Brymbo - Hawarden - Holywell 33kV Reinforcement

ED2 Engineering Justification Paper

ED2-LRE-SPM-028-CV1-EJP

Issue	Date	Comments
Issue 0.1	Feb 2021	Issue to SRG and external assurance
Issue 0.2	May 2021	Reflecting comments from SRG
Issue 0.3	Jun 2021	Reflecting assurance feedback
Issue 1.0	Jun 2021	Draft Business Plan Submission
Issue 1.1	Oct 2021	Reflecting updated DFES forecasts
Issue 1.2	Nov 2021	Reflecting updated CBA results
Issue 2.0	Dec 2021	Final Business Plan Submission

Scheme Name	Brymbo – Hawarden – Holywell 33kV Reinforcement		
Activity	Reinforcement Deferral using Flexible Services		
Primary Investment Driver	Voltage Constraints		
Reference	ED2-LRE-SPM-028-CV1-EJP		
Output Type	Load Index		
Cost	£0.453m		
Delivery Year	2024-2028		
Reporting Table	CV1		
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**	**ED2**	**ED3**
	-	**£0.453m**	**-**

Technical Governance Process
Project Scope Development

IP1(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.
IP1 – To request project inclusion in the investment plan and to undertake project design work or request a modification to an existing project
IP1(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:	Brymbo-Hawarden-Holywell 33kV Reinforcement
Project Reference:	ED2-LRE-SPM-028-CV1-EJP
Decision Required:	To give concept approval for contracting with flexible service providers to mitigate the low voltage issues in the Brymbo-Hawarden-Holywell group through the RIIO-ED2 period.

Summary of Business Need:

The Brymbo-Hawarden-Holywell 33kV grid group supplies to ca. 26,315 customers fed from long overhead line circuits.

The group is presently at voltage limits and network suffers from marginal voltages excursions outside of statutory limits and is presently operationally managed. Studies indicate that with the additional demand growth and LCT uptake will lead to steady state and voltage step issues beyond operational management in the network around Flint, Greenfield, Holway, North Wales Paper and Woodfield Avenue under N-1 33kV outages during periods of high demand and low generation.

Half-hourly time-profile studies have been undertaken to quantify the hours at risk and to define the flexibility services that would be required to manage the constraint. An annual total of 6.3MW of Secure product were issued for tender. Flexibility tender responses totalling 6.5MW have been received sufficient to manage the constraint.

With the demand growth network will be ESQCR non-compliant. It is proposed to procure flexibility services from the market to maintain the 33kV steady state voltage within ± 6% and to maintain voltage step within ± 10%.

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

The proposed option is an innovative solution involves mitigating the low voltage issues in the group through procuring flexibility services from the market through Secure product throughout the RIIO-ED2 period.

The total cost of the flexibility, based on tenders, is £0.453m for the RIIO-ED2 period. This defers ca. £4.0m associated with the reinforcement option of reconfiguration of 33kV the Holway Road substation with installation of a 5MVAr capacitor bank at North Wales Paper primary substation.

Expenditure Forecast (in 2020/21 Prices)

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CV1	Innovation/Flexible Services	0.453	0.002	0.023	0.052	0.172	0.205
Total Expenditure within RIIO-ED2			**0.453**					

PART B – PROJECT SUBMISSION

Proposed by	Ramesh Pampana	Signature	P. Ramesh	Date:	30/11/2021
Endorsed by	Russell Bryans	Signature		Date:	30/11/2021

PART C – PROJECT APPROVAL

Approved by	Malcolm Bebbington	Signature		Date:	30/11/2021

Contents

1 Introduction

The SP Manweb (SPMW) network in North Wales around the Brymbo, Flint, Hawarden and Holywell areas are fed from the Brymbo-Hawarden-Holywell 33kV grid group in turn fed from the Connah's Quay-Pentir- St. Asaph 132kV group to ca. 26,315 customers which includes a major industrial area in Kimberly Clark and North Wales Paper. Figure 1-1 shows the SPMW 132kV and 33kV network area fed from Brymbo-Hawarden-Holywell grid network.

This network group suffers from low voltage issues and the voltage excursions are outside the voltage limits set out in the Electricity Safety Quality and Continuity Regulations (ESQCR). The voltage issues need to be mitigated to be able to accommodate additional demand associated with demand growth and LCT uptake in the RIIO-ED2 period.

The proposed option is an innovative solution involves mitigating the low voltage issues in the group through procuring flexibility services from the market through Secure product throughout the RIIO-ED2 period. The total cost of the solution if £0.453m for the RIIO-ED2 period paid under CV1 (Primary reinforcement).

