermediate cool and intermediate warm demand conditions in 2028. With CMR units installed, this rating can be increased by an additional 3.8 MVA. No overloads are then observed until 2030.

To fully alleviate the overloads observed, this option could be used in conjunction with option 3 below to permanently transfer demand away from Merlin's Bridge to nearby primaries.

New limiting factor for constraint(s) considered:

Merlin's Bridge T1/T2 with a CMR value of 15 MVA

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

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

Detailed description: To release additional capacity available at Merlin's Bridge Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries. Haverfordwest Primary is located within 2 km of Merlin's Bridge and is the only realistic option for support, however this primary is forecast considerable load growth by 2034.

Approximately 5 MVA would need to be transferred away from Merlin's Bridge to solve the constraint.

It is recommended that this option is used in conjunction with Network Constraint 4.8 that proposes a new 33/11 kV primary substation in the vicinity of both Haverfordwest Primary and Merlin's Bridge.

The 11 kV interconnections have not been studied in detail, further analysis of the 11 kV network surrounding Merlin's Bridge would be required to fully analyse any potential transfer capability. However if a transfer of up to 5 MVA is achievable to the new primary then this would alleviate the constraints across this assessed period.

New limiting factor for constraint(s) considered:

Merlin's Bridge T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 4 – Procure flexibility at Merlin's Bridge

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

Detailed description: Flexibility services could be procured at Merlin's Bridge to help alleviate the projected overloads. The viability of utilising flexibility will be further considered as part of the DNOA process. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

This could rise up to 5 MVA by 2034.

Solution Recommendation

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

Following this, a technical comparison should be made between uprating the existing 33/11 kV transformers at Merlin's Bridge (Option 1) against de-loading Merlin's Bridge by 11 kV transfers (Option 3) in conjunction with Network Constraint 4.8 that recommends a new 33/11 kV primary substation within the area.

Both options will ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

South Pembrokeshire 33 kV Network

4.9 Milford Haven 132/33 kV BSP Substation

Overloads are observed under SCO conditions when an arranged outage of Golden Hill GT1 is followed by a fault to either Haverfordwest GT. Milford Haven GT1 is left to supply a sizable 33 kV group alongside one Haverfordwest GT resulting in excessive overloads. Future years will also lead to the 33 kV circuit supplying Milford Haven GT1 to exceed its rating.

These SCO overloads occur even with operational outage windows restricted to intermediate warm and summer demand periods only.

Constraint Overview

Generation Demand

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

Table 4.9.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Milford Haven GT1 overload	Arranged outage to either Golden Hill GT/ 132 kV circuit	Haverfordwest GT fault/ 132 kV circuit fault	N/A	N/A	2032	2032
Milford Haven to Neyland 33 kV circuit overload	Arranged outage to either Golden Hill GT/ 132 kV circuit	Haverfordwest GT fault/ 132 kV circuit fault	N/A	N/A	2028	2028

Solution Options

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

Table 4.9.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reconfigure Milford Haven BSP	✓	✓	✓	Viable
Operational Mitigation					
2	Review Seasonal Ratings	✓	✓	✓	Viable
Load Management Schemes					
3	Active Network Management schemes	×	✓	✓	Viable
Flexibility services					
4	Procure flexibility at Milford Haven BSP	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Based on the long term DFES projections, constraints are observed from 2028 onwards under Leading the Way, Consumer Transformation and Best View scenarios. Under System Transformation and Falling Short, constraints are observed from 2030 and 2032 respectively.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in transformer and circuit overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would risk damaging the transformers.

Existing limiting factor for constraint(s) considered:

Milford Haven to Neyland 33 kV interplant circuit:

37.0 MVA (winter cyclic)

Option 1 – Reconfigure Milford Haven BSP

Capacity Released for constraint(s) considered: 60 MVA Viable

Detailed description: In conjunction with Network Constraints 4.3 and 4.14 and based on the high demand/generation growth forecast, including the SCO overloads highlighted above, it is proposed that Milford Haven BSP is reconfigured to assist with splitting the Pembrokeshire 33 kV group.

The following reinforcement strategy has been proposed at Milford Haven BSP to alleviate the projected overloads up to 2034 and beyond, to enable Haverfordwest, Milford Haven and Golden Hill to run independently:

- Install an indoor GIS 33 kV switchboard.
- Install a second 132/33 kV Grid Transformer (GT2) rated at 40/60 MVA.
- Extend the 132 kV closed mesh arrangement to create a bay for GT2.

- Re-direct the Golden Hill to Neyland 33 kV circuit for connection at the proposed 33 kV switchboard (away from Neyland). This will require an extension to the existing 33 kV circuit by approximately 2.8 km, built to 0.1 sq.in. HDC conductor or similar.
- Loop the Steynton to Haverfordwest 33 kV circuit into the proposed 33 kV switchboard. It will be a requirement to re-conductor approximately 3 km of 33 kV circuit from Steynton to the assumed loop-in location to 200mm^2 AAAC conductor or similar.
- Two 1.5 km 33 kV circuits will need to be installed from the loop-in location to Milford Haven BSP, assumed 185mm^2 copper EPR cable or similar.
- Carry out a condition based assessment of the 33 kV interplant cable to determine if this circuit can be utilised as a 33 kV feeder to Neyland Primary.
- Propose 33 kV open points to be at the Haverfordwest end of the new loop-in circuit and at the Milford Haven end of the newly extended Golden Hill 33 kV circuit. The final 33 kV open point should be at the Broadfield end of the Haverfordwest circuit.

