Middlewich Primary Reinforcement

ED2 Engineering Justification Paper

ED2-LRE-SPM-027-CV1-EJP

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

Scheme Name	Middlewich Primary Reinforcement		
PCFM Cost Type	Load Related Expenditure		
Activity	Primary reinforcement		
Primary Investment Driver	Thermal constraints		
Reference	ED2-LRE-SPM-027-CV1		
Output Type	Load Index		
Cost	£2.088m		
Delivery Year	2024-2026		
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**
	£m	**£2.088m**	**£m**

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:	**Middlewich Primary Reinforcement**
Project Reference:	**ED2-LRE-SPM-027-CV1**
Decision Required:	**To give concept approval for installation of new 33/11kV 10MVA transformer at Middlewich and transferring Morrisons primary into Lostock - Gadbrook 33kV circuit.**

Summary of Business Need:

The Middlewich primary substation comprises of 1 x 7.5MVA 33/11kV transformer which is supplied from the 33kV Elworth/Knutsford grid group. The Middlewich primary network group supplies over 2489 customers predominantly domestic customers. The 11kV group network is normally operated split from the adjacent primary group network. The existing firm capacity of the Middlewich primary group is 7.5MVA and the present load index position is LI1 with loading at 68% of the group capacity.

HS2 Phase 2B line will have a crossing point to the west of Middlewich and it is anticipated to supply around 1.5MVA to 2MVA of the HS2 construction supplies from the Middlewich primary group. Also, within in RIIO-ED2, DFES forecasts over 794 Electric Vehicles and 332 Heat Pumps. There will also be significant industrial demand growth around the Middlewich/Midpoint industrial estate with 2.7MVA accepted demand connections.

Detailed network assessments indicate that with the additional demand within RIIO-ED2, the loading on the 33/11kV 7.5MVA transformer at Middlewich and 33kV circuits between Knutsford-Lostock and Elworth-RHM Foods would exceed the thermal capacity.

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

Proposed works include:

- Extension of the 33kV switchboard at Middlewich and installation of new 33/11kV 10MVA Primary transformer.
- Replacement of the existing 11kV Oil Circuit Breakers with New 11kV board.
- Transferring Morrisons primary substation into Lostock – Gadbrook 33kV circuit and re-routing the existing 33kV Lostock – Morrisons circuit to Middlewich.
- Contract flexibility services to manage the network risk through the delivery stage at a cost of £3k.

It is proposed to start the works in 2023/24 and the release capacity of 2.5MVA will be claimed in 2025/26 at the end of the project. The estimated cost for the above is £2.088m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

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

License Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CV1	Primary Reinforcement	**2.085**	0.625	1.042	0.417	-	-
SPM	CV1	Flexible Services	**0.003**	0.001	0.002	-	-	-
		Total Solution Cost(£m)	**2.088**	0.626	1.044	0.417	-	-
This Proposal								

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 Middlewich primary substation comprises of 1 x 7.5MVA 33/11kV transformer which is supplied from the 33kV Elworth/Knutsford grid group. The Middlewich primary network group supplies over 2489 customers predominantly domestic customers. The 11kV group network is normally operated split from the adjacent primary group network.

The existing firm capacity of the Middlewich primary group is 7.5MVA and the present load index position is LI1 with loading at 68% of the group capacity.

HS2 Phase 2B line will have a crossing point to the west of Middlewich and it is anticipated to supply around 1.5MVA to 2MVA of the HS2 construction supplies from the Middlewich primary group. The 33kV network around Middlewich is shown in Figure 1.

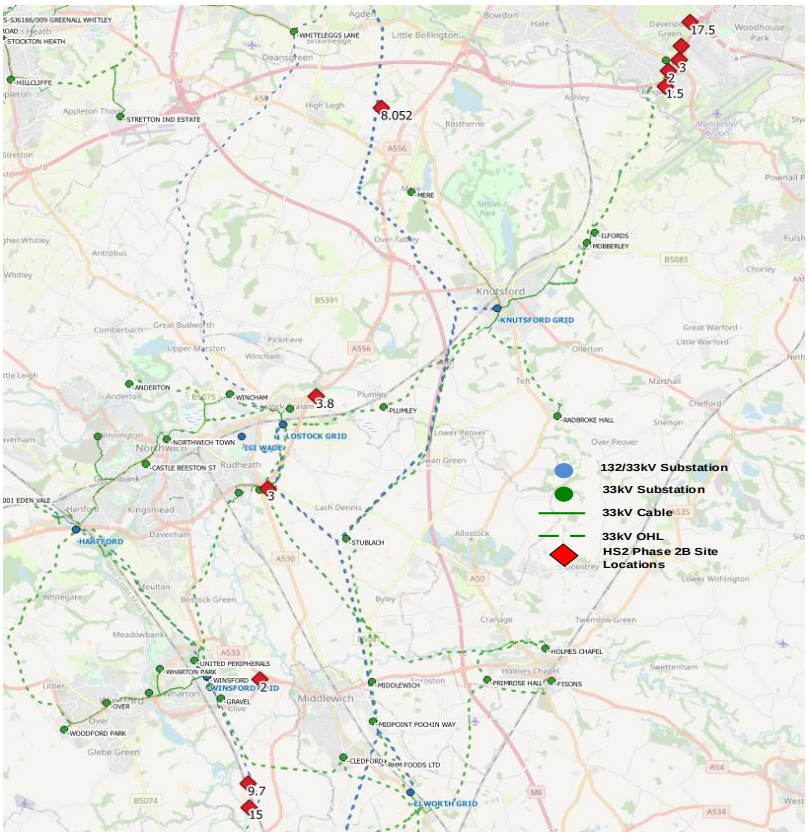

Figure 1. SPM network area around Middlewich

The Distribution Future Energy Scenarios (DFES) for this group under the baseline scenario forecast a significant number of LCTs including 794 Electric Vehicles and 332 Heat Pumps, the total demand of 8.4MVA by the end of RIIO-ED2 period.

Detailed network studies indicate that with the additional demand within RIIO-ED2 period, the loading on the 33/11kV 7.5MVA transformer at Middlewich and 33kV circuits between Knutsford-Lostock and Elworth-RHM Foods would exceed the thermal capacity. In order to secure supplies within the group, as per EREC P2/7, to meet the licence obligation for maintaining economic, efficient and coordinated network, to accommodate future demand growth within the area, it is proposed to mitigate the thermal constraint in the Middlewich group by installing an additional primary transformer at Middlewich.

