Newtown-Morda 33kV Reinforcement

ED2 Engineering Justification Paper

ED2-LRE-SPM-010-CV1-EJP

Issue	Date	Comments
Issue 0.1	May 2021	Issue to internal governance and external assurance
Issue 0.2	May 2021	Reflecting comments from internal governance
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	Newtown-Morda 33kV Reinforcement		
Activity	33kV Network Reinforcement		
Primary Investment Driver	Voltage Constraints		
Reference	ED2-LRE-SPM-010-CV1-EJP		
Output	Load Index		
Cost	£3.994m		
Delivery Year	2024-28		
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**
	-	**£3.994**	-

SP ENERGY NETWORKS

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:	Newtown-Morda 33kV Reinforcement
Project Reference:	ED2-LRE-SPM-010-CV1-EJP
Decision Required:	To give concept approval to install a 10MVAr STATCOM at Newtown and 5MVAr Mechanically Switched Capacitor Bank at Morda 33kV substations.

Summary of Business Need:

The Newtown and Morda areas of the SP Manweb network lie within the Legacy/Newtown/Oswestry/Welshpool 33kV group which supplies over 69,035 customers predominantly fed from long overhead line circuits. The group is presently at voltage limits and at risk of marginal voltage excursions outside of statutory limits. it is presently being operationally managed.

Studies indicate that with the forecast l demand growth and LCT uptake will lead to steady state and voltage step issues beyond operational management in the network affecting Newtown, Caersws, Llandinam, Llandu Quarry, Llanfair Caereinion, Llanfyllin, Llanidloes, Milford, Mochdre and Morda during N-1 33kV outages in periods of high demand and low generation.

It is proposed to carry out system reinforcement in the RIIO-ED2 price control period in order to mitigate the voltage violations and maintain the steady state voltage of the 33kV network to within +/- 6% of the declared voltage under the ESQCR 2002 and maintain voltage step within +/- 10%.

The SPM DFES, under the Baseline scenario, forecasts a significant number of LCTs including 16,031 Electric Vehicles and 11,278 Heat Pumps by the of RIIO-ED2 period.

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

An innovative reactive power compensation scheme is proposed which comprises a STATCOM and Mechanically Switched Capacitor Bank (MSC). The proposed scheme includes:

- Installation of ±10MVAr STATCOM at Newtown Grid substation, a 33/11kV step up transformer and dedicated outdoor CB.
- Installation of 33kV, 5MVAr MSC at Morda and a dedicated outdoor circuit breaker
- Procure Flexible serviced through the scheme delivery to manage the network risk at £288k.

Total scheme cost – £3.994m (2020/21 prices), which is fully funded by SPEN in the ED2 period.

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**	**Primary Reinforcement**	**3.707**	0.371	0.741	0.741	0.927	0.927
SPM	**CV1**	**Flexible Services**	**0.288**	0.039	0.058	0.074	0.117	-
		Total Expenditure	**3.994**	0.410	0.799	0.815	1.044	0.927

PART B – PROJECT SUBMISSION

Proposed by	Kailash Singh	Signature	Kp. Singh	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 (SPM) network in Dee Valley Mid Wales around the Legacy, Newtown, Oswestry, and Welshpool is supplied from Legacy 400/132kV GSP. It secures supply to 69,035 customers which includes a several recreational/tourist destinations, industrial customers and distributed generation. The Newtown and Morda areas lie to the southern section of the network group. Figure 1-1 shows the SPM 132kV and 33kV network area fed from Legacy/Newtown/Oswestry/Welshpool grid network.

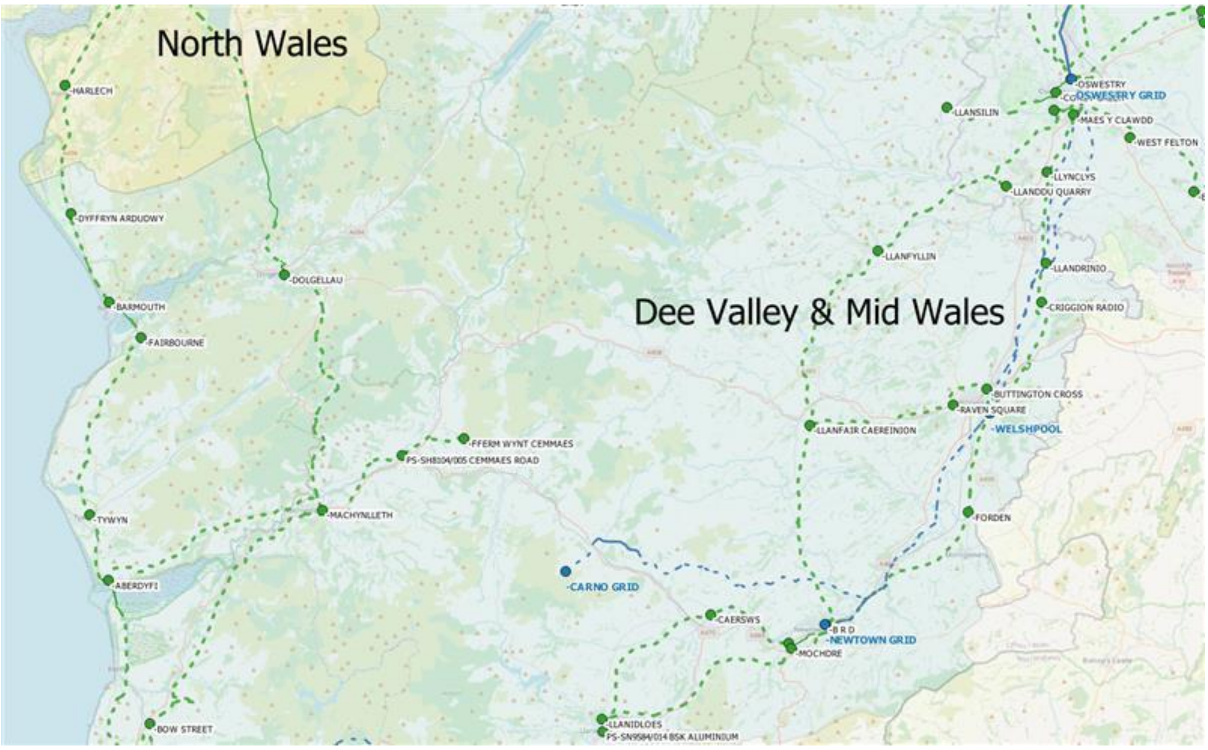


Figure 1-1: 132kV and 33kV network area

The voltage in this network group is presently operating at network limits set out in the Electricity Safety Quality and Continuity Regulations (ESQCR). The voltage issues which impact the network south of Oswestry need to be mitigated to accommodate additional load growth and forecast LCT uptake. The SPM Distribution Future Energy Scenarios (DFES), under the Baseline View, forecasts a significant number of LCTs including 16,031 Electric Vehicles and 11,278 Heat Pumps by the of RIIO-ED2 period.

To mitigate the voltage violations an innovative reactive power compensation scheme is proposed which comprises of a STATCOM and a Mechanically Switched Capacitor Bank (MSC). The proposed scheme includes:

- Installation of ±10MVAr STATCOM at Newtown Grid substation, this will require a 33/11kV step up transformer and a dedicated outdoor circuit breaker
- Installation of 33kV, 5MVAr MSC and a dedicated outdoor circuit breaker at Morda primary substation.
- Procure Flexible serviced through the scheme delivery to manage the network risk at £288k.

Total scheme cost – £3.994m (2020/21 prices), which is fully funded by SPEN in the ED2 period.

It is proposed to start the works in 2023/24 and the capacity release of 15MVA will be claimed in 2027/28 at the end of the project for the group. The timing of the project is based on delivering the highest NPV, while managing the network risk via operational management through flexibility services during project delivery.

2 Background Information

2.1 Existing/Authorised Network

The existing Legacy/Newtown/Oswestry/Welshpool 33kV network group is fed via 3 x 60MVA grid transformers each at Newtown/Oswestry/Welshpool and a 45MVA grid transformer at Legacy, all the grid sites are supplied from the Legacy 400/132kV GSP. The 33kV network group secures HV network comprising 27 primary transformers and supplies to ca. 69,035 customers, operates interconnected with the neighbouring Oswestry / Whitchurch 33kV group. The grid group mainly feeds the demand groups in Dee Valley and Mid Wales areas like the area like Ruabon, Johnstown, Ifton, Milford, Oswestry Newtown and Welshpool etc. Due to the group's geographic expanse, the load centres are well separated and are fed off long overhead line circuits. The authorised 33kV Legacy/Newtown/Oswestry/Welshpool group network is shown in Figure 2-1.

