Bootle Canal Quarter Regeneration Scheme

ED2 Engineering Justification Paper

ED2-LRE-SPM-031-CV1-EJP

Issue	Date	Comments
Issue 0.1	Oct 2021	Issued for external review and assurance
Issue 0.2	Oct 2021	Reflecting updated DFES forecasts
Issue 0.3	Nov 2021	Reflecting updated CBA results
Issue 1.0	Dec 2021	Final Business Plan Submission

Scheme Name	Bootle Canal Quarter Regeneration Scheme		
Activity	Voltage uprating of 6.3kV network groups		
Primary Investment Driver	Thermal and Fault Level Constraints		
Reference	ED2-LRE-SPM-031-CV1-EJP		
Output	Primary Reinforcement		
Cost	£3.432m		
Delivery Year	2024-2027		
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**
	-	**£3.432m**	**-**

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:	Bootle Canal Quarter Regeneration Scheme
Project Reference:	ED2-LRE-SPM-031-CV1-EJP
Decision Required:	Concept approval for Voltage Uprating in 6.3kV network groups in Bootle by uprating to 11kV voltage.

Summary of Business Need:

SP Manweb (SPM) network supplies to the areas under the areas of Liverpool and surrounding areas in Merseyside. The Liverpool City Region Combined Authority (LCRCA) together with Sefton Council have committed development plans to provide improved infrastructure, housing, retail, culture, and leisure facilities through Bootle Canal Quarter Regeneration project, expected to be completed by 2030. Phase 1 of this project involves development of commercial and residential areas will result in significant demand growth in the form of LCT uptake as well as public EV charging stations and additional demand.

Proposed development areas under Phase 1 are predominately supplied from 2 separate network groups operating at a non-standard 6.3kV voltage level within the SPM licence areas, namely, Bibbys/Regent Road/Inland Revenue Offices and Delamore Street/Kirkdale/Walton primary groups. These network groups are currently approaching thermal limits and already fault level constrained; being operationally managed leaving no ability to accommodate future demand growth and wider generation connections.

To facilitate the completion of regeneration project, LCT uptake and accommodate future demand/generation growth, it is required to increase the thermal and fault level headroom in these two groups. As such, the voltage uprating solution is proposed to alleviate the prospective network constraints for the RIIO-ED2 period and beyond. Preparatory works were proposed to carry out under Green Recovery initiative through March 2023 which will pave significant inroads for these two groups to be uprated to operate the network at the standard 11kV voltage. The proposed voltage uprating solution will additionally provide network operating efficiencies and significant reduction in network losses.

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

1. Replace the non-standard single voltage plant equipment such as primary, secondary transformers and voltage measurement transformers with dual ratio units to operate at 11kV voltage.
2. Refurbish the HV oil CBs and install with tele-control to provide operational flexibility.

The estimated cost for the above is **£3.432m** (in 2020/21 prices) under CV1 with 100% contribution to be included in the ED2 load related expenditure. The proposed uprating scheme will create additional fault level headroom of 107MVA and provide and increases the firm capacity by ca 2.5MVA to 20MVA in each group.

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

Licence Area	Reporting Table	Description	Total (£m)	Incidence (£m)				
				2023/24	2024/25	2025/26	2026/27	2027/28
SPM	CV1	Fault Level Reinforcement	3.432	0.947	1.306	1.408	1.126	-
Total Expenditure within RIIO-ED2			3.432					

PART B – PROJECT SUBMISSION

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

PART C – PROJECT APPROVAL

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

Contents

1 Introduction

SP Manweb (SPM) network supplies to the areas under the areas of Liverpool and surrounding areas in Merseyside. The Liverpool City Region Combined Authority (LCRCA) together with Sefton Council have committed development plans to provide improved infrastructure, housing, retail, culture, and leisure facilities through Regeneration of Bootle Canal Quarter. The phased project involves widespread redevelopment of various areas of Bootle town including and expected to be complete by 2030. The proposed development of commercial and residential areas will result in significant demand growth in the form of LCT uptake as well as public EV charging stations and additional demand.

The proposed development areas are predominately supplied from 2 separate network groups within the SPM licence areas, Bibbys/Regent Road/Inland Revenue Offices and Delamore Street/Kirkdale/Walton primary groups. These two network groups are currently operating at a non-standard voltage of 6.3kV, as a result fast approaching both thermal and fault level limits. The Bibbys/Regent Road/Inland Revenue Offices group is being operationally managed leaving no ability to accommodate future demand growth and wider generation connections. The diminishing population of 6.3kV plant also presents risks from the perspective of fault repairs and availability of spares leading to longer repair time and increased customer restoration times.

To facilitate the realisation of the LCRCA plans, accommodate future demand/generation growth and LCT uptake, it is required to increase the thermal and fault level headroom in these two groups. The proposed solution is to uprate the two 6.3kV operated groups to 11kV within the RIIO-ED2 period to facilitate additional thermal and fault level headroom uplift, network operating efficiencies and significant reduction in network losses. Preparatory works were proposed to carry out under Green Recovery initiative through March 2023 which will pave significant inroads for these two groups to be uprated to operate the network at the standard 11kV voltage.

The estimated cost for the above is £3.432m (in 2020/21 prices) with 100% contribution to be included in the ED2 load related expenditure under CV1(primary reinforcement) which includes only the cost and volumes and excludes the preparatory works under Green Recovery initiative. The proposed uprating scheme increases the firm capacity by 2.5MVA to 20MVA and fault level headroom by 107MVA to 250MVA in each group by the 2026/27 when the scheme is delivered. The increase in fault level headroom also prepares the network for the future installation of new 33kV infeeds to further increase capacity as more demand / generation appears in the network.

2 Background Information

2.1 Existing/Authorised Network

The Bibbys/Regent Road/Inland Revenue Offices and Delamore Street/Kirkdale/Walton 6.3kV groups are fed from the upstream Bootle – Burlington – Lister Drive 33kV group, each group is supplied by supplied via 3 x 7.5MVA primary transformers, one at each primary substation.

The Bibbys/Regent Road/Inland Revenue Offices 6.3kV group has 50 secondary substations, supplies to ca. 2625 customers of which 12 are HV customers i.e. connected at 6.3kV. Fault levels at Bibbys primary substation is presently in exceedance of the design limit of 143MVA and is being operationally managed via split point at Caird, resulting in radialised circuit operation and increases risk of losing supplies. There is an additional voltage split point at Pacific Road 11kV primary substation. The group's connectivity and primary substation locations are shown in Appendix - 8.1.

The Delamore Street/Kirkdale/Walton 6.3kV has 55 secondary substations, supplies to ca. 12443 customers of which 4 are HV customers i.e. connected at 6.3kV. The group is split from the neighbouring groups at Inland Revenue, Kirkdale and Walton via operating the bus section circuit breaker as normally open. The group's connectivity and primary substation locations are shown in Figure 8-1.

