

Maentwrog – Porthmadog 33kV Reinforcement

ED2 Engineering Justification Paper

ED2-LRE-SPM-005-CVI-EJP

Issue	Date	Comments
Issue 0.1	January 2021	Issue to internal governance and external assurance
Issue 0.2	April 2021	Reflecting comments from internal governance
Issue 0.3	May 2021	Reflecting assurance feedback
Issue 1.0	June 2021	Draft Business Plan Submission
Issue 1.1	October 2021	Reflecting updated DFES forecasts
Issue 1.2	November 2021	Reflecting updated CBA results
Issue 2.0	December 2021	Final Business Plan Submission

Scheme Name	Maentwrog – Porthmadog 33kV Reinforcement		
Activity	Primary reinforcement		
Primary Investment Driver	Thermal constraints		
Reference	ED2-LRE-SPM-005-CVI-EJP		
Output Type	Load Index		
Cost	SPM - £5.794m		
Delivery Year	2024-2027		
Reporting Table	CVI		
Outputs included in ED1	Yes/No		
Business Plan Section	Develop the Network of the Future.		
Primary Annex	Annex 4A.2: Load Related Expenditure Strategy: Engineering Net Zero Annex 4A.6: DFES		
Spend Apportionment	ED1 £m	ED2 £5.794m	ED3 £m





Technical Governance Process

Project Scope Development

IPI(S)

To be completed by the Service Provider or Asset Management. The completed form, together with an accompanying report, should be endorsed by the appropriate sponsor and submitted for approval.

IPI – To request project inclusion in the investment plan and to undertake project design work or request a modification to an existing project

IPI(S) – Confirms project need case and provides an initial view of the Project Scope

IP2 – Technical/Engineering approval for major system projects by the System Review Group (SRG)

IP2(C) – a Codicil or Supplement to a related IP2 paper. Commonly used where approval is required at more than one SRG, typically connection projects which require connection works at differing voltage levels and when those differing voltage levels are governed by two separate System Review Groups.

IP2(R) – Restricted Technical/Engineering approval for projects such as asset refurbishment or replacement projects which are essentially on a like-for-like basis and not requiring a full IP2

IP3 – Financial Authorisation document (for schemes > £100k prime)

IP4 – Application for variation of project due to change in cost or scope

PART A – PROJECT INFORMATION

Project Title:	Maentwrog – Porthmadog 33kV Reinforcement
Project Reference:	ED2-LRE-SPM-005-CVI-EJP
Decision Required:	To give concept approval for establishment of new 33kV 11kms 400 Sqmm XLPE AL cable circuit between Maentwrog grid to Porthmadog.

Summary of Business Need:

The SP Manweb (SPM) network in North Wales around Maentwrog, Porthmadog, Pwllheli, Criccieth, Blaenau Ffestiniog, Harlech and Morfa Nefyn is supplied from Trawsfynydd GSP. The 132kV network group secures Maentwrog / Four Crosses 33kV group supplying over 41,930 customers which includes several recreational/tourist destinations spread across the network.

The primary drivers for this investment are insufficient thermal headroom and security of supply risk. Studies indicate that with the additional demand from 10,089 Electric Vehicles and 9,338 Heat Pumps the 33kV circuit between Maentwrog –Llanfrothen – Porthmadog will be loaded beyond the cyclic ratings and would risk cascade tripping of the group and loss of supplies to over 18,000 customers during outage on the 132/33kV 45MVA grid transformer at Four Crosses grid substation.

Summary of Project Scope, Change in Scope or Change in Timing:

Proposed works include:

- Establish new 11kms 33kV 400sqmm XLPE AL cable circuit between Maentwrog grid to Porthmadog.
- Extend the 33kV switchboards at Maentwrog grid and Porthmadog substation.
- Contract flexibility services to support the network during the project delivery from year 2023/24 through 2025/26.

It is proposed to start the works in 2024/25 and the capacity release of 20MVA will be claimed in 2026/27 at the end of the project. The estimated cost for the above is £5.794 (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Expenditure Forecast (Where available based on Regulatory Allowance – 2020/21)

License Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CVI	Primary Reinforcement	5.539	-	2.215	2.769	0.554	-
SPM	CVI	Flexible Services	0.255	0.038	0.076	0.141	-	-
This Proposal			5.794	0.038	2.291	2.910	0.554	-

PART B – PROJECT SUBMISSION

Proposed by	Kailash Singh	Signature	<i>Kp. Singh</i>	Date:	30/11/2021
Endorsed by	Russell Bryans	Signature	<i>Russell Bryans</i>	Date:	30/11/2021

PART C – PROJECT APPROVAL

Approved by	Malcolm Bebbington	Signature	<i>M. Bebbington</i>	Date:	30/11/2021
-------------	--------------------	-----------	----------------------	-------	------------

Contents

Technical Governance Process	1
Contents	2
1 Introduction	3
2 Background Information	4
3 Needs Case.....	6
4 Optioneering	9
5 Detailed Analysis & Costs	10
6 Deliverability & Risk.....	18
7 Conclusion	23
8 Appendices.....	24

I Introduction

The SP Manweb (SPM) network in North Wales around Maentwrog, Porthmadog, Pwllheli, Criccieth, Blaenau Ffestiniog, Harlech and Morfa Nefyn is supplied from Trawsfynydd GSP. The 132kV network group secures Maentwrog / Four Crosses 33kV group supplying over 41,930 customers which includes several recreational/tourist destinations spread across the network.

The area is located partially within the Snowdonia National Park and is adjacent to the Llyn Peninsula Area of Outstanding Natural Beauty (AONB). There are numerous other environmental and historical designated areas in this location, including three Historic Landscape areas (Lleyn and Bardsey Island, Aberglaslyn and Ardudwy), Special Areas of Conservation (SAC) and Special Protection Areas (SPA), as well as other smaller SSSIs and cultural heritage sites.

Studies indicate that with the additional demand from 10,089 Electric Vehicles and 9,338 Heat Pumps the 33kV circuit between Maentwrog –Llanfrothen – Porthmadog will be loaded beyond the cyclic ratings and would risk cascade tripping of the group and loss of supplies to over 18,000 customers during outage on the 132/33kV 45MVA grid transformer at Four Crosses grid substation.

In order, to secure supplies within the group as per Engineering Recommendation (EREC) P2/7, to meet the licence obligation for maintaining economic, efficient and coordinated network, to accommodate future demand growth within the area and to mitigate the thermal and security of supply constraints in the 33kV group, it is proposed to:

- Establish new 11kms 33kV 400sqmm XLPE AL cable circuit between Maentwrog grid to Porthmadog.
- Extend the 33kV switchboards at Maentwrog grid and Porthmadog substation.
- Contract flexibility services to support the network during the project delivery from year 2023/24 through 2025/26.

The timing of the project is based on delivering the highest NPV, while maintaining security of supply. Detailed analysis indicates that with tendered service costs, flexibility services can support the network during the project delivery between 2023/24 to 2025/26 as the flexibility service bids received for later years is considerably above the annual ceiling cost of £228k for reinforcement deferral. It is recommended to continue annual tendering for flexibility in this area to procure enough capacity and review the scheme depending on future tenders resulting competitive bids enabling to defer the proposed reinforcements.

It is proposed to start the reinforcement works in 2024/25 and the capacity release of 20MVA will be claimed in 2026/27 at the end of the project. The estimated cost for the above is £5.794 (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

2 Background Information

2.1 Existing/Authorised Network

The existing 33kV Maentwrog/Four Crosses network cover widespread supply area (>1,200km²) and network was originally designed to supply the local demand. The 33kV distribution network in North Wales is operated fully interconnected. The 33kV Maentwrog/Four Crosses group network comprises of long overhead line circuits supplied by three 132/33kV grid transformers with 2 x 60MVA at Maentwrog and 1 x 45MVA at Four Crosses. The network group secures HV network comprising of 29 primary transformers and these primary transformers supply 41,930 customers. Figure 1 shows the SPM 132kV and 33kV network area fed from Maentwrog/Four Crosses grid network.