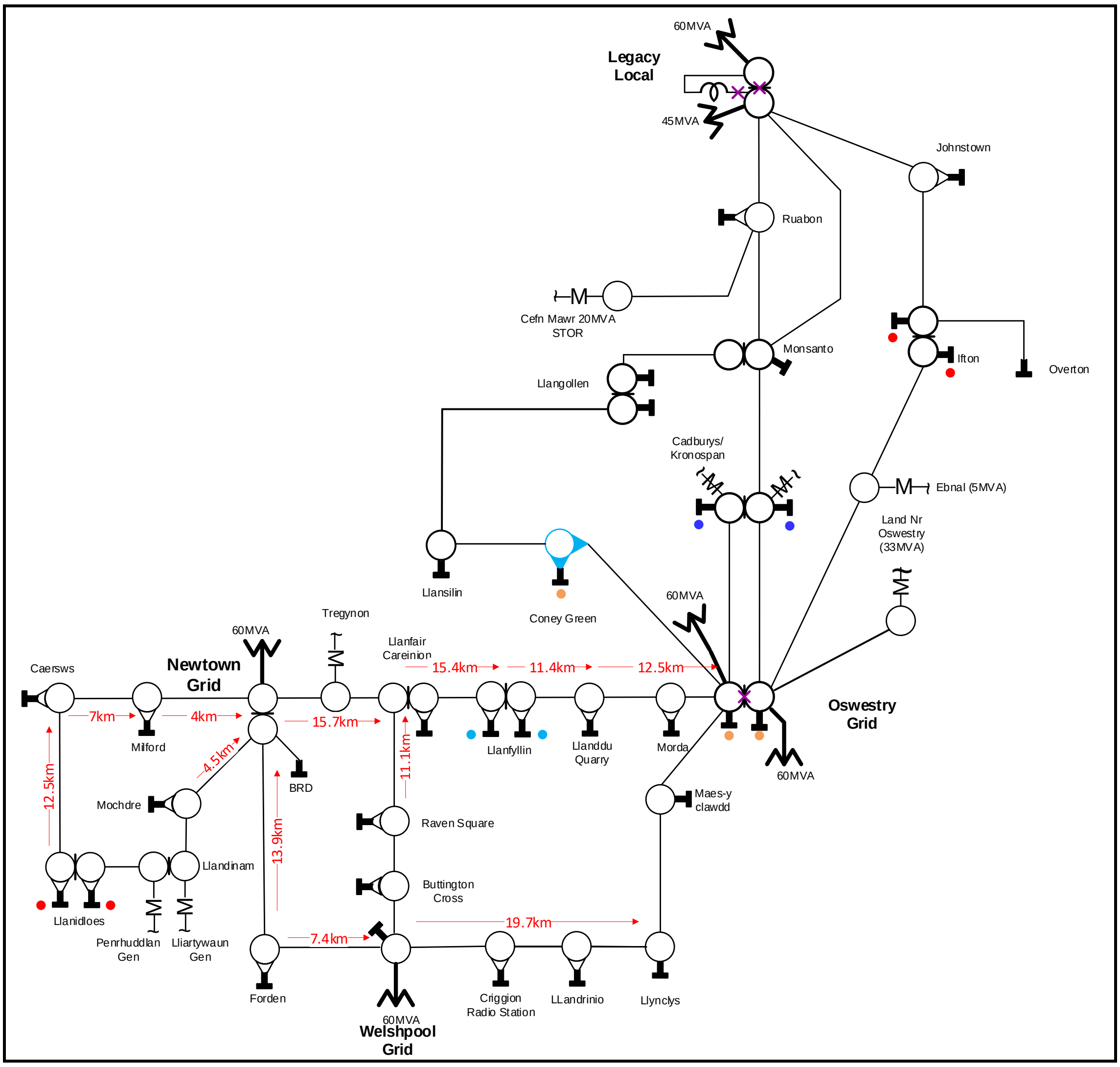


Figure 2-1: Authorised Legacy/Newtown/Oswestry/Welshpool 33kV network

2.2 Network supply / circuit capacity

The existing 33kV Legacy/Newtown/Oswestry/Welshpool network is classed as EREC P2/7 Group D (≥60MW up to 300MW) and as a minimum must be secured for second circuit outages. With the 4 grid infeeds, the group is compliant for both N-1 and N-1-1 outages. Table 2-1 presents the existing network supply capacity of the 33kV group.

Table 2-1: Summary of authorised EHV group network

Substation	No. of customers	Scenario	LI firm capacity	Maximum demand	Load Index	Group P2/7 Class
EHV						
Legacy/Newtown/ Oswestry/Welshpool	69,035	N-1	163	108	LI1	D

2.3 Embedded Generation

The 33kV group network has significant penetration of distributed generation with 128.6MW connected and an additional 72.5MW contracted as shown in Table 2-2. The area is subject to significant generation connection interest which is restricted by capacity limitations on both the SPM and NGET networks, and all new generation connections in the network group are subject to Modification application to NGET.

Table 2-2: Embedded generation in Legacy/Newtown/Oswestry/Welshpool 33kV group

Status	Type	Registered capacity (MW)	Total Capacity (MW)
Connected	Onshore Wind	48.5	128.6
	Fossil Gas	49.5	
	PV	46.3	
Contracted	Fossil Gas	42.5	72.5
	PV	30	
			201.1

2.4 Fault levels

The existing fault levels in the group at Legacy and Oswestry are operationally managed. The contracted generation connections have inter-tripping schemes to mitigate the fault level exceedances.

3 Needs Case

The 33kV Legacy/Newtown/Oswestry/Welshpool network group supplies 69,035 customers, covers widespread supply area overlapping the counties of Denbighshire, Wrexham, Powys and Shropshire. The generation is not uniformly distributed across the group and the demand is supplied via long overhead line circuits to the distant load centres. Under outage conditions, the network group is presently at voltage limits and at risk of marginal voltages excursions outside of statutory limits. These risks are presently operationally managed.

With the forecast demand growth and uptake of LCTs, within the RIIO-ED2 period and beyond, these voltage excursions are expected to worsen, will be outside the primary transformer tap changer range and cannot be operationally managed.

As the network will become "Non-Compliant" it is proposed to carry out system reinforcement in the RIIO-ED2 price control period in order to accommodate the future demand growth within the area, maintain the steady state voltage of the 11kV network to within +/- 6% of the declared voltage under the ESQCR 2002 and 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 network solutions required to mitigate the voltage violations.

3.1 Existing voltage excursions

The network is presently at risk of marginal voltage excursions outside of statutory limits. Studies indicate that under N-1 conditions of an outage of the 33kV circuit from to Oswestry Grid to Morda, or for an outage of the Newtown grid transformer in periods of high demand and low generation, there are voltages that are marginally below the primary transformer tap changer range, but can be operationally managed by transferring demand on to adjacent HV substation group.

The calculated 33kV voltage profiles at Morda, Llanidloes, BRD primary and Newtown primary grid substation are shown in Figure 3-1.

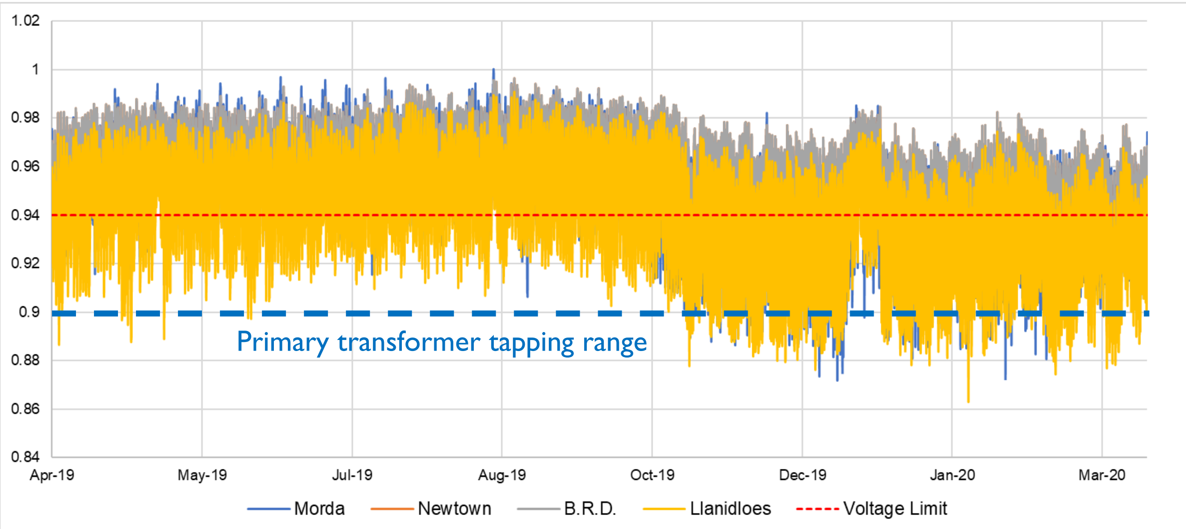


Figure 3-1: Calculated voltage profiles in the existing 33kV group under N-1 outage conditions

3.2 Forecast Demand

The Distribution Future Energy Scenarios (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 SPM's Process Instrumentation (PI) network monitoring data historian system and stakeholder endorsed DFES and considers our pipeline of known developments.