Summary of the proposed scheme:

- Extension of the 33kV switchboard at Middlewich and installation of new 33/11kV 10MVA Primary transformer.
- Replacement of the existing 11kV Oil Circuit Breakers with New 11kV board.
- Transferring Morrisons primary substation into Lostock – Gadbrook 33kV circuit and re-routing the existing 33kV Lostock – Morrisons circuit to Middlewich.

It is proposed to start the works in 2023/24 and the release capacity of 2.5MVA will be claimed in 2025/26 at the end of the project. The estimated cost for the above is £2.088m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure. 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.

It is recommended to continue annual tendering for flexibility in this area to procure enough capacity and review the scheme depending on future tenders resulting competitive bids enabling to defer the proposed reinforcements.

2 Background Information

2.1 Existing/Authorised Network

The 33kV group feeding Middlewich primary substation is supplied from Elworth/Lostock/Hartford/Knutsford/Winsford grid substations which comprises of total 8 x 132/33kV grid transformers and secures supplies to over 70,863 customers fed from 37 primary transformers.

The 33/11kV Middlewich substation is equipped with 1 x7.5MVA transformer with 2 x 33kV infeed's from Lostock grid via Morrisons and Elworth grid via RHM Foods which is predominantly OHL circuit. The 11kV site is equipped with 6 panel board with 5 circuits supplying over 55 secondary substations with total 2489 customers across the Middlewich town. The 11kV network is operated radially and is split from adjacent primary substation 11kV networks supplied from Cledford, Midpoint Pochin way, and Morrisons. The authorised 33kV and 11kV network around Middlewich primary group is shown in Figure 2.

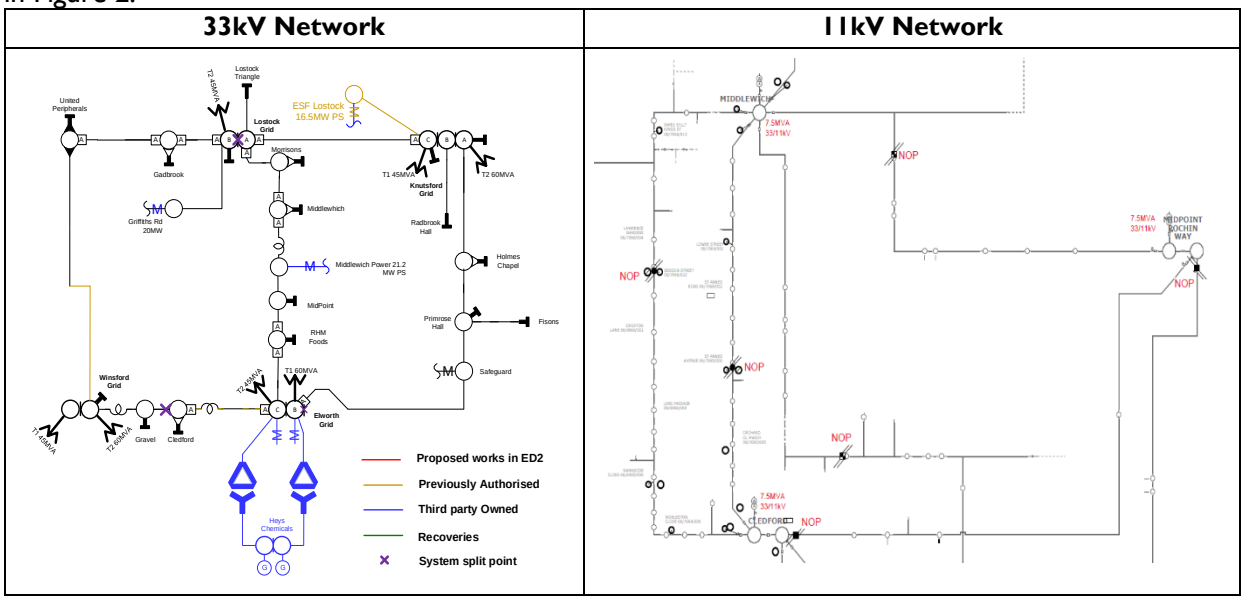

Figure 2. Middlewich 33kV and 11kV network group

2.2 Network supply / circuit capacity

The existing 11kV network group is classed as EREC P2/7 Group B (>1MW and ≤12MW) with the network demand of 4.8MVA against firm capacity of 7.5MVA.

The 11kV network primarily consists of 95 sq. mm AL and mix of 0.05/0.1/0.15 ins CU overheard line conductor (OHL) sections. The networks secondary substations supply a mixture of domestic, commercial, and industrial customers. The neighbouring Cledford, Holmes Chapel and Midpoint Pochin Way 11kV groups are currently operating at 76%, 83% and 25% utilization correspondingly. Table 2.1 shows the existing network supply position of the group.

Table 2.1. Summary of existing Middlewich primary group network

Substation	Customers	Scenario	LI firm capacity (MVA)	Maximum demand (MVA)	Load Index	Class of Supply(P2/7)
Middlewich T1	2489	N-1	7.5	4.8	LI1	B

3 Needs Case

The single primary transformer at Middlewich is rated for 7.5MVA (continuous) and 10MVA (Cyclic). The group's existing firm capacity is 7.5MVA under the loss of the primary transformer (N-1 condition); the limitation is due to the thermal capacity of the underlying 11kV network.

The existing 11kV network is radially operated with split points to the adjacent primary transformer group network. The "Normally Open" points enables to secure the customer supplies during the primary transformer outages, as the load is transferred to the adjacent 11kV groups and vice versa. However, with the authorised demand on the adjacent primary transformers several cable sections are approaching cyclic thermal capacity under the outage. The SPM DFES projections for the Middlewich 11kV group forecast a sizeable number of LCTs including 794 Electric Vehicles and 332 Heat Pumps. The adjacent primary groups will have in total of 1300 EVs and 600 Heat Pumps. Additionally, 1.5MVA to 2MVA of the HS2 construction supply demand is expected to be supported from this group within the RIIO-ED2 period.

There will be insufficient network capacity (thermal) in the 11kV group and the needs case for reinforcement is determined by the magnitude and location of the new demand. This new demand is the sum of the HS2 demand, economic growth and demand from LCT uptake. Given this, the fixed HS2 demand projection along with the known developments/customer connections was added on top of the SPENs future energy scenario projections.

