Scottish & Southern Electricity Networks

RIIO-ED2 Engineering Justification Paper (EJP)

LV Feeders

Investment Reference No: 70/SHEPD/LRE/LVFeeders

Contents

Definitions and Abbreviations

Acronym	Definition
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CEM	Common Evaluation Methodology
CI	Customers Interrupted
CML	Customers Minutes Lost
CT	Consumer Transformation
CVP	Consumer Value Propositions
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DSO	Distribution System Operator
EJP	Engineering Justification Paper
EREC	Engineering Recommendation
ENA	Energy Networks Association
EV	Electric Vehicle
GIS	Geographic Information System
GM	Ground Mounted
GMT	Ground Mounted Transformer
HP	Heat Pump
HV	High Voltage
IDP	Investment Decision Pack
km	kilometres
kVA	kilo volt-ampere
LCT	Low Carbon Technology
LRE	Load Related Expenditure
LV	Low Voltage
mm^2	Square millimetre
MVA	Mega volt-ampere
NPV	Net Present Value
PM	Pole Mounted
PMT	Pole Mounted Transformer
SEPD	Southern Electric Power Distribution
SHEPD	Scottish Hydro Electric Power Distribution
SSEN	Scottish and Southern Electricity Network

1 Executive Summary

This Engineering Justification Paper (EJP) identifies the need to carry out works on the SSEN (SEPD and SHEPD) LV circuits asset class category to accommodate the forecast load growth. This includes the LV underground cables and overhead lines which will be overloaded under our stakeholder supported DFES. The primary driver of the proposed expenditure is capacity-related (demand or generation).

This paper describes our proposed load-related investment plan for LV circuits portfolio, which is the expenditure SSEN requires to ensure our networks can facilitate the change in demand and generation at the distribution level. LRE improves network resilience, enables the connection of new load and minimises the frequency and duration of outages our customers might have to experience.

It is essential not to exceed the thermal rating of LV underground (UG) cables and overhead lines (OHL). Failure to do so is likely to lead to the unplanned failure of assets in operation – with the associated customer supply interruptions. With the anticipated LCT uptake during RIIO-ED2, it is expected that there will be substantial growth in demand, which will require adequate availability of capacity on the LV feeders.

Our assessment of capacity requirements on the LV network has been informed by SSEN stakeholders, whose views have informed the network planning studies undertaken in respect of the RIIO-ED2 period. Our stakeholders are supportive of our adoption of the DFES 2020 Consumer Transformation scenario as the baseline scenario for the assessment of the impact of low carbon technologies (LCT) on our HV and LV network – particularly the large anticipated increased in the number of electric vehicles (EVs) and heat pumps (HPs).

It has been found that approximately 3% of SSEN LV circuits are expected to have sections overloaded by end of RIIO-ED2 due, principally, to LCT uptake. Following optioneering and detailed analysis, as set out in this paper, the proposed scope of work can be summarised as follows.

- Reinforce approximately 165 km of LV mains
- Procure approximately 11 MVA of flexibility services

Any further investment requirements beyond our ex-ante baseline funding are to be facilitated by our load-related expenditure uncertainty mechanism.

This proposed LV circuit expenditure programme delivers the following customer outputs and benefits:

- The uplift in network capacity needed to meet the ongoing capacity needs of our customers.
- Facilitates the efficient, economic, and co-ordinated development of our distribution network to support and facilitate the delivery of net zero.

In order to protect our customers against the costs of forecasting uncertainties, our ex-ante baseline funding only includes the LV circuit load related investment required in the first two years in the RIIO-ED2 period[1].

Our anticipated load-related expenditure on LV circuits in ED2 is £19m. Of this, £7.8m is included in our ex-ante baseline funding request and £11.2m is expected to be funded through an appropriately designed and implemented load-related expenditure Uncertainty Mechanism. The work is planned to be completed during the ED2 period.

This EJP investment sits within our Net Zero ex-ante baseline expenditure proposal, as shown in Figure 1.

[1] The proposed approach to funding for load-related expenditure is set out in more detail in our ***Load Related Plan Build and Strategy (Annex 10.1)***

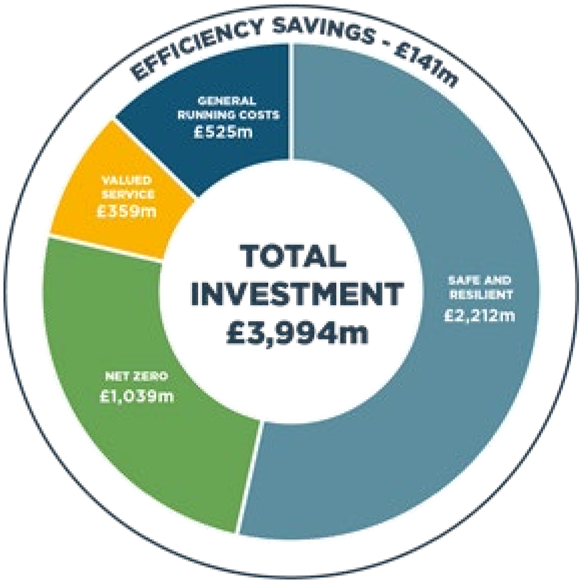

Figure 1: SSEN total investment cost within RIIO ED2

2 Investment Summary Table

Table 1 provides a high-level summary of the key information relevant to this Engineering Justification Paper (EJP) and the management of SSEN's LV Feeder portfolio.