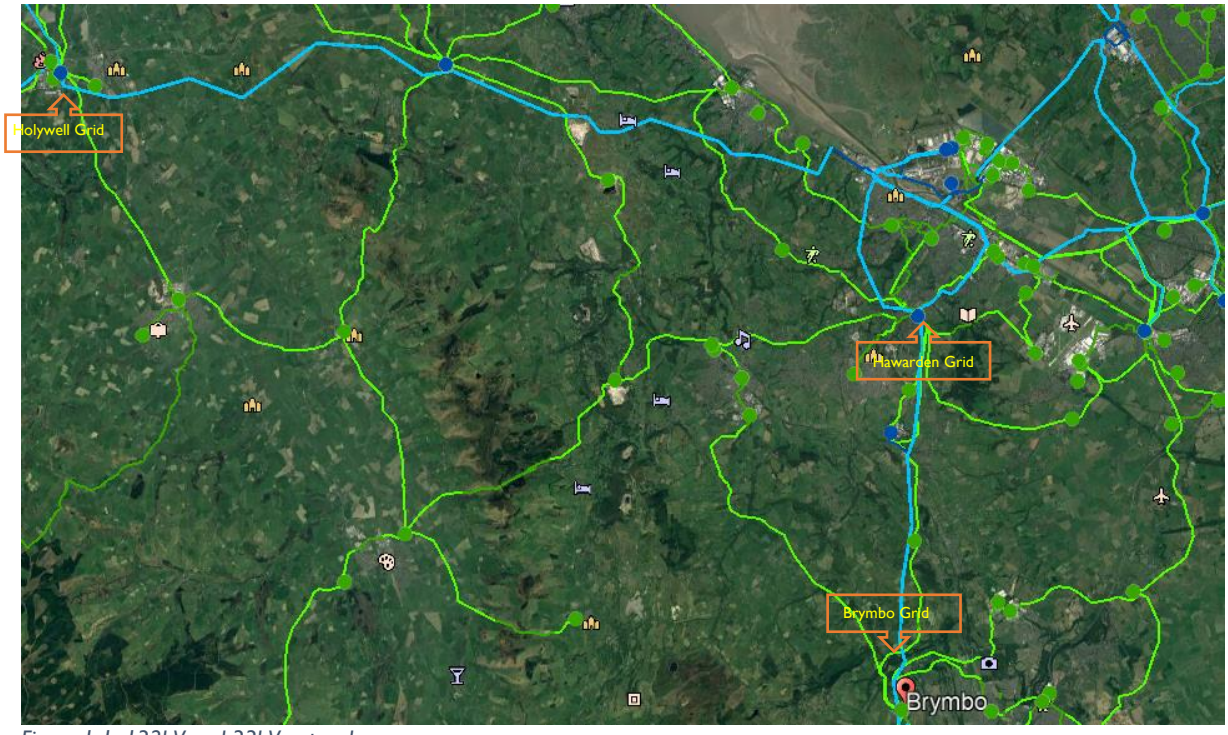


Figure 1-1: 132kV and 33kV network area

2 Background Information

2.1 Existing/Authorised Network

The existing 33kV network comprises a mixture of underground cable and overhead lines and is supplied by three grid transformers located at Holywell, Hawarden and Brymbo. Holywell GT1 & GT2 additionally feed Holywell/Rhyl/St Asaph group due to the crossing of circuits on the Holywell Grid 33kV busbars. The 33kV bus section at Holywell is operated as a normal open point to control fault levels and is equipped with an auto close scheme for loss of either GT1 or GT2. The bus section is also usually closed during transformer outages.

The authorised 33kV Brymbo-Hawarden-Holywell and 132kV connectivity group network is shown in Figure 2-1and Figure 2-2.

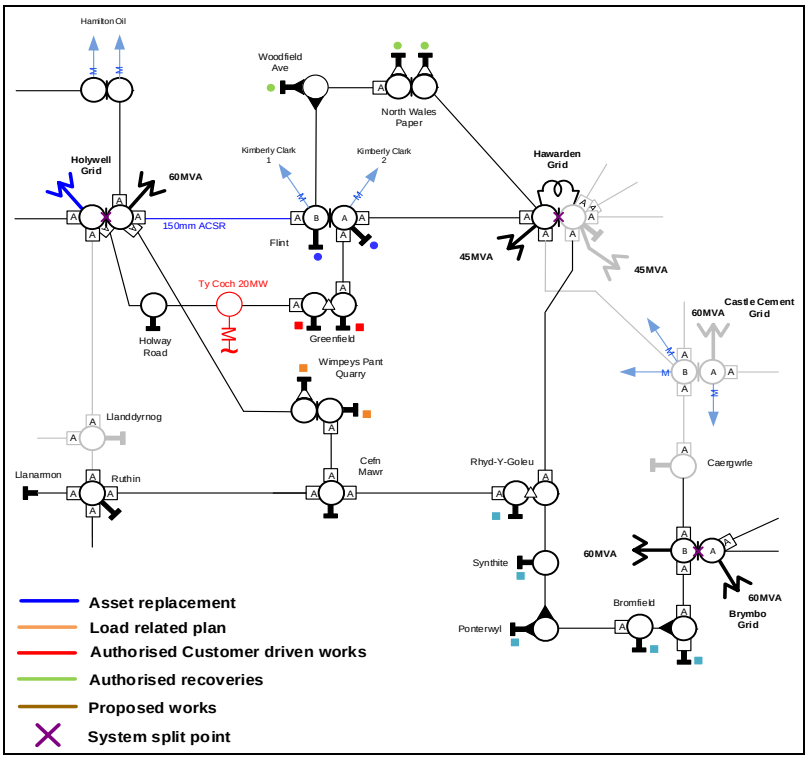


Figure 2-1:Existing 33kV system

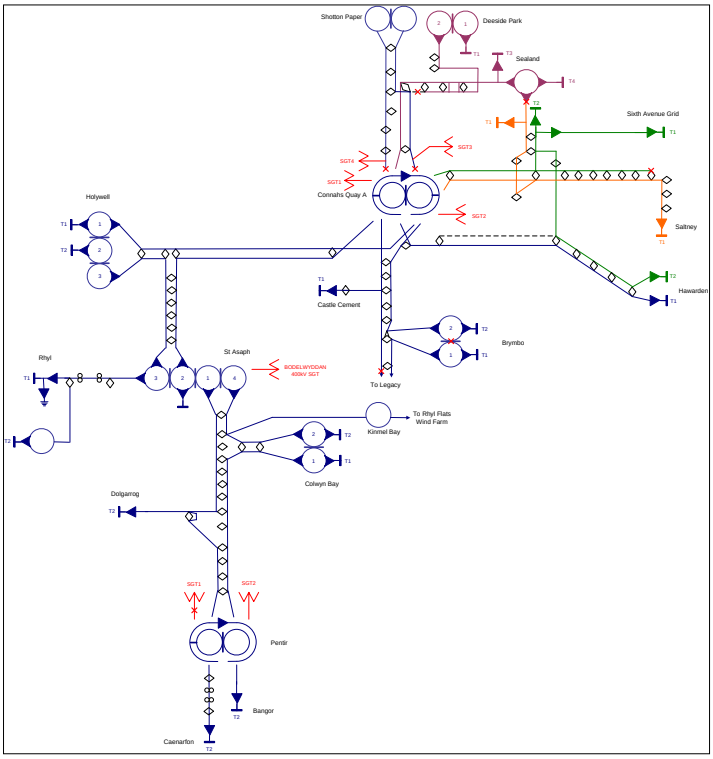


Figure 2-2: Existing 132kV System.

2.2 Network supply / circuit capacity

The existing 33kV Brymbo-Hawarden-Holywell network is classed as P2/7 Group D (≥60MW and <300MW) Table 3-1 presents the existing network supply capacity of the 33kV group.

Table 2-1: Summary of authorised EHV group network

Grid group	Customers (#)	Outage Scenario	LI Firm Capacity (MVA)	Group demand (MVA)	Load Index	EREC P2/7 Class
Brymbo -Hawarden - Holywell	26,315	N-1	82	60.5	LI1	D

2.3 Embedded Generation

The group has gas generation of 20MW contracted to connect at 33kV and connected generation of ca. 12MW at 11kV.

2.4 Fault levels

Studies indicate that with the authorised customer connections the existing break duty and peak make duty fault levels for the Brymbo-Hawarden-Holywell 33kV substation group are within plant ratings. However, there are existing fault issues in the adjacent groups (St. Asaph/Holywell/Rhyl and Hawarden/Castle Cement/Saltney) which is interconnected with the Brymbo-Hawarden-Holywell group.