Further in order 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 demand requirements and accommodate future load growth.

3.1 Forecast Demand

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

3.1.1 Local Considerations and stake holder feedback

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

3.1.1.1 HS2

SPEN has engaged extensively with the HS2 to understand the total demand requirements which have been advised as per Table 3.1.

Table 3.1. HS2 total capacity requirements with SPM license area

MVA	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
HS2	-	3.5	7.2	7.2	35	50	72	77	82	82	82	97	97

This demand consists of large supplies for tunnel bore machines (which account for a step increase in demand in early 2025) as well as other construction supplies to be located across the Crewe and Cheshire area of the SPM network.

Table 3.2 shows a breakdown of this HS2 demand by voltage level within the Cheshire plain area. The HS2 demand requirement will impact the network across at all voltage levels.

Table 3.2. HS2 Cheshire plain area demand requirements

GSP Group	EHV Network group	Capacity Requirements (MVA)			
		Phase 2A (11kV)	Phase 2B (33kV)	Phase 2B (11kV)	Total
Carrington / Fiddlers Ferry	**Cheshire Plain** Elworth-Hartford-Winsford-Knutsford-Lostock 33kV Group	-	27.2	25.4	52.6
	TOTAL	**-**	**27.2**	**25.4**	**52.6**

3.1.1.2 SPEN's own experience

Around Crewe and across Cheshire, SPM network has experienced an unprecedented level of demand connection applications and enquiries due to these regional and local growth policies. For example, the Crewe, Nantwich, Alsager, Sandbach, Warrington Town Centre, Warrington electric bus depot, Congleton and Middlewich conurbations have all seen large numbers of housing scheme applications; ongoing stakeholder engagement suggests many more are in the pipeline.

3.1.2 Distribution Future Energy Scenarios

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

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

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

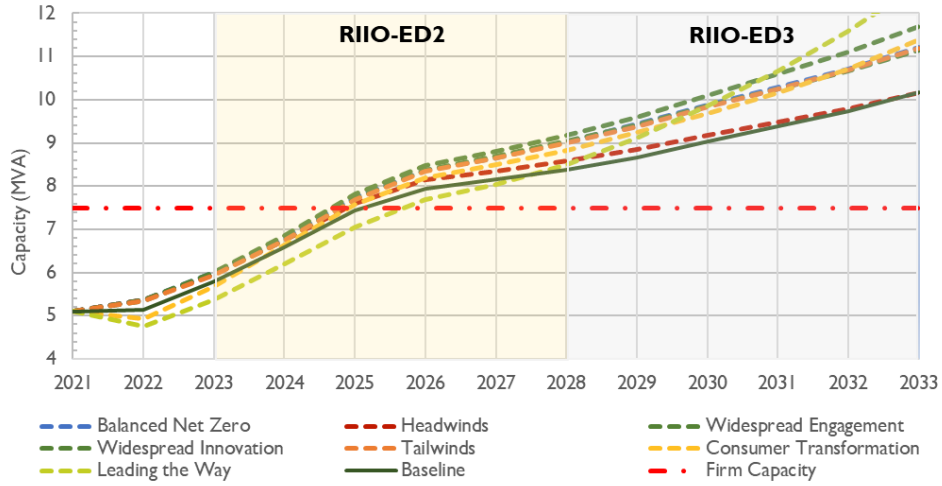

Figure 3. Demand (MVA) forecast for Middlewich primary substation

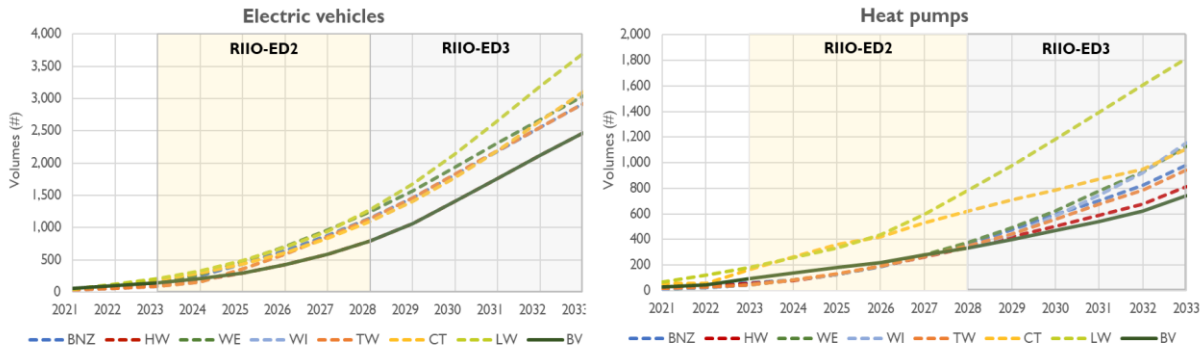

Figure 4. Forecast Electric Vehicle and Heat Pump uptakes for Middlewich primary substation group

3.1.3 Baseline View

For the Middlewich 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 3.3.

Table 3.3. Baseline View forecast

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Forecast Demand (MVA)	5.1	5.1	5.8	6.6	7.4	7.9	8.1	8.4	8.7	9.0	9.4	9.7	10.2
Firm Capacity (MVA)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Utilisation (%)	68	69	77	88	99	106	109	112	116	121	125	130	136
Load Index	LI1	LI1	LI1	LI2	LI4	LI5	LI5	LI5	LI5	LI5	LI5	LI5	LI5

3.2 Network Impact Assessment

Detailed network studies covering network intact and outage (N-1) conditions and fault level assessments were carried out for the upstream 33kV network and 11kV network fed from the Middlewich primary substation considering the different demand forecast scenarios.

The network thermal constraint during the most onerous outage was identified and time profile-based simulations (17,520 half-hourly simulations/year) were performed considering the historical half hourly measured Supervisory control and data acquisition (SCADA) data at primary substation overlaid with the DFES demand forecasts for each year through the RIIO-ED2 price control period. These studies identify the risk in terms of the thermal capacity exceedances with the forecast demand, the anticipated annual hours at risk and risk window of the constraint. The half-hourly studies performed for years starting from 2023 through 2028 determined the risk hours and the capacity required to overcome the constraint by using flexibility services. The key results from the half hourly profile-based simulations are furnished in Appendix 1.