3.2.1 Local Considerations and stake holder feedback

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

3.2.1.1 Electric Vehicles Charging Strategy

In December 2020, Welsh Government published their electric vehicles charging strategy[1] 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. Welsh Government predicts 32,000 EVs by 2025 and 135,000 EVs by 2030 in the SPM network license area.

3.2.2 Distribution Future Energy Scenarios

The existing network is forecast to exceed capacity limits within the ED2 period. This forecast is based on actual system measurement data from the PI system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers SPM's pipeline of known developments. The winter demand forecast based on the future energy scenarios along with the projected demand from contracted connections is shown in Figure 3-2.

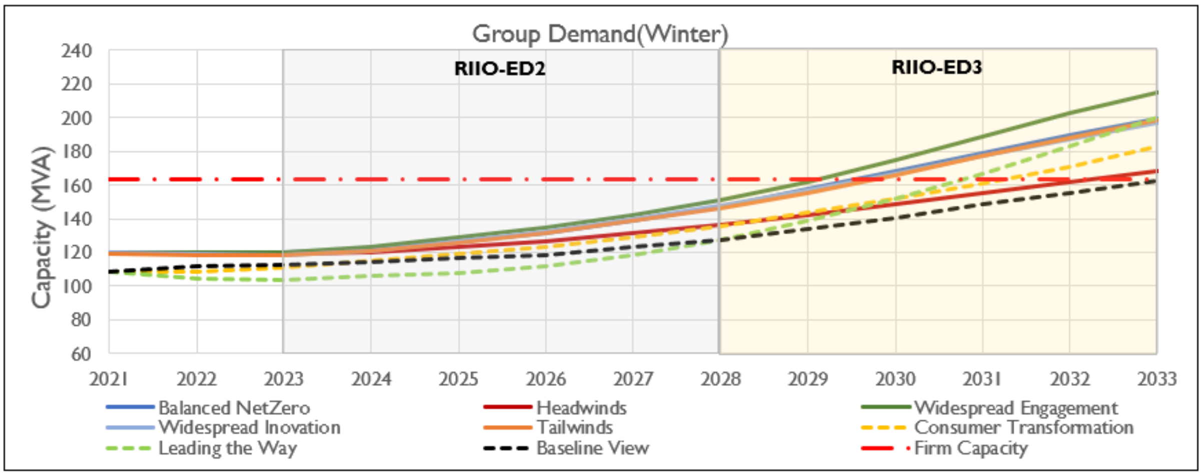
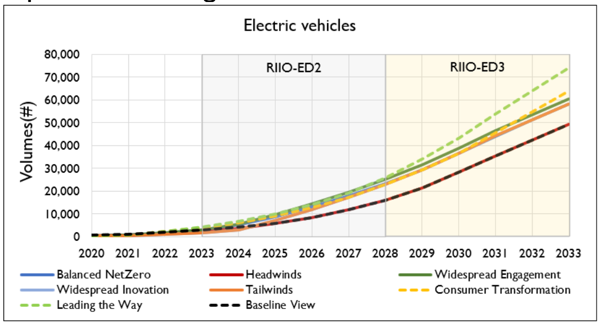


Figure 3-2: Demand forecast for the Legacy/Newtown/Oswestry/Welshpool group

The anticipated residential electric vehicle and heat pump uptake based on the future energy scenarios is presented in Figure 3-3.



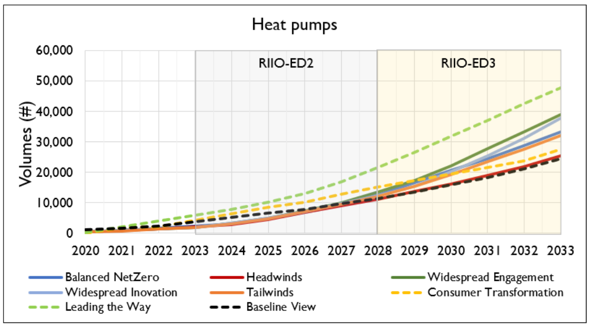


Figure 3-3: LCT uptake profile for Legacy/Newtown/Oswestry/Welshpool group

3.2.3 Baseline View

For the 33kV 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.

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

Table 3-1: Baseline View forecast

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Forecast Demand (MVA)	108	112	113	114	117	119	123	127	134	141	148	155	163
Firm Capacity (MVA)	163	163	163	163	163	163	163	163	163	163	163	163	163
Utilisation (%)	66	68	69	70	72	73	75	78	82	86	91	95	100
Load Index	LI1	LI1	LI1	LI1	LI1	LI1	LI1	LI1	LI2	LI2	LI2	LI3	LI4

3.3 Network Impact Assessment

Detailed network studies covering Intact, N-1 and fault level assessments are 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

There were no thermal constraints in the 33kV network.

3.3.2 Voltage Constraints and security of supply

System studies indicate that for outages of either Oswestry to Morda 33kV circuit or Newtown grid transformer there will be steady state and voltage step violations. These 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 25000 customers. The steady state and voltage step violations for most onerous outage at 33kV substations is shown in Table 3-2.

Table 3-2: 33kV network voltage violations

Substation	Most Onerous Violation Type	Calculated voltage	Limits (min / max)	Outage
Llanfair Caereinion	Steady State	0.89 pu	0.94/1.06 pu	Llanfair Caereinion bus section
Morda	Steady State	0.9 pu	0.94/1.06 pu	Oswestry - Morda 33kV circuit
Llandu Quarry	Steady State	0.91 pu	0.94/1.06 pu	
Llanfyllin	Steady State	0.91 pu	0.94/1.06 pu	Llanfair Caereinion bus section
Llanidoles	Steady State	0.91 pu	0.94/1.06 pu	Newtown 60MVA Grid Transformer
Caersws	Steady State	0.91 pu	0.94/1.06 pu	
Llandinam	Steady State	0.91 pu	0.94/1.06 pu	
Milford	Steady State	0.92 pu	0.94/1.06 pu	
Mochdre	Steady State	0.92 pu	0.94/1.06 pu	
BRD	Steady State	0.92 pu	0.94/1.06 pu	
Tregynon	Steady State	0.92 pu	0.94/1.06 pu	
Llanfair Caereinion	Voltage Step	-12%	±10%	Llanfair Caereinion bus section
Llandinam	Voltage Step	-10%	±10%	Newtown 60MVA Grid Transformer
Milford	Voltage Step	-10%	±10%	
Mochdre	Voltage Step	-10%	±10%	
BRD	Voltage Step	-10%	±10%	
Newtown	Voltage Step	-10%	±10%	
Morda	Voltage Step	-10%	±10%	Oswestry - Morda 33kV circuit

3.3.3 Fault Level Constraint

System studies indicate that the 33kV group network is at fault level limits. The fault level related constraints for this group along with mitigation measures is addressed in ED2-LRE-SPEN-001-CV3-EJP – Fault Level Monitoring and Management.

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 (17520 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. The key results from the half hourly profile-based simulations are furnished in Appendix A.

These profiles-based studies indicate that the under-voltage risk potential starts from the beginning of RIIO-ED2 and with a combination of operational mitigation these risks can be minimised, however cannot be alleviated. The capacity required with a combination of operational management would be ca. 7.9MW and 3.8MVAr by 2028. Based on these requirements, flexible services (Sustain[2] product) were tendered in May 2021 to provide services between 2023-28 period. The qualified tenders return show sufficient flexible capacity is available during the scheme delivery through 2026/27.

Table 3-3 below shows the network risk hours calculated in combination with operational management by transferring demand to adjacent HV groups, tendered capacity and qualified capacity from the connected/future customers in the group.

Table 3-3: Network risk duration and Flexible Capacity (MW)

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Risk Duration (Hrs)	173	254.5	309.5	499.5	837
Required Flexible Capacity (MW)	5.9	5.9	6.0	6.2	7.93
Required Flexible Capacity (MVAr)	2.9	2.9	2.9	3.0	3.8
Received Flexible capacity (MW)	5.99	5.96	6.19	6.53	8.49
Received Flexible capacity (MVAr)	-	-	-	-	-
Flexible MW capacity met (%)	101%	101%	102%	100%	107%
Cost(£m)	0.039	0.058	0.074	0.117	0.249

[2] Sustain – under this product the DNO procures the services ahead time to prevent the network going beyond its firm capacity.