2.2 Network supply / circuit capacity

All the 6.3kV groups are currently are classed as P2/7 Group C (≥12MW and <60MW). Table 3-1 presents the existing network supply capacity of the 6.3kV groups in consideration.

Table 2-1: Summary of authorised EHV group network

HV group	Customers (#)	Outage Scenario	LI Firm Capacity (MVA)	Group demand (MVA)	Load Index	EREC P2/7 Class
Bibbys / Regent Road / Inland Revenue Offices	2625	N-1	17.5	12.09	LI1	C
Delamore Street / Kirkdale / Walton	12443	N-1	17.4	13.12	LI1	C

The HV circuits are entirely of underground cables, the construction-conductor, ampacity and lengths are provided in Appendix-8.4.

2.3 Embedded Generation

There is no HV connected embedded generation in any of the groups.

2.3.1 Thermal Constraints

Table 2-2 shows the identified thermal constraints on the 132kV network level. No other thermal constraints were identified on the 33kV groups.

Table 2-2: Thermal constraints

Network Item	Outage item	Outage	Loading (%)
Bibbys primary transformer	Inland Revenue Office / Regent Road primary transformer	N-1	110
Delamore St primary Transformer	Kirkdale primary transformer	N-1	102

2.4 Fault levels

The current 6.3kV networks design fault level limits are 143MVA/13.12kA (RMS Break). The upstream 33kV network fault level design limits are 1000MVA/17.5kA for modern switchgear substations and 750MVA/13.12kA for legacy switchgear substations.

Table 2-3 shows the calculated 33kV and 6.3kV RMS Break fault levels at each of the primary substation in the respective groups. As highlighted, both the 6.3kV groups are in exceedance of the RMS Break design limit of 143MVA and are operationally managed currently.

Table 2-3: 33kV Fault Levels of each primary group

33kV Group	HV Group	Primary Substation Name	RMS Break Fault Level (MVA)	
			33kV	6.3kV
Bootle / Burlington Street / Lister Drive	Bibbys / Regent Road / Inland Revenue Offices	Bibbys	678	**149**
		Regent Road	679	134
		Inland Revenue Offices	691	128
	Delamore Street / Kirkdale / Walton	Delamore Street	628	**162**
		Kirkdale	646	**150**
		Walton	644	140

3 Needs Case

The Bibbys/Regent Road/Inland Revenue Offices and Delamore Street/Kirkdale/Walton 6.3kV groups together supplies to densely populated areas around Bootle to ca. 15,000 customers, predominantly domestic type. These two 6.3 kV Primary network groups are currently approaching thermal and fault level limits (Bibbys/Regent Road/Inland Revenue group is operationally managed at present), leaving no capacity to connect demand and generation.

The network around Bootle Canal area is expected to see a significant demand increase due to LCT uptake, as well as the future development plans proposed by the LCRCA as part of the Bootle Canal Quarter Regeneration project. Considering this level of demand growth around this area, there will be insufficient thermal / fault level headroom to accommodate any future connections within the groups and require intervention to address the network constraints. The primary drivers for network intervention in these two groups are explained below.

3.1 Forecast Demand

The system is forecast to grow and approach/likely to exceed the firm capacity by the end of RIIO-ED2 period under all scenarios. 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

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 helped determine the resultant demand increase and impact on our network

Liverpool City Region Combined Authority (LCRCA) have an ambitious, sustainable strategy to facilitate economic growth in the area over the next 25 years. Within Sefton Council area there is a commitment to the £100 million Regeneration of Bootle Canal Quarter[1] that fulfils LCRCA's plans by providing improved infrastructure, housing, retail, culture, and leisure facilities.

The project involves widespread redevelopment of various areas of Bootle town including Retail, Commercial and Residential. The local authority's initial estimates from their outline strategy indicates they expect the project to be phased and completed by 2030. With their submission for Green Recovery funding the local authority has indicated that they would like their vision to begin with development of the residential area to the south of the zone, which includes 187 residential units with ground source heat pumps and EV charging presence proposed. The Town Centre will also include EV charging points to facilitate both public and service vehicle charging. Estimated demand, assuming every house will have a heat pump and EV charger uptake will be 1 per 4 homes requiring 1.25MVA of additional capacity and reinforcement of the 11kV network. In addition, there are 8-12 commercial developments including car parks also with EV charging presence. At a high level it is predicted this will require around 9-12MVA of additional capacity from the SPM Network.

The proposed development of commercial and residential areas to the south of this regeneration area under Phase 1, will predominately be supplied from 2 separate 6.3kV networks fed from the Bibbys/Regent Road/Inland Revenue and Delamore Street/Kirkdale/Walton primary groups. The primary groups have no headroom to accept additional capacity and require intervention to facilitate

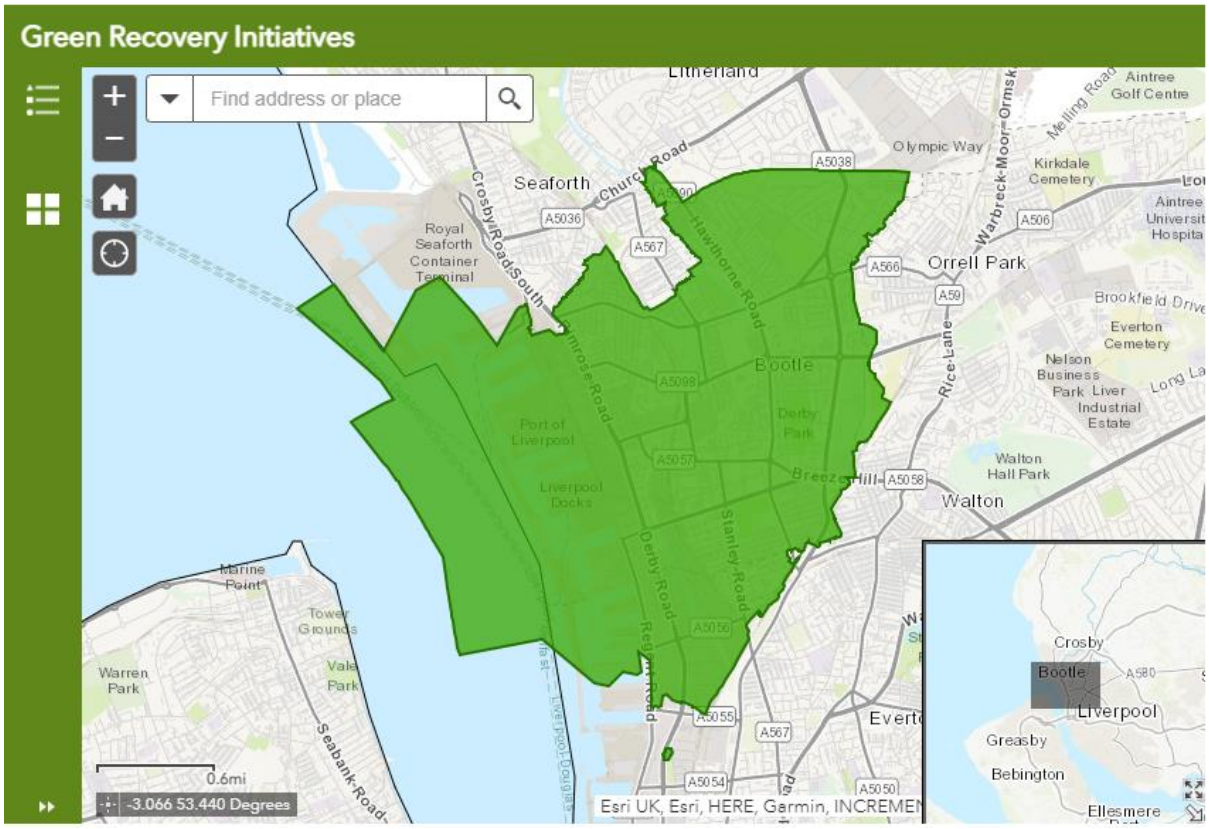
[1] https://mysefton.co.uk/2021/05/21/bootle-canalside-takes-major-step-forward-as-plans-are-submitted/