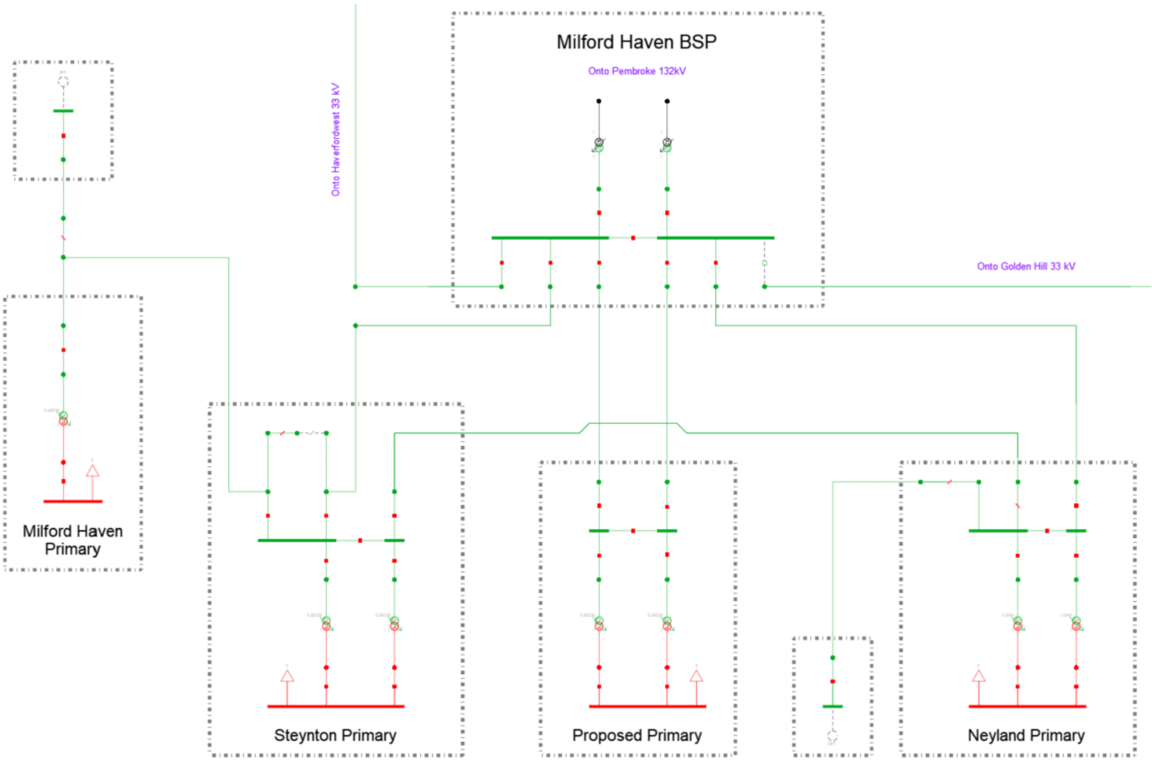

Figure 4.11.1 Proposed reconfiguration of Milford Haven BSP 33 kV network single line diagram

Load growth projections could lead to 40 MVA being supplied to both Steynton and Milford Haven Primary by 2034. Under outage conditions of the existing network arrangement this will lead to significant overloads on the nearby Haverfordwest to Steynton and Steynton to Neyland 33 kV circuits.

Furthermore, voltages at the Steynton and Milford Haven Primary end when supplied by Haverfordwest 33 kV begin to fall considerably below statutory limits with increasing load observed at the primaries.

Network Constraint 4.12 proposes a new substation in the area as a possible solution to de-load nearby primaries. If this proposal is to go ahead, two 33 kV circuits from the new substation will require connection to the proposed 33 kV switchboard at Milford Haven BSP.

Once running independently, this group demand, consisting of Milford Haven Primary, Steynton and Neyland is projected to reach 32.8 MVA by 2028 and rise up to 47.8 MVA by 2034.

Uprating Milford Haven GT1 by use of cyclic ratings should be considered towards the end of the 0-10 year horizon period. This will increase the winter cyclic rating to 58 MVA.

New limiting factor for constraint(s) considered:

Milford Haven GT1 45 MVA rating.

Option 2 – Review Seasonal Ratings

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

Detailed description: Overloads are observed under intermediate cool and intermediate warm demands notably from 2028 onwards. An internal review of the transformer seasonal ratings may conclude that these constraints are not present as early as estimated. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating.

This could defer the overloads by a number of years.

New limiting factor for constraint(s) considered:

Existing Milford Haven to Neyland 33 kV interplant circuit:

37.0 MVA (winter cyclic)

Option 3 – Active Network Management schemes

Capacity Released for constraint(s) considered: Dependent on ANM scheme **Viable**

Detailed description: Any additional connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.

New limiting factor for constraint(s) considered:

Existing Milford Haven to Neyland 33 kV interplant circuit:

37.0 MVA (winter cyclic)

Option 4 – Procure flexibility at Milford Haven BSP

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

Detailed description: Flexibility services could be procured throughout the South Pembrokeshire 33 kV network to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

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

Following this and in-line with the high demand/generation growth forecast and constraints observed, in conjunction with Network Constraints 4.3 and 4.14, it is recommended that a technical review of the reinforcement strategy (Option 1) is carried out to assist with running Haverfordwest, Milford Haven and Golden Hill independently.

This reinforcement strategy will provide greater network operability while also improving network security and resilience under SCO conditions, particularly by splitting this 33 kV network moving forward.

This option allows for future load growth within the Pembrokeshire area, alleviating constraints observed across this assessed period and ensures compliance with statutory voltage limits and P2/8 throughout the forecasted load growth period and beyond.

4.10 Steynton 33/11 kV Primary Substation

Constraint Overview

Generation | **Demand**

For a first circuit outage (arranged or fault) which results in the loss of either Steynton 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with future load growth projections. Future years will also lead to the 33 kV circuits supplying the primary to overload under 33 kV busbar outages at the substation.

The Steynton group demand is projected to reach 23 MVA by 2028 and rise over 34 MVA by 2034.

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

Table 4.10.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Steynton T1 or T2 remaining in-service	Outage to either Steynton T1 or T2 (arranged or fault)	None	2028	2028	2028	2028
Steynton to Neyland 33 kV circuit overload	Main 1 33 kV busbar outage at Steynton (arranged or fault)	None	2030	2028	2030	2030
Steynton to Haverfordwest 33 kV circuit overload	Main 2 33 kV busbar outage at Steynton (arranged or fault)	None	2028	2028	2028	2028

Solution Options

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

Table 4.10.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Steynton	×	✓	✓	Discounted
2	Build a new 33/11 kV Primary Substation	✓	✓	✓	Viable
3	Reconfigure Milford Haven Primary	✓	✓	✓	Viable
4	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	✓	✓	Viable
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
5	Procure flexibility at Steynton Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present from 2028 onwards under Leading the Way and Best View. Under Consumer Transformation by 2032 and System Transformation by 2034. No overloads are observed under Falling Short by 2034.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in transformer and circuit overloads for the conditions described above. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Steynton Primary.

Existing limiting factor for constraint(s) considered:

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

Option 1 – Uprate the 33/11 kV transformers

Capacity Released for constraint(s) considered: 15 MVA **Discounted**

Detailed description: Installing new 20/40 MVA transformers at Steynton Primary would alleviate the transformer overloads observed across this assessed period, initially identified from 2028.

The next limiting factor will be the 33 kV circuits supplying the primary from the surrounding 33 kV network. FCO conditions could lead to 40 MVA being supplied to both Steynton and Milford Haven Primary by either 33 kV circuit by 2034, resulting in significant thermal overloads.

Voltages at the Steynton/Milford Haven Primary end, when supplied by Haverfordwest 33 kV, begin to fall considerably below statutory limits with increasing load observed at the primaries.