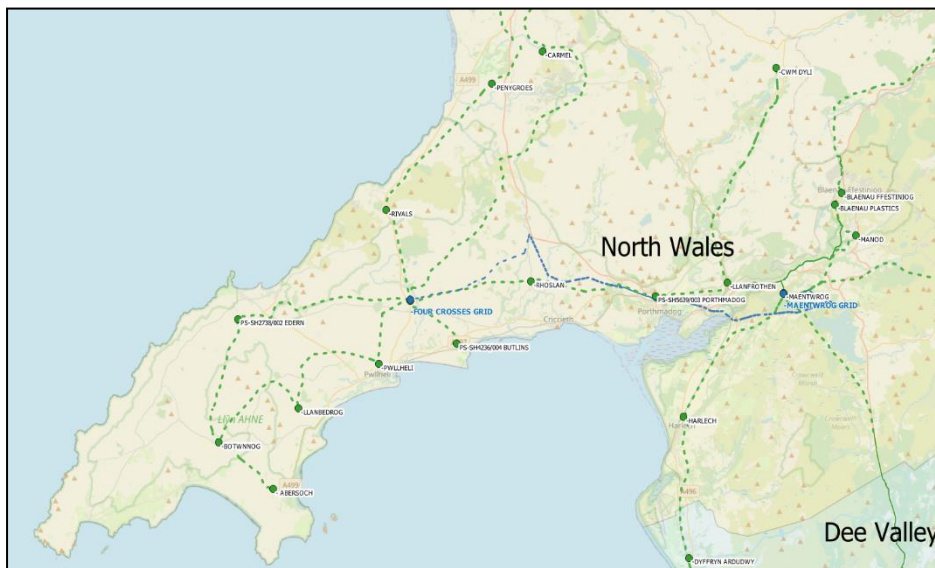


Figure 1. 132kV and 33kV network around Four Crosses and Maentwrog

The 33kV group is interconnected to five adjacent grid group networks. Considering the wide voltage angular difference between Trawsfynydd GSP and Swansea North GSP, 33kV interconnectors between Maentwrog grid and Aberystwyth grid are operated split at Fairbourne and Machynlleth. The authorised 33kV Maentwrog/Four Crosses grid group network is shown in Figure 2.

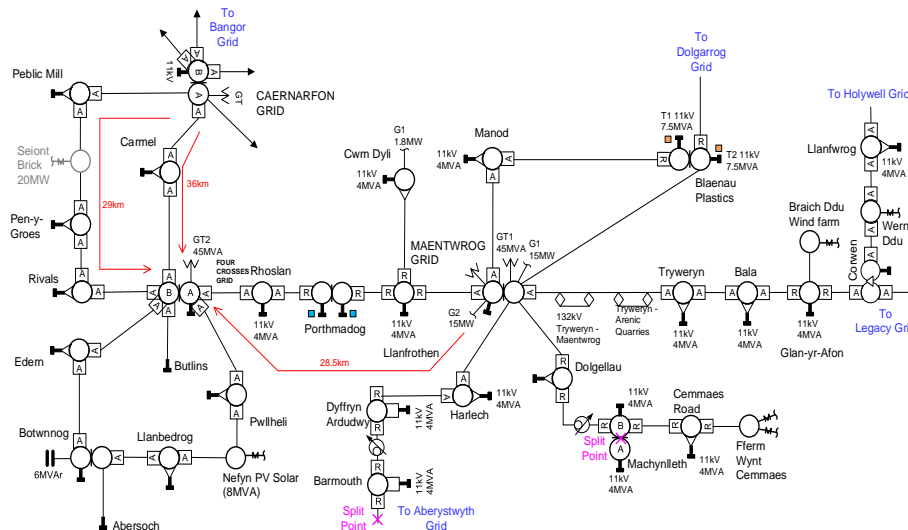


Figure 2. Authorised 33kV Four Crosses – Maentwrog group network

2.2 Network supply / circuit capacity

The existing 33kV Maentwrog/Four Crosses grid group network is classed as P2/7 Group D ($\geq 60\text{MW}$ up to 300MW) Table 2.1 shows the existing network supply position of the 33kV groups.

Table 2.1. Summary of Four Crosses / Maentwrog 33kV grid group

Substation	No. of customers	Scenario	LI firm capacity	Maximum demand	Load Index	Group P2/7 Class
33kV						
Four Crosses GT2/Maentwrog GT1/Maentwrog GT2	41930	N-1	69.6	68.8	LI3	D

2.3 Embedded Generation and Demand connections

The 33kV group network has significant penetration of distributed generation with 116.2MW generation as shown in Table 2.2. Due to significant generation connection activity, an advanced Active Network Management (ANM) scheme is delivered in ED1 with a Constraint Management Zone being established at Four Crosses grid substation. This ANM system manages generation driven constraints in the group, particularly loading reverse on the Four Crosses Grid transformer, and is unable to manage the demand driven constraint outlined in this paper.

Table 2.2. Connected/Contracted generation

Site	Status	Type	Registered capacity (MW)
Wern Ddu	Connected	Onshore wind	12
Trweryn Lake Hydro	Connected	Hydro	4.51
Maentwrog Hydro	Connected	Hydro	29.6
Cwm Dyli	Connected	Hydro	10.2
Cemmaes Wind Farm	Connected	Onshore wind	17.4
Bryn Bachau	Connected	Solar	4.2
Nefyn Solar	Connected	Solar	8.0
Braich Ddu	Connected	Onshore wind	4.5
Hafoty Ucha	Connected	Onshore wind	3.0
Liverpool Corporation Powerhouse	Connected	Hydro	4.0
Lon Pin	Connected	Solar	5.0
Nant Bach Scheme	Connected	Onshore wind	1.5
Gelli Gron I	Connected	Solar	2.3
Llwyndyrus Farm	Connected	Solar	5.0
Gelert House	Contracted	Diesel	5.0
Total			116.2

2.4 Fault levels

There are no fault level related constraints in the 33kV group network.

3 Needs Case

The network around Four Crosses and Porthmadog supplies over 18,300 customers and accounts for over 45% of the group demand supplied from 12 primary transformers. The existing network capacity headroom of the group is 1MVA which is limited due the loading on the 33kV interconnector between Maentwrog grid and Four Crosses grid substation during outage of Four Crosses grid transformer.

System studies indicate that with the forecasted demand growth around Four Crosses network, thermal loading on the Maentwrog – Porthmadog section of the 33kV Maentwrog grid – Four Crosses grid interconnector will exceed the cyclic ratings with the most onerous loading of >145% of the circuit summer intact rating during summer maintenance outage of grid transformer at Caernarfon followed by outage of Four Crosses grid transformer. The thermal overloading is well above the protection settings of the circuit and would lead to potential cascade tripping of the group and loss of supplies to over 18000 customers.

The network will be “Non-Compliant” and it is proposed to carry out system reinforcement in the RIIO-ED2 price control period in order to accommodate future demand growth within the area, secure supplies within the group, meet the licence obligations under EREC P2/7 – Security of Supply.

3.1 Forecast Demand

The system is forecast to grow and exceed firm capacity within the RIIO-ED2 period. This forecast is based on actual system measurement data from the Process Instrumentation (PI) system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments.

3.1.1 Local Considerations and stake holder feedback

As part of DFES scenario development SPEN held stakeholder engagement sessions with councils to continue to refine the understanding of their economic growth plans and other drivers. This helps determine the resultant demand increase and impact on our network.

3.1.1.1 Electric Vehicles Charging Strategy

In December 2020, Welsh Government published their electric vehicles charging strategy¹ to facilitate transition of Wales towards Net-Zero in-line with UK Government’s targets with a vision that by 2025, all users of electric cars and vans in Wales are confident that they can access electric vehicle charging infrastructure when and where they need it. Welsh Government to invest in public charging infrastructure to at least meet the demand created by 60% of new sales for cars and vans being electric vehicles by 2030. Welsh Government is proposing to invest in the region of £30m over the next five-year period on electric vehicle charging to make this strategy happen.