the realisation of the LCRCA plan, wider customer connections and LCT uptake. Figure 3-1 shows the geographic extent of the proposed Bootle Canal Quarter Regeneration scheme.

3.1.2 Stakeholder Feedback

The LCRCA and Sefton Council are fully invested in this project in line with their strategic growth and sustainability strategies. They have a strong support from the Canal and River Trust and Safe Generation Ltd. SPEN also supports the development and reinforcement works required. The Council will act as a facilitator and enabler to stimulate the necessary conditions capable of supporting future investment.

Figure 3-1: Bootle Canal Quarter Regeneration scheme geographic extent.



3.1.3 Limitations of 6.3kV network groups

In SPM, majority of the HV network is operated at the standard11kV voltage level, with few patches of the network operated at non-standard 6.6kV or 6.3kV voltage level, which accounts for up to 10% of the total HV group population. These non-standard voltage networks can result in constrained system capacity, additional reinforcement needs (e.g. 6.3kV cables overload before their 11kV equivalents) and incremental costs for dual ratio equipment for plant installations.

The 6.3kV network, when compared to the 11kV equivalents, have the inherent issues like:

1. Constrained system thermal headroom – The maximum primary transformer infeed is limited to 8.72 MVA (due switchgear limitation), compared 10MVA (primary transformer cyclic loading limit) on 11kV networks.
2. Constrained HV feeder circuits - For the same ampacity, the feeder circuits operating at 6.3kV voltage carry ca. 75% less power when compared to operating at 11kV.

3. Constrained system fault level headroom – The fault levels limits are 143MVA compared to 250MVA on 11kV network, the additional 107MVA headroom is the result of voltage upscaling of 1.75 times.
4. Higher network losses - The losses are typically 3.05 times higher compared to the 11kV network, due to higher current flows.
5. Require additional reinforcement needs due to limited (thermal / fault level) capacity as well as the incremental cost to the customers for installing dual-ratio equipment.
6. The diminishing population of 6.3kV equipment also presents risks from the perspective of fault repairs, availability of spares and as a result leading to increased restoration times.

Additionally, few of the 6.3kV primary substations operate with legacy switchgear, do not have tele-control for remote switching operations, requires manual switching during outages/abnormal conditions poses a potentially safety hazard on the network does not provide the operational flexibility.

The perpetuated operation of these 6.3kV groups is becoming challenging with the demand/generation growth and offers very little or no headroom for the prospective customers. Therefore, an overarching solution is necessary to increase the network thermal/fault level capacity, address the fault level constraints, reduce the network losses, increase operational efficiency, and reduce the overall network operational costs.

3.2 Distribution Future Energy Scenarios

3.2.1 Forecast Demand

The DFES forecast is based on actual system measurement data from the PI system and stakeholder endorsed Distribution Future Energy Scenarios (DFES) and considers our pipeline of known developments. The winter demand forecast based on the future energy scenarios along with the projected demand from authorised connections is shown in Figure 3.2. The demand forecast for the RIIO-ED2 period is expected to approach the firm capacity limit by the end of RIIO-ED2 for both the groups.

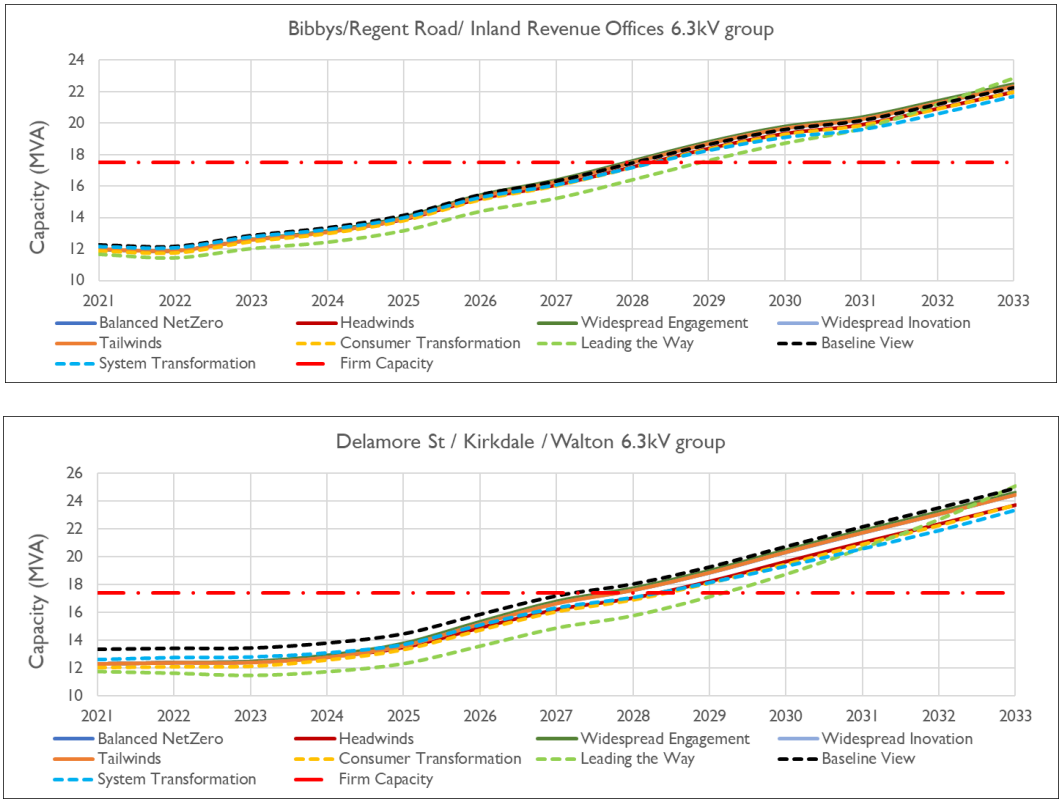


Figure 3-2: Demand forecast for each of the group

The forecast electric vehicle volumes are show in Figure 3.3. Please note that DFES forecast show no heat pump uptake in both the groups.