New limiting factor for constraint(s) considered:

Steynton to Haverfordwest 33 kV circuit:

23.3 MVA (winter variable pre-fault) and 25.5 MVA (post fault)

Steynton to Neyland 33 kV circuit:

24.9 MVA (winter cyclic)

Option 2 – Build a new 33/11 kV Primary Substation

Capacity Released for constraint(s) considered: 14 MVA **Viable**

Detailed description: The Steynton group demand is projected to exceed the firm capacity of the primary by 2028 and rise over 34 MVA by 2034. This causes significant 33 kV circuit overloads and voltage concerns especially towards the end of the 0-10 year horizon period. Based on this load growth and anticipation of hydrogen electrolysis projected to connect in this area, it is recommended to deload Steynton suitably and transfer some of the load projected away.

This could be achieved by building a new two 7.5/15 MVA transformer 33/11 kV primary substation in the surrounding area. The substantial growth projected at Steynton may necessitate this level of investment. Furthermore, if the expected level of load projected does in fact connect in the nearby area, primaries in close enough proximity could also benefit from a new primary to shift load to (the closest other primaries are Neyland, which is around 5 km away and Milford Haven Primary, which is around 4 km away).

In conjunction with Network Constraint 4.11 that recommends the establishment of a 33 kV switchboard at Milford Haven BSP and surrounding 33 kV network reconfiguration, this new primary would propose two 33 kV feeder circuits to the proposed 33 kV switchboard at Milford Haven BSP.

This option has the potential to provide the most network benefit for this area in the long-term in addition to releasing additional capacity for future growth.

New limiting factor for constraint(s) considered:

New Primary T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 3 – Reconfigure Milford Haven Primary

Capacity Released for constraint(s) considered: 14 MVA

Viable

Detailed description: This option considers the possibility of reconfiguring Milford Haven Primary.

A second 7.5/15 MVA 33/11 kV transformer could be installed to go alongside the existing unit (including removal of any ancillary rating limitations). The Milford Haven Primary group demand is projected to rise to 6 MVA by 2034.

In conjunction with Network Constraint 4.11 it would be proposed to re-direct the existing Milford Haven Primary T1 33 kV circuit from its connection at Steynton and onto the new 33 kV switchboard. This 33 kV circuit would require an extension of approximately 4 km and be built to an assumed 100mm^2 ACSR conductor or similar. The 2.6 km limiting sections of this existing circuit should be reconductored to match this construction to provide a winter variable pre-fault rating of 18.4 MVA.

A new 33 kV circuit of approximately 7 km would also be required. This is to be installed between the new primary transformer T2 and the proposed 33 kV switchboard at Milford Haven BSP. This is to be built to the same construction as that of the T1 33 kV circuit.

This option, if used in conjunction with 11 kV demand transfers to Neyland, could offer a solution to the high demands forecast at Steynton while also improving the network security of Milford Haven Primary.

New limiting factor for constraint(s) considered:

Milford Haven Primary T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 4 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Up to 11 MVA

Viable

Detailed description: To release additional capacity available at Steynton Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries.

Approximately 11 MVA would need to be transferred away from Steynton Primary to overcome the constraints by 2034. It is recommended that this option is used in conjunction with Option 3 that proposes a new 33/11 kV primary substation in the vicinity of Steynton, Neyland and Merlin's Bridge Primary.

The 11 kV interconnections have not been studied in detail, further analysis of the 11 kV network surrounding Steynton would be required to fully analyse any potential transfer capability. However if a transfer in the order of 11 MVA is achievable to the new primary then this would alleviate the constraints across this assessed period.

New limiting factor for constraint(s) considered:

New Primary T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 5 – Procure flexibility at Steynton Primary

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Steynton Primary to help alleviate the projected overloads. This could rise up to 11 MVA by 2034. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

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

Following this, a technical comparison should be made between building a new 33/11 kV primary in the nearby area (Option 2) against reconfiguring Milford Haven Primary (Option 3).

Option 2 may provide the most network benefit for this area in the long-term and will ensure compliance with statutory voltage limits and P2/8 throughout the forecasted load growth period and beyond.

A new substation in the nearby area will have the added benefit of being able to de-load nearby primaries sufficiently whilst providing additional capacity for the area.

4.11 Neyland 33/11 kV Primary Substation

Constraint Overview

Generation **Demand**

For a first circuit outage (arranged or fault) which results in the loss of either Neyland 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with future load growth projections.

The Neyland group demand is projected to reach 5.6 MVA by 2028 and rise over 7 MVA by 2034.

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

Table 4.11.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Neyland T1 or T2 remaining in-service	Outage to either Neyland T1 or T2 (arranged or fault)	None	2034	2030	2032	2034

Solution Options

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

Table 4.11.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Neyland	✓	✓	✓	Viable
2	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	✓	✓	Viable
Operational Mitigation					
3	Review Seasonal Ratings	✓	✓	✓	Viable
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility at Neyland Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present from 2030 under Leading the Way, Consumer Transformation, Best View and System Transformation. No overloads are observed under Falling Short until 2032.

Solution Development

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

Option 0 – No Intervention

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

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

Existing limiting factor for constraint(s) considered:

Neyland T1/T2 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers

Capacity Released for constraint(s) considered: 6.3 MVA — Viable

Detailed description: Installing new 7.5/15 MVA primary transformers at Neyland Primary would alleviate the transformer overloads up to 2034 and beyond the period covered by this analysis.

Transformer overloads are observed from 2030 under intermediate cool conditions.

New limiting factor for constraint(s) considered:

Neyland T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 2 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Up to 2 MVA

Viable

Detailed description: To release additional capacity available at Neyland Primary, new 11 kV circuits may be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries.

It is recommended that this option is used in conjunction with Network Constraint 4.12 that proposes a new 33/11 kV primary substation in the vicinity of Steynton, Neyland and Milford Haven Primary.

The 11 kV interconnections have not been studied in detail, further analysis of the 11 kV network surrounding Neyland would be required to fully analyse any potential transfer capability. However if a transfer in the order of 2 MVA is achievable to the new primary then this would alleviate the constraints across this assessed period.

New limiting factor for constraint(s) considered:

Neyland T1/T2 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Option 3 – Review Seasonal Ratings

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

Viable

Detailed description: As this constraint is initially observed under intermediate cool demands by 2030, an internal review of the transformer seasonal ratings may conclude that this constraint is not present at this time. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating.

This could defer the overloads by a number of years.

New limiting factor for constraint(s) considered:

Neyland T1/T2 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Option 4 – Procure flexibility at Neyland

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Neyland to help alleviate the projected overloads. The viability of utilising flexibility will be further considered as part of the DNOA process. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement. This could rise up to 2 MVA by 2034.