3.1.2 Distribution Future Energy Scenarios

Distribution Future Energy Scenarios (DFES) includes granular forecasts to 2050 for demand, generation and Low Carbon Technologies. They assess credible future scenarios covering a range of uncertainties, including differing levels of consumer ambition, policy support, economic growth and technology development and the forecasts are underpinned by extensive stakeholder engagement.

The peak demand forecast based on DFES, including authorised connections are depicted in Figure 3. The anticipated total electric vehicle and heat pump uptakes based on the future energy scenarios is depicted in Figure 4.

¹ <https://gov.wales/sites/default/files/consultations/2020-12/electric-vehicle-charging-strategy-consultation-document.pdf>

The scenario range considers the range of Net Zero compliant scenarios developed by us, the Electricity System Operator (ESO), and the Climate Change Committee (CCC). These are the five scenarios from the CCC 6th carbon budget, and the Leading the Way and Consumer Transformation scenarios from our DFES and the ESO Future Energy Scenarios (FES). We haven't included the System Transformation (ST) scenario as it is an outlier against the other Net Zero compliant scenarios and does not achieve interim carbon targets.

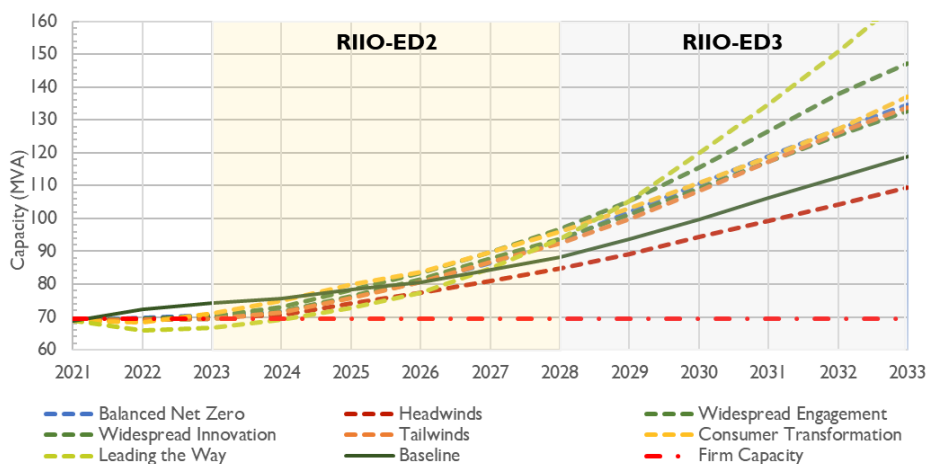


Figure 3. Demand (MVA) forecast for 33kV Four Crosses/Maentwrog group

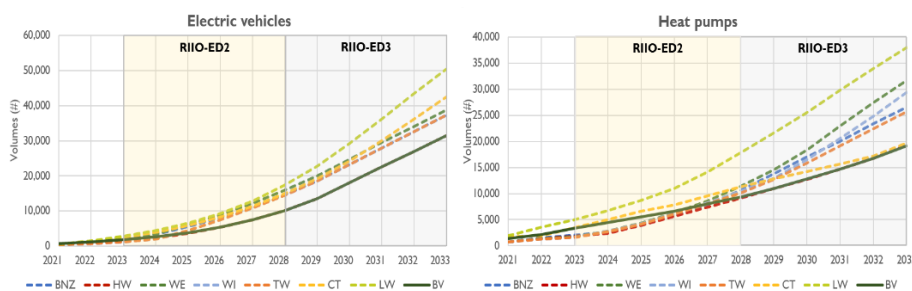


Figure 4. Forecast Electric Vehicle and Heat Pump uptakes for 132kV GSP group

3.1.3 Baseline View

For the 33kV GSP group demand, the forecast demand growth under our Baseline scenario, along with the firm capacity and utilisation through to RIIO-ED3 period is shown in Table 3.1.

Table 3.1. Baseline View forecast

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Winter (N-1)													
Forecast Demand (MVA)	68.8	72.3	74.2	75.7	78.3	80.5	84.4	88.2	93.6	99.8	106.4	112.6	119.0
Firm Capacity (MVA)	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6	69.6
Utilisation (%)	99	104	107	109	112	116	121	127	134	143	153	162	171
Load Index	L13	L15	L15	L15	L15	L15	L15	L15	L15	L15	L15	L15	L15

3.2 Network Impact Assessment

Detailed network studies covering network intact and N-1 outage conditions and fault level assessments were carried out for the 33kV network fed from Four Crosses / Maentwrog grid group considering the different demand forecast scenarios.

The network thermal constraint during the most onerous outage was identified and time profile-based simulations (17,520 half-hourly simulations/year) were performed considering the historical half hourly measured Supervisory control and data acquisition (SCADA) data at primary substation overlaid with the DFES demand forecasts for each year through the RIIO-ED2 price control period. These studies identify the risk in terms of the thermal capacity exceedances with the forecast demand, the anticipated annual hours at risk and risk window of the constraint. The half-hourly studies performed for years starting from 2024 through 2028 determined the risk hours and the capacity required to overcome the constraint by using flexibility services. The key results from the half hourly profile-based simulations are furnished in Appendix-2.

The findings from the network impact assessments are detailed in sections below.

3.2.1 Thermal Constraints

Considering the DFES forecast demand in the group, the thermal constraints that would appear in the RIIO-ED2 period are listed in Table 3.2.

Table 3.2. Thermal constraint at 33kV voltage level

Section	Length (km)	MVA Rating (Cont. / Cyclic)		Winter Loading (MVA)	Summer Loading (MVA)	Outage Scenario
		Winter	Summer			
Maentwrog to Llanfrothen	6.36	21.5 / 23.0	19.8 / 21.9	29.2	28.9	Winter (N-1): Four Crosses GT Summer (N-1-1): Caernarfon GT + Four Crosses GT
Llanfrothen to Porthmadog	5.25	22.4 / 26.06	19.8 / 22.41	26.1	25.8	
Porthmadog to Rhoslan	8.94	22.4 / 26.06	19.8 / 22.41	20.5	20.7	
Rhoslan to Four Crosses	8.41	22.4 / 26.06	19.8 / 22.41	15.6	16.6	

3.2.1.1 Voltage Constraints

There will be marginal voltage excursions at several 33kV primary substation around Four Crosses grid substation during outage of Four Crosses grid transformer.

3.2.2 Flexibility services

Our assessments indicate that the network constraints in the 33kV group network starts from 2024 throughout to the year 2028 for the most onerous scenario. In order to manage the network risk and security of supply constraint a max capacity of 7.8MW is required to alleviate the constraints. Table 3.3 below shows flexibility services in terms of the network risk hours and tendered capacity.

Table 3.3. Network annual hours at risk and flexible capacity tendered

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Annual hours at risk (Hrs)	47	78	133	363	811
Required Flexible Capacity (MW)	3.8	4.6	5.2	6.1	7.8

4 Optioneering

Table 4.1 shows a summary of the options considered for this reinforcement and option 3 represents the minimum level of intervention.