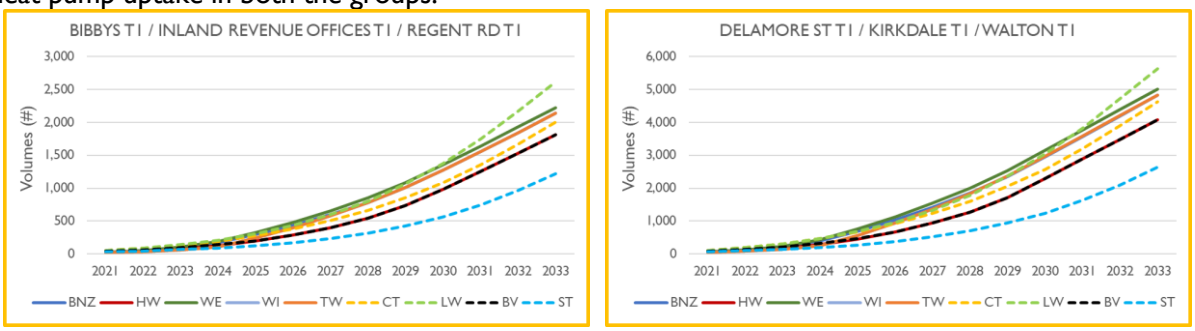


Figure 3-3: Electric Vehicle volumes forecast for each of the group

3.2.2 Baseline View

For both the 6.3kV network group, this forecast demand growth under Baseline View, along with the firm capacity and load index position through to ED3 period 2033 and as shown in Table 3-1.

Table 3-1: Baseline View scenario forecast

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Bibbys / Inland Revenue Offices / Regent Road	**Forecast Demand (MVA)**	12	12	12	13	13	14	15	16	17	19	20	20	21
	Firm Capacity (MVA)	18	18	18	18	18	18	18	18	18	18	18	18	18
	Utilisation (%)	70	70	74	76	81	88	93	100	106	112	115	121	127
	Load Index	LI1	LI1	LI1	LI1	LI2	LI2	LI2	LI4	LI5	LI5	LI5	LI5	LI5
Delamore St / Kirkdale / Walton	**Forecast Demand (MVA)**	13	13	13	14	14	16	17	18	19	21	22	24	25
	Firm Capacity (MVA)	17	17	17	17	17	17	17	17	17	17	17	17	17
	Utilisation (%)	77	77	77	79	83	91	99	104	111	119	127	135	143
	Load Index	LI1	LI1	LI1	LI1	LI2	LI2	LI3	LI5	LI5	LI5	LI5	LI5	LI5

3.3 Network Impact Assessment

The 6.3kV groups have been assessed with the forecast demand growth, covering thermal and fault level considering the different demand forecast scenarios and network operational condition. The findings from the network impact assessments are detailed in sections below.

3.3.1 Thermal Constraints

The two 6.3kV network groups are forecast to experience additional thermal constraints under outage conditions with the forecast peak demand.

3.3.2 Fault Level Constraints

The fault level issues in each of the groups will remain and perpetuate into RIIO-ED2, certainly exacerbated with the connection of new generation on the upstream networks and require further operational measures to manage the fault level exceedances.

Considering the above-mentioned drivers for network intervention and 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 demand requirements and accommodate future load growth.

4 Optioneering

Table 4-1shows a longlist of the options considered for this reinforcement. Few of the longlist options are rejected based on the technical and commercial rustications, the reasons are provided. The shortlisted options are taken forward for detailed analysis and included in the cost-benefit analysis. The baseline option represents the conventional option, i.e. the 'do minimum' level of intervention to mitigate the both thermal and fault level constraints.

Table 4-1: Summary of the options

	Option	Status	Reasons for rejection
(a)	Do Nothing	Rejected	Leads to perpetuation of 6.3kV networks. Limited thermal / fault level headroom, deters any LCT uptake, local developments and new demand/generation connections, higher network losses and does not offer network operational and maintenance efficiencies.
(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)	Voltage uprating to 11kV	Considered (**Baseline**)	
(d)	Voltage uprating to 11kV with network transition	Considered (**Option 1**)	
(g)	Higher impedance transformers and overlay the constrained circuit sections	Considered (**Option 2**)	
(g)	Flexible services and active fault level management and monitoring and	Rejected	• Flexibility Services option is dismissed as insufficient to meet expected demand growth. The customers are predominantly domestic type for demand side management and no generation available in the groups to offset the future demand. • Fault Level management is dismissed as it cannot address the existing fault level issues and does not provide any operational benefits, as the exceedances are already being operationally managed.
(h)	Split the networks groups	Rejected	This option can result in network groups of two primary infeeds each, which can lead to islanded operation during outages. Also reduces the security of supply, due to the reduced thermal headroom.

5 Detailed Analysis

5.1 Baseline (Proposed): Voltage uprating to 11kV

The proposed conventional solution involves uprating the two 6.3kV network groups to 11kV. Prior to the changeover, the existing 33/6.3kV and 6.3kV/LV substations will be converted to dual ratio sites (where not already) and thereafter migrated over to 11kV operation. The proposed scheme is an overarching solution, offers benefits of thermal and fault level headroom uplift, technical losses reduction, improves operational flexibility and reduces the overall network operating costs.

There are 105 secondary transformers in total across the two existing 6.3kV groups (excluding 3 IDNO and 3 HV customer transformers). It is estimated that approximately 30% are already dual ratio transformers so 74 would need to be replaced to allow the uprating of both groups to 11kV. It is expected that SPEN will be able to complete 50% of the 74 transformer replacements by March 2023 under Green Recovery scheme. For maximum benefit, the Bibbys/Regent Road/Inland Revenue Group is completed first as this encompasses an anticipated 36 transformer changes in total. The rest of the secondary transformer replacements within the Delamore Street/Kirkdale/Walton 6.3kV are considered in this proposal for voltage uprating scheme.

It should be noted that few of the customers in each of the groups, fed directly from the 6.3kV network. This will be their preferred choice of connection and will remain unchanged until such times as their own requirements trigger an application for change. As, part of the proposed uprating scheme, an early engagement with these customers is recommended to progress the scheme.