Solution Recommendation

It is recommended to firstly consider flexibility as an option to defer reinforcement in the short-term, subject to a CBA and confirmation through the DNOA process. An internal review of the transformer seasonal ratings should be carried out to help address the overloads observed at Neyland Primary.

Following this, a technical comparison should be made between uprating the existing 33/11 kV transformers at Neyland (Option 1) against de-loading Neyland by 11 kV transfers (Option 2) in conjunction with Network Constraint 4.12 that recommends a new 33/11 kV primary substation within the area.

Both options will ensure compliance with P2/8 throughout the forecasted load growth period and beyond. A new substation in the nearby area will have the added benefit of being able to de-load nearby primaries, such as Neyland, whilst also providing additional capacity for the area.

4.12 Golden Hill 132/33 kV BSP Substation

Overloads are observed under SCO conditions when an arranged outage of Milford Haven GT1 is followed by a fault to either Golden Hill GT. The remaining Golden Hill GT in service is left to supply the Pembrokeshire 33 kV network alongside both Haverfordwest GTs resulting in overloads towards the end of the 0-10 year horizon.

These SCO overloads occur even with operational outage windows restricted to intermediate warm and summer demand periods only.

Constraint Overview

Generation | Demand

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

Table 4.12.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Golden Hill GT1 or GT2 overload	Arranged outage to Milford Haven GT1/ 132 kV circuit	Golden Hill GT fault/ 132 kV circuit fault	N/A	N/A	2032	2034

Solution Options

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

Table 4.12.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate Golden Hill GTs by use of cyclic ratings	✓	✓	✓	Viable
Operational Mitigation					
2	Review Seasonal Ratings	✓	✓	✓	Viable
Load Management Schemes					
3	Active Network Management schemes	-	-	-	Viable
Flexibility services					
4	Procure flexibility at Golden Hill BSP	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Based on the long term DFES projections, constraints are observed from 2032 onwards under Leading the Way, Consumer Transformation and Best View scenarios. Under System Transformation, constraints are observed by 2034.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in GT overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would risk damaging the transformers.

Existing limiting factor for constraint(s) considered:

Existing Golden Hill 90 MVA GT Rating

Option 1 – Uprate Golden Hill GTs by use of cyclic ratings

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

27 MVA (winter cyclic increase) and 9 MVA (summer cyclic increase)

Detailed description: Uprating the existing GTs via use of cyclic ratings in accordance with British Standard 171/IEC60076 and NGED Standard Technique SD8C will provide additional capacity for the network. This requires a capability assessment of all transformer ancillaries. In addition, an assessment of the cyclic profile of the load will be required to determine if transformer temperature and ageing is within acceptable limits.

These works will increase the winter cyclic rating to 117 MVA and summer cyclic to 99 MVA if the assessment permits the use of cyclic ratings.

SCO overloads will be alleviated across this assessed period.

New limiting factor for constraint(s) considered:

Golden Hill GT1/GT2 with a 117 MVA (winter cyclic) and 99 MVA (summer cyclic) rating.

Option 2 – Review Seasonal Ratings

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

Detailed description: Overloads are observed under intermediate cool and intermediate warm demands notably from 2032 onwards. An internal review of the transformer seasonal ratings may conclude that these constraints are not present as early as estimated. This could be the situation if it is deemed that these seasonal ratings are viewed as overly pessimistic as they align to the summer rating.

This could defer the overloads by a number of years.

New limiting factor for constraint(s) considered:

Existing Golden Hill 90 MVA GT Rating

Option 3 – Active Network Management schemes

Capacity Released for constraint(s) considered: Dependent on ANM scheme — **Viable**

Detailed description: Any additional connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.

New limiting factor for constraint(s) considered:

Existing Golden Hill 90 MVA GT Rating

Option 4 – Procure flexibility at Golden Hill BSP

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

Detailed description: Flexibility services could be procured throughout the South Pembrokeshire 33 kV network to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a CBA and confirmation through the DNOA process. An assessment of cyclic ratings should be carried out alongside an internal review of the transformer seasonal ratings, to help address the overloads observed at Golden Hill BSP.

Following this and in-line with the high demand/generation growth forecast and constraints observed up to 2034, notably at Haverfordwest BSP, it is recommended that detailed studies (also 33 kV reinforcement as necessary) are carried out to be able to run Haverfordwest, Milford Haven and Golden Hill independently.

The Golden Hill BSP group demand under independent running, consisting of Golden Hill Primary, St Twynells, St Florence, Tenby and Broadfield is projected to rise up to 95.8 MVA by 2034.

Please see Network Constraints 4.3 & 4.11 for proposals associated to both Haverfordwest and Milford Haven BSPs that propose a future network split.

This allows for future load growth within the Pembrokeshire area, alleviating constraints observed across this assessed period and ensures compliance with P2/8 throughout the forecasted load growth period and beyond.

4.13 Golden Hill 33/11 kV Primary Transformers

Constraint Overview

Generation Demand

For a first circuit outage (arranged or fault) which results in the loss of either Golden Hill 33/11 kV Primary Transformer (T31 or T4) the remaining transformer in service begins to overload in-line with future load growth projections.

The Golden Hill Primary group demand is projected to reach 22 MVA by 2028 and rise over 32 MVA by 2034. A steady increase of distributed generation is projected to connect to the primary by 2028. By 2034, a large amount of solar generation is expected to connect, rising over 20 MVA.

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

Table 4.13.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Golden Hill T3 or T4 remaining in-service	Outage to either Golden Hill T3 or T4 (arranged or fault)	None	2028	2028	2028	2028

Solution Options

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

Table 4.13.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at Golden Hill	✓	✓	✓	Viable
2	Reinforce 11 kV circuits to transfer demand to other Primaries	×	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
3	Procure flexibility at Golden Hill	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. It first becomes present by 2028 under Leading the Way and Best View. Constraints are present under Consumer Transformation by 2030 and System Transformation by 2034.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

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

Existing limiting factor for constraint(s) considered:

Existing Golden Hill T3/T4 with a 23 MVA (winter cyclic) and 18 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers

Capacity Released for constraint(s) considered: 15 MVA

Viable

Detailed description: Golden Hill 11 kV demand is projected to rise over 32 MVA by 2034. Based on this load growth and anticipation of hydrogen electrolysis projected to connect in this area, it is proposed that Golden Hill Primary Transformers are uprated to 20/40 MVA units.

This will alleviate the overloads observed up to 2034 and beyond.

New limiting factor for constraint(s) considered:

Golden Hill Primary T3/T4 with a 38 MVA (winter cyclic) and 30 MVA (summer cyclic) rating.