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

3.2.1 Thermal Constraints

Considering the DFES forecast demand and rapid EV charging demand in the group, the thermal constraints that would appear in the RIIO-ED2 period are listed below.

3.2.1.1 Primary Transformer

The primary transformers are rated for 7.5MVA and with the forecast would exceed the group firm capacity of 7.5MVA within the RIIO-ED2 period without any intervention.

3.2.1.2 11kV network

The 11kV network primarily consists of 95 sq. mm AL UGC and mix of 0.1/0.15 sq. in CU OHL sections. Studies indicate that 11kV OHL sections are approaching cyclic thermal capacity under N-1 conditions, with forecast demand growth and are expected to exceed this rating within the RIIO-ED2 period.

3.2.1.3 33kV network

System studies indicate that with additional demand around Middlewich, Morrisons and Midpoint Pochin Way primary group, thermal capacity will exceed the cyclic ratings for following 33kV circuits:

Table 3.4. Thermal constraint on 33kV circuits

33kV Circuit	Voltage (kV)	Outage
Knutsford - Lostock	33	Outage of Elworth – RHM Foods circuit
Elworth – RHM Foods	33	Outage of Knutsford – Lostock circuit

3.2.1.4 Voltage Constraints

There were no voltage constraints identified in the 11kV group network.

3.2.2 EREC P2/7 – Security of Supply

The forecast demand is 8.4MVA by the end of RIIO-ED2 and 10MVA by the end of RIIO-ED3. The forecasted demand will exceed the groups firm capacity during outage scenario. The Cledford, Holmes Chapel and Mid-Point Pochin Way 11kV groups utilisation is forecast to be 82%, 91% and 74% respectively by the end of RIIO-ED3 and these groups will be thermally constrained in picking up the demand from Middlewich under primary transfer outages.

3.2.3 Flexibility services

Our assessments indicate that the risk of thermal overload on the Middlewich primary transformer group network starts from 2025/26 throughout to the year 2028 for the most onerous scenario including an additional 5% for the asset protection margin. In order to manage the network risk and security of supply constraint a max capacity of ca. 1.7MW is required to alleviate the constraints. Based on these requirements, flexibility services were tendered to provide services between 2025/26 – 2027/28 period. Table 3.5 below shows flexibility services in terms of the network risk hours and tendered capacity.

Table 3.5. Network annual hours at risk and flexible capacity tendered

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Annual hours at risk (Hrs)	45	63	121	348	991
Required Flexible Capacity (MW)	0.79	0.84	0.99	1.26	1.67
Qualified Flexible Capacity (MW)	0.26	0.26	2.24	0.46	0.36

4 Optioneering

Table 4.1 shows a summary of the options considered for this reinforcement. Option 1 represents the lowest cost conventional option, i.e. the minimum level of intervention without application of innovation.

Table 4.1. Longlist of solution options

#	Options	Status	Reason for rejection
(a)	No Intervention	Rejected	The overloading will be over the transformer cyclic ratings and would lead to tripping of the transformer and in turn loss of supplies to HS2 and over 4000 customers (including largest adjacent single primary group) with potential CI/CML implications.
(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 33/11kV 10MVA primary substation at King Street, Middlewich and transfer of Morrisons primary substation into Lostock – Gadbrook 33kV circuit.	Considered (**Baseline**)	-
(d)	Installation of second primary transformer at Middlewich and transfer of Morrisons primary substation into Lostock – Gadbrook circuit along with flexibility services to manage network risk during project delivery.	Considered **(Option 1) Proposed Option**	-
(e)	Installation of second primary transformer at Middlewich and establishing 33kV circuit between Middlewich – Knutsford and Middlewich – Holmes Chapel by looping into 33kV circuit between Holmes Chapel - Knutsford.	Considered (**Option2**)	-
(f)	Real Time Thermal Rating of the 33/11kV 7.5MVA Grid Transformer and transfer of Morrisons primary substation into Lostock – Gadbrook 33kV circuit.	Rejected	Considering the thermal loading during the outage being over the cyclic rating of the transformer, installation of RTTR at primary transformer will not provide any capacity uplift to alleviate the constraint.
(g)	Transfer of Middlewich primary demand onto Cledford and Midpoint Pochin Way primary substations along with transfer of Morrisons primary substation into Lostock – Gadbrook 33kV circuit.	Rejected	This option does not alleviate the constraints as Midpoint Point and Cledford demand would be required to be picked up by Middlewich primary substation during outage of either of the primary transformers.
(h)	Permanent interconnection of Middlewich, Cledford and Midpoint Pochin way substation.	Rejected	The 11kV fault levels under this option will be above the plant ratings. Further there will be cross flows through the HV network leading circuit overloads with the Middlewich Power 20MW generation being near to Middlewich primary substation.
(i)	Flexibility Services.	Rejected	Rejected considering limited response to flexibility tenders.

5 Detailed Analysis & Costs

Network studies indicate that with the additional demand from HS2 and LCT uptake across the network thermal loading on the 33/11kV 7.5MVA transformer at Middlewich will exceed the firm capacity along with thermal overloads on 33kV circuits between Knutsford- Lostock and Elworth – RHM Foods. These thermal constraints would lead to loss of supplies to HS2 and over 4000 customers around Middlewich, Cledford and Midpoint Pochin Way with potential IIS (CI/CML) related penalties.

With the initial flexibility tender rounds indicating not enough response to provide flexible capacity in the group, to address the thermal constraints in the group, a conventional build solution is proposed.

5.1 Proposed Option (Option 1) – Install additional primary transformer at Middlewich

The proposed solution is to alleviate the thermal constraints by installation of additional primary transformer at Middlewich. Table 5.1 shows the scheme summary.

Table 5.1. Proposed option summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)
Conventional	Middlewich Primary Reinforcement	• Extension of the 33kV switchboard at Middlewich and installation of additional 33/11kV 10MVA Primary transformer. • Replacement of the existing 11kV Oil Circuit Breakers with New 11kV board. • Transferring Morrisons primary substation into Lostock – Gadbrook 33kV circuit and re-routing the existing 33kV Lostock – Morrisons circuit to Middlewich. • Contract flexibility services to manage the network risk during project delivery.	2.088

With the new primary transformer, the proposed scheme will increase the group's firm capacity from 7.5MVA to 10MVA under the loss of one primary transformer, this would be sufficient to meet the forecast demand within the RIIO-ED2 period. Under intact conditions, the group will be able to support up to maximum of 20MVA. At 33kV the proposed scheme would increase the circuit capacity by 5MVA.