Table 4.1. Longlist of solution options

#	Options	Status	Reason for rejection
(a)	No Intervention	Rejected	The thermal overloading is close to the protection settings of the circuit and may lead to potential cascade tripping of the group and loss of supplies to over 18000 customers. The 33kV group network will be “Non-compliant” with security of supply requirements as per EREC P2/7.
(b)	Intervention plan using only Energy Efficiency	Rejected	Discounted due to lower cost effectiveness (peak MW reduction per £) and the number of individual interventions required across the wide area supplied by this network.
(c)	Real Time Thermal Rating of the 33kV circuit between Maentwrog to Llanfrothen and Llanfrothen to Porthmadog.	Rejected	As the thermal overloading of the circuit is close to the protection setting RTTR would not alleviate the constraint and there would be risk of cascade tripping.
(d)	Reinforcement deferral into RIIO-ED3 via demand side response and flexibility services	Rejected	Considering the increased risk duration, capacity requirements and cost of flexibility services through RIIO-ED2, deferral beyond 3 years is not commercially viable. A combination of flexibility and reinforcement is proposed in Option 3.
(e)	Uprating 33kV circuit between Maentwrog and Porthmadog.	Rejected	Uprating of the existing circuit will aggravate the constraint as the circuit uprating will reduce the net circuit impedance and in turn will increase the circuit loading beyond the 33kV circuit thermal over current settings and would lead to cascade tripping.
(f)	Installation of 30MVA X=10% series reactor in 33kV circuit between Maentwrog – Llanfrothen.	Rejected	This option does not alleviate the thermal constraint on the 33kV circuit. In addition to thermal constraint the series reactor leads to voltage issues below statutory limits around Four Crosses grid group network area.
(g)	New 33kV circuit between Maentwrog to Porthmadog.	Considered (Baseline)	-
(h)	New 60MVA 132/33kV grid transformer at Four Crosses.	Considered (Option 1)	-
(i)	Installation of 30MVA X=10% series reactor in 33kV circuit between Maentwrog – Llanfrothen and uprating both the 33kV interconnectors between Caernarfon grid to Four Crosses grid.	Rejected	This option does not alleviate the thermal constraint on the 33kV circuit. In addition to thermal constraint the series reactor leads to voltage issues below statutory limits around Four Crosses grid group network area.
(j)	New 33kV circuits between Maentwrog to Porthmadog and Porthmadog to Harlech by loop into existing Maentwrog to Harlech circuit.	Considered (Option 2)	-
(k)	Contract with Flexibility Services to manage the network constraint and establishment of new 33kV circuit between Maentwrog to Porthmadog.	Considered (Option 3) Proposed	-
(l)	New 5 Panel 132kV switchboard and 60MVA 132/33kV grid transformer at Porthmadog grid.	Considered (Option 4)	-

5 Detailed Analysis & Costs

System studies indicate that with the additional demand from LCT uptake the sections on the existing 33kV interconnector between Maentwrog grid to Four Crosses grid substation will be overloaded during outage of Four Crosses grid substations. The interconnector loadings will be aggravated with Maentwrog and Cwm Deli Hydro power stations operating at full export capacity.

The thermal overloading on the section between Maentwrog to Llanfrothen is well above the protection settings of the circuit and would lead to potential cascade tripping of the group and loss of supplies to over 18,000 customers around Four Crosses and Porthmadog. These overloading issues cannot be operationally managed, and reinforcement would be required within RIIO-ED2 price control period. Considering the scale of the impact on the network, a strategic intervention is required to mitigate the network constraint.

5.1 Proposed Option (Option 3) – Flexibility Services and Baseline reinforcements

The proposed solution is to alleviate network constraints by combination of conventional network reinforcement and flexibility services. The proposed solution includes:



Table 5.1. Proposed option summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Flexibility services and Conventional Circuit	Maentwrog - Porthmadog 33kV reinforcements	<ul style="list-style-type: none"> Establish new 11kms 33kV 400sqmm XLPE AL cable circuit between Maentwrog grid to Porthmadog. Extend the 33kV switchboards at Maentwrog grid and Porthmadog substation. Contract flexibility services to support the network during the project delivery from year 2023/24 through 2025/26. 	5.794	-

The increase in capacity and cost of flexibility, due to demand growth, was considered against the benefit of deferral in each year of RIIO-ED2. This is assessed using flexibility to manage the constraint while the level and number of risk hours is relatively low, to commission the above proposed works when efficient to do so. The annual reinforcement deferral ceiling cost was calculated to be £228k per year to manage the constraint via flexibility. Summary of anticipated cost of flexibility services from recent round of tenders along with annual ceiling cost is shown in Table 5.2.

Table 5.2. Summary of flexibility service costs

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Reinforcement Deferral Ceiling Cost - per year	£0.23m	£0.23m	£0.23m	£0.23m	£0.23m
Cost of Flexibility Services (100% Capacity)	£0.04m	£0.08m	£0.14m	£0.38m	£0.86m
Flexibility Outlook	●	●	●	●	●

-  Accept bids and support the network during reinforcement delivery
 Reject bids and deliver reinforcements

The cost of flexibility for 2023/24 to 2025/26 based on the recent tenders is £0.255m for a total of 14.0MW.

Considering the above it is proposed to start the reinforcement works in 2024/25 and the capacity release of 20MVA will be claimed in 2026/27 at the end of the project. The estimated cost for the

above is £5.794 (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

We will continue to tender for flexibility in this area before the reinforcement starts to ensure we are using the most efficient intervention.

Table 5.3 shows a summary of reinforcement costs and volumes for the proposed option within RIIO-ED2. Figure 5 shows the 33kV cable route and site location and Figure 6 shows proposed 33kV works.

Table 5.3. Proposed option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	11.00	2.669	2.669	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	2.00	0.341	0.341	-
Pilot Wire Underground	11.00	1.219	1.219	-
Civil Works at 33 kV & 66 kV Substations		0.174	0.174	-
Wayleaves/Easements/Land Purchase		0.915	0.915	-
Other Costs (Identify Below)		0.222	0.222	-
Cost of Flexibility for the year 2023/24 – 2025/26		0.255	0.255	-
Total Costs		5.794	5.794	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control and SCADA equipment located at a site and remote ends (£22k)				
Environmental survey and studies (£50k)				
River Crossing and Railway Crossing (£125k)				
Planning and Design Studies (£25k)				

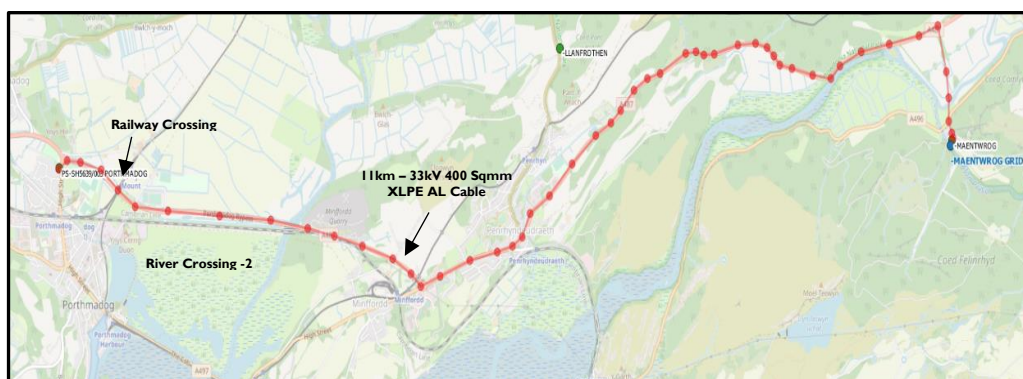


Figure 5. Proposed substation location and cable route

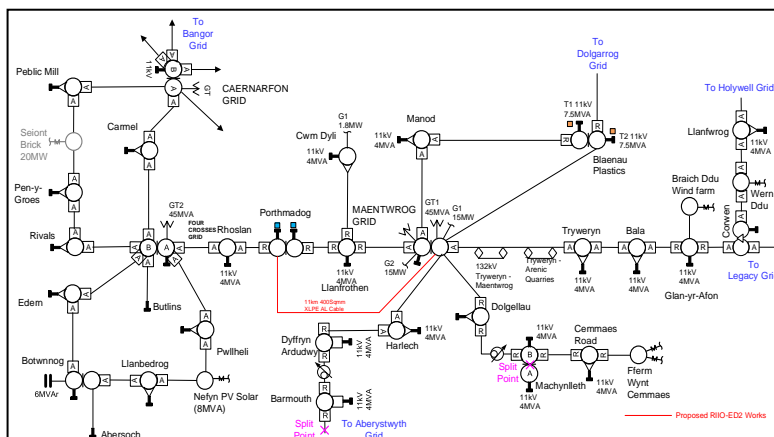


Figure 6. Proposed works in the 33kV group

5.2 Baseline – New 33kV circuit between Maentwrog to Porthmadog

The baseline option is to establish a new 33kV circuit between Maentwrog grid substation to Porthmadog Table 5.4 shows baseline option scheme summary.