Option 2 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Minimal

Discounted

Detailed description: To release additional capacity available at Golden Hill, new 11 kV circuits would need to be installed (or existing circuits reinforced) to provide greater interconnectivity towards nearby primaries. This may only offer marginal benefit in the short term and will limit potential future growth as additional reinforcement at Golden Hill may still be required at a later date to release additional capacity in the long-term.

Approximately 9 MVA would need to be transferred away from Golden Hill to solve the constraint.

New limiting factor for constraint(s) considered:

Existing Golden Hill T3/T4 with a 23 MVA (winter cyclic) and 18 MVA (summer cyclic) rating.

Option 3 – Procure flexibility at Golden Hill

Flexibility service type: Demand turn down or generation turn up

Viable

Detailed description: Flexibility services could be procured at Golden Hill to help alleviate the projected overloads. This could rise up to 9 MVA by 2034. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

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

Following this, it is recommended to uprate the existing 33/11 kV transformers at Golden Hill to 20/40 MVA units (Option 1). This option will ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

4.14 St Twynells 33/11 kV Primary Substation

Constraint Overview

Generation | **Demand**

For a first circuit outage (arranged or fault) which results in the loss of either St Twynells 33/11 kV Primary Transformer (T1 or T2) the remaining transformer in service begins to overload in-line with future load growth projections.

The St Twynells group demand is projected to reach 7.8 MVA by 2028 and rise to 11.67 MVA by 2034.

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

Table 4.14.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
St Twynells T1 or T2 remaining in-service	Outage to either St Twynells T1 or T2 (arranged or fault)	None	2028	2028	2028	2028
Golden Hill to St Twynells 33 kV circuit overload	Intact	None	2034	2034	2034	2034

Solution Options

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

Table 4.14.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Uprate the transformers at St Twynells and re-conductor the T2 33 kV circuit	✓	✓	✓	Viable
2	Reinforce 11 kV circuits to transfer demand to other Primaries	×	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
3	Procure flexibility at St Twynells Primary	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Overloads first become present by 2028 under Leading the Way, Best View, Consumer Transformation, System Transformation and Falling Short scenarios.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

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

Existing limiting factor for constraint(s) considered:

St Twynells T1/T2 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Option 1 – Uprate the 33/11 kV transformers and re-conductor the T2 33 kV circuit

Capacity Released for constraint(s) considered: 6.3 MVA — Viable

Detailed description: Uprating the 33/11 kV transformers at St Twynells Primary to 7.5/15 MVA units will alleviate the constraints observed at the primary. The next limiting factor following replacement of the primary transformers will be the St Twynells T2 33 kV circuit supplied from Golden Hill BSP which has winter cyclic rating of 11.5 MVA.

This rating is expected to be reached by 2034. To alleviate this circuit overload, it would be proposed to reconductor approximately 5.4 km of the limiting 33 kV sections of this circuit to 0.1 sq.in. HDC conductor or similar to provide a winter variable pre-fault rating of 17.6 MVA.

New limiting factor for constraint(s) considered:

St Twynells T1/T2 with a 14 MVA (winter cyclic) and 11.2 MVA (summer cyclic) rating.

Option 2 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Minimal — Discounted

Detailed description: Unfortunately due to the location of St Twynells, no primary is in close enough proximity to be able to transfer the sufficient level of 11 kV demand required in order to alleviate these constraints.

Approximately 4 MVA would need to be transferred away to overcome the constraints by 2034.

New limiting factor for constraint(s) considered:

Existing St Twynells T1/T2 with a 7.7 MVA (winter cyclic) and 6.2 MVA (summer cyclic) rating.

Option 3 – Procure flexibility at St Twynells

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

Detailed description: Flexibility services could be procured at St Twynells to help alleviate the projected overloads. This could rise up to 4 MVA by 2034. It is unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement.

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

Solution Recommendation

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

Following this, it is recommended to uprate the 33/11 kV transformers at St Twynells and reconductor the limiting sections of the T2 33 kV circuit (Option 1). This option will ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

4.15 Golden Hill – St Florence / Tenby / Broadfield 33 kV Network

Constraint Overview

Generation | **Demand**

An EHV reinforcement scheme to install a 33 kV circuit from Golden Hill BSP to Broadfield Primary is currently in active development and it is expected to be completed by 2028. This scheme has been included in all studies from 2028 onwards.

For a first circuit outage (arranged or fault) which results in the loss of Broadfield 33 kV Main 2 busbar, the remaining Golden Hill to Broadfield (via St Florence and Tenby) 33 kV circuit is left to support the demand from these primaries and will soon overload in-line with future load growth projections.

Currently this group, consisting of St Florence, Tenby and Broadfield, has a maximum demand of 14.5 MVA which is projected to reach 17.9 MVA by 2028 and rise up to 26.5 MVA by 2034.

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

Table 4.15.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Golden Hill – St Florence 33 kV circuit overload	Broadfield 33 kV Main 2 Busbar arranged or fault outage	None	2028	2028	2028	2030
St Florence – Tenby Tee 33 kV circuit overload	Broadfield 33 kV Main 2 Busbar arranged or fault outage	None	2030	2030	2030	2032

Solution Options

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

Table 4.15.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Reprofile and/or reconductor the existing 33 kV circuits supplying this group	✓	✓	✓	Viable
2	Reinforce 11 kV circuits to transfer demand to other Primaries	✓	×	×	Discounted
Operational Mitigation					
-	*None Identified*	-	-	-	-
Load Management Schemes					
-	*None Identified*	-	-	-	-
Flexibility services					
4	Procure flexibility at the primaries	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: These constraints are initially alleviated through the EHV reinforcement scheme. Based on the long term DFES projections, greater thermal constraints are observed from 2028 onwards across this 33 kV group under all scenarios except Falling Short.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

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

Existing limiting factor for constraint(s) considered:

Golden Hill to St Florence 33 kV circuit:

17.6 MVA (winter variable pre-fault) and 19.3 MVA (post fault)

Option 1 – Reprofile and/or reconductor the existing Golden Hill to St Florence and St Florence to Tenby Tee 33 kV circuits

Capacity Released for constraint(s) considered: 15.8 MVA

Viable

Detailed description: The Golden Hill to St Florence 33 kV circuit rating is expected to be reached by 2028. Reprofiling approximately 7.2 km of the limiting 0.1 sq.in. HDC conductor for operation at 75°C would resolve this overload up until 2030.

To alleviate the overloads on this circuit up to 2034 and beyond, it would be proposed to reconductor approximately 8.5 km of limiting overhead line sections to 200mm^2 AAAC conductor or similar to provide a winter variable pre-fault rating of 30.3 MVA.