4 Optioneering

Table 4 1 shows the long list of options considered for the scheme. Few of the longlist options are rejected based on the technical and commercial rustications and the reasons are provided in the table. Option 3 involving reactive compensation at Newtown Grid and Morda primary substations is the minimum required scheme to mitigate the voltage issues in the 33kV group. The shortlisted options are taken forward for detailed analysis and included in the cost-benefit analysis

Table 4-1: Long list of options considered

	Option	Status	Reason for rejection
(a)	No Intervention	Rejected	Not compliant with ESQCR, Distribution code limits and 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)	New 22km long 132kV cable route between Aberystwyth -Newtown and new 60MVA GT at Newtown and new ca. 4.5km long 33kV circuit between Morda and Oswestry.	Considered (**Baseline**)	-
(d)	New 60MVA GT at Welshpool and new 33kV circuits between Newtown-Welshpool Grid substations and Morda - Llansilin primary substations.	Considered (**Option 1**)	-
(e)	New 34kms – 33kV Interconnector between Machynlleth to Caersws and 5MVAr MSC at Morda.	Rejected	Does not meet the needs case Due to the phase angle difference between the GSP groups, the interconnection would lead to thermal overloads and would potentially increase the security supply risk to customers across the group networks resulting in significant CI/CML impact.
(f)	Installation of 10MVAr MSC at Newtown and 5MVAr MSC at Morda.	Rejected	Does not meet the needs case Installation of MSC at Morda alleviates the voltage constraint at Morda, however installation of MSC at Newtown is rejected as it does not alleviate the voltage step issues.
(g)	Installation of Phase Shifting Transformer (PST) at Llanidloes and new 33kV – 32kms circuits from Rhydlydan grid and 5MVAr MSC at Morda.	Rejected	The overall scheme cost will be significantly higher considering the installation of PST and 32kms – 33kV feeder from Rhydlydan.
(h)	New ±10MVAr STATCOM at Newtown and new circuit between Morda - Llansilin and Morda - Coney Green via 2x1.25km 400 sq. mm XLPE AL cable by looping into existing 33kV Coney Green - Llansilin circuit.	Considered (**Option 2**)	-
(j)	Installation of ±10MVAr STATCOM at Newtown and 5MVAr MSC at Morda.	Considered (**Option 3**)	-
(k)	HVDC back to back convertor at Llanidloes and 132kV circuit interconnections from Carno and Rhydlydan and 5MVAr MSC at Morda.	Rejected	The overall scheme cost for back to back HVDC convertor will be significantly higher with a long lead time.
(l)	MVDC link between Machynlleth and Caersws and 5MVAr MSC at Morda.	Rejected	The overall scheme cost for MVDC convertor and DC link with >30kms will be significantly higher and will have a long lead time.
(m)	Management of voltage constraints using flexibility services	Rejected	Flexibility services are not suitable to mitigate the voltage step issues as the response time needs to be fast acting in real-time. We will continue to tender for flexibility services in this area in order to test the market for technically compliant flexibility solutions to resolve this complex voltage constraint.

5 Detailed Analysis

The demand and generation are not uniformly distributed across the group with primary substations being supplied by reasonably long or high impedance 33kV circuits which can 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 cannot be operationally managed and reactive power support would be required within RIIO-ED2 price control period.

5.1 Proposed solution (Option 3) – New ±10MVAr STATCOM at Newtown and 5MVA MSC at Morda

Studies have been undertaken to assess a wide range of options in both location and static/dynamic voltage support. To mitigate the voltage issues in the group, it is proposed to install new reactive compensation devices at the existing Newtown grid and Morda primary substations Newtown is identified the most suitable location for fast-acting dynamic MVAr support in the form of a ±10MVAr STATCOM to manage steady state and voltage step issues. Additionally, installation of 5MVAr of reactive support in the form of a capacitor at Morda is required to support the steady voltage during circuit outages. Together these mitigate both steady state and voltage step issues in the group through RIIO-ED2 and RIIO-ED3 periods.

The STATCOM is a 'smart' solution, comprises a DC capacitor behind a power electronics voltage source converter to act as either a sink or source of reactive power. This provides fast acting reactive power support and smooth controllable voltage regulation. The STATCOM device would likely be controlled to 0 MVAr output during Intact (system normal) conditions to enable it to respond with reactive power support during contingent outage conditions. Cost estimates include for provision of a ±10MVAr STATCOM.

At Newtown it is proposed to extend the existing 33kV switchboard to accommodate a dedicated circuit breaker for STATCOM which will be connected via a 33/11kV step up transformer. At Morda, it is proposed to install a Mechanically Switched Capacitor (MSC) bank with 2 steps of 2.5MVAr each for better voltage regulation. The capacitor bank will be connected at 33kV voltage level via a dedicated (additional) outdoor circuit breaker. The layout and line diagram of the proposed solutions are shown in Appendix A (section 8.2). The overall network with the proposed solutions is shown in Figure 5-1 and the costs of works under the proposed option is shown in Table 5-1.

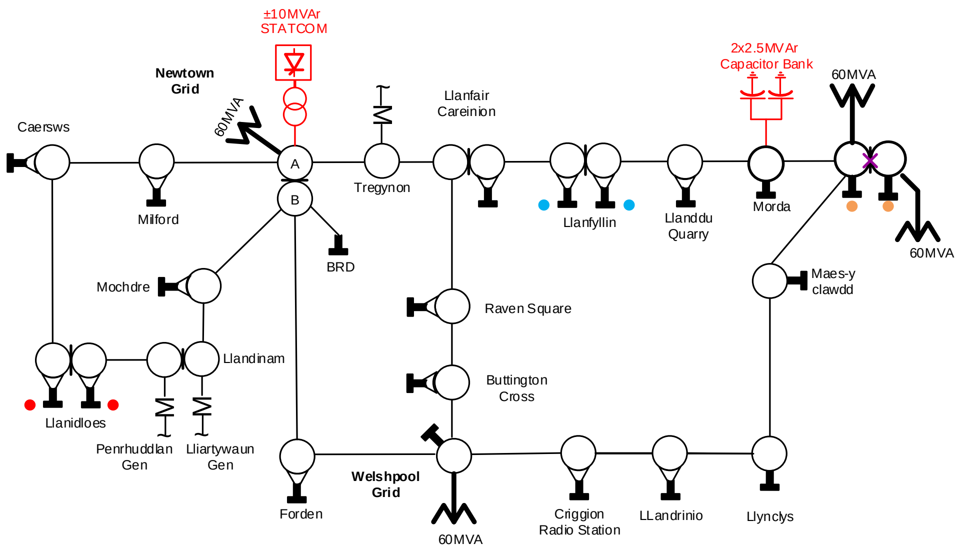


Figure 5-1: Proposed works in the 33kV group

Table 5-1: Proposed solution costs

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution(£m)
6.6/11kV UG Cable	0.05	0.006	0.006
6.6/11kV CB (GM) Primary	1.	0.028	0.028
33kV UG Cable (Non-Pressurised)	0.10	0.024	0.024
33kV CB (Air Insulated Busbars)(OD) (GM)	2	0.117	0.117
33kV Switch (GM)	1	0.047	0.047
33kV Transformer (GM)	1	0.314	0.314
Batteries at 33kV Substations	1	0.009	0.009
Flexible Services	-	0.288	0.288
Civil Works at 33 kV & 66 kV Substations	-	0.227	0.227
Wayleaves/Easements/Land Purchase	-	0.030	0.030
±10MVAr STATCOM at Newtown	1	2.500	2.500
5MVAr MSC at Morda - £0.25m	1	0.250	0.250
Other Costs (Identify Below)	-	0.154	0.154
	Total Costs	**3.994**	**3.994**
Associated protection, control or SCADA equipment located at a site and remote ends if applicable - £104k			
Environmental considerations and Design & Engineering Studies – £50k			

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 are relatively low, to commission the above proposed works when efficient to do so. The cost of flexibility for 2023/24 to 2026/27 considering 50% utilization based on the recent tenders for a total of 24.39MW 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
Secured Flexibility Services (MW)	5.99	5.96	6.19	6.25	8.49
Cost of Flexibility Services(£m)	0.039	0.058	0.074	0.117	0.249
Annual Reinforcement Deferral Cost(£m)	0.146	0.146	0.146	0.146	0.146
Flexibility Outlook	green	green	green	green	red

green: *Accept flexibility bids and defer reinforcements*
red: *Reject flexibility bids and deliver reinforcements*

It is proposed to start the works in 2023/24 and the capacity release of 15MVA between the two 33kV groups will be claimed in 2027/28 at the end of the project. The timing of the project is based on delivering the highest NPV, while managing the network risk via operational management through flexibility services during project delivery.