3 Needs Case

The Brymbo-Hawarden-Holywell 33kV group supplies 26,315 customers cover widespread supply area across the North Wales. Due to the vast geographic expanse of the group, the demand is supplied via long overhead line circuits and not enough generation to meet the demand locally. As such, the group is presently at voltage limits and network suffers from marginal voltages excursions outside of statutory limits and are being operationally managed. With the anticipated demand growth and uptake of LCTs these voltage excursions will be outside the primary transformer tap range limits and unable to be operationally managed.

With the demand growth network will be ESQCR non-compliant. It is proposed to procure flexibility services from the market to maintain the 33kV steady state voltage within ± 6% and to maintain voltage step within ± 10%.

Further to comply with section 9 of the Electricity Act and Condition 21 of our license obligation "to develop and maintain an efficient, coordinated and economical system for the distribution of electricity" an enduring design solution is required in order to satisfy the existing customer requirements and accommodate future load growth. This concept paper covers the 33kV network solutions required to mitigate the voltage violations.

3.1 Existing voltage issues

The group is presently operating at voltage limits and network suffers from marginal voltages excursions outside of statutory limits. Studies indicate that for an outage of the 33kV circuit from Holywell Grid to Holway Road in periods of high demand and low generation, voltages are marginally below the primary transformer tap changer range. At present this situation is operationally managed by procuring flexibility services from the market through to the end of RIIO- ED1 period. The network studies based on historical measured demands in the group indicating voltage issues under N-1 outages at different primary substation in the are shown in Figure 3.1.

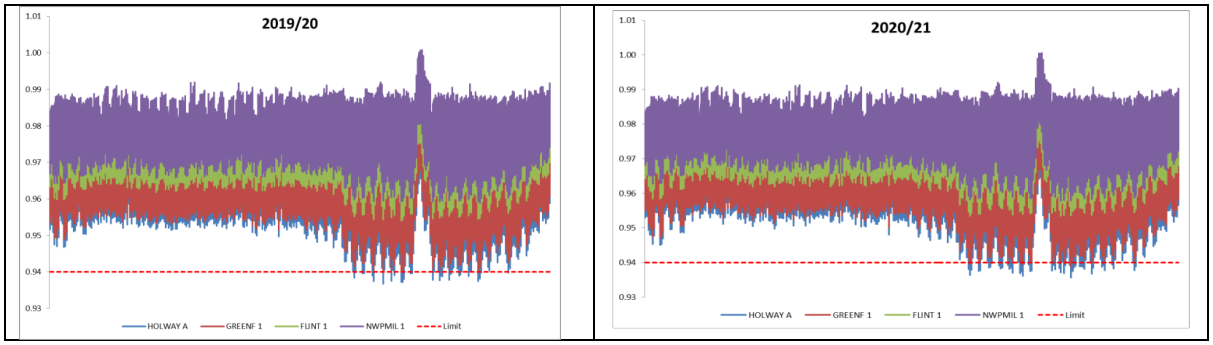


Figure 3-1:Network voltage profile with increased demand

3.2 Forecast Demand

The DFES includes granular forecasts to 2050 for demand, generation and Low Carbon Technologies (LCTs). They assess four 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.

This forecast is based on actual system measurement data from the PI system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments.

3.2.1 Distribution Future Energy Scenarios

The system is forecast exceed network capacity within the ED2 period as well as exacerbate the exiting voltage issues. This forecast is based on actual system measurement data from the PI system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments. The winter demand forecast based on the future energy scenarios along with the projected demand from authorised connections is shown in Figure 3.2.

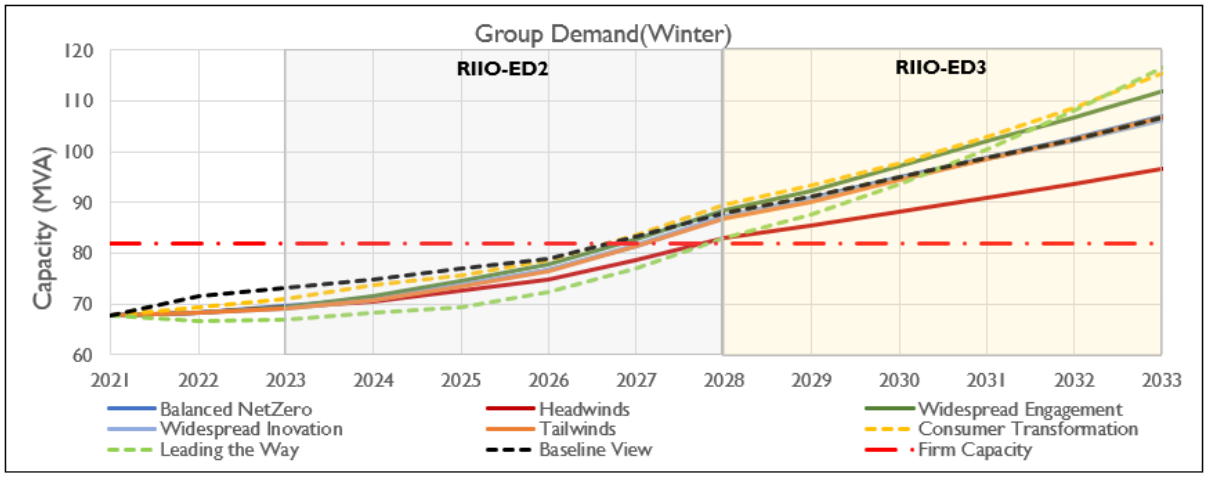
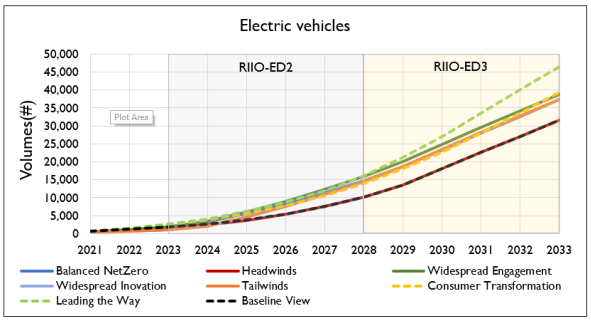


Figure 3-2: Demand forecast using DFES 2021

The anticipated residential electric vehicle and heat pump uptake based on the future energy scenarios is presented in Figure 3.3.