In addition, it would be required to overlay approximately 0.35 km of limiting underground cable sections to 185mm^2 copper EPR cable or similar to provide a winter cyclic rating of 32.6 MVA

The St Florence to Tenby Tee 33 kV circuit rating is expected to be reached by 2030. Reprofiling approximately 4.2 km of the limiting 0.1 sq.in. HDC conductor for operation at 75°C would resolve this overload up until 2032.

To alleviate the overloads on this circuit up to 2034 and beyond, it would be proposed to reconductor these limiting sections to 0.2 sq.in. HDC conductor or similar to provide a winter variable pre-fault rating of 27.4 MVA.

New limiting factor for constraint(s) considered:

Golden Hill to St Florence 33 kV circuit:

30.3 MVA (winter variable pre-fault) and 33.09 MVA (post fault)

St Florence to Tenby Tee 33 kV circuit:

27.4 MVA (winter variable pre-fault) and 30.0 MVA (post fault)

Option 2 – Reinforce 11 kV circuits to transfer demand to other Primaries

Capacity Released for constraint(s) considered: Minimal **Discounted**

Detailed description: Any 11 kV demand transfers would have to be made to primaries supplied outside of this group. Unfortunately due to the location of St Florence, Tenby and Broadfield, no primary is in close enough proximity to be able to transfer the sufficient level of demand required in order to alleviate this constraint.

New limiting factor for constraint(s) considered:

Golden Hill to St Florence 33 kV circuit:

17.6 MVA (winter variable pre-fault) and 19.3 MVA (post fault)

Option 3 – Procure flexibility within this 33 kV network group

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

Detailed description: Flexibility services could be procured within this area to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement. This could be in excess of 10 MVA by 2034.

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

Solution Recommendation

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

Following this, a technical review of reprofiling and/or reconductoring the existing 33 kV circuit sections between Golden Hill to St Florence and St Florence to Tenby should be made. This option will ensure compliance with P2/8 throughout the forecasted load growth period and beyond.

4.16 Pembrokeshire 33 kV Hydrogen Electrolysis

Constraint Overview

The table below summarises the scale of the hydrogen electrolysis forecast to connect to the Pembroke 33 kV network up to 2034. The constraints this could cause and the network reinforcement required to mitigate against them will be dependent on the geographic locations of the connecting electrolysers and their sizes.

Table 4.16.1 Total demand from hydrogen electrolysis forecast to connect to the Pembrokeshire 33 kV network

DFES Scenario	Demand			
	Baseline	2025	2028	2034
Best View	0 MW	12.40 MW	22.32 MW	46.59 MW
System Transformation	0 MW	9.40 MW	13.20 MW	29.58 MW
Leading the Way	0 MW	12.40 MW	22.32 MW	46.59 MW
Consumer Transformation	0 MW	1.08 MW	3.26 MW	17.05 MW
Falling Short	0 MW	0.25 MW	2.34 MW	13.11 MW

Uncertainty under other Distribution Future Energy Scenarios: As shown in the table above the Best View scenario is aligned to Leading the Way for this area, with lower hydrogen electrolysis forecast under System Transformation and significantly lower forecast under Consumer Transformation and Falling Short.

Solution Options

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

Table 4.16.2 solution options to solve constraint(s)

Option	Description
Reinforcement	
1	Uprate the existing primaries supplied from within the Pembroke 33 kV network
2	Build a new primary substation
3	Build a new BSP

Solution Development

These options have been assessed on their technical viability and their likely cost-effectiveness pending a full CBA. This CBA will be subsequently carried out by the DNO to determine the optimal reinforcement solution as part of the connections planning process.

Option 1 – Uprate the existing primaries supplied from the Pembroke 33 kV network

Capacity released for constraint(s) considered:

Dependent on the reinforcement strategy for each affected primary

Viable

Detailed description: If the forecast demand of hydrogen electrolysis is split among a high number of smaller electrolysers which are geographically dispersed within the area supplied within the Pembroke 33 kV network, a single point of connection would not be practical or economical. If this is the case reinforcing the existing network would be the optimal reinforcement strategy. This could involve bringing forward some of the reinforcement options discussed in each of the other sections of this report.

New limiting factor for constraint(s) considered:

Haverfordwest / Golden Hill / Milford Haven GT capacity

Option 2 – Build a new primary substation

Capacity released for constraint(s) considered: Up to 38 MVA

Viable

Detailed description: If the forecast demand from hydrogen electrolysis is made up of a smaller number of electrolysers which are located in close proximity to each other and not to any of the existing substations supplied from within the Pembroke 33 kV network then building a new primary substation may be the optimal solution to accommodate this demand.

This option would create significant additional capacity which could be further utilised to deload some of the existing primaries and alleviate or push back some of the forecast constraints at each substation. The technical and economic feasibility of such transfers would be heavily dependent on both the location of the new primary and the capacity of the existing 11 kV network.

New limiting factor for constraint(s) considered:

Haverfordwest / Golden Hill / Milford Haven GT capacity

Option 3 – Build a new BSP

Capacity released for constraint(s) considered: Dependent on new BSP

Discounted

Detailed description: The forecast volume of hydrogen electrolysis located around Pembroke is not of sufficient magnitude to warrant a dedicated 132 kV connection. Unless this changes and a large single hydrogen electrolysis customer wishes to connect this solution is likely to remain prohibitively expensive compared to the options discussed above which involve accommodating the electrolysers on the 33 kV and/or 11 kV networks.

New limiting factor for constraint(s) considered: Pembroke 132 kV network

Solution Recommendation

The forecast demand from hydrogen electrolysis expected to connect to the network, fed from within the Pembroke 33 kV network, is not of sufficient magnitude to prompt a dedicated 132 kV connection.

Options for accommodating the demand on the 33 kV and 11 kV networks include building a new primary and fortifying the existing primaries.

The optimal solution will be heavily dependent on the size and location of the electrolysers and will be considered in depth as part of NGED's connections planning process (and in future NDP reports to consider the synergies with other constraints).

Pembrokeshire 132 kV Network

Pembroke GSP is currently supplied by two 400/132 kV 240 MVA SGTs (SGT1 & SGT2) which supply the entire Pembrokeshire network, operating as a standalone group under intact network conditions.

The table below summarises the scale of the demand and generation forecast to connect to the Pembrokeshire Group up to 2034 under NGED's DFES Best View scenario.

Table 4.16.3 Maximum demand forecast to connect to the Pembrokeshire Group

DFES Scenario	Demand		
	Baseline	2028	2034
Best View	168.70 MW	249.79 MW	331.12 MW

Table 4.16.4 Maximum generation forecast to connect to the Pembrokeshire Group

DFES Scenario	Generation		
	Baseline	2028	2034
Best View	209.05 MW	360.50 MW	473.98 MW

With several new developments proposed to connect within the group at 132 kV, 33 kV and at 11 kV in the near future, the demand and generation forecast is expected to increase. However, this will vary depending if such developments materialise.