The increase in capacity and cost of flexibility, due to demand growth, was considered against the benefit of deferral in each year of RIIO-ED2. This is assessed using flexibility to manage the constraint while the level and number of risk hours is relatively low, to commission the above proposed works when efficient to do so. The annual reinforcement deferral ceiling cost was calculated to be £81k per year to manage the constraint via flexibility. Summary of anticipated cost of flexibility services from recent round of tenders along with capacity secured is shown in **Error! Reference source not found.**.

Table 5.2. Flexibility consideration in Baseline plan

Year	2023/24	2024/25	2025/26	2026/27	2027/28
Qualified Flexible Capacity (% - Required)	33%	31%	226%	37%	22%
Cost (£m)	0.001	0.002	-	-	-
Flexibility Outlook					

 *Accept bids and support the network during reinforcement delivery*

 *Reject bids and deliver reinforcements*

With the spring flexibility tender round not procuring required capacity, the proposed scheme will help in meeting the future demand and it is proposed to utilize flexibility services to manage the risk during project delivery. It is recommended to continue annual tendering for flexibility in this area to procure enough capacity and the proposed conventional/build solutions will be reviewed depending on procuring enough capacity in the future tenders.

Table 5.3 shows a summary of reinforcement costs and volumes for Baseline option under RIIO-ED2. The proposed works under this option is shown in Figure 5.

Table 5.3. Proposed option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.10	0.012	0.012	-
6.6/11kV CB (GM) Primary	8.00	0.222	0.222	-
33kV UG Cable (Non Pressurised)	0.80	0.194	0.194	-
33kV CB (Air Insulated Busbars)(OD) (GM)	2.00	0.117	0.117	-
33kV Switch (GM)	5.00	0.237	0.237	-
33kV Transformer (GM)	1.00	0.314	0.314	-
Batteries at 33kV Substations	1.00	0.009	0.009	-
Pilot Wire Underground	0.80	0.089	0.089	-
Flexible Services	-	0.003	0.003	-
Civil Works at 33 kV & 66 kV Substations		0.512	0.512	-
Wayleaves/Easements/Land Purchase		0.184	0.184	-
Other Costs (Identify Below)		0.196	0.196	-
Total Costs		**2.088**	**2.088**	**-**
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control or SCADA equipment located at a site and remote ends (Morrisons, Lostock, Gadbrook) - (£85k)				
Environmental considerations, survey and studies (£17k)				
Planning and Design Studies (£50k)				
11kV NCP (£44k)				

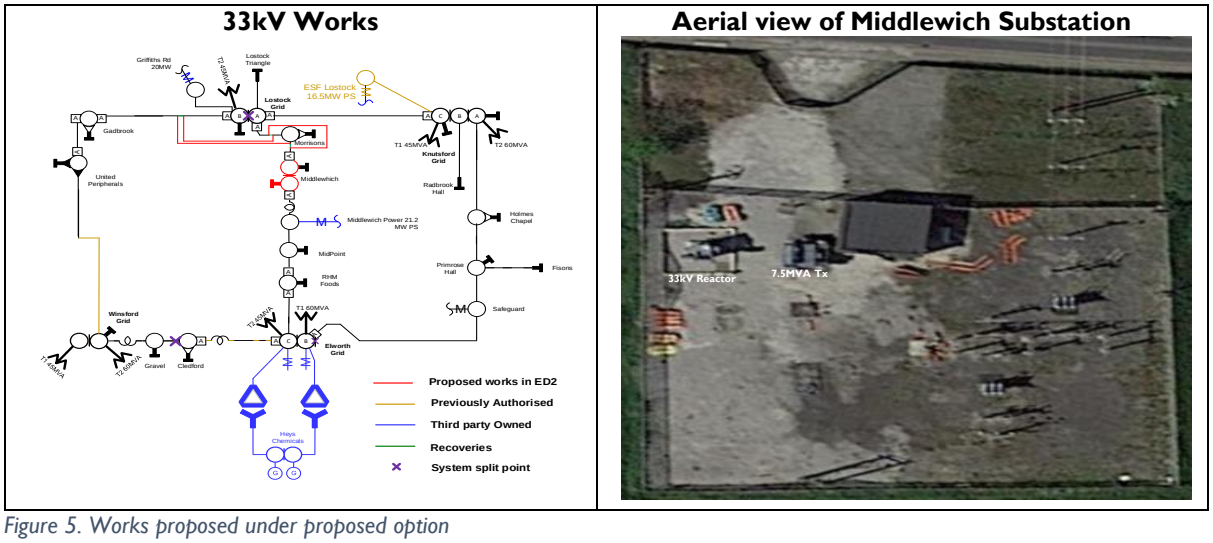

Figure 5. Works proposed under proposed option

5.2 Baseline – New 33/11kV substation at King Street

This option considers establishment of a new 33/11kV 10MVA primary substation at a new site preferably at King Street along with new 11kV interconnector to Middlewich.

This option would provide 2.5MVA additional network capacity and would prevent thermal overloading on Middlewich primary substation group. At 33kV the proposed scheme would increase the circuit capacity by 5MVA.

This option is rejected due its relatively high cost and does not represent a minimum level of intervention required to alleviate the network constraint. Table 5.4 shows the scheme summary.

Table 5.4. Baseline option scheme summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)
Conventional	Middlewich Primary Reinforcement	• Establish new 1 x 10MVA 33/11kV primary substation at King Street • 2 x 3kms 33kV 400Sqmm XLPE AL Cable looped into Holmes Chapel to Knutsford circuit. • 11kV interconnectors between King Street to Middlewich. • Extend 11kV switchboard at Middlewich.	4.502

Table 5.5 shows a summary of reinforcement costs and volumes for Baseline option under RIIO-ED2. The proposed works under this option is shown in Figure 5.