5.2 Baseline – New 60MVA grid infeed at Newtown and 33kV circuit between Morda and Oswestry

The considered Baseline option involves a 60 MVA new grid infeed at Newtown, ca. 22km of 132kV cable circuit between Newtown – Welshpool and additional 33kV circuit between Oswestry -Morda. The 132kV circuit will support the connection of wind generation at Carno and hence the 132kV cabling works will be apportioned with the customer. The additional GT and 33kV between Morda-Oswestry will support the 33kV network under N-1 outages in the group.

Table 5-3 shows the scheme summary and cost apportionments. Figure 5-2 shows the required works.

Table 5-3: Baseline scheme summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Circuit & Substation	Newtown-Morda 33kV Reinforcement	1. Install a new 60MVA grid infeed at Newtown grid substation from the MB circuit (at tower MB190).	£15.746	£16.906

		2. Install a new 33kV ca. 5km long OHL circuit between Oswestry and Morda (requires board extension at Oswestry & Morda)		

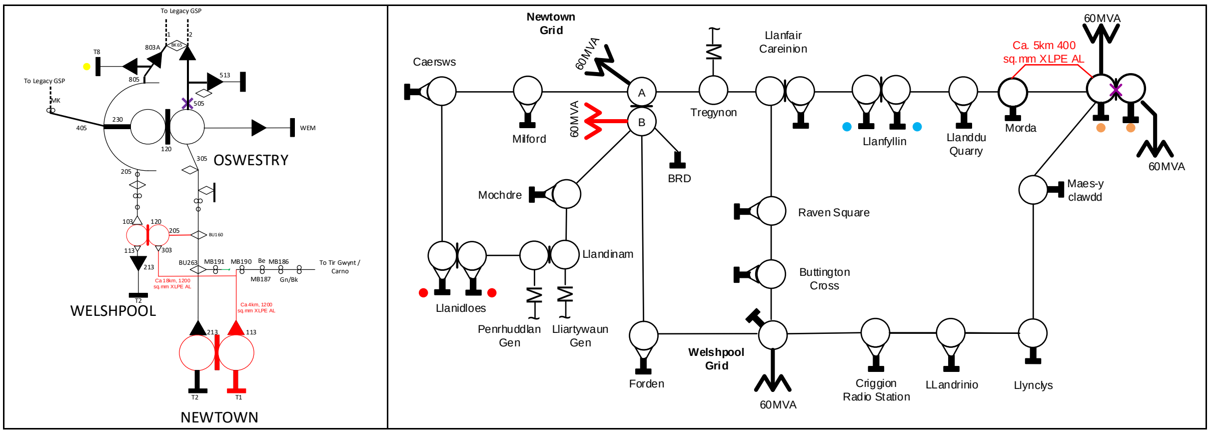


Figure 5-2: Proposed 132kV (left) and 33kV (right) works under Baseline scheme

Table 5-4: Costs and Volumes of Baseline scheme

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	6.20	1.504	1.504	-
33kV CB (Air Insulated Busbars) (OD) (GM)	2.00	0.117	0.117	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	1.00	0.170	0.170	-
33kV Switch (GM)	1.00	0.047	0.047	-
132kV OHL (Tower Line) Conductor	0.05	0.003	0.003	-
132kV Tower	2.00	0.228	0.228	-
132kV Fittings	2.00	0.006	0.006	-
132kV UG Cable (Non-Pressurised)	22.20	24.619	9.248	15.371
132kV CB (Air Insulated Busbars)(OD) (GM)	1.00	0.176	0.176	-
132kV Switchgear - Other	5.00	0.091	0.091	-
132kV Transformer	1.00	1.214	1.214	-
Batteries at 132kV Substations	1.00	0.008	0.008	-
Pilot Wire Underground	22.20	2.459	0.924	1.535
Civil Works at 33 kV & 66 kV Substations	-	0.292	0.292	-
Civil Works at 132 kV Substations	-	0.636	0.636	-
Wayleaves/Easements/Land Purchase	-	0.757	0.757	-
Other Costs (Identify Below)	-	0.810	0.810	-
Total Costs		**32.652**	**15.746**	**16.906**
Associated protection, control or SCADA equipment - £760k				
Environmental considerations – £50k				

5.3 Option 1 – New 60MVA grid infeed at Welshpool and new 33kV interconnector circuits

The considered Option 1 involves a 60 MVA new grid infeed at Welshpool, ca. 19km of 132kV cable circuit and additional 33kV circuit between Welshpool – Newtown Grid substations, also 33kV circuit between Llansilin and Morda. The additional GT at Welshpool and 33kV between Morda-Llansilin will support the 33kV network under N-1 outages in the group.

Table 5-5 shows the scheme summary and cost apportionments. Figure 5-3 shows the required works.

Table 5-5: Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Circuit & Substation	Newtown-Morda 33kV Reinforcement	1. Establish a new 60MVA grid infeed at Welshpool by looping Oswestry - Newtown 132kV OHL circuit. 2. Establish a new 24km interconnector between Newtown and Welshpool Grids substations. 3.Establish a new 33kV, 6km circuit between Llansilin and Morda primary substations.	£15.004	-

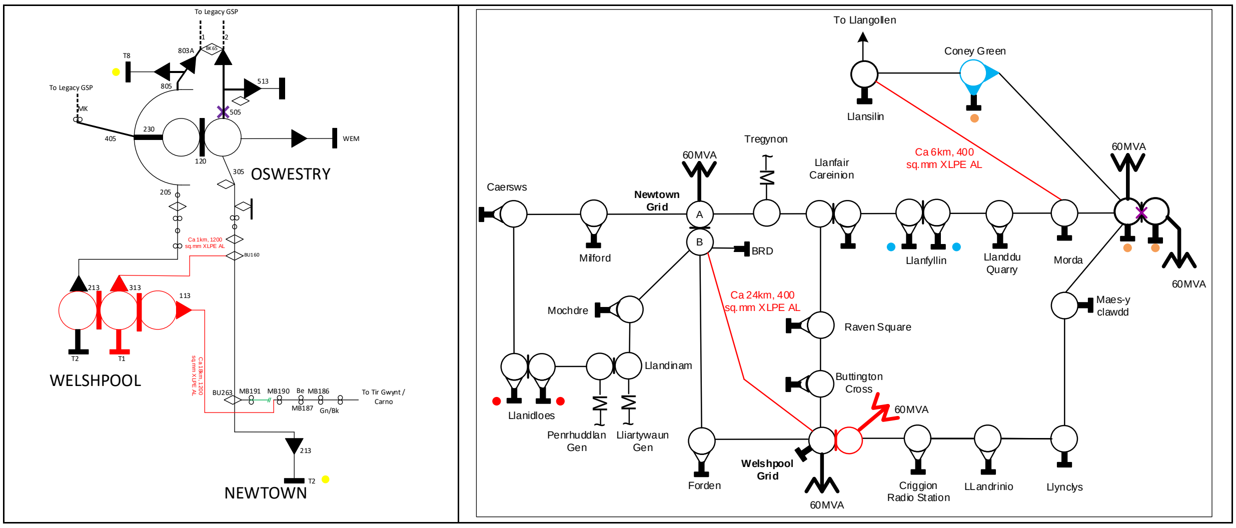


Figure 5-3 Proposed 132kV (left) and 33kV (right) works under Option -1

Table 5-6: Costs and Volumes for Option 1

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	30.00	7.278	7.278	-
33kV CB (Air Insulated Busbars) (ID) (GM)	1.00	0.180	0.180	-
33kV CB (Air Insulated Busbars) (OD) (GM)	2.00	0.117	0.117	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	1.00	0.170	0.170	-
Batteries at 33kV Substations	1.00	0.009	0.009	-
132kV OHL (Tower Line) Conductor	0.05	0.003	0.003	-
132kV Tower	1.00	0.114	0.114	-
132kV Fittings	1.00	0.003	0.003	-
132kV UG Cable (Non-Pressurised)	1.00	1.109	1.109	-
132kV Switchgear - Other	2.00	0.037	0.037	-
132kV Transformer	1.00	1.214	1.214	-
Batteries at 132kV Substations	1.00	0.008	0.008	-
Pilot Wire Underground	24.00	2.659	2.659	-
Civil Works at 33 kV & 66 kV Substations		0.317	0.317	-
Civil Works at 132 kV Substations		0.978	0.978	-
Wayleaves/Easements/Land Purchase		0.835	0.835	-
Other Costs (Identify Below)		0.909	0.909	-
Total Costs		**15.004**	**15.004**	**-**
Associated protection, control or SCADA equipment located at a site				
Environmental considerations				

5.4 Option 2 - New ±10MVAr STATCOM at Newtown and 33kV circuit reconfiguration at Morda

This option involves installation of a ±10MVAr STATCOM at STATCOM and a new 33kV circuit looping Morda primary substation between Llansilin and Coney Green, along with switchboard replacement at Morda.

Table 5-7 shows the scheme summary and cost apportionments. Figure 5-4 shows the required works.