This group becomes vulnerable to FCO and SCO conditions, notably towards the end of the 0-10 year horizon period as a result of the load growth projections. These limitations are highlighted below.

4.17 Pembroke SGT Capacity

Constraint Overview

Generation | Demand

For a first circuit outage (arranged or fault) which results in the loss of either Pembroke SGT (SGT1 or SGT2), the remaining SGT in service will soon overload.

From 2028, an additional two SGTs are anticipated at Pembroke GSP, aligned to the latest compliance report received as part of the annual data exchange between DNOs and National Grid Electricity Transmission. These assets however have not been taken into account for the purposes of this study.

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

Table 4.17.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
Pembroke SGT1 or SGT2 overload	Fault to either SGT1 or SGT2	None	2027	2027	2027	2028

Solution Options

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

Table 4.17.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install a third SGT	✓	✓	✓	Viable
Operational Mitigation					
2	Demand transfers to an adjacent group	×	×	✓	Discounted
Load Management Schemes					
3	Post-fault transfers	×	×	✓	Discounted
4	Active Network Management schemes	×	✓	✓	Viable
Flexibility services					
5	Procure flexibility across the group	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Based on the long term DFES projections, constraints are observed from 2027 onwards under Leading the Way and Best View scenarios. Under System Transformation and Consumer Transformation constraints are observed from 2028 with Falling Short observed from 2032.

Solution Development

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

Option 0 – No Intervention

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

Detailed description: Doing nothing to mitigate the constraint would result in SGT overloads for the conditions described above. Therefore, not intervening would cause problems with system integrity (overloads) and would risk damaging the transformers. This would lead to an inability to meet the Security of Supply requirements of Engineering Recommendation P2 for Pembroke GSP.

Existing limiting factor for constraint(s) considered:

Existing Pembroke 240 MVA SGT Rating

Option 1 – Install a third SGT at Pembroke GSP

Capacity Released for constraint(s) considered: 240 MVA (third SGT) **Viable**

Detailed description: Installing a third 240 MVA SGT at Pembroke GSP would alleviate all constraints up to 2034 and beyond by ensuring two SGTs remain in-service for any first circuit outage event. A third SGT also reduces the risk of a subsequent SCO fault (double SGT loss) that under the existing arrangement can lead to the loss of the entire Pembrokeshire group, notably if the group demand is greater than the Haverfordwest to Carmarthen overload trip scheme. This is intended to operate when the circuit loading is above 500A (DT, 3 seconds).

In the baseline studies the group demand of Pembroke GSP is 168.70 MW, which falls into Class D of P2. By 2032, the group demand is expected to rise over 300 MW, which increases to Class E.

At which point, the P2 requirement will be to immediately restore 2/3 of the group demand under SCO. It is assumed that normal maintenance will only be taken within an access window representing the period when group demand is less than 2/3 of the Group Demand. However, due to the high amount of industrial customers which are modelled at full import capacity for all half hours of all peak demand representative days, summer peak demand does not fall below 2/3 of the group demand observed under winter peak conditions. In this instance, P2 restoration requirements are increased to match that of the maintenance period demand.

In-line with the projected load growth and several large new connections planned in the Pembroke GSP area, the group will soon become non-compliant with just two SGTs installed at Pembroke as load transfers will become inadequate.

It is recommended that a discussion with NGET is had to determine if these overloads, when initially observed from 2027, are within the short-term ratings of the Pembroke SGTs or if any operational mitigation is in place to manage these overloads, such as being able to transfer load out of the group.

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

New limiting factor for constraint(s) considered:

Combination of the remaining Pembroke SGTs in-service during FCO conditions

Option 2 – Demand transfers to an adjacent group

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

Detailed description: The A-route 132 kV circuit between Haverfordwest to Carmarthen is typically used to support the Pembroke group during SGT outage conditions. There is also the possibility to transfer both Nevern and Penblewin primaries onto the Swansea North group as necessary.

If additional load can be transferred out of the group then this option should be explored, such as, transferring Haverfordwest BSP onto Swansea North via the A-route 132 kV circuit, under SGT outage conditions.

However, given that both Haverfordwest BSP and Swansea North GSP are growing significantly during the assessed period the total availability for transfers will need to be routinely checked and as such this option would likely only defer reinforcement works.

New limiting factor for constraint(s) considered:

Existing Pembroke 240 MVA SGT Rating

Option 3 – Post-fault Transfers

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

Detailed description: By utilising the short term ratings of the SGTs at Pembroke it would be possible to consider holding an overload on the remaining SGT for a sufficient duration to enact a transfer, the issue remains where the adjacent group is also being constrained.

Depending on the timing and quantity of growth this option may be useful for periods in the future.

New limiting factor for constraint(s) considered:

Existing Pembroke 240 MVA SGT Rating

Option 4 – Active Network Management schemes

Capacity Released for constraint(s) considered: Dependent on ANM scheme **Viable**

Detailed description: Any additional connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.

New limiting factor for constraint(s) considered:

Existing Pembroke 240 MVA SGT Rating

Option 5 – Procure flexibility across Pembroke GSP

Estimated Flexibility Required (MVA): 91+ MVA by 2034 (Best View) **Viable**

Detailed description: Flexibility services could be procured throughout the Pembrokeshire network to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement and may not be a viable permanent solution

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

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a CBA and confirmation through the DNOA process. An assessment of available demand transfers in conjunction with short-term ratings should be reviewed to help with the initial overloads observed at Pembroke GSP.

Following this and in-line with the high demand/generation growth projected throughout this 0-10 year horizon, it is recommended to install a third SGT at Pembroke GSP (Option 1).

This allows for future load growth within the Pembrokeshire area, alleviating the constraints observed across this assessed period and ensures compliance with P2/8 throughout the forecasted load growth period and beyond.

4.18 Pembroke 132 kV Circuit Capacity

Constraint Overview

Generation | Demand

The 132 kV network currently has three outgoing circuits between the double busbar arrangement at Pembroke GSP and Milford Haven's 132 kV closed mesh arrangement:

- AW-route from Pembroke 305 to Milford Haven 603, teed onto the RR-route (Waterston GT1)
    - Winter variable pre-fault rating: 137 MVA
    - Winter post fault rating: 150 MVA
- CW-route from Pembroke 105 to Golden Hill GT1, teed onto the EE-route (Milford Haven 803)
    - Winter variable pre-fault rating: 137 MVA
    - Winter post fault rating: 150 MVA
- Cable from Pembroke 205 to Golden Hill GT2, also teed onto the EE-route (Milford Haven 203)
    - Winter cyclic rating: 150 MVA

These circuits supply the Milford Haven, Golden Hill and Haverfordwest BSP group that is run in parallel at 33 kV. This is alongside some large industrial customers on the 132 kV network.