Table 5.5. Baseline option summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	2	0.235	0.235	-
6.6/11kV CB (GM) Primary	9	0.250	0.250	-
33kV OHL (Pole Line) Conductor	0.10	0.003	0.003	-
33kV Pole	1	0.003	0.003	-
33kV UG Cable (Non-Pressurised)	6	1.456	1.456	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	3	0.511	0.511	-
33kV Transformer (GM)	1	0.314	0.314	-
Batteries at 33kV Substations	1	0.009	0.009	-
Pilot Wire Underground	6	0.665	0.665	-
Civil Works at 33 kV & 66 kV Substations		0.450	0.450	-
Wayleaves/Easements/Land Purchase		0.357	0.357	-
Other Costs (Identify Below)		0.250	0.250	-
Total Costs		**4.502**	**4.502**	**-**
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control or SCADA equipment located at a site and remote ends - (£105k)				
Environmental considerations, survey and studies (£50k)				
Planning and design studies (£52k)				
11kV NCP (£33k)				
Noise survey and abatement costs(£10k)				

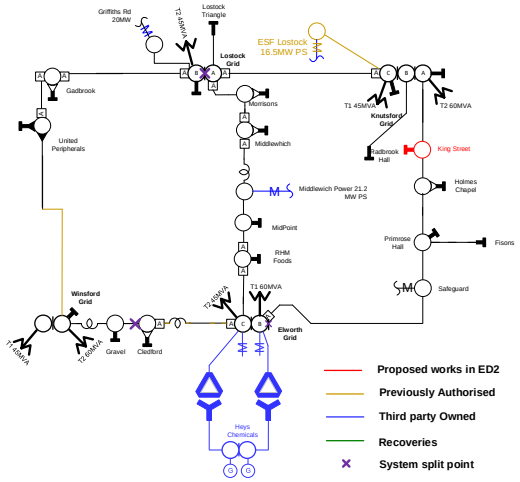

Figure 6 Baseline option 33kV and 11kV works

5.3 Option 2 – New transformer at Middlewich and 33kV circuit

This option considers installation of a new 33/11kV 10MVA primary transformer at existing Middlewich substation and along with 33kV interconnection to Middlewich by looping into Holmes Chapel to Knutsford circuit.

This option would provide 2.5MVA additional network capacity and would prevent thermal overloading on Middlewich primary substation group. At 33kV the proposed scheme would increase the circuit capacity by 4MVA.

This option is rejected due its relatively high cost and does not represent a minimum level of intervention required to alleviate the network constraint. Table 5.6 shows the scheme summary.

Table 5.6. Option 2 scheme summary

Category	Scheme Name	Scheme Summary	RIIO-ED2 Contribution (£m)
Conventional	Middlewich Primary Reinforcement	• Establish additional 1 x 10MVA 33/11kV primary substation at Middlewich • 2 x 2.5kms 33kV 400Sqmm XLPE AL Cable looped into Holmes Chapel to Knutsford circuit. • Replacement of 33kV outdoor board with 7 panel indoor board • Replacement of the existing 11kV Oil Circuit Breakers with New 11kV board.	4.536

Table 5.7 shows a summary of reinforcement costs and volumes for Option 2 under RIIO-ED2. The proposed works under this option is shown in Figure 5.

Table 5.7. Option 2 summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.10	0.012	0.012	-
6.6/11kV CB (GM) Primary	8	0.222	0.222	-
33kV UG Cable (Non-Pressurised)	5	1.213	1.213	-
33kV CB (Gas Insulated Busbars) (ID) (GM)	7	1.193	1.193	-
33kV Transformer (GM)	1	0.314	0.314	-
Batteries at 33kV Substations	1	0.009	0.009	-
Pilot Wire Underground	5	0.554	0.554	
Civil Works at 33 kV & 66 kV Substations		0.575	0.575	-
Wayleaves/Easements/Land Purchase		0.203	0.203	-
Other Costs (Identify Below)		0.242	0.242	-
Total Costs		**4.536**	**4.536**	-
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control or SCADA equipment located at a site and remote ends - (£105k)				
Environmental considerations, survey and studies (£49k)				
Planning and design studies (£55k)				
11kV NCP (£33k)				

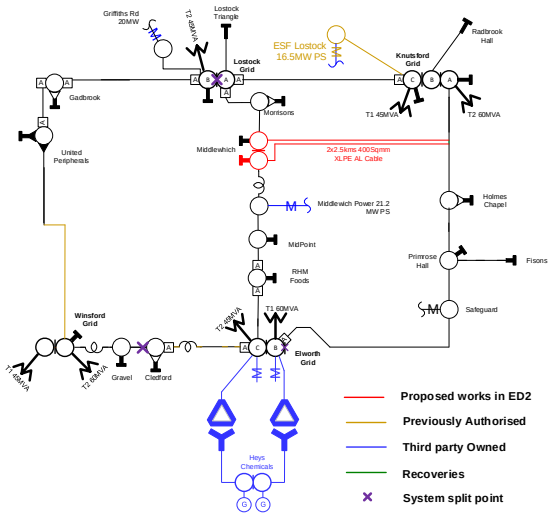

Figure 7 Option 2 33kV and 11kV works

5.4 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.8.

Table 5.8. Cost summary for considered options

Options	Option Summary	RIIO-ED2 Cost (£m)
Baseline	New 7.5/10MVA primary transformer substation at King Street and 11kV circuit interconnection to transfer demand from Middlewich.	4.502
Option 1 (Proposed)	Install additional 7.5/10MVA primary transformer at Middlewich and 33kV circuit reconfiguration and contract flexibility services to manage the network risk during project delivery.	2.088
Option 2	Install additional 7.5/10MVA primary transformer at Middlewich and new 33kV circuit to Middlewich.	4.536

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

6 Deliverability & Risk

6.1 Preferred Options & Output Summary

The adopted option is to install additional primary transformer at Middlewich along reconfiguration of 33kV circuit by transferring Morrisons primary substation into Lostock – Gadbrook 33kV circuit and re-routing the existing 33kV Lostock – Morrisons circuit to Middlewich. It is also proposed to contract with flexibility services providers from 2023/24 to 2024/25 which will enable to manage the risk during project delivery. The proposed reinforcement works are to be started in 2023/24 and the capacity release will be claimed in 2025/26 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.

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 against other options. The summary of the cost benefit analysis is presented in Table 6.1. The full detailed CBA is provided within 'ED2-LRE-SPM-027-CV1-CBA – Middlewich Primary Reinforcement'.