5.1.1 Scope of works

The proposed works under the uprating these two groups are:

Bibbys/Regent Road/Inland Revenue Offices Group:

The proposed works under the uprating these in the group are:
Primary substation works:

- Replace the single ratio 6.3kV primary transformers with dual ratio transformers - 1 x Bibbys, 1 x Regent Road and 1 x Inland Revenue Offices.
- Refurb and retrofit the existing HV oil CBs with vacuum units and tele-control - 8 x Bibbys, 7 x Regent Road and 6 x Inland Revenue Offices.
- Replace the single ratio VTs with dual ratio units – 9 (in total).

Secondary substations work:

- No additional works are proposed as the 6.3/LV transformer are replaced with dual ratio units as part of Green Recovery scheme and expected to finish by March 2023.

With the proposed uprating solution, the firm capacity increases to 20MVA and fault level limit increases to 250MVA in this group. The normally open split point at Caird secondary substation can be closed and this will increase the network security. Further, with the group uprated to 11kV, it can be interconnected with and can support the adjacent 11kV network groups , like for e.g. can be inter connected at Pacific Road site with the Bootle Grid / Kelloggs / Pacific Rd / Washington St / Waterloo 11kV group and with Delamore Street/Kirkdale/Walton Group once uprated.

Delamore Street/Kirkdale/Walton Group

The proposed works under the uprating these in the group are:
Primary substation works:

- Replace the single ratio 6.3kV primary transformers with dual ratio transformers - 1 x Delamore Street, 1 x Kirkdale and 1x Walton
- Retrofit the existing HV oil CBs with vacuum units and tele-control - 6 x Walton
- Replace the single ratio VTs with dual ratio units – 3 (in total).

Secondary substations work:

- Replace 6.3kV / LV single ratio secondary transformers with dual ratio transformers – 38 x ground mounted.

With the proposed uprating solution, the firm capacity increases to 20MVA and fault level limit increases to 250MVA in this group. Further, with the group uprated to 11kV, it can be interconnected with and can support the adjacent 11kV network groups, like for e.g. can be interconnected at Inland Revenue Offices primary site with Bibbys/Regent Road/Inland Revenue Offices Group once uprated.

5.1.2 Technical Losses Reduction

With the proposed uprating scheme, the network groups also benefit from the reduction of technical losses. In theory, uprating to 11kV can reduce the losses as much as 3.05 times compared to 6.3kV networks, which gives significant savings over the lifetime of the assets and thereby contributing to reduction in CO_2 emissions. The combined losses reduction post uprating in all the groups is calculated to be ca. 1.7GWh/year by the end of 2027 and considered to be same over the next 45 years.

For the cost-benefit analysis of the proposed scheme, the reduction in technical losses are considered under societal benefits which increases the net present value of the uprating options.

5.1.3 Overall Scheme Costs

Table 5-1shows the cumulative cost and volumes breakdown of the assets under the proposed scheme. Table 5-2 shows the cost incidence in the two groups across the ED2 period. The detailed cost and volumes breakdown for each of the primary substation is given in Appendix 8.2. The assets identified are currently single ratio units, under the proposed scheme they will be replanted with dual ratio units for the purpose of uprating.

Table 5-1: Cost breakdown for Option 1

Asset Description	Volumes	Unit Cost (£m)	Prime Costs (£m)
33kV Transformer (GM)	6	0.314	1.886
6.3/11kV Transformer (GM)	38	0.015	0.551
6.3/11kV Transformer (PM)	-	0.006	-
6.3/11kV CB(GM) Primary - Refurb	30	0.019	0.575
HV VT replacement	12	0.005	0.060
Civil Works at 33 kV & 66 kV Substations	-	-	0.360
		Total Costs (£m)	**3.432**

Table 5-2: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

HV Group	Total	Incidence (£m)				
	(£m)	2023/24	2024/25	2025/26	2026/27	2027/28
Bibbys / Regent Road / Inland Revenue Offices	1.604	0.321	0.962	0.321	-	-
Delamore street / Kirkdale / Walton	1.828	-	1.097	0.366	0.366	-

The works are expected to start win the Bibbys group in 2023/24 to continue the work carried as part of Green Recovery in the ED1 period and aimed to finish in 2025/26. The works in Delamore St. group are expected to begin 2024/25 and finish in 2026/28. A thermal headroom uplift of ca. 2.5 and fault level headroom uplift of 107MVA will claimed after the delivery of the scheme in 2026/27.

5.2 Option 1 (Rejected): Voltage uprating to 11kV with network transitioning

This option, in addition to the voltage uprating to 11kV, considers the opportunity of network transitioning i.e., conversion of X-Type substations to Y-Type. The X-Type substations feed interconnected networks, while the Y-substations are run radially. The costs of X-Type networks are greater than a typical Y-Type(radial) networks due to the bespoke unit protection equipment, including pilot wires, protection panels, batteries, LV circuit breakers and additional civil costs of brick-built

substations. On the other hand, Y-Type networks are relatively low cost, but are prone to higher customer interruptions compared to X-Type networks.

The prime driver for the network transition is based on SPM's long-term strategy to develop the network to facilitate a low carbon future and to provide optimal network benefits whilst minimising network cost (see Interconnected Network Transitioning Policy, ESDD-01-013 and Annex 4.48: SPM Company Specific Factors of our ED2 Business plan). The transitioning policy outlines that network transitioning opportunity should be explored on a case-by-case basis and to be implemented where the overall benefits of the transition outweigh the benefits offered by the interconnected networks. The transition criteria apply to networks where there is low level of LV interconnection, feeders with X & Y Type substations mix (Y-Type >=50%), majority of asset base in poor health (e.g. HI5) and voltage uprating schemes etc.
As the voltage uprating encompasses interventions for whole of the network groups in consideration, it provides an opportunity of assessing the benefits offered by transitioning in addition to the voltage uprating. For each of the 6.3kV network groups, the X & Y-Type substation proportions are analysed and shown in Table 8-4. Both the Bibbys/Regent Road/Inland Revenue Offices and Delamore Street/Kirkdale/Walton groups comprises mostly X-Type secondary substations and those with higher X-type proportions are considered for transitioning. It should be noted that the transitioning will often will lead to increase in customer interruptions relatively, however the CI/CML performance of the Y-Type networks can be matched to that of X-Types by network automation though directional fault passage indicators (dFPIs) and Smart LV sectionalisers. The capital expenditure (Capex) costs involved in the transitioning as well as the operational expenditure (Opex) savings post transitions are considered as follows:

- Capex cost of X-Type to Y-Type conversion - £10k / substation
- Capex savings from newly built Y-Type substations - £60k / substation
- Opex savings of converted X-Type substations - £152 / substation / year
- Opex savings from newly built Y-Type substations - £452/substation / year
- Cost of increased CI / CMLs post transition – included under societal benefits

The above costs are in addition to the voltage uprating costs of installing dual-ratio equipment as mentioned in Baseline option and the calculations are detailed in the CBA working sheets under Option-1. The scheme also carries similar benefits in losses as reduction as mentioned in section 5.1.2. As with the proposed uprating solution, this option also creates additional fault level and thermal headroom in all the 6.3kV groups in consideration. Table 5-3 shows the cumulative cost and volumes breakdown of the assets under the proposed scheme.