Table 5.4. Baseline option summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Conventional Circuit	Maentwrog - Porthmadog 33kV reinforcements	<ul style="list-style-type: none"> Establish new 11kms 33kV 400sqmm XLPE AL cable circuit between Maentwrog grid to Porthmadog. Extend the 33kV switchboards at Maentwrog grid and Porthmadog substation. 	5.539	-

Under this option it is proposed to start the reinforcement works from year 2023/24 and deliver the project in 2025/26 against which the capacity release of 20MVA at 33kV will be claimed. However, this option is rejected based on lower NPV against proposed option.

Table 5.5 shows a summary of reinforcement costs and volumes for the baseline option within RIIO-ED2. Figure 5 shows the 33kV cable route and site location and Figure 6 shows proposed 33kV works.

Table 5.5. Baseline option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	11.00	2.669	2.669	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	2.00	0.341	0.341	-
Pilot Wire Underground	11.00	1.219	1.22	-
Civil Works at 33 kV & 66 kV Substations		0.174	0.174	-
Wayleaves/Easements/Land Purchase		0.915	0.915	-
Other Costs (Identify Below)		0.222	0.222	-
Total Costs		5.539	5.539	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control and SCADA equipment located at a site and remote ends (£22k)				
Environmental survey and studies (£50k)				
River Crossing and Railway Crossing (£125k)				
Planning and Design Studies (£25k)				

5.3 Option I – New 132/33kV grid transformer at Four Crosses

This option considers establishing a new 132/33kV grid transformer at Four Crosses grid substation which will be connected via a new 33kms 132kV cable circuit from Trawsfynydd GSP. In order to accommodate the new grid transformer and 132kV circuit this option involves extension of 132kV bay and installation of 132kV outdoor switchboard at Trawsfynydd GSP and Four Crosses grid substation.

This option would provide the capacity release of 60MVA at 33kV. There will be no fault level headroom created by this option.

This option is rejected due its relatively high cost and does not represent optimum level of intervention required as it does not create any fault level headroom in the network. Table 5.6 shows the scheme summary.



Figure 8. Proposed 132kV cable route and site location

5.4 Option 2 – 33kV circuit between Maentwrog – Porthmadog - Harlech

This option considers establishing a new 33kV circuits between Maentwrog to Porthmadog and Porthmadog to Harlech by looping into existing 33kV circuit between Maentwrog to Harlech. In order to accommodate the new 33kV circuits at Porthmadog this option involves extension of 33kV indoor board by 2 panels.

This option would provide the capacity release of 10MVA at 33kV. There will be no fault level headroom created by this option.

This option is rejected due its high cost and does not represent optimum level of intervention required as it does not create any fault level headroom in the network. Table 5.8 shows the scheme summary.

Table 5.8. Option 2 scheme summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)
Conventional Circuit	New 33kV circuit between Maentwrog – Porthmadog and Porthmadog – Harlech	<ul style="list-style-type: none"> Establish new 2x7.5kms 33kV 400sqmm XLPE AL cable circuit to Porthmadog by looping into existing 33kV circuit between Maentwrog grid to Harlech. Extending the 33kV switchboards at Porthmadog substation. 	7.098

Table 5.9 shows a summary of reinforcement costs and volumes for Option 2 under RIIO-ED2. Figure 9 shows proposed 33kV works.

Table 5.9. Option 2 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV OHL (Pole Line) Conductor	0.20	0.005	0.005	-
33kV Pole	1.00	0.003	0.003	-
33kV UG Cable (Non-Pressurised)	15.00	3.639	3.639	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	2.00	0.341	0.341	-
Batteries at 33kV Substations	1.00	0.009	0.009	-
Pilot Wire Underground	15.00	1.662	1.662	-
Civil Works at 33 kV & 66 kV Substations		0.097	0.097	-
Wayleaves/Easements/Land Purchase		0.918	0.918	-
Other Costs (Identify Below)		0.425	0.425	-
Total Costs		7.098	7.098	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control and SCADA equipment located at a site and remote ends (£75k)				
Environmental survey and studies (£75k)				
River Crossing and Railway Crossing (£225k)				
Planning and Design Studies (£50k)				

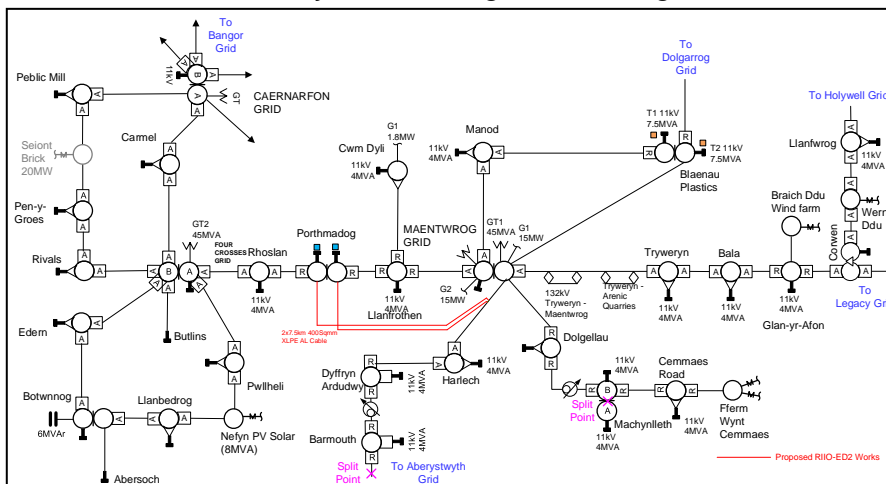


Figure 9. Proposed works under Option 2 at 33kV group network

5.5 Option 4 – New 132/33kV grid transformer at Porthmadog

This option considers establishing a new 132/33kV grid transformer at Porthmadog 33kV substation which will be connected via a new 15.5kms 132kV cable circuit from Trawsfynydd GSP. In order to accommodate the new grid transformer and 132kV circuit this option involves extension of 132kV bay and installation of 132kV outdoor switchboard at Trawsfynydd GSP and establishment of 132kV bay at Porthmadog substation.

This option would provide the capacity release of 60MVA at 33kV. There will be no fault level headroom created by this option.

This option is rejected due its relatively high cost and does not represent optimum level of intervention required as it does not create any fault level headroom in the network. Table 5.6 shows the scheme summary.

Table 5.10. Option 4 scheme summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)
Conventional Substation	New 60MVA 132/33kV grid transformer at Porthmadog	<ul style="list-style-type: none"> Extension of 33kV switchboard at Porthmadog. Installation of new 132/33kV 60MVA transformer at Porthmadog substation. Installation of 132kV outdoor circuit breaker at Trawsfynydd GSP. New 15.5kms - 132kV circuit between Trawsfynydd GSP to Porthmadog substation. 	23.146

Table 5.7 shows a summary of reinforcement costs and volumes for Option 4 within RIIO-ED2. Figure 7 shows single line diagram of 132kV Trawsfynydd GSP and Figure 8 shows proposed 132kV cable route and 33kV single line diagram.