Table 5-7: Option 1 summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
Circuit & Substation	Newtown-Morda 33kV Reinforcement	1.Installation of ±10MVAr STATCOM with associated 33/11kV transformer at Newtown 33kV substation and extending outdoor 33kV switchboard with one breaker. 2. Establishing new circuit between Morda - Llansilin and Morda - Coney Green via 2x1.25km 400Sqmm XLPE AL Cable by looping into existing 33kV Coney Green - Llansilin circuit. 3. Replacement of existing outdoor 33kV board with 6-Panel indoor 33kV board at Morda.	£5.4741	-

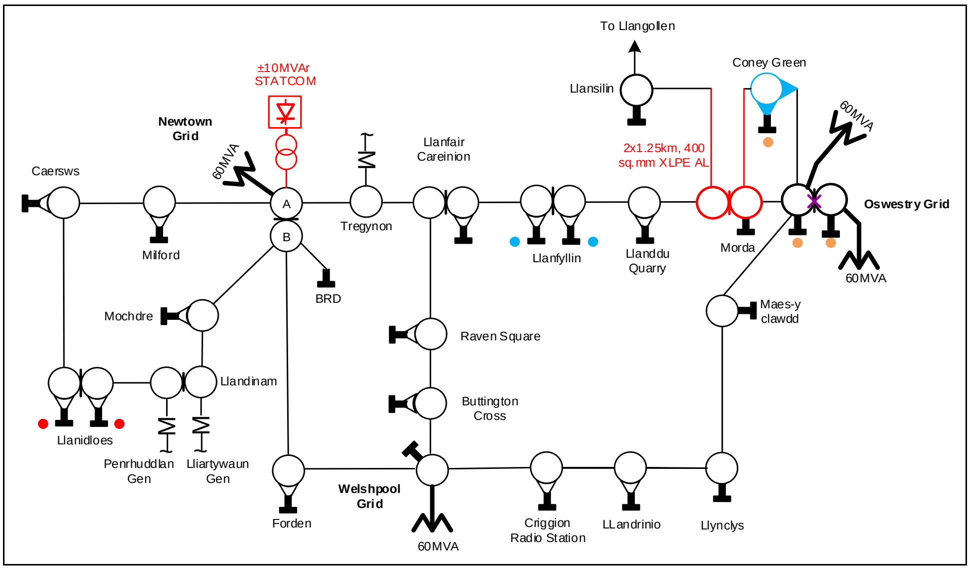


Figure 5-4: Proposed works under Option -2

Table 5-8: Costs and Volumes for Option 1

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.05	0.010	0.010	-
6.6/11kV CB (GM) Primary	1	0.028	0.028	-
33kV UG Cable (Non-Pressurised)	2.55	0.650	0.650	-
33kV CB (Air Insulated Busbars)(OD) (GM)	1	0.050	0.050	-
33kV CB (Gas Insulated Busbars)(ID) (GM)	6	0.747	0.747	-
33kV Transformer (GM)	1	0.309	0.309	-
Batteries at 33kV Substations	1	0.009	0.009	-
Pilot Wire Underground	2.50	0.290	0.290	-
±10MVAr STATCOM at Newtown	1	2.500	2.500	
Civil Works at 33 kV & 66 kV Substations	-	0.353	0.35	-

Wayleaves/Easements/Land Purchase	-	0.074	0.07	-
Other Costs	-	0.214	0.214	-
Total Cost (£m)		5.474	5.474	-
Associated protection, control or SCADA equipment located at a site				
Environmental considerations				

5.5 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5-9.

Table 5-9: Costs summary for considered options

Options	Solution Costs(£m)
Baseline – New grid infeed at Newtown and new 33kV circuits	£15.746
Option 1- New grid infeed at Welshpool and new 33kV circuits	£15.004
Option 2 – Innovation – STATCOM and 33kV circuit reconfiguration	£5.4741
Option 3 – Innovation – STATCOM and MSC	£3.994

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 Option 3, to install a ±10MVAr STATCOM at Newtown and 5MVAr MSC at Morda to mitigate the voltage (steady state & step) issues in the group. The adopted solution is enduring, provides an additional uplift of 15MVA to the group and meet the demand growth in the group beyond RIIO-ED3.

6.2 Cost Benefit Analysis

A cost-benefit analysis was carried out to compare the NPV of the four options discussed in the previous sections. Considering the lowest forecast capital expenditure, the proposed option has the highest total NPV and represents the lowest-cost option when other operational costs are included in the analysis. Based on the outcome of the CBA, the proposed option is to install reactive compensation, in the form of ±10MVAr STATCOM at Newtown with 5MVAr MSC at Morda is selected. The summary of the cost benefit analysis is presented in Table 6-1.

The detailed costing of each of the options is provide in the cost benefit analysis document, "ED2-LRE-SPM-010-CV1-CBA – Newtown-Morda 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
Baseline – New GT at Newtown and 33kV circuit between Oswestry – Morda	Rejected	Discounted based high reinforcement cost.	-	-	-	-
Option1 -New GT at Welshpool and 33kV circuits between Welshpool – Newtown and Oswestry -Morda	Rejected	Discounted based high reinforcement cost.	0.64	0.78	0.85	0.91
Option2 – STATCOM at Newtown and circuit reconfigurations between Morda – Coney Green and Morda – Llansilin	Rejected	Discounted based high reinforcement cost.	5.96	8.03	9.26	10.20
Option3 -10MVAr STATCOM at Newtown and 5MVAr MSC at Morda	Adopted	Enables maximum benefit and value for customers money.	7.09	9.44	10.83	11.88

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 £3.994m.

Table 6-2: Proposed solution costs

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution(£m)
6.6/11kV UG Cable	0.05	0.006	0.006
6.6/11kV CB (GM) Primary	1.00	0.028	0.028
33kV UG Cable (Non-Pressurised)	0.10	0.024	0.024
33kV CB (Air Insulated Busbars) (OD) (GM)	2.00	0.117	0.117
33kV Switch (GM)	1.00	0.047	0.047
33kV Transformer (GM)	1.00	0.314	0.314
Batteries at 33kV Substations	1.00	0.009	0.009
Flexible Services	-	0.288	0.288
Civil Works at 33 kV & 66 kV Substations	-	0.227	0.227
Wayleaves/Easements/Land Purchase	-	0.030	0.030
±10MVAr STATCOM at Newtown	1	2.500	2.500
5MVAr MSC at Morda - £0.25m	1	0.250	0.250
Other Costs (Identify Below)	-	0.154	0.154
	Total Costs	**3.994**	**3.994**
Associated protection, control or SCADA equipment located at a site and remote ends if applicable - £104k			
Environmental considerations and Design & Engineering Studies – £50k			

Table 6-3: Cost incidence over the RIIO-ED2 period

Investment category	Total	Incidence (£m)				
	(£m)	2023/24	2024/25	2025/26	2026/27	2027/28
CV1 – Primary reinforcement	**3.707**	0.371	0.741	0.741	0.927	0.927
CV1 – Flexible Services	**0.288**	0.039	0.058	0.074	0.117	-
Total Cost(£m)	**3.994**	0.410	0.799	0.815	1.044	0.927

6.4 Risks

The Legacy/Newtown/Oswestry/Welshpool 33kV network group is a sizeable both in terms of geographic expanse and customer base. As the group is forecast to experience both steady state and voltage step issues, the adopted option is a reactive compensation scheme through STATCOM and MSC installations to mitigate the issue.

STATCOM technology is well developed, has a technology readiness level of 9 (TRL9), however it is not part of BaU in SPEN networks. MSC's are also very well-established technologies and there are few MSC installations in the SPM network. The business will actively engage with the OEM suppliers and train relevant personnel for operational and maintenance.

Both Newtown Grid and Morda primary substations has 33kV AIS switchgear and there is ample space within the substations, so the installation does not require additional civil costs (e.g. building extensions etc).

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 driver for this investment is steady state and voltage step issues on the network around Newtown grid substation and at primaries namely, Caersws, Llandinam, Llandu Quarry, Llanfair

Caereinion, Llanfyllin, Llanidloes, Milford, Mochdre and Morda which will be beyond operational management mainly due to the additional demand growth and LCT uptake. The investment does not have a strong reliance on environmental benefits.

6.6.2 Payback Periods

The CBA indicates that a positive NPV result in all assessment periods (10, 20, 30 & 45 years). As the intervention is forecast to carry at least a 45-year asset life expectancy, the positive 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 has been tested against and has been found to be consistent with the network requirements determined in line with the section 9 of the Electricity Act and License Condition 21. Additionally, the proposed option is consistent with the SPENs DSO vision and future network strategy.