Table 5-3: Cost breakdown for Option 2

Asset Description	Volumes	Unit Cost (£m)	Prime Costs (£m)
33kV Transformer (GM)	6	0.314	1.886
6.3/11kV Transformer (GM)	38	0.015	0.551
6.3/11kV Transformer (PM)	-	0.006	-
6.3/11kV CB(GM) Primary - Refurb	30	0.019	0.575
HV VT replacement	12	0.005	0.060
X-Type to Y-Type Conversion	84	0.010	0.840
Civil Works at 33 kV & 66 kV Substations	-	-	0.360
		Total Costs (£m)	**4.272**

5.3 Option 2 (Rejected): Higher impedance primary transformers and HV circuit overlays.

This option considers the perpetuated operation at 6.3kV voltage level, however in order to mitigate the network constraints, it is proposed to replant the existing primary transformers with higher

impedance units thereby reducing the fault infeed into the 6.3kV groups, as well as overlaying the HV cable section with limited thermal rating.

Primary Transformers:
A total of 6 primary transformers(3 in each group) across the two groups are proposed to be replaced with higher impedance units(13% impedance compared to standard 10% impedance), the impedance value is chosen to limit the voltage step change on the network during the primary transformer switching. As such this option creates limited additional fault level and thermal headroom in all the 6.3kV groups in consideration.

HV circuit overlays:
The combined length of the HV circuits is 38.2km in Bibbys/Regent Road/Inland Revenue Offices group and 25.3km in Delamore Street/Kirkdale/Walton primary groups, ca. 63.5km in total. The detailed breakdown of the each of the circuit in terms of conductor type, length and ampacity is provided in Appendix – 8.4.

To mitigate the thermal issues in the network, the criterion is set to mainly overlay the sections rated for less than 200A to facilitate interconnection of the groups and load sharing /transferring across the two groups. These sections' lengths amount to ca.3.8km in Bibbys group and 3.3km in the Delamore Street group. Additionally, there are cable section with indeterminate construction of ca. 2km and 1.4 km in the Bibbys and Delamore Street groups respectively. This amounts to a total of 10.5km overlay ca, 16.5% of total volume of 63.5km. There may be additional circuit sections that might be thermally overloaded depending future HV customer connections, which shall be apportioned to the customer.

It should be noted that, the Bibbys and Delamore Street group are supply to parts of the Liverpool City Centre and the circuit overlay might be require additional permissions from the City Council as well as considerable amount of traffic management as well which can increase the scheme cost as well as longer lead times for delivery.

Table 5-4: Cost breakdown for Baseline option

Asset Description	Volumes	Prime Costs (£m)
6.6/11kV UG Cable	10.5	1.234
33kV Transformer (GM)	6	2.075*
Civil Works at 33 kV & 66 kV Substations	-	0.360
	Total Costs (£m)	**3.668**

*The higher impedance primary transformers will be of bespoke design, hence costed higher (assumed to 10% higher) than the BaU units.

5.4 Options Cost Summary Table

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

Table 5-5: Technical summary for considered options

Options	Summary	RIIO-ED2 Cost (£m)
Baseline	Voltage uprating to 11kV	3.432
Option 1	Voltage uprating to 11kV and network transitioning	4.272
Option 2	Higher impedance primary transformers and HV circuit overlays	3.668

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 1 to uprate the 6.3kV network groups to 11kV. Th adopted option is an overarching solution facilitating additional thermal and fault level headroom uplift, network operating efficiencies and reduction in network losses.

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 and represents the optimal cost option when losses and other operational costs are included in the analysis. Based on the outcome of the CBA, the proposed option is to uprate the identified 6.3kV network groups to operate at 11kV voltage. The summary of the cost benefit analysis is presented in Table 6-1. The full detailed CBA is provided within 'ED2-LRE-SPM-031-CV1-CBA - Bootle Canal Quarter Regeneration Scheme'.

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 - Voltage uprating to 11kV	Adopted		0.00	0.00	0.00	0.00
Option 1 - Voltage uprating to 11kV and network transitioning	Rejected	Rejected based on the cost benefit analysis, the NPV diminishes over the long term compared to Baseline.	-0.67	-1.06	-1.32	-1.55
Option 2- Higher impedance primary transformers and HV circuit overlays	Rejected	Rejected based on the cost benefit analysis, the network transitioning does not offer any additional cost benefit compared to Baseline.	-0.54	-1.02	-1.31	-1.59

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 6-2*. The total cost of the proposed scheme is £3.432m.

Table 6-2: Cost breakdown for Baseline option

Asset Description	Volumes	Prime Costs (£m)
33kV Transformer (GM)	6	1.886
6.3/11kV Transformer (GM)	38	0.551
6.3/11kV Transformer (PM)	-	0.008
6.3/11kV CB(GM) Primary - Refurb	30	0.575
6.3/11kV VT replacement	12	0.060
Civil Works at 33 kV & 66 kV Substations	-	0.360
Total Costs (£m)		**3.432**

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

HV Group	Total	Incidence (£m)				
	(£m)	2023/24	2024/25	2025/26	2026/27	2027/28
Bibbys / Regent Road / Inland Revenue Offices	1.604	0.321	0.962	0.321	-	-
Delamore street / Kirkdale / Walton	1.828	-	1.097	0.366	0.366	-
Total Investment (Primary Reinforcement / CV1)	3.432	0.947	1.306	1.408	1.126	-

6.4 Risks

The voltage uprating schemes typically encompasses interventions across the entire network groups and can have longer lead delivery times. Currently, within the RIIO-ED1 period, SPM has experience of voltage uprating and transitioning the Southport area's Banastre Rd / Dover Rd / Grantham Close 6.6kV network group, the learnings from delivering this scheme will help in delivering of the proposed scheme.

The proposed scheme has two 6.3kV network groups identified for voltage uprating, the timing and delivery of the scheme on the individual network group level is chosen to have minimum network impact, this could be further optimised at the detailed design stage. From the SPM's experience of voltage uprating schemes, we have decided that an early engagement with the all customers and particularly those connected to the 6.3kV voltage directly as this will be their preferred choice of connection and will remain unchanged until such times as their own requirements trigger an application for change.

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 the thermal and fault level fault level constraints in the two 6.3kV network groups; the perpetuated operation at 6.3kV voltage level resulting in thermal and fault level headroom limitations, higher network losses and does not support future demand / generation growth in the groups.