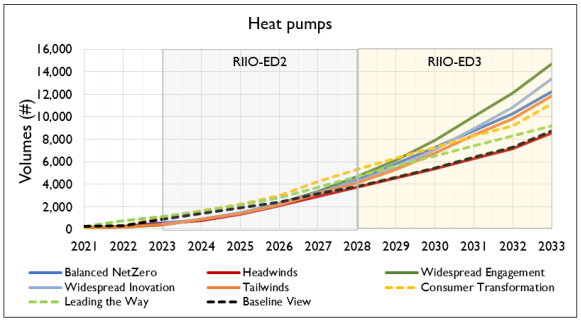


Figure 3-3: Electric Vehicles and Heat Pump uptake profile

3.2.2 Baseline View

The forecasted demand growth under Baseline View, along with the firm capacity and load index position through RIIO-ED3 period is shown in Table 3-1.

Table 3-1: Baseline View forecast

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Winter (N-1)														
Forecast Demand (MVA)	68	72	73	75	77	79	84	89	92	96	100	103	107	68
Firm Capacity (MVA)	82	82	82	82	82	82	82	82	82	82	82	82	82	82
Utilisation (%)	83	88	90	92	94	97	102	108	112	117	121	126	131	83
Load Index	LI2	LI2	LI2	LI2	LI2	LI3	LI5	LI5	LI5	LI5	LI5	LI5	LI5	LI2

3.3 Network Impact Assessment

Detailed network studies covering Intact, N-1 and fault level assessments were conducted for the 33kV network considering the different demand forecast scenarios. The findings from the network impact assessments are detailed in sections below.

3.3.1 Thermal Constraints

No thermal constraints in the group under intact and outage conditions.

3.3.2 Voltage Constraints and security of supply

System studies indicate that for an outage of 33kV circuit from Hawarden – Holywell the network will foresee steady state voltage issues. The voltage excursions at several 33kV substations will be well below the primary transformer tap changer range and will be beyond operational management leading to significant CI/CML impact with security of supply issues to over 10,500 customers. The steady state voltages for most onerous outage at 33kV substations is shown in Table 3-2.

Figure 3-4 and Figure 3-5 shows the calculated voltage profiles through the RIIO-ED2 period based on the forecast demand. As seen, the voltages are forecast to be go below the ESQCR limits under N-1 outage conditions and winter peak demand.

Table 3-2: Calculated voltage violations in 2027/28

Substation	Violation Type	Voltage (pu)	ESQCR Voltage Limit(pu)	Outage
Greenfield	Steady state	0.9316	0.94	Hawarden – Holywell ckt outage
Holway	Steady state	0.9285	0.94	Hawarden – Holywell ckt outage
Ty Coch	Steady state	0.9303	0.94	Hawarden – Holywell ckt outage

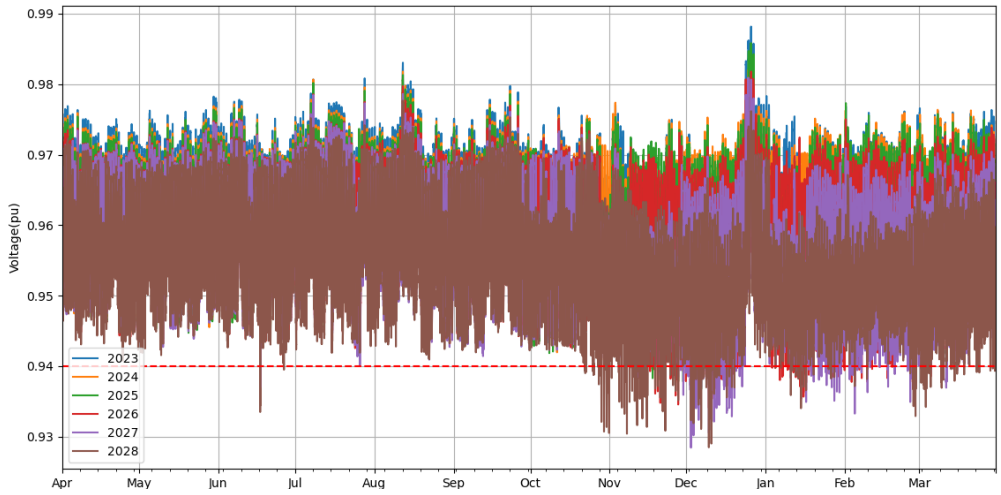


Figure 3-4: Holway primary substation voltage profile(calculated) in RIIO- ED2

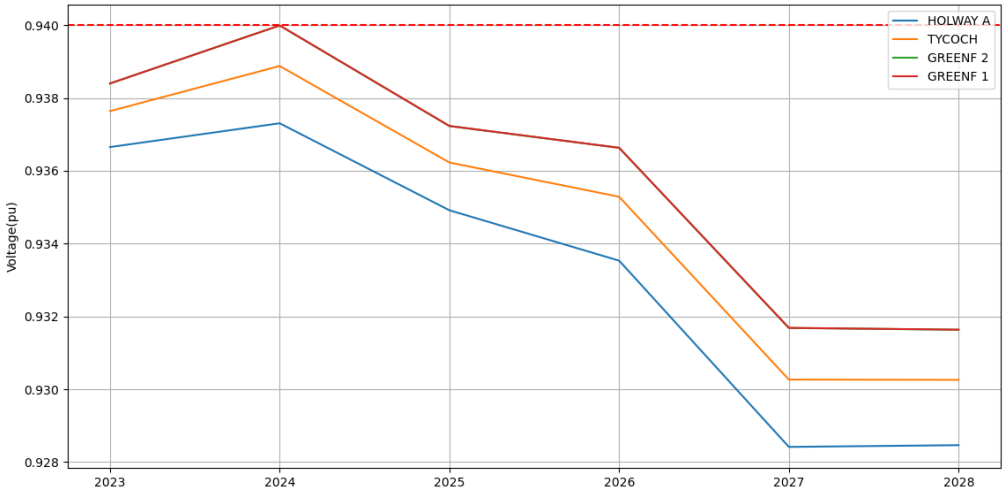


Figure 3-5: Primary substation voltages (calculated) in RIIO-ED2(without intervention)

3.3.3 Fault Level Constraint

There is no fault level related constraint in the 33kV group.

3.3.4 Network Risk and Flexibility

Network studies identified the risk in terms of the voltage excursions with the forecast demand and the anticipated duration of the risk. Further a time profile-based simulation (17,520 simulations/year) were performed considering the historical half hourly measured SCADA data combined with the DFES demand projections. These considered each year through the RIIO-ED2 price control period to identify the potential risk duration and risk window. The half-hourly studies performed for years starting from 2024 through 2028 helped identify the anticipated time of risk on the network as well as the flexible capacity required to alleviate the constraints on the network.