Table 5.11. Option 4 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.30	0.073	0.073	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	1.00	0.170	0.170	-
132kV UG Cable (Non-Pressurised)	15.50	17.189	17.19	-
132kV CB (Air Insulated Busbars) (OD) (GM)	1.00	0.176	0.176	-
132kV Switchgear - Other	1.00	0.018	0.018	-
132kV Transformer	1.00	1.214	1.214	-

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Batteries at 132kV Substations	1.00	0.008	0.008	-
Pilot Wire Underground	15.50	1.717	1.717	-
Civil Works at 33 kV & 66 kV Substations		0.121	0.121	-
Civil Works at 132 kV Substations		1.083	1.083	-
Wayleaves/Easements/Land Purchase		0.997	0.997	-
Other Costs (Identify Below)		0.380	0.380	-
		23.146	23.146	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control and SCADA equipment located at a site and remote ends (£105k)				
Environmental considerations, survey and studies (£75k)				
Planning and design studies (£50k)				
River Crossing and Railway Crossing (£150k)				

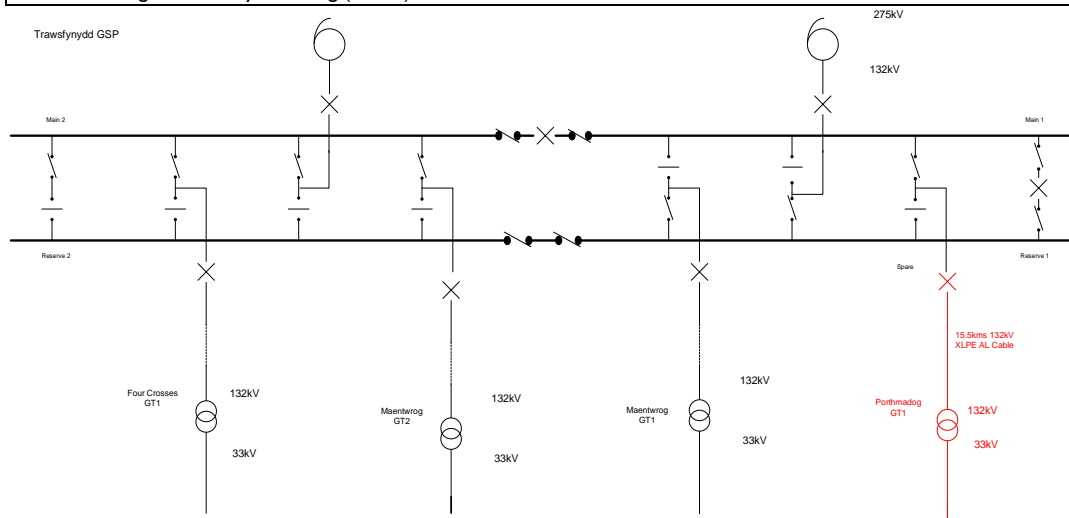


Figure 10 Single line diagram of 132kV Trawsfynydd GSP

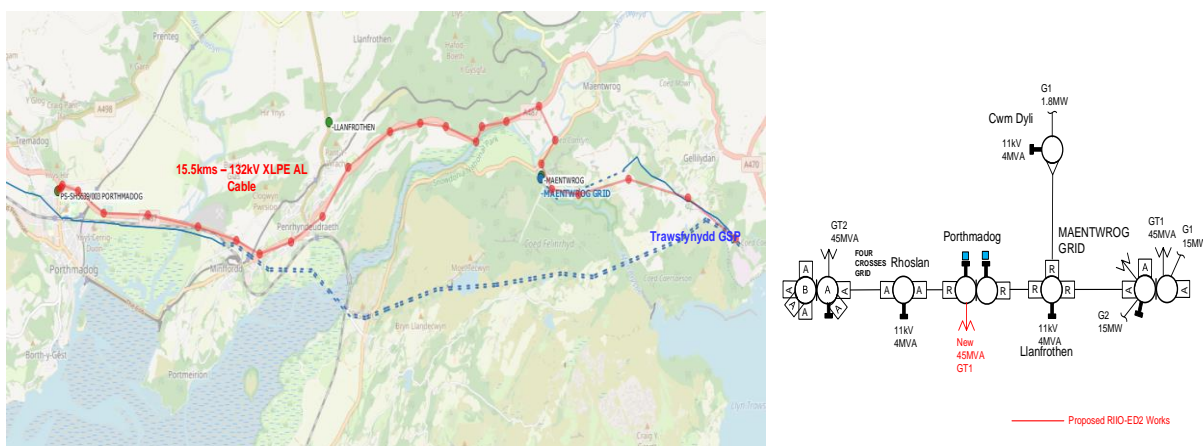


Figure 11. Proposed 132kV cable route and 33kV single line diagram

5.6 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.12.

Table 5.12. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	New 33kV 11kms circuit between Maentwrog grid to Porthmadog.	5.539
Option 1	Installation of new 132/33kV GT at Four Crosses fed from 33kms XLPE cable from Trawsfynydd GSP.	44.540
Option 2	Establishment of new 33kV circuit to Porthmadog by looping into existing circuit between Maentwrog grid to Harlech primary substation.	7.098
Option 3 (Proposed)	Contract with Flexibility Services to manage the network constraint and establishment of new 33kV circuit between Maentwrog to Porthmadog.	5.794
Option 4	Installation of new 132/33kV GT at Porthmadog which is to be fed from 15.5kms XLPE cable from Trawsfynydd GSP.	23.146

Derivation of costs for these options are based on the SPEN RIIO-ED2 Unit Cost Manual for intervention. This is based on bottom up cost assessment of the components of activity detailed within the RIGs Annex A for the above activities, SPEN's contractual rates for delivery, market available rates and historic spend levels.

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is to establish a new 33kV circuit between Maentwrog grid and Porthmadog substation along with extension of 33kV switchboards and contract flexibility services from 2023/24 to 2025/26 which will support the network during the project delivery. It is proposed to start the works in 2024/25 and the capacity release of 20MVA will be claimed in 2026/27 at the end of the project.

6.2 Cost Benefit Analysis Results

A cost benefit analysis (CBA) was carried out to compare the NPV of the options discussed in the previous sections. Considering the forecast capital expenditure, the proposed option has the highest total NPV against other options. The summary of the cost benefit analysis is presented in Table 6.1. The full detailed CBA is provided within 'ED2-LRE-SPM-005-CVI-CBA –Maentwrog Porthmadog 33kV Reinforcement'.

Table 6.1. Cost benefit analysis results

Options considered	Decision	Comment	NPVs based on payback periods, £m (2020/21 prices)			
			10 years	15 years	30 years	45 years
Baseline: New 33kV 11kms circuit between Maentwrog grid to Porthmadog	Rejected	Discounted based on lower NPV against proposed option.	-	-	-	-
Option 1: Installation of new 132/33kV GT at Four Crosses fed from 33kms XLPE cable from Trawsfynydd GSP.	Rejected	Discounted based on higher scheme cost and lower NPV against proposed option.	-£23.26	-£32.07	-£37.29	-£41.31
Option 2: Establishment of new 33kV circuit to Porthmadog by looping into existing circuit between Maentwrog grid to Harlech primary substation.	Rejected	Discounted based on higher scheme cost and lower NPV against proposed option.	-£0.90	-£1.21	-£1.40	-£1.54
Option 3: Combination of flexibility services and baseline reinforcements.	Adopted	The proposed option enables to manage the network constraints during reinforcement delivery and renders better value to the customers.	£0.11	£0.04	-£0.00	-£0.04
Option 4: Installation of new 132/33kV GT at Porthmadog which is to be fed from 15.5kms XLPE cable from Trawsfynydd GSP.	Rejected	Discounted based on higher scheme cost and lower NPV against proposed option.	-£13.00	-£17.70	-£20.48	-£22.61

6.3 Cost & Volumes Profile

Table 6.2 shows the breakdown of expenditure for the proposed scheme (in 2020/21 prices) and the cost incidence (in 2020/21 prices) over the RIIO-ED2 period is shown in Table 6.3. The total cost of the proposed scheme is £5.794m.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	11.00	2.669	2.669	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	2.00	0.341	0.341	-
Pilot Wire Underground	11.00	1.219	1.219	-

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Civil Works at 33 kV & 66 kV Substations		0.174	0.174	-
Wayleaves/Easements/Land Purchase		0.915	0.915	-
Other Costs (Identify Below)		0.222	0.222	-
Cost of Flexibility for the year 2023/24 – 2025/26		0.255	0.255	-
Total Costs		5.794	5.794	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control and SCADA equipment located at a site and remote ends (£22k)				
Environmental survey and studies (£50k)				
River Crossing and Railway Crossing (£125k)				
Planning and Design Studies (£25k)				

Table 6.3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

Total Investment	Total (£m)	Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
CVI – Primary Reinforcement	5.539	-	2.215	2.769	0.554	-
CVI – Flexible Services	0.255	0.038	0.076	0.141	-	-
Total Cost (£m)	5.794	0.038	2.291	2.910	0.554	-

6.4 Risks

The main delivery risks are the necessary approvals and traffic management for the new 33kV circuit route between Maentwrog grid to Porthmadog substation. We intend to mitigate these risks by actively engaging with local authorities.