6.6.2 Payback Periods

The CBA indicates that a positive NPV result in all assessment periods (10, 20, 30 & 45 years) which are consistent with the lifetime of the intervention. Consumers benefit from reduced network connection costs immediately on completion of the project. Additionally, the reduction in network technical losses will result in significant cost savings and reduction in CO_2 emissions.

6.6.3 Sensitivity to Future Pathways

The network capacity and capability that results 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 cumulative volumes of electric vehicle and heat pump uptakes for the two network groups across a range of future pathways and Table 6-5 shows the sensitivity of the proposed solution and Table 6-6 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero complaint future pathways.

Table 6-4: Electric Vehicle and Heat Pump uptakes across a range of future pathways

End of RIIO-ED2	SPEN	DFES			CCC				
	Baseline	System Transformation*	Consumer Transformation	Leading the Way	Balanced Net Zero	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
EVs	1821	1,345	2,353	2,877	2,633	1821	2863	2611	2611
HPs#	-	1	-	1	-	-	-	-	-

** System Transformation is excluded from future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.*

 # DFES scenarios does not forecast any heat pump volumes in these two groups.

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								R1						
Consumer Transformation								R1						
Leading the Way								R1						R2
Balanced Net Zero								R1						R2
Headwinds								R1						
Widespread Engagement								R1					R2	
Widespread Innovation								R1						R2
Tailwinds								R1						R2

R1 – Voltage uprating to 11kV (proposed solution)
R2 – New primary substation in each group

The adopted is the Baseline option involving uprating both 6.3kV networks to 11kV and it is the 'do minimum' scheme robust across wide range of forecast scenarios. This is the minimum requirement to address the network constraints (both thermal & fault levels) in the group, as well as it stands as a prerequisite to any subsequent reinforcement in the groups. Under high uptake scenarios, it is expected that further thermal constraints may require a subsequent reinforcement in the form of additional primary substation in each of the groups by the end of RIIO-ED3.

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

	Baseline	Uncertain
RIIO-ED2 Expenditure(£m)	3.432	-
Comment	Proposed option.	-

6.6.4 Asset Stranding Risks & Future Asset Utilisation

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

6.6.5 Losses / Sensitivity to Carbon Prices

Losses have been considered in accordance with 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. 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.

The adopted solution is found to be sensitive to the impact of the carbon cost of losses. The proposed solution will reduce the network losses in all the uprated groups to the tune of 1.7GWh per year, these losses reduction is considered in the CBA under societal benefits. Losses have been considered as part of this design solution and it has not been necessary to carry out any Losses justified upgrades. The proposed solution to upgrade two 6.3kV operated groups to 11kV in the SPM area will increase network operating efficiencies, reducing network losses and the associated carbon emissions.

6.6.6 Whole Systems Benefits

Whole system benefits have been considered as part of this proposal as the adopted solution provides the benefits of thermal, fault level headroom uplift, network operational efficiencies and reduction in losses. The capacity and capability of the preferred option is consistent with the provision of whole system solutions.

6.7 Sustainability and Environmental Considerations

6.7.1 Operational and embodied carbon emissions

The proposed scheme has the potential to impact on the embodied carbon resulting from the replacement of non-standard single voltage plant equipment such as primary, secondary transformers and voltage measurement transformers, and the retrofit of the existing switchgear with tele-control.

The volumes of carbon emissions are calculated based on the asset category and volumes for each of the options considered and included in the CBA under societal benefits.

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 Proposed 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 proposed 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 proposed scheme will only affect developed sites 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

The project will take account of sustainability initiatives that are relevant to this site and reflect wider licenced business sustainable development objectives set out in the Environmental Action Plan. The project will avoid environmental impacts where possible and provide mitigation and improvements when required, and all relevant environmental and planning consents will be secured.

7 Conclusion

The primary driver for the investment proposal is to address the thermal and fault levels in the two 6.3kV groups mainly, Bibbys/Regent Road/Inland Revenue Offices and Delamore St / Kirkdale / Walton groups, as well support the economic development around the Bootle area proposed as part of Bootle Canal Quarter Regeneration by the Liverpool City Region Combined Authority (LCRCA) and Sefton Council.

The two 6.3kV network groups are both thermal and fault level constrained and the Bibbys/Regent Road/Inland Revenue Offices group is currently operationally managed to mitigate the fault level exceedances. Due to the significant growth in distributed generation in the upstream groups, it is anticipated that the fault levels in the already constrained networks will exacerbated in the RIIO-ED2 period. Further these 6.3kV networks result in constrained system thermal and fault level capacities, higher network losses, additional reinforcement needs due to limited capacity compared to their 11kV equivalents. The diminishing population of 6.3kV plant also presents risks from the perspective of fault repairs and availability of spares.

The proposed scheme is an overarching solution offers additional benefits of thermal headroom uplift, increases the fault level headroom, technical losses reduction and improves operational flexibility. The proposed solution is most technically feasible option considering that the two considered 6.3kV groups feed parts of the Liverpool City Centre, and any circuit overlays would require significant number of permits from the city council and as well road traffic management.

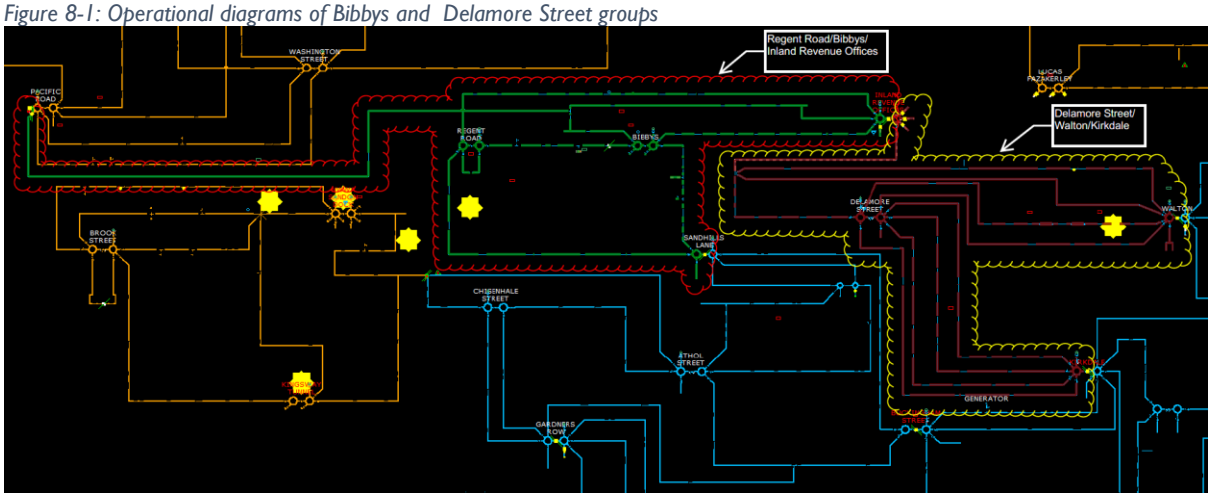
Total scheme cost £3.432m (2020/21 prices) represents most efficient solution to address the future demand growth within the groups, create additional thermal and fault level headroom, making the networks ready to support the economic growth to the Bootle area.