4 Optioneering

Table 4-1below presents a summary of the options considered for this project. Few of the longlist options are rejected based on the technical and commercial rustications, the reasons are provided in the table. The shortlisted options are taken forward for detailed analysis and included in the cost-benefit analysis. Among the considered options, Option 4, involving the flexibility services to mitigate the voltage constraints and reinforcement deferral is the 'do minimum' reinforcement for this project.

Table 4-1: Summary of the options

	Option	Status	Reason for rejection
(a)	No Intervention	Rejected	Rejected as Network calculations indicate low voltage issues at Greenfield, Holway and Ty Coch primary substations which are below ESQCR compliant limit of 0.94pu.
(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)	Establish an additional 132kV Grid in-feed in the Flint area.	Shortlisted as **Baseline**	
(d)	33kV interconnection between Point of Ayr and Greenfields and installation of 5MVAr capacitor bank at North Wales Paper	Shortlisted as **Option1**	
(e)	Reconfiguration of 33kV Holway Road substation and installation of 5MVAr capacitor bank at North Wales Paper	Shortlisted as **Option2**	
(f)	Install a 10MVAr STATCOM (reactive compensation) at Flint	Shortlisted as **Option3**	
(g)	Flexibility Services and reinforcement deferral	Shortlisted as **Option4**	

5 Detailed Analysis

The demand and generation are not uniformly distributed across the group with primary transformer substations being supplied by reasonably long or high impedance 33kV circuits which lead to voltage issues. Steady state under-voltage and voltage step issues were identified at several substations within the 33kV group. System studies indicate that these under voltage issues get exacerbated and would become unmanageable to be operationally managed and reactive power support would be required within RIIO-ED2 price control period.

5.1 Proposed solution

Profile based studies indicate that the under-voltage risk perpetuates in to the RIIO-ED2 period. The flexible capacity required with a combination of operational management would be ca. 6.3MW and 3.1MVAr by 2028. Based on these requirements, flexible services (Secure[1] product) were tendered in September 2020 to provide services between 2024-28 period. From the tender pre-qualifications, four bids have been qualified with 103% of the required capacity for a total of 27.7MW, at total cost of £453,349 over ED2 period.

Table 5-1 below shows the network risk hours calculated in combination with operational management, tendered capacity, and qualified capacity from the connected/future customers in the group.

[1] Under Secure product, the DNO procures, ahead of time, a pre-agreed change in input or output over a defined time period to prevent a network going beyond its firm capacity.

Table 5-1: Network risk duration and Flexible Capacity (MW)

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Risk Duration (Hrs)	2	23	51	139	159.5
Required Flexible Capacity (MW)	4.8	4.8	4.9	5.9	6.3
Required Flexible Capacity (MVAr)	2.3	2.3	2.4	2.9	3.1
Received Flexible capacity (MW)	4.97	4.97	5.14	6.14	6.46
Received Flexible capacity (MVAr)	-	-	-	-	-
Flexible MW capacity met (%)	104	104	105	104	103
Cost of Flexibility Services	£2,004	£24,786	£56,656	£171,519	£219,384

The procured flexible capacity will be sufficient to manage the voltage issues in the 33kV group. As the flexibility requirements are based on the demand forecast under our Baseline scenario, in the event of high demand growth in the group, higher volumes of flexibility services will be required within the RIIO-ED2 period, the costs of this will be ca.57k. Beyond RIIO-ED2, where the voltage constraints are manageable via flexibility, a reinforcement scheme in the form of a build solution will be required.

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 required reinforcement works when efficient to do so. The annual reinforcement deferral ceiling cost was calculated to be £0.228m 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 /year	£0.228m	£0.228m	£0.228m	£0.228m	£0.228m
Cost of Flexibility Services (100% Capacity)	£0.002m	£0.023m	£0.052m	£0.172m	£0.205m
Flexibility Outlook	●	●	●	●	●
● - *Accept bids and defer reinforcements*					
● - *Reject bids and deliver reinforcements*					

5.2 Baseline Option (Rejected) – Establish a 132kV Grid in-feed at Flint area.

The Baseline option involves establishing a new 60MVA grid infeed into the Flint area. Flint primary with its relatively large point load is electrically ideal for the location of a 132/33kV grid infeed. A suitable 132kV circuit (Connah's Quay A to St Asaph) is within 1.6km and there is sufficient density of 33kV circuits to adequately utilise the grid transformer's capacity. A 132/33kV injection at Flint would mitigate all of the under voltage and future thermal issues in the group. Fault levels at Flint primary would rise above the switchgear rating forcing replacement of the switchgear or fault level limiting measures. The existing Flint primary substation is also within a flood plain and an alternative suitable plot of land would have to be sought.

Table 5-3 and
Table 5-4 show the scheme summary and cost & volume breakdown of the Baseline option. Figure 5-1 shows the proposed works at Flint under Baseline option.

Table 5-3: Scheme summary and costs

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
New Substation	Brymbo-Hawarden-Holywell reinforcement scheme	Establish a new 132/33kV grid infeed into the Flint area	**7.209**	**-**