6.5 Outputs Included in RIIO-ED1 Plans

There are no outputs expected to be delivered in RIIO-ED1 that are funded within this proposal.

6.6 Future Pathways – Net Zero

6.6.1 Primary Economic Driver

The primary drivers for this investment are insufficient thermal headroom and security of supply risk. The investment does not have a strong reliance on environmental benefits.

6.6.2 Payback Periods

The CBA indicates that proposed option demonstrates better NPV results in assessment periods (10, 15, 30 years) against other options. As the intervention is forecast to carry at least a 45-year asset life expectancy, the CBA at this time justifies the intervention. Consumers will also benefit from reduced network risk immediately on completion of the project.

6.6.3 Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option is consistent with the network requirements determined in line with the section 9 of the Electricity Act and Condition 21. Additionally, the proposed option is consistent with the SPEN's Distribution System Operator (DSO) Strategy and Distribution Future Energy Scenarios.

Table 6.4 shows electric vehicle and heat pump uptakes across a range of future pathways and

Table 6.5 shows the sensitivity of the proposed solution and Table 6.6 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero compliant future pathways other Climate Change Committee (CCC) scenarios.

Table 6.4: Electric Vehicle and Heat Pump uptakes across a range of future pathways

End of RIIO-ED2	SPEN	DFES			CCC				
	Baseline	System Transformation*	Consumer Transformation	Leading the Way	Balanced Net Zero Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	10,089	8,253	14,950	17,336	14,589	10,089	15,861	14,463	14,463
HPs	9,338	10,219	11,327	17,797	10,644	9,110	11,424	10,407	10,136

*Note: We have excluded System Transformation from our future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.

Table 6.5: Sensitivity of the proposed solution against future pathways

Solution Requirements	RIIO-ED1				RIIO-ED2					RIIO-ED3				
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Baseline					F	F	F	R ¹					R ²	
Leading the Way					F	F	F	R ¹			R ⁴			
Consumer Transformation					F	F	F	R ¹				R ³		
Balanced Net Zero Pathway					F	R ¹			R ²			R ³		
Headwinds					F	F	F	R ¹						R ²
Widespread Engagement					F	R ¹			R ²		R ³			R ⁴
Widespread Innovation					F	R ¹			R ²			R ³		
Tailwinds					F	R ¹			R ²			R ³		

F – Utilise flexibility services to support network during reinforcement delivery

R¹ – 33kV circuit between Maentwrog to Porthmadog

R² – Extension of the 33kV Maentwrog -Porthmadog circuit to Rhoslan

R³ – Extension of the 33kV Maentwrog -Porthmadog circuit to Four Crosses

R⁴ – New 132/33kV grid transformer at Four Crosses

In the Baseline and Headwinds scenarios this solution is expected to provide sufficient capacity to cater for network requirements to late ED3 (2032).

The timing of the requirement within RIIO-ED2 is sensitive to uptake rates and is found to be required under all scenarios within the RIIO-ED2 period.

Under the higher uptake scenarios, the next circuit along the interconnector, Porthmadog – Rhoslan, is forecast to exceed its cyclic ratings by 2028, approximately 4 years earlier than the equivalent constraint in the Baseline scenario. Intervention on this circuit may be required within the RIIO-ED2 period. The additional funding of **+£5.169m** needed to upgrade the Porthmadog – Rhoslan circuit would need to be recovered through an uncertainty mechanism. The RIIO-ED2 regulatory framework will need to allow DNOs' allowances to flex in response to higher uptakes.

Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	5.794	5.169
Comment	Proposed option	Extension of the 33kV circuit from Maentwrog – Porthmadog to Rhoslan.

6.6.4 Asset Stranding Risks & Future Asset Utilisation

Electricity demand are forecast to increase under all scenarios. The stranding risk is therefore considered to be low.

6.6.5 Losses Sensitivity

Losses have been considered in accordance with Licence Condition SLC49 and the SP Energy Networks Losses Strategy and Vision to “consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers”. Reasonable design efforts have been taken to minimise system losses without detriment to system security, performance, flexibility or economic viability of the scheme. This includes minimising conductor lengths/routes, the choice of appropriate conductor sizes, designing connections at appropriate voltage levels and avoiding higher impedance solutions or network configurations leading to higher losses.

Losses have been considered as part of the design solution and it has not been necessary to carry out any losses justified upgrades. MWh losses for each of the shortlisted options have been included within the CBA and solution selection was not found to be sensitive to the impact of the carbon cost of losses.

6.6.6 Whole Systems Benefits

Whole system solutions have been considered as part of this proposal. No alternatives have been identified that could be provided through a whole systems solution. The completion of this scheme will maintain the integrity of the distribution network and its enduring ability to facilitate wider whole system benefits.

6.7 Environmental Considerations

6.7.1 Environment and Sustainability

This scheme may be subject to Environmental Impact Assessment and other statutory planning requirements, and the contents of this environmental section are not provided in lieu of any Environmental Statement that may be required.

6.7.2 Operational and embodied carbon emissions

The Maentwrog - Porthmadog 33kV Reinforcement programme will result in the emissions of embodied carbon arising from the manufacture and supply of switchboards and cable, and from civil engineering works involved in the installation of the new 11km circuit from Maentwrog grid to Porthmadog. There is likely to be little or no impact on SPEN’s Business Carbon Footprint (BCF).

During the evaluation of the options associated with the proposed scheme, we have embedded within the CBA, where data are available, an assessment of the embodied carbon and the associated carbon cost to inform our NPV evaluation. The mass of carbon dioxide emitted (CO₂e) during the manufacture of the main equipment deployed to deliver this scheme is estimated to be 143 tonnes. The monetised embodied carbon value associated with this emission is £7k. It should be noted that the embodied carbon evaluation undertaken has only considered the manufacture and supply of materials. Further collaborative industry-wide work is planned for the RIIO-ED2 price review period to better understand the overall embodied carbon values including, for example installation and commissioning services, decommissioning and disposal activities as well as refurbishment

opportunities. More information regarding this can be found in Section 3.1.2 of our Environmental Action Plan².

6.7.3 Supply chain sustainability

For us to take full account of the whole-life carbon impact of our Maentwrog - Porthmadog 33kV Reinforcement programme, we need access to reliable data to be provided by our suppliers. The need for carbon and other sustainability credentials to be provided now forms part of our wider sustainable procurement policy.

We believe that such a requirement sends a strong message to our suppliers that we take sustainability seriously, and that such positive engagement is key to improving the overall sustainability of our collective supply chain.

6.7.4 Resource use and waste

The Maentwrog - Porthmadog 33kV Reinforcement programme will result in the consumption of resources and the generation of waste materials from end of life assets.

Where waste is produced it will be managed in accordance with the waste hierarchy which ranks waste management options according to what is best for the environment. The waste hierarchy gives top priority to preventing waste in the first instance, then preparing for re-use, recycling, recovery, and last of all disposal (e.g. landfill).