For the Legacy/Newtown/Oswestry/Welshpool 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 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	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	16,031	12,515	22,895	25,972	23,181	16,031	25,202	22,981	22,981
HPs	11,278	10,598	15,178	21,570	12,683	11,232	13,419	12,236	12,082

** 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									R^1					
Consumer Transformation								R^1						
Leading the Way								R^1						
Balanced Net Zero								R^1						R^2
Headwinds									R^1					
Widespread Engagement							R^1						R^3	
Widespread Innovation							R^1							R^2
Tailwinds							R^1							R^2

R^1 – Proposed Option - Reactive Compensation (±10MVAr STATCOM & 5 MVAr MSC)
R^2 – Additional 33kV interconnection
R^3 – Additional 132/33kV grid infeed

The proposed 'smart' solution is expected to provide sufficient capacity to cater for network requirements beyond RIIO-ED2 and well into ED3 across all scenarios. The timing of the RIIO-ED2 requirement is sensitive to the volume of LCT uptakes but is required by the end of RIIO-ED2 in all scenarios.

A collaborative Whole Systems planning approach is required to identify the optimal long-term Distribution/Transmission solutions to upgrade the mid-Wales networks to meet long term demand and generation requirements and be Net Zero ready.

Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	3.994	0
Comment	Proposed option.	N/A

6.6.4 Asset Stranding Risks & Future Asset Utilisation

Electricity generation, demand and system transfers are forecast to increase under all scenarios. The stranding risk is therefore considered to be very low. It has been assessed that the preferred option is consistent with the future generation and demand scenarios and that the risk of stranding is very low.

6.6.5 Losses / Sensitivity to Carbon Prices

Losses have been considered in accordance with License 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. Network losses have not been evaluated as part of optioneering the optimum solution for the scheme. As the proposed scheme involves reactive compensation equipment which is primarily to support the voltage issues in the grid group, the impact of the voltage support on the network losses involves a complex network analysis. As such. the detailed losses assessment will be carried out during the design stage of the proposed scheme.

6.6.6 Whole Systems Benefits

Whole system benefits have been considered as part of this proposal as the recommended solution enables to create additional thermal headroom in the group and addresses the thermal overloads in the group.

6.7 Environmental Considerations

6.7.1 Operational and embodied carbon emissions

Delivery of the adopted scheme has the potential impact on the embodied carbon resulting from the delivery of the programme. There is likely to be little or no impact on SPEN's Business Carbon Footprint (BCF).

During the evaluation of the options associated with Voltage issues in the Newtown grid group, , 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.

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
For us to take full account of the sustainability impacts associated of the DB adopted scheme we need access to reliable data from our suppliers. The need for carbon and other sustainability credentials to be provided now forms part of our wider sustainable procurement policy.

6.7.3 Resource use and waste
The adopted scheme 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).

6.7.4 Biodiversity/ natural capital
The adopted scheme will only affect a single named site containing existing assets. Therefore, the impact on, and the opportunity to improve biodiversity and natural capital is expected to be minimal.

6.7.5 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.

6.7.6 Visual amenity
SPEN continually seeks to reduce the landscape and visual effects of our networks and assets but recognises that the nature of our substations makes it challenging to minimise their visual impact.

6.7.7 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.

7 Conclusion
The Newtown and Morda areas of the SP Manweb network lie within the Legacy/Newtown/ Oswestry 33kV group which supplies over 69,035 customers predominantly fed from long overhead line circuits. The group is presently at voltage limits and at risk of marginal voltage excursions outside of statutory limits, it is presently being operationally managed.

The adopted option is a strategic and innovative solution, proposed to install reactive power compensation devices at Newtown Grid and Morda primary substations in the RIIO-ED2 period in order to mitigate the voltage violations and maintain the steady state voltage of the 33kV network to within ±6% of the declared voltage under the ESQCR 2002 and maintain voltage step within ±10%.

The proposed solution represents the lowest cost and most efficient engineering solution to meet the forecast demand growth when compared with the alternative schemes identified.
The recommended solution comprises:
- Installation of 33kV, ±10MVAr STATCOM at Newtown Grid substation, this will require a 33/11kV step up transformer and a dedicated outdoor circuit breaker.
- Installation of 33kV, 5MVAr MSC at Morda and a dedicated outdoor circuit breaker
- Procure flexible services to manage network risk during scheme delivery.

As the voltage step issues cannot be mitigated through flexibility as the mitigation need to be fast acting in real-time, it is proposed to use flexibility services to minimize the network risk and support during the project delivery. We will continue to tender for flexibility services in this area to test the market for technically compliant flexibility solutions to resolve this complex voltage constraint.

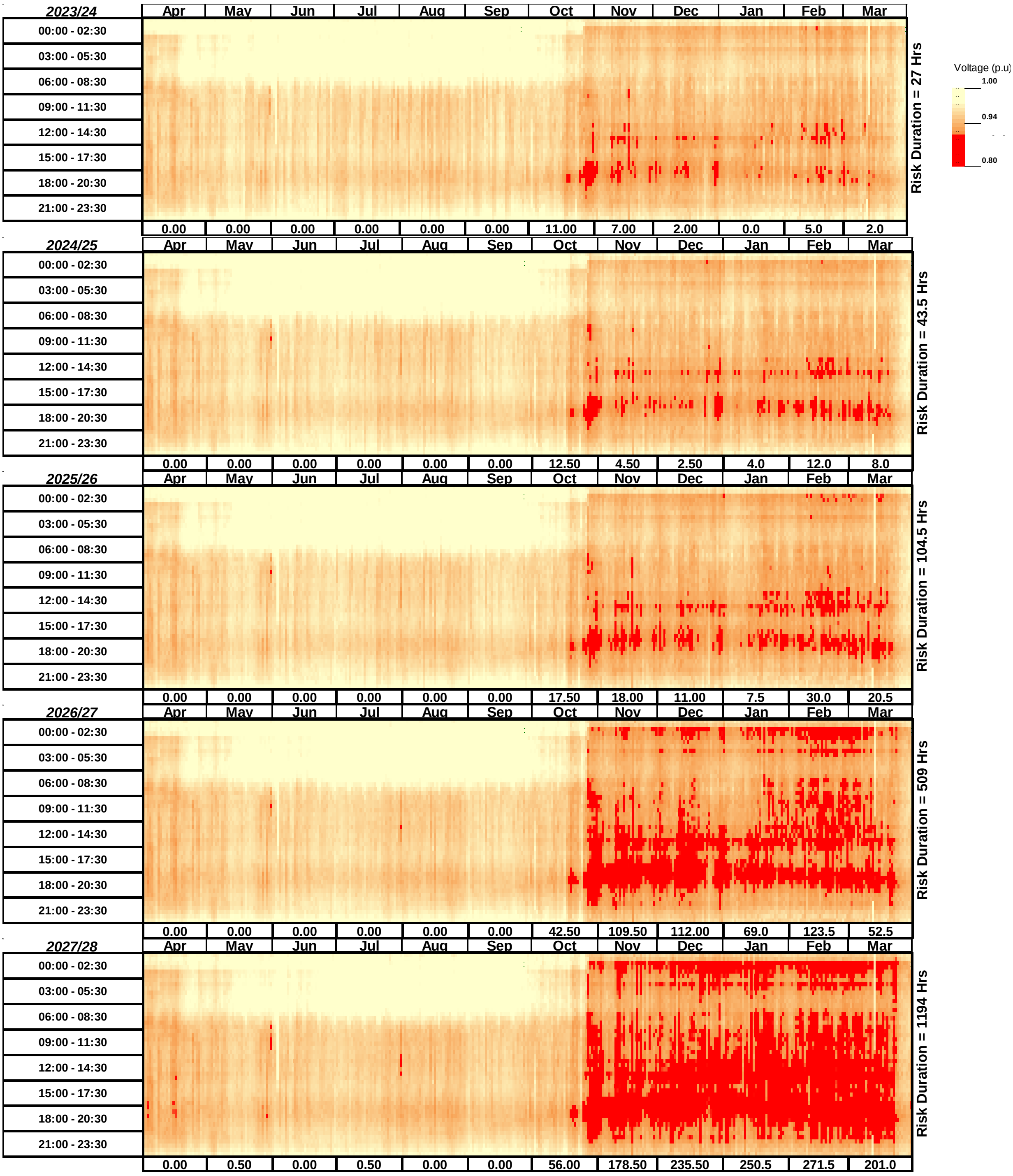
Total scheme cost – £3.994m (2020/21 prices), fully funded by SPEN in the RIIO-ED2 period. The scheme is expected to provide thermal headroom of 15MVA, which will be claimed at the end of the project delivery.

It is proposed to start the works in 2023/24 and the capacity release of 15MVA between the two 33kV groups will be claimed in 2027/28 at the end of the project. The timing of the project is based on delivering the highest NPV, while managing the network risk via operational management through flexibility services during project delivery.