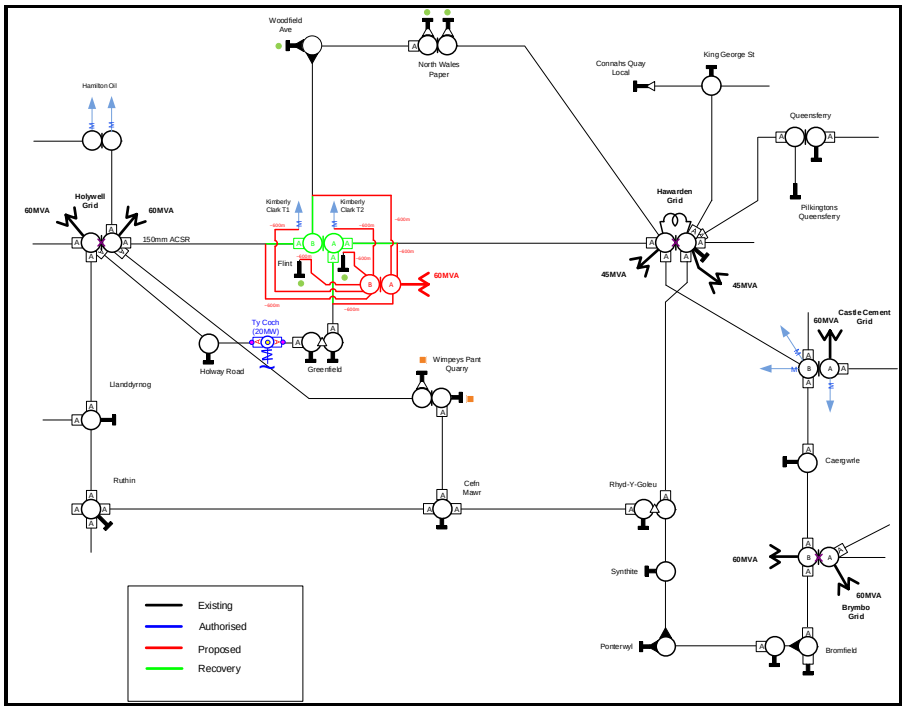


Figure 5-1: Baseline schematic

Table 5-4: Scheme costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	4.20	1.019	1.019	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	10	1.704	1.704	-
132kV Fittings	1	0.003	0.003	-
132kV UG Cable (Non-Pressurised)	1.60	1.774	1.774	-
132kV Switchgear - Other	1	0.018	0.018	-
132kV Transformer	1	1.214	1.214	-
Pilot Wire Underground	1.60	0.177	0.177	-
Civil Works at 132 kV Substations	-	0.750	0.750	-
Wayleaves/Easements/Land Purchase	-	0.250	0.250	-
Relays/protection changes for all sites	-	0.300	0.300	-
Engineering time	-	0.050	0.050	
Total Costs		**7.209**	**7.209**	-

5.3 Option1 (Rejected) – 33kV interconnection and reactive compensation

Option 1 involve s setting new primary substation at Warwick Chemicals and 33kV interconnection to Point of Ayr and Greenfields primary substations, along with reactive compensation(5MVAr capacitor bank) at North Wales Paper primary substation. The total scheme cost is £3.666m.

Table 5-5 and Table 5-6 show the scheme summary and cost & volume breakdown of Option 1. Figure 5-2 shows the proposed works at Flint under Option 1.

Table 5-5: Scheme summary and costs

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)

Innovation	Brymbo-Hawarden-Holywell reinforcement scheme	33kV interconnection between Point of Ayr and Greenfields and new 5MVAr Capacitor ban at North Wale Paper	**3.926**	-

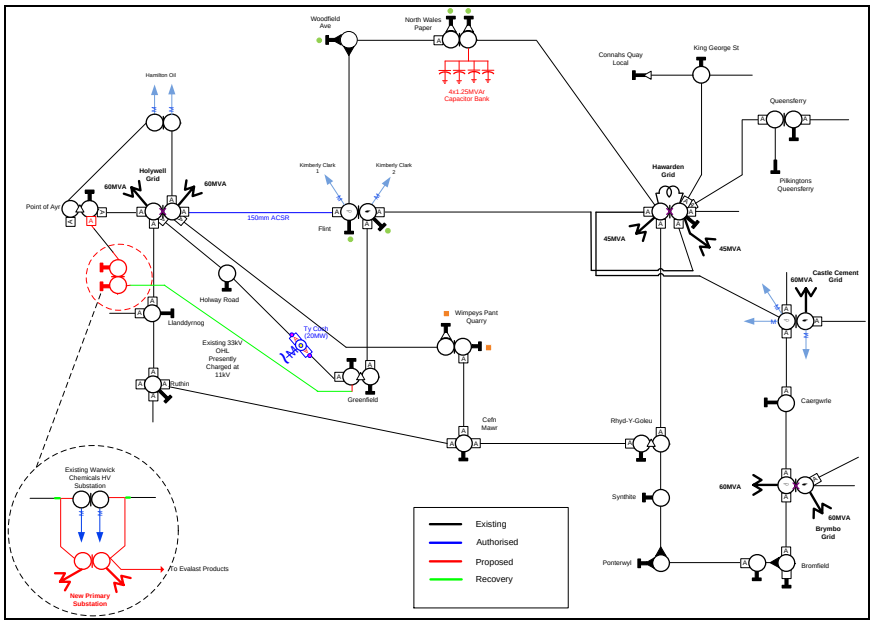


Figure 5-2: Option 1 Schematic

Table 5-6: Scheme costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.60	0.070	0.070	-
6.6/11kV CB (GM) Secondary	6.00	0.247	0.247	-
33kV UG Cable (Non-Pressurised)	2.00	0.485	0.485	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	6.00	1.022	1.022	-
33kV Transformer (GM)	2.00	0.629	0.629	-
Batteries at 33kV Substations	20.00	0.183	0.183	-
Pilot Wire Underground	0.80	0.089	0.089	-
Mechanically Switched capacitor bank	1	0.100	0.100	-
Civil Works at 33 kV & 66 kV Substations	-	0.300	0.300	-
Wayleaves/Easements/Land Purchase	-	0.070	0.070	-
Relays/protection changes for all sites	-	0.250	0.250	-
Engineering time	-	0.050	0.050	
Total Costs		**3.926**	**3.926**	-

5.4 Option 2 (Rejected) – 33kV Reconfiguration and reactive compensation

Option 2 involves looping existing Holway primary substation into the existing 33kV circuit between Holywell Grid substation and Flint, along with reactive compensation (5MVAr capacitor bank) at North Wales Paper primary substation. The total scheme cost is £3.851m.

Table 5-7 and Table 5-8 show the scheme summary and cost & volume breakdown of Option 2. Figure 5-3 shows the proposed works at Flint under Option 2.