Currently, the maximum demand across the Pembroke 132 kV network which the three 132 kV circuits are required to supply is currently 130.40 MVA. This falls into Class D of P2. In the baseline studies, the existing network is compliant with P2 and the entire group demand can be restored under both FCO and SCO conditions.

An EHV reinforcement scheme to install a fourth 132 kV circuit between Pembroke GSP and Milford Haven is currently in active development which is expected to be completed by 2028. This scheme proposes the installation of a new 7 km 132 kV underground cable circuit between Pembroke and Golden Hill GT1, teed onto the EE-route (Milford Haven 803). This circuit will have a winter cyclic rating of 150 MVA.

The intention is to disconnect the existing CW-route at Golden Hill GT1 and extend this circuit with a new 9 km 132 kV underground cable to the extended 132 kV closed mesh arrangement at Milford Haven.

These works have been included in all studies from 2028 onwards.

In-line with the high load growth forecast, SCO combinations resulting in the loss of two out of the four 132 kV circuits between Pembroke and Milford Haven will lead to further network reinforcement being required in order to secure the entire group demand by 2034.

These SCO overloads occur even with operational outage windows restricted to summer demand periods only.

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

Table 4.18.1 constraint(s) and condition under which constraint occurs

Constraint	N-1 Condition	Subsequent N-2 Condition	First year constraint is observed in each season under Best View			
			Winter	Int Cool	Int Warm	Summer
SCO overload as a result of two 132 kV circuits left in-service between Pembroke and Milford Haven 132 kV	Arranged circuit outage between Pembroke and Milford Haven 132 kV	Circuit fault between Pembroke and Milford Haven 132 kV	N/A	N/A	N/A	2030

Solution Options

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

Table 4.18.2 solution options to solve constraint(s)

Solution Options	Description	Solves Constraint	Wider Area Benefit	Potential to be cost effective	Viable or Discounted
0	No Intervention	×	×	×	Discounted
Reinforcement					
1	Install a new 132 kV circuit from Pembroke GSP to Milford Haven 132 kV	✓	✓	✓	Viable
Operational Mitigation					
2	Split the 132 kV network into smaller independent groups	×	✓	✓	Discounted
Load Management Schemes					
3	Active Network Management schemes	×	✓	✓	Viable
Flexibility services					
4	Procure flexibility within the group	×	✓	✓	Viable

Uncertainty under other Distribution Future Energy Scenarios: This constraint is not an issue under the current baseline scenario. Based on the long term DFES projections, constraints are observed from 2030 onwards under Leading the Way and Best View scenarios. Under Consumer Transformation and System Transformation constraints are observed from 2032 and 2033 respectively. Falling Short is observed by 2034.

Solution Development

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

Option 0 – No Intervention

Capacity Released for constraint(s) considered: 0 MVA

Discounted

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

Limiting factor for constraint(s) considered:

SCO post fault summer rating of the remaining Pembroke to Milford Haven 132 kV circuits in-service:

Baseline arrangement: 134 MVA

2028 arrangement: 268 MVA

Option 1 – Install a new 132 kV circuit from Pembroke GSP to Milford Haven 132 kV

Capacity Released for constraint(s) considered: Dependent on construction type **Viable**

Detailed description: Installing a fifth 132 kV circuit between Pembroke GSP and Milford Haven would alleviate the constraints identified for all scenarios up to 2034 and beyond. Circuit overloads are initially observed from 2030 onwards under summer peak demand SCO conditions.

A direct circuit of approximately 14 km would be required from Pembroke to Milford Haven. The construction of which would have to be carefully assessed to ensure the power flow across these five circuits is not unequally distributed, taking into account the existing circuit types and impedances of each circuit already in-service.

This proposal will release additional capacity particularly in-line with the high demand/generation growth projected to connect in this area while also improving network security and resilience under SCO conditions.

New limiting factor for constraint(s) considered:

Combination of the remaining 132 kV circuits in-service during SCO conditions

Option 2 – Split the 132 kV network into smaller independent groups

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

Detailed description: Network Constraint 4.11 has proposed a reinforcement strategy to enable Haverfordwest, Milford Haven and Golden Hill to run independently on the 33 kV network.

This strategy could be advanced further on the 132 kV network by splitting the 132 kV network into smaller independent groups by reconfiguring the Milford Haven 132 kV mesh to run with a split arrangement.

This could be achieved by grouping Milford Haven with Golden Hill on one side of the mesh and Haverfordwest on the adjacent side with the large industrial customers at South Hook BSP, Robeston BSP and Waterston BSP distributed in a balanced approach across the mesh.

However, given that the Pembrokeshire 33 kV network is growing significantly during this 0-10 year horizon, a split 132 kV network is likely to lead to 132 kV circuit overloads under FCO conditions, notably towards the end of this assessed period.

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

Option 3 – Active Network Management schemes

Capacity Released for constraint(s) considered: Dependent on ANM scheme **Viable**

Detailed description: Any additional connections into this group may be included in an Active Network Management (ANM) scheme, which could also be utilised to manage constraints on over-committed networks.

New limiting factor for constraint(s) considered:

SCO post fault summer rating of the remaining Pembroke to Milford Haven 132 kV circuits in-service:

Baseline arrangement: 134 MVA

2028 arrangement: 268 MVA

Option 4 – Procure flexibility across Pembroke GSP

Estimated Flexibility Required (MVA): 91+ MVA by 2034 (Best View) **Viable**

Detailed description: Flexibility services could be procured throughout the Pembrokeshire network to help alleviate the projected overloads. It is highly unlikely that sufficient flexibility could be procured as a long-term solution. The amount required will continue to grow as demand grows meaning this would likely only defer the reinforcement and may not be a viable permanent solution. Dispatch of services may be required for extended periods of time at peak demand.

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

Solution Recommendation

It is recommended to firstly consider flexibility as an option to gauge the level of procurement available within the area, subject to a CBA and confirmation through the DNOA process. In a similar approach to the SGT overloads, an assessment of available demand transfers should be reviewed to help with the initial circuit overloads observed between Pembroke GSP and Milford Haven.

Following this and in-line with the high demand/generation growth projected throughout this 0-10 year horizon, it is recommended to install a fifth 132 kV circuit between Pembroke GSP and Milford Haven (Option 1). This option will improve network security and resilience under SCO conditions.

This allows for future load growth within the Pembrokeshire area, alleviating the constraints observed across this assessed period and ensures compliance with P2/8 throughout the forecasted load growth period and beyond.

DSO | nationalgrid electricity distribution

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