8 Appendices

8.1 Profile based study results

The post operational management voltages calculated based on half hourly profile-based simulations using historical SCADA data are shown below:



8.2 Sites and proposed equipment

8.2.1 Newtown Grid substation

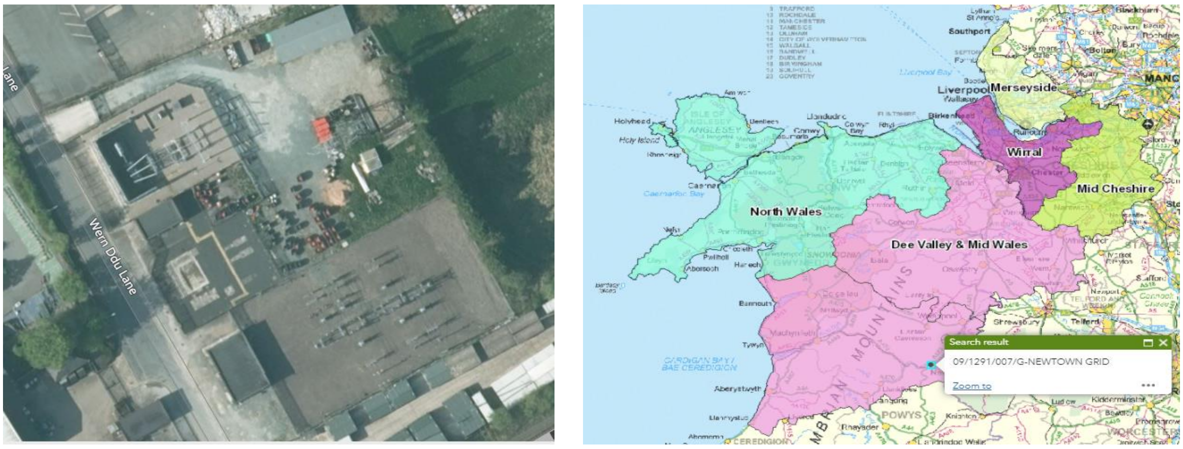


Figure 8-1: Newtown grid substation layout and location

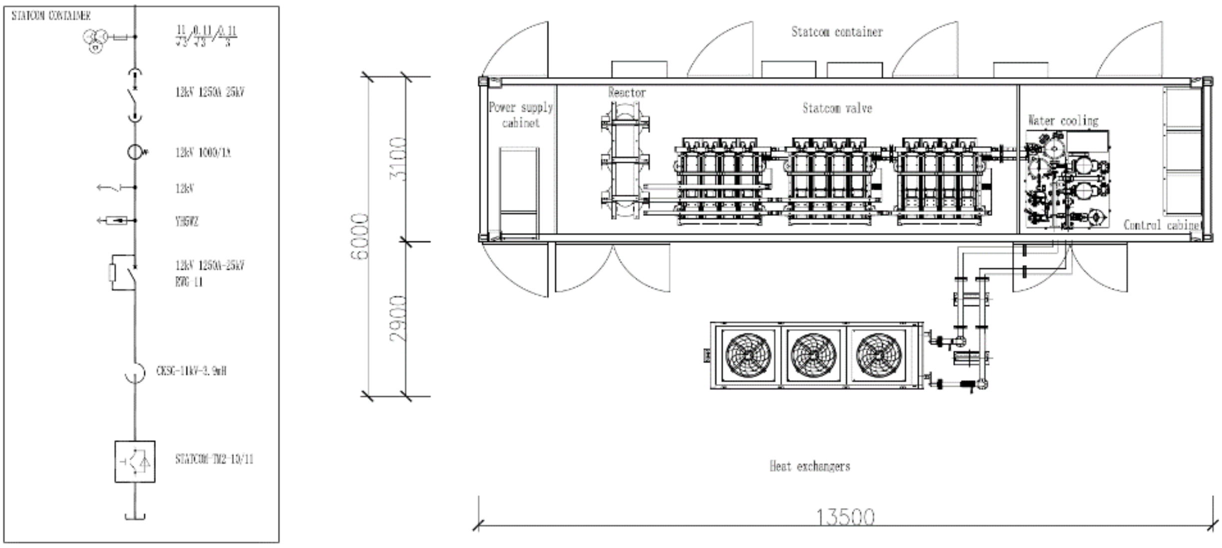


Figure 8-2: STATCOM single line diagram and layout

8.2.2 Morda Primary Substation

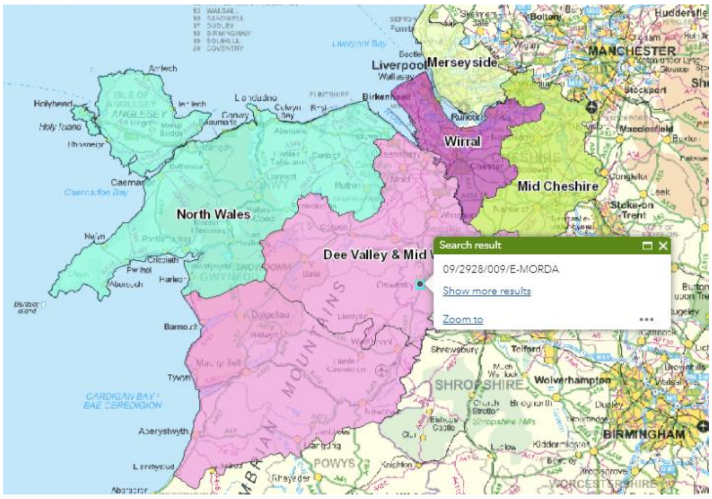


Figure 8-3: Morda primary substation layout and location

Figure 8-4: Typical arrangement of Enclosed Capacitor Bank

8.3 STATCOM Datasheet

STATCOM Datasheet	
Rated capacity	10Mvar
Nominal voltage level	11kV
Ambient temperature	-20~+50°C
Relative humidity	100%
Cooling	Water cooled
Maximum continuous operating capacity	11Mvar
Temporary overload capacity (10s)	12Mvar
Minimum operating voltage capability	0.2 pu. / 10s
Step-change response	<100ms
Maximum overshoot	<10%
Continuous Operating frequency range	47~53Hz
Installation Type	Container（Valve & control container） Valve container size：13500*3100*3000mm (LWH) Valve container weight：22t
STATCOM Controller	
Controller	Digital programmable controller using RXHK HUIC Control System
Control Modes	Slope based voltage controller, Constant Reactive Power, LVRT, HVRT
Reference voltage	0.9pu – 1.1pu
Slope	1.0%-5.0% (0.1% steps)
STATCOM Valve	
No. of Phase Branches per Valve	3
Rated STATCOM reactive power	±10 MVAr
Nominal frequency	50 Hz
Nominal voltage level	11kV
Three phase converter type	Y (Star)
Rated Current (phase)	0.525kA
Series Number of Power Module per phase	5
Redundancy of Power Module per phase	1
TOTAL number of Power Modules per phase	6
The frequency of PWM switching of PP-IGBT	350Hz
Short-term overload	[1.2x 10s] depending on overload selection
Insulation to Earth	17.5kV
STATCOM Power Module	
Power Module nominal DC voltage	2200-2650 V
Power Module nominal AC output voltage (RMS)	1540-1874V
PM maximum DC voltage	3000 V
No of IGBT per PM	4
No of DC capacitor per PM	1
PM total weight	230kg
PM power block weight	100kg
PM DC capacitor weight	90kg
IGBT Ratings	
V_{CE}	4500 V
I_{CP}	3000 A
DC Capacitor	
Rated Capacitance	4000 μF
Rated Voltage	2800 V
Maximum rms current	750 A
1.15pu Overvoltage	30 minutes
1.3pu Overvoltage	1 minute
STATCOM Cooling	
Type of cooling	Closed loop deionised water with forced air external heat exchanger. No make-up needed for normal cooling operation. Integrated deionisation loop.
Material	304 and 316L
Pumps	Main and standby centrifugal main pump
Heat exchangers	1 heat exchangers each with 3 fans.
STATCOM Protection	
Main Protection (RXHK HUIC Controller)	Over-current, Differential current, Controller fault, Communication Fault, Loss of synchronization fault, emergency stop, bypass fault, HV switch abnormal operation fault, overvoltage, undervoltage. Breaker failure
Backup Protection (by others)	Feeder over-current, earth-fault, breaker failure.
STATCOM Auxiliary Supplies Required	
LVAC (single or dual)	3-phase, 50Hz, 415V,
LVDC (dual supplies)	110VDC,
Capacity Required	LVAC 30kVA LVDC 10A
STATCOM SCADA Interface	
Local HMI	Included as panel mounted IPC with screen and keyboard
Remote SCADA	TCP/IP via Fibre IEC104/IEC61850/DNP3/Modbus
STATCOM Maintenance	
Routine Service	Annual
Time to replace failed module	2hrs