Table 5-7: Scheme summary and costs

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Innovation	Brymbo-Hawarden-Holywell reinforcement scheme	Reconfiguration of Holway Road primary substation and installation of 5MVAr capacitor bank at North Wales Paper primary substation.	**3.851**	**-**

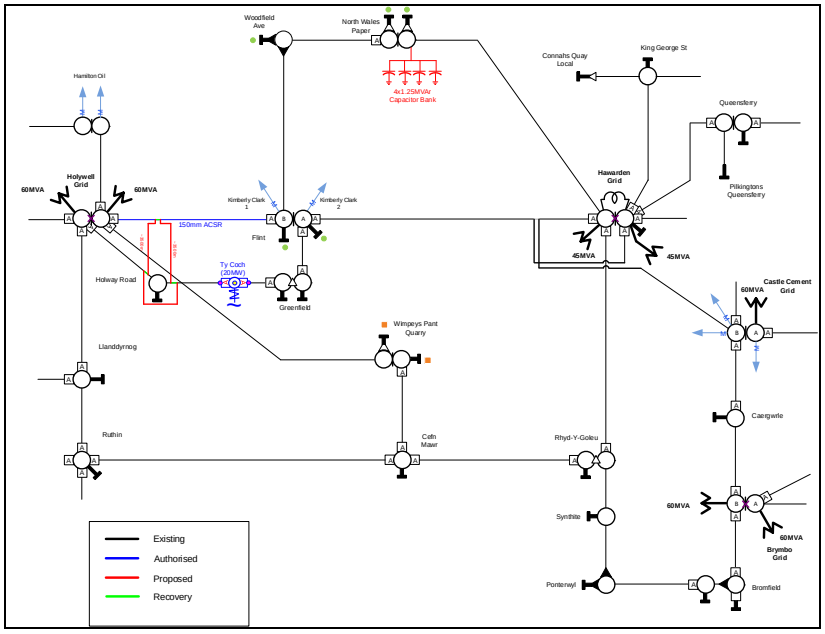


Figure 5-3: Option-2 Schematic

Table 5-8: Scheme costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.60	0.070	0.070	-
6.6/11kV CB (GM) Secondary	6	0.247	0.247	-
33kV UG Cable (Non-Pressurised)	7	1.698	1.698	-
Pilot Wire Underground	7	0.775	0.775	-
Mechanically switched capacitor bank	1	0.500	0.500	-
Wayleaves/Easements/Land Purchase		0.300	0.300	-
Auto-close scheme at Hawarden	-	0.060	0.060	-
Relays/protection changes for all sites	-	0.150	0.150	-
Engineering time	-	0.050	0.050	-
Total cost		**3.851**	**3.851**	-

5.5 Option 3 (Rejected) – Reactive compensation at Flint

Option 3 involves installing a ±10MVAr reactive support device (STATCOM) at a new site near the existing Flint substation.

Table 5-9 and Table 5-10 show the scheme summary and cost & volume breakdown of Option 3. Figure 5-2: Option 1 Schematic Table 5-6 shows the proposed works at Flint under Option 3.

Table 5-9: Scheme summary and costs

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Innovation	Brymbo-Hawarden-Holywell reinforcement scheme	Install a 10MVAR STATCOM (reactive compensation) device at Flint	**4.310**	-

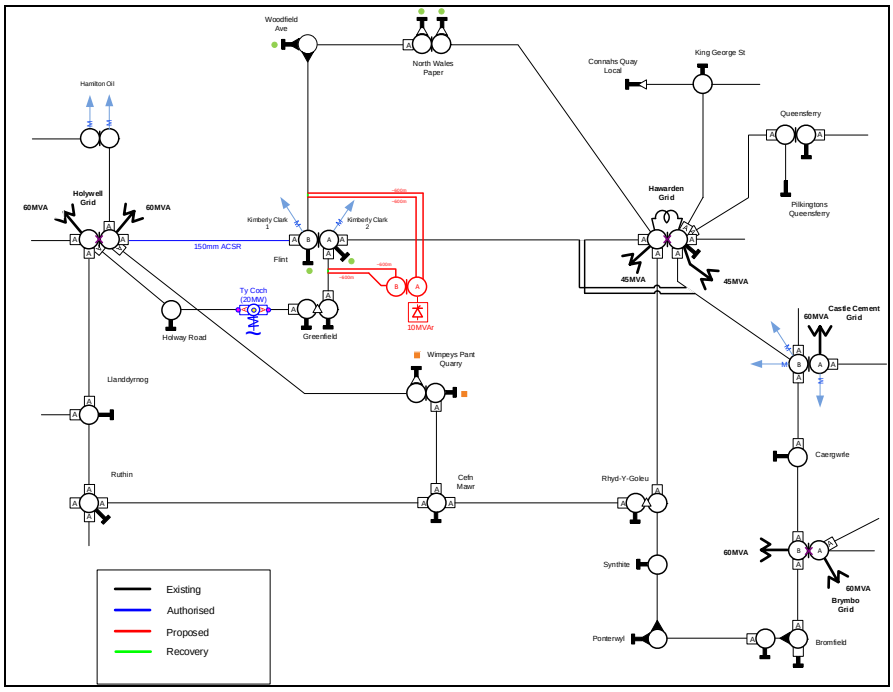


Figure 5-4: Option-2 Schematic

Table 5-10: Scheme costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.50	0.121	0.121	-
STATCOM , 33kV ,10MVAr	1	2.500	2.500	-
Batteries at 33kV Substations	20	0.170	0.170	-
33kV Diversions	-	0.210	0.210	-
Civil Works at 33 kV & 66 kV Substations	-	0.900	0.900	-
Relay upgrades / Protection changes	-	0.175	0.175	-
Engineering cost	-	0.050	0.050	-
Total Cost	**-**	**4.310**	**4.310**	-

5.6 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5-11.

Table 5-11: Costs summary for considered options

Options	Description	Total Costs(£m)
Baseline	Establish an additional 132kV Grid in-feed in Flint area.	7.209

Option 1	33kV interconnection between Point of Ayr and Greenfields and installation of 5MVAr capacitor bank at North Wales Paper	3.926
Option 2	Reconfiguration of 33kV Holway Road substation and installation of 5MVAr capacitor bank at North Wales Paper	3.851
Option 3	Install a 10MVAr STATCOM (reactive compensation) at Flint	4.310
Option 4	Flexible Services and reinforcement deferral into ED3	0.453

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is the option 4 to solution is to procure and contract with flexibility services from the market throughout the RIIO-ED2 period to mitigate the forecast voltage issues. The adopted would defer the conventional reinforcement of reactive power compensation at Flint (± 10 MVAr STATCOM) into RIIO-ED3.

The proposed option is to manage the voltage constraints in the Brymbo-Hawarden-Holywell through flexibility services, hence this option does not provide any thermal headroom.

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 lowest forecast capital expenditure, the proposed option has the highest total NPV. The summary of the cost benefit analysis is presented in Table 6-1. The full detailed CBA is provided within "ED2-LRE-SPM-028-CV1-CBA– Brymbo Hawarden Holywell 33kV Reinforcement".