6.7.5 Biodiversity/ natural capital

The installation of a new 11km circuit from Porthmadog to Maentwrog has the potential to impact on natural capital and biodiversity. We will minimise the area of land take required and will minimise disturbance to soils and vegetation during the laying of the circuit. We will replace and enhance the existing habitat, working with relevant stakeholders to identify the measures required to achieve a net gain in biodiversity and wider ecosystem services.

6.7.6 Preventing pollution

SPEN will always follow all relevant waste regulations and will make sure that special (hazardous) waste produced or handled by our business is treated in such a way as to minimise any effects on the environment.

6.7.7 Visual amenity

SPEN continually seeks to reduce the landscape and visual effects of our networks and assets, and we note that part of the new 11km circuit is located in Snowdonia National Park. We will take all appropriate steps to minimise the landscape and visual impact of this programme.

6.7.8 Climate change resilience

In addition to our efforts to minimise our direct carbon emissions in line with our net-zero ambitions, we are also conscious of the need to secure the resilience of our assets and networks in the face of a changing climate. We have also modified our policy on vegetation control in the face of higher temperatures and longer growing seasons.

² Annex 4C.3: Environmental Action Plan, SP Energy Networks, Issue 2, 2021.

7 Conclusion

The proposed option is to establish a new 11kms 400Sqmm XLPE AL 33kV circuit between Maentwrog grid and Porthmadog substation along with extension of 33kV switchboards. The timing of the project is based on delivering the highest NPV, while maintaining security of supply. Detailed analysis indicates that with tendered service costs, flexibility services can support the network during the project delivery between 2023/24 to 2025/26 as the flexibility service bids received for later years is considerably above the annual ceiling cost of £228k for reinforcement deferral. It is recommended to continue annual tendering for flexibility in this area to procure enough capacity and review the scheme depending on future tenders resulting competitive bids enabling to defer the proposed reinforcements.

It is proposed to start the reinforcement works in 2024/25 and the capacity release of 20MVA will be claimed in 2026/27 at the end of the project. The estimated cost for the above is £5.794 (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

8 Appendices

Appendix I. Key Study Results

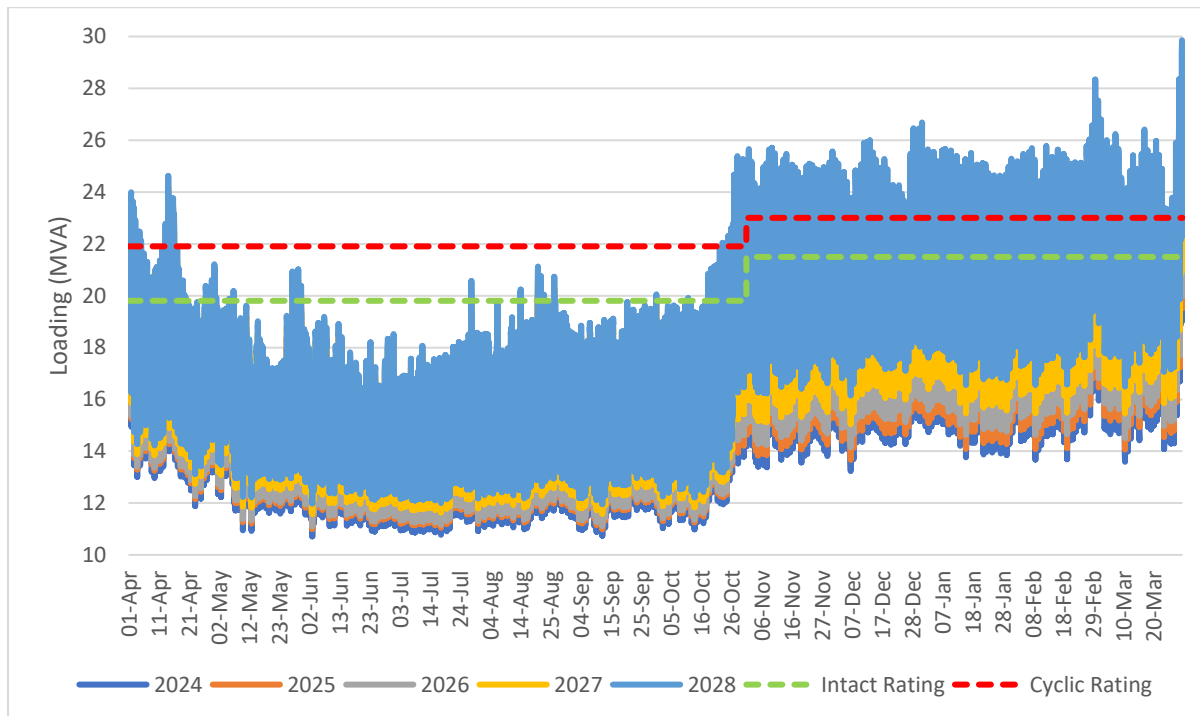


Figure 12. 33kV Maentwrog – Llanfrothen circuit loading profile during N-1 outage

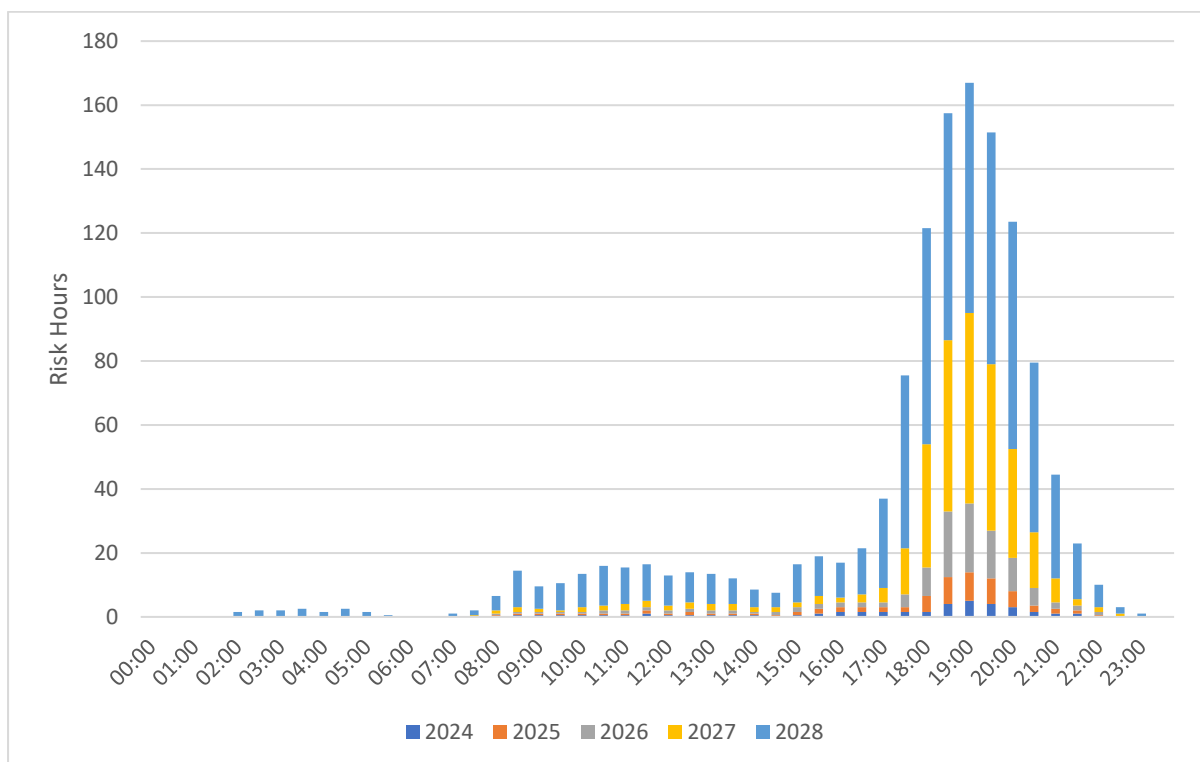


Figure 13. Calculated daily network risk hour window