The works are expected to start win the Bibbys group in 2023/24 to continue the work carried as part of Green Recovery in the ED1 period and aimed to finish in 2025/26. The works in Delamore St. group are expected to begin 2024/25 and finish in 2026/28. A thermal headroom uplift of ca. 2.5 and fault level headroom uplift of 107MVA will claimed after the delivery of the scheme in 2026/27.

8 Appendices

8.1 Operational diagrams for the 6.3kV groups

Figure 8-1: Operational diagrams of Bibbys and Delamore Street groups



8.2 Costs & Volume breakdown for the proposed option

Table 8-1: Bibbys / Regent Road / Inland Revenue Offices primary group

Primary Substation	Asset Category	Volumes	Cost
Bibbys	33kV Transformer (GM)	1	£ 374,356
	6.6/11kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (PM)	-	£ -
	6.6/11kV CB (GM) Primary	8	£ 153,416
	6.6/11kV VT	3	£ 15,000
Regent Road	33kV Transformer (GM)	1	£ 374,356
	6.6/11kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (PM)	-	£ -
	6.6/11kV CB (GM) Primary	7	£ 134,239
	6.6/11kV VT	3	£ 15,000
Inland Revenue Office	33kV Transformer (GM)	1	£ 374,356
	6.6/11kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (PM)	-	£ -
	6.6/11kV CB (GM) Primary	5	£ 95,885
	6.6/11kV VT	2	£ 10,000
Sandhills Lane	33kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (PM)	-	£ -
	6.6/11kV CB (GM) Primary	3	£ 57,531
	6.6/11kV VT	-	£ -
		Total Cost	**£ 1,604,140**

Table 8-2: Delamore Street/Kirkdale/Walton primary group

Primary Substation	Asset Category	Volumes	Cost
Delamore Street	33kV Transformer (GM)	1	£ 374,356
	6.6/11kV Transformer (GM)	14	£ 202,944
	6.6/11kV Transformer (PM)	-	£ -
	6.6/11kV CB (GM) Primary	-	£ -
	6.6/11kV VT	1	£ 5,000
Kirkdale	33kV Transformer (GM)	-	£ -
	6.6/11kV Transformer (GM)	1	£ 374,356
	6.6/11kV Transformer (PM)	14	£ 202,944
	6.6/11kV CB (GM) Primary	-	£ -

	6.6/11kV VT	-	£	-
Walton	33kV Transformer (GM)	1	£	5,000
	6.6/11kV Transformer (GM)	-	£	-
	6.6/11kV Transformer (PM)	1	£	374,356
	6.6/11kV CB (GM) Primary	10	£	144,960
	6.6/11kV VT	0	£	-
Inland Revenue Offices	33kV Transformer (GM)	6	£	115,062
	6.6/11kV Transformer (GM)	1	£	5,000
	6.6/11kV Transformer (PM)	-	£	-
	6.6/11kV CB (GM) Primary	-	£	-
	6.6/11kV VT	-	£	-
		Total Cost	**£**	**1,828,156**

Table 8-3: Cost incidence over the RIIO-ED2 period, £m (2020/21 Prices)

HV Group	Total (£m)	Incidence (£m)				
		2023/24	2024/25	2025/26	2026/27	2027/28
Bibbys /Regent Road / Inland Revenue Offices	1.604	0.321	0.962	0.321	-	-
Delamore Street / Kirkdale /Walton	1.828	-	1.097	0.366	0.366	-

8.3 Secondary (HV) substation types

Table 8-4: HV Substation types per each circuit

HV Group	Circuit ID	Total HV Substations (#)	Y-Type Substations (#)	X-Type Substations (#)	X -Type Proportion (%)
Bibbys /Regent Road / Inland Revenue Offices	MW15904	10	8	2	80%
	MW15901	8	6	2	75%
	MW15903	9	8	1	89%
	MW 15902	5	1	4	20%
	MW16002	0	0	0	0%
	MW16004	9	8	1	89%
	MW21201	0	0	0	0%
	MW21204	1	0	1	0%
	MW21205	1	0	1	0%
	MW20604	0	0	0	0%
	MW20605	0	0	0	0%
	MW20601	6	5	1	83%
	MW20602	1	0	1	0%
Delamore Street / Kirkdale /Walton	MW22104	1	0	1	0%
	MW16002	14	10	4	71%
	MW21508	5	4	1	80%
	MW21506	7	7	0	100%
	MW21507	8	8	0	100%
	MW21510	7	7	0	100%
	MW16102	4	4	0	100%
	MW16101	9	8	1	89%
	MW16109	1	0	1	0%

8.4 HV circuit information

8.4.1 Bibbys / Regent Road / Inland Revenue Offices primary group

Table 8-5: HV Circuit sectional length in metres

Conductor Type →	0.0225 CU	0.03 AL	0.1 CU	0.15 CU	0.2 AL	0.2 CU	0.3 AL	0.3 CU	0.4 CU	185 AL	185 CU	240 AL	95 AL	UNKNOWN
Ampacity(A) →	100	128	180	220	199	256	256	325	325	273	415	380	189	0
MW15901			1068	84		410	140	2207	164	957	73		1223	332
MW15902								191		264				4
MW15903								1969		596	40			90
MW15904				599		1502		1524		1974				437
MW16002			1081		119	2774		2707		1632	129	14	127	516
MW16004				760		448	205	1196		948				301
MW20601	9					2171		46		756				95
MW20602		4												
MW20604											11			1
MW20605						776		21		3089	170		9	138
MW21201						233		571		879			3	50
MW21204								66		110				
MW21205													172	
Total Length(m) →	9	4	2150	1443	119	8314	345	10498	164	11205	423	14	1534	1965

8.4.2 Delamore Street/Kirkdale/Walton primary group

Table 8-6: HV Circuit sectional length in metres

Conductor Type →	0.1 AL	0.1 CU	0.15 CU	0.2 AL	0.2 CU	0.3 CU	185 AL	185 CU	240 AL	300 AL	95 AL	UNKNOWN
Ampacity(A) →	141	180	220	199	256	325	273	415	380	357	189	0
MW16002		1081		119	2774	2707	1632	129	14		127	516
MW16101		315			1644	1128	1198					164
MW16102					1140	253	250					83
MW16109				2								
MW21506				224	473	528	799					194
MW21507			1012		796	517	975					389
MW21508					498	110	70					8
MW21510	321	1081			371		1524					74
MW22104										21		
Total Length(m) →	321	2477	1012	345	7696	5242	6447	129	14	21	127	1428