Table 6-1: Summary of Cost Benefit Analysis

Options considered	Decision	Comment	NPVs based on payback periods from 2023/24 (£m)			
			10 years	20 years	30 years	45 years
Establish an additional 132kV Grid in-feed in the Flint area.	Rejected	Rejected based on high scheme costs.	0.00	0.00	0.00	0.00
33kV interconnection between Point of Ayr and Greenfields and installation of 5MVAr capacitor bank at North Wales Paper	Rejected	Rejected based on high scheme costs.	2.27	3.29	3.87	4.17
Reconfiguration of 33kV Holway Road substation and installation of 5MVAr capacitor bank at North Wales Paper	Rejected	Rejected based on high scheme costs.	3.06	4.86	5.86	6.17
Install a 10MVAr STATCOM (reactive compensation) device at Flint.	Rejected	Rejected based on high scheme costs.	2.06	3.01	3.56	3.82
Flexibility Services and reinforcement deferral	**Adopted**		2.56	3.19	3.54	3.66

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 £0.453m

Table 6-2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Flexibility Services	-	0.453	0.453	
Total Costs (£m)		**0.453**	**0.453**	

Table 6-3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

Total Investment	Total	Cost Incidence (£m)				
	(£m)	2023/24	2024/25	2025/26	2026/27	2027/28
CV1 Expenditure	0.453	0.002	0.023	0.052	0.172	0.205

6.4 Risks

Currently, flexible services are procured for the Brymbo-Hawarden-Holywell 33kV group to mitigate the existing voltage for the years 2020-23. The learnings, particularly on the operations side, managing the voltage issues in the group by flexible services will certainly help in the RIIO-ED2 period.

Further, as mentioned above, the flexibility tenders from September 2020 have shown there is enough capacity available in the group through the RIIO-ED2 period to manage the voltage constraints in the group. Under Higher demand uptake in the group, additional volumes of flexibility will be procured and a cost of £57k will be claimed under the relevant funding options within the RIIO-ED2 period. Owing to these, the level of network risk is quite minimal.

6.5 Outputs Included in RIIO-ED1 Plans

There are no asset volume outputs expected to be delivered in RIIO-ED1 that are funded within this proposal. Flexibility services are presently in use in RIIO-ED1 to manage this constraint.

6.6 Future Pathways – Net Zero

6.6.1 Primary Economic Driver

The primary driver for this investment is to maintain network voltages within statutory limits defined in the ESQCR, Distribution Code and EREC P28. The investment does not have a strong reliance on environmental benefits.

6.6.2 Payback Periods

The CBA indicates that for the proposed option demonstrates better NPV results in all assessment periods (10, 20, 30 & 45 years) against other four options. Option-4, flexibility services is the least cost option among those chosen and further defers the need for reinforcement beyond RIIO-ED2 period, hence chosen as the adopted option.

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.

For the Brymbo-Hawarden-Holywell 33kV group, 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 complaint future pathways.

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	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	6,860	5,191	9,521	10,826	9,920	6,860	10,784	9,834	9,834
HPs	3,229	2,034	4,376	5,079	3,585	3,273	3,743	3,416	3,416

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

The proposed solution is robust across a wide range of pathways as shown in Table 6-5. This solution is expected to endure to the end of RIIO-ED2 under the Baseline View. Under higher uptake scenarios higher flexible capacities will need to be procured. However, as the SPEN flexible tenders are run annually/bi-annually, the capacity requirements will be refined year-on-year and depending on the uptake volumes, the reinforcement need will be ascertained. The RIIO-ED2 regulatory framework will need to allow DNOs' allowances to flex in response to higher uptakes.

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	F1							R1		
Consumer Transformation			F	F	F2						R1			
Leading the Way			F	F	F2						R1			
Balanced Net Zero			F	F	F2						R1			
Headwinds			F	F	F1								R1	
Widespread Engagement			F	F	F2						R1			
Widespread Innovation			F	F	F2							R1		
Tailwinds			F	F	F2							R1		

F – Flexibility services within RIIO-ED1
F1 – Flexibility Services (Proposed Option)
F2 – Increased Flexibility Services
R1 – Install a 10MVAr STATCOM at Flint primary substation

Table 6-6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	0.453	+0.057
Comment	Proposed option.	Assumed increase in flex capacity requirement under high uptake scenarios

6.6.4 Asset Stranding Risks & Future Asset Utilisation

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

6.6.5 Losses / Sensitivity to Carbon Prices

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. Solution selection was not found to be sensitive to the impact of the carbon cost of losses.
Losses have been considered as part of this design solution and it has not been necessary to carry out any losses justified upgrades.

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 without compromising the safe operation of the network.

6.7 Environmental Considerations

6.7.1 Operational and embodied carbon emissions

Due to the nature of the proposed intervention, there will be no impact in relation to SPEN's Business Carbon Footprint (BCF). During the evaluation of the options associated with the group's low voltage issues, 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.

By employing flexibility and deferring the Baseline option, an estimated 416.78 tCO2 emissions are deferred as well, thus resulting in a cost saving (in the form of carbon emission reductions) of £19.32k

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

6.7.2 Supply chain sustainability

Due to the nature of the proposed intervention, there will be no impact in relation to the sustainability of our supply chain.

6.7.3 Resource use and waste

Due to the nature of the proposed intervention, there will be no impact in relation to resource use and waste.

6.7.4 Biodiversity/ natural capital

Due to the nature of the proposed intervention, there will be no impact in relation to biodiversity and natural capital.

6.7.5 Preventing pollution

Due to the nature of the proposed intervention there will be no impact in relation to pollution.

6.7.6 Visual amenity

Due to the nature of the proposed intervention, there will be no impact in relation to visual amenity.

6.7.7 Climate change resilience

Due to the nature of the proposed intervention, no impacts are anticipated in relation to future changes in climate.

7 Conclusion

The Brymbo-Hawarden-Holywell 33kV grid group supplies to ca. 26,315 customers fed from long overhead line circuits. The group is presently at voltage limits and network suffers from marginal voltages excursions outside of statutory limits and is presently operationally managed. Studies indicate that with the additional demand growth and LCT uptake will lead to steady state and voltage step issues beyond operational management in the network around Flint, Greenfield, Holway, North Wales Paper and Woodfield Avenue under N-1 33kV outages during periods of high demand and low generation.

In order to accommodate additional demand from LCT uptake and mitigate the steady state and voltage step risk a strategic reinforcement scheme with innovative solution is proposed. The recommended solution is to procure and contract with flexibility services from the market throughout the RIIO-ED2 period.

The proposed option is to manage the voltage constraints through flexibility services and as well defer the reinforcement beyond into early ED3. Because the voltage constraints are managed throughout RIIO-ED2 period, there is no thermal uplift created by this option.

The total scheme cost is £0.453m (2020/21 prices) represents the lowest cost and most efficient solution to meet the forecast demand growth when compared with the alternative schemes identified.