Table 6.1. Cost benefit analysis results

Options considered	Decision	Comment	NPVs based on payback periods, £m (2020/21 prices)			
			10 years	15 years	30 years	45 years
Baseline – New primary substation at Kind Street	Rejected	Discounted based on higher scheme cost and lower NPV against proposed option.	-	-	-	-
Alternate Option1 - Additional Transformer at Middlewich and 33kV circuit reconfiguration	**Adopted**	The proposed scheme is the least cost solution to accommodate forecasted demand from LCT Uptake.	£1.94	£2.43	£2.72	£2.95
Alternate Option2 - Additional Transformer at Middlewich and new 33kV circuit	Rejected	Discounted based on higher scheme cost and lower NPV against proposed option.	£0.57	£0.56	£0.56	£0.55

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 £2.088m.

Table 6.2: Summary of reinforcement costs and volumes

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
6.6/11kV UG Cable	0.10	0.012	0.012	-
6.6/11kV CB (GM) Primary	8.00	0.222	0.222	-

Asset Description	Volumes	Prime Costs (£m)	RIIO-ED2 Contribution (£m)	Customer Contribution (£m)
33kV UG Cable (Non-Pressurised)	0.80	0.194	0.194	-
33kV CB (Air Insulated Busbars) (OD) (GM)	2.00	0.117	0.117	-
33kV Switch (GM)	5.00	0.237	0.237	-
33kV Transformer (GM)	1.00	0.314	0.314	-
Batteries at 33kV Substations	1.00	0.009	0.009	-
Pilot Wire Underground	0.80	0.089	0.089	-
Flexible Services	-	0.003	0.003	-
Civil Works at 33 kV & 66 kV Substations		0.512	0.512	-
Wayleaves/Easements/Land Purchase		0.184	0.184	-
Other Costs (Identify Below)		0.196	0.196	-
Total Costs		**2.088**	**2.088**	**-**
Identify activities included within other costs (please provide high-level detail of cost areas)				
Associated protection, control or SCADA equipment located at a site and remote ends (Morrisons, Lostock, Gadbrook) - (£85k)				
Environmental considerations, survey and studies (£17k)				
Planning and Design Studies (£50k)				
11kV NCP (£44k)				

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

Total Investment	Total	Incidence (£m)				
	(£m)	2023/24	2024/25	2025/26	2026/27	2027/28
CV1 – Primary Reinforcement	2.085	0.625	1.042	0.417	-	-
CV1 – Flexible Services	0.003	0.001	0.002	-	-	-
Total Cost	2.088	0.626	1.044	0.417	-	-

6.4 Risks

The main delivery risks are the necessary approvals especially related to traffic management for 33kV circuit reconfiguration works. We intend to mitigate these risks by engaging with local authorities.

6.5 Outputs Included in RIIO-ED1 Plans

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

6.6 Future Pathways – Net Zero

6.6.1 Primary Economic Driver

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

6.6.2 Payback Periods

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

6.6.3 Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option is consistent with the network requirements determined in line with the section 9 of the Electricity Act and Condition 21.

Additionally, the proposed option is consistent with the SPEN's Distribution System Operator (DSO) Strategy and Distribution Future Energy Scenarios.

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

Table 6.5 shows the sensitivity of the proposed solution and Table 6.6 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero 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 Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	794	610	1,097	1,276	1,149	794	1,249	1,139	1,139
HPs	332	253	624	784	366	339	379	346	349

*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

	RIIO-ED1				RIIO-ED2					RIIO-ED3				
Solution Requirements	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Baseline							R1							
Leading the Way							R1				R2			
Consumer Transformation							R1					R2		
Balanced Net Zero Pathway							R1					R2		
Headwinds							R1							
Widespread Engagement							R1					R2		
Widespread Innovation							R1					R2		
Tailwinds							R1					R2		

R1 – Install additional primary transformer at Middlewich and 33kV reconfiguration
R2 – HV circuit reinforcements

The proposed solution is robust across the range of future pathway scenarios. The selected solution is required under all scenarios. Under higher uptake scenarios HV circuit reinforcements may be required by end of RIIO-ED3.

Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure

	Baseline	Uncertain
RIIO-ED2 Expenditure (£m)	2.088	N/A
Comment	Proposed option	Under higher uptake scenarios HV circuit reinforcements may be required by end of RIIO-ED3.

6.6.4 Asset Stranding Risks & Future Asset Utilisation

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

6.6.5 Losses Sensitivity

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

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

6.6.6 Whole Systems Benefits

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

6.7 Environmental Considerations

6.7.1 Operational and embodied carbon emissions

The Middlewich Primary Reinforcement programme has the potential to impact on SPEN's Business Carbon Footprint (BCF) and on the embodied carbon resulting from the delivery of the programme.

During the evaluation of the options associated with the proposed scheme, we have embedded within the CBA, where data are available, an assessment of the embodied carbon and the associated carbon cost to inform our NPV evaluation. The mass of carbon dioxide emitted (CO2e) during the manufacture of the main equipment deployed to deliver this scheme is estimated to be 135 tonnes. The monetised embodied carbon value associated with this emission is £7k. It should be noted that the embodied carbon evaluation undertaken has only considered the manufacture and supply of materials. Further collaborative industry-wide work is planned for the RIIO-ED2 price review period to better understand the overall embodied carbon values including, for example installation and commissioning services, decommissioning and disposal activities as well as refurbishment opportunities. More information regarding this can be found in Section 3.1.2 of our Environmental Action Plan[1].

Upfront costs associated with resized assets used within the reinforcement programme (e.g. embodied carbon in the materials and emissions associated with civil engineering works) will be considered against the potential operational efficiency improvements associated with the new assets from a lifetime carbon perspective. For example, with the carbon emissions resulting from the raw materials and manufacture of a new transformer only contributing around 5-10% of its whole-life carbon impact, it is entirely possible that a transformer with a higher embodied carbon footprint may have lower whole-life carbon emissions if it can operate more efficiently with fewer losses.

[1] 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 Middlewich Primary Reinforcement programme, 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.

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

6.7.3 Resource use and waste

The Middlewich Primary Reinforcement programme will result in the consumption of resources and the generation of waste materials from end of life assets.

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

6.7.4 Biodiversity/ natural capital

The Middlewich Primary Reinforcement programme 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

To accommodate the demand growth, improve security of supply and alleviate thermal constraints in the Middlewich group network, the proposed solution is to install additional primary transformer at Middlewich along with 33kV reconfiguration by transferring Morrisons primary substation into Lostock – Gadbrook 33kV circuit and re-routing the existing 33kV Lostock – Morrisons circuit to Middlewich. It is also proposed to contract with flexibility services providers from 2023/24 to 2024/25 which will enable to manage the risk during project delivery. It is recommended to continue annual tendering for flexibility in this area to procure enough capacity and review the scheme depending on future tenders resulting competitive bids enabling to defer the proposed reinforcements.

It is proposed to start the works in 2023/24 and the release capacity of 2.5MVA will be claimed in 2025/26 at the end of the project. The estimated cost for the above is £2.088 (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

8 Appendices

Appendix 1. System Study Results

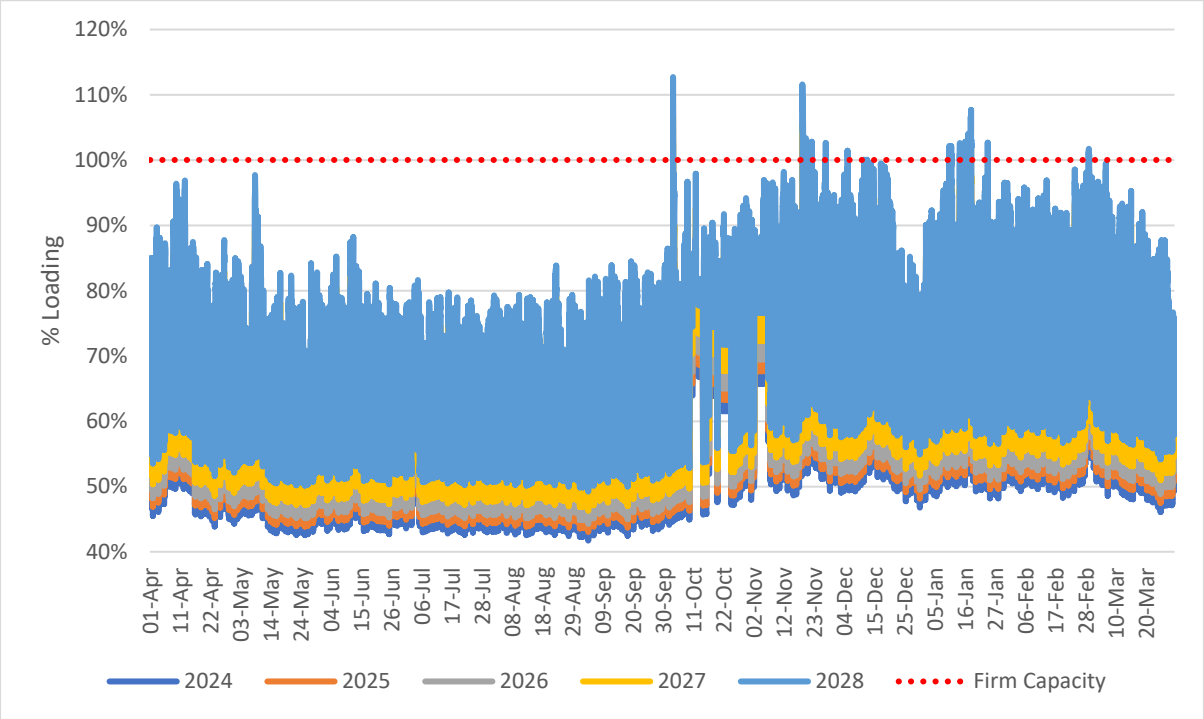

Figure 8. Half-hourly loading on 33/11kV Middlewich primary transformer

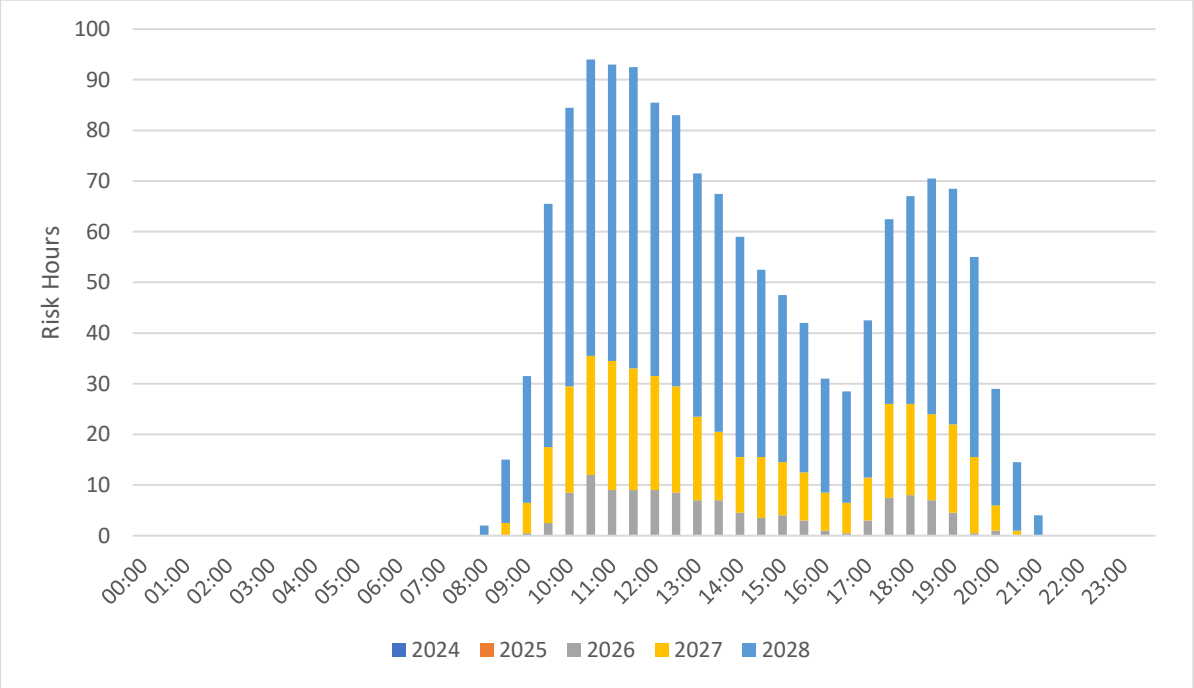

Figure 9. Calculated daily network risk hour window