<table>
<tr><th>Name of Programme</th><th colspan="4">LV Feeders</th></tr>
<tr><td>Primary Investment Driver</td><td colspan="4">Load-related (thermal capacity)</td></tr>
<tr><td>Investment reference/mechanism or category</td><td colspan="4">70/SHEPD/LRE/LVFeeders</td></tr>
<tr><td>Output reference/type</td><td colspan="4">LV main (UG Plastic) cable</td></tr>
<tr><td>Cost</td><td colspan="4">£7.8 million</td></tr>
<tr><td>Delivery year</td><td colspan="4">2023/24 – 2027/28</td></tr>
<tr><td>Reporting Table</td><td colspan="4">CV2: Secondary Reinforcement</td></tr>
<tr><td>Outputs included in RIIO – ED1 Business Plan</td><td colspan="4">No</td></tr>
<tr><td rowspan="3">Spend Apportionment (£m)</td><td rowspan="2">ED1</td><td colspan="2">ED2</td><td rowspan="2">ED3+</td></tr>
<tr><td>Ex-ante Baseline</td><td>Uncertainity Mechanism</td></tr>
<tr><td>-</td><td>7.8</td><td>11.2</td><td>-</td></tr>
<tr><td>TOTAL (£m)</td><td>-</td><td colspan="2">19</td><td>-</td></tr>
</table>

Table 1 Investment Summary

3 Introduction

Our ***Load Related Plan Build and Strategy (Annex 10.1)***[2] sets out our methodology for assessing load-related expenditure and describes how we use the Distribution Future Energy Scenarios (DFES) 2020 as the basis for our proposals. We have established a baseline view of demand, providing a robust projection of the drivers of load-related expenditure for the ED2 period. Our ex-ante baseline funding request is based on the minimum investment required under all credible scenarios and is strongly supported by our stakeholders. Our plan will create smart, flexible, local energy networks that facilitate the accelerated progress towards net zero – with an increased focus on collaboration and whole-systems approaches.

This investment is a component of our strategic goal of 'Accelerating progress towards a net zero world'.

Our LV network characteristics and background information are provided in **section 4**. A brief of our RIIO-ED2 planning forecast is provided in **section 5**.

Section 6 provides details of the options considered through the optioneering process to establish the most economic and efficient solution. Each option is described in detail, with the EJP setting out the justification for those options which are deemed unviable solutions, and therefore not taken forward to the Cost Benefit Analysis.

Section 7, Cost Benefit Analysis (CBA) Summary, provides the comparative results of all the options considered within the CBA and sets out the rationale and justification for the preferred solution.

Section 8 presents the volumes needed and associated costs during RIIO-ED2. This section also describes how we have established the cost efficiency of the plan with reference to the unit costs that have been chosen. The deliverability plan and potential risks are explained in **section 9**.

Finally, our proposed investment plan conclusion is drawn in **section 10**.

[2] ***SECTION D: (Chapter 10), Responding to the net zero Opportunity, (Annex 10.1), Load Related Plan Build and Strategy***

4 Background Information

This section provides background information and description of the LV feeder asset class under consideration, the relevant SSEN and industry policies, and the approach used to identify those assets that will require investment during RIIO ED2.

4.1 LV Feeders

SSEN distributes electricity to its customers via the electrical network, the last leg of which is the LV feeder which connects directly into customer properties or commercial premises. SSEN installs LV feeders either as cable or overhead line (OHL) depending on economic and environmental factors e.g. SHEPD in the North has many more LV OHLs than SEPD in the South.

4.2 License Obligations and Industry Standards

It is a statutory requirement that SSEN plans its network to meet the ESQC Regulations. It is also part of the License Conditions to comply with the industry codes such as ENA Engineering recommendations Security of Supply P2/7, G98 and G100 etc.

According to ENA EREC P2/7 a 'circuit' is the part of an electricity supply system between two or more circuit breakers, switches and/or fuses inclusive. It may include 'transformers, reactors, cables and overhead lines'. Furthermore, a circuit should not be 'loaded to a point where it would suffer unacceptable loss of life'[3]. Security Standard P2/7 goes on to state that

> "Circuit Capacity is the appropriate continuous rating or cyclic rating or, where it can be satisfactorily determined, the appropriate emergency rating, taking into account the relevant environmental conditions and the expected demand profile, should be used for all circuit equipment and associated protection systems".

4.3 Primary Investment Drivers

The principal investment driver for LV circuits in ED2 relates to load growth, where the anticipated uptake in LCTs will increase customer demands (as well as significantly alter the cyclic profiles) and this additional load result in circuits approaching or exceeding thermal capacity limits.

According to our latest scenario analysis[4,] in all DFES scenarios it is expected that there will be in excess of 4.3 million EVs connected by the 2040s in SEPD and over 800,000 in SHEPD within the same time period. The UK Government's commitment to stop the sale of petrol and diesel engine vehicles by 2030 is a huge contributory factor. The switch of domestic and non-domestic heating to electric heat pumps is less certain, however there is still expected to be substantial uptake across both licence areas (c. 1.7 million properties in SEPD and c. 700,000 properties in SHEPD) in some of the DFES scenarios. In addition, some 600,000 new houses are expected to be built in SEPD and around 112,000 in SHEPD across all scenarios by 2050.

It is not certain how LCT uptake will take shape throughout ED2, however, it is expected that we will start to see the changes in demand patterns from customer LCT uptake, and some areas of network will approach, reach or even exceed their thermal capacity limits and remove cyclic rating capabilities of assets during the price control period.

---

[3] It should be noted that EREC P2 is not applicable to individual end customers and so specific solutions can be designed as per customer requirements.

[4] Based on DFES 2020 Southern England licence area Results and Methodology Report, December 2020 https://www.ssen.co.uk/WorkArea/DownloadAsset.aspx?id=20282 and DFES 2020 North of Scotland licence area Results and Methodology Report, December 2020 https://www.ssen.co.uk/WorkArea/DownloadAsset.aspx?id=20283 .

4.4 LV Feeder Faults from Thermal Overloading

There is limited interconnection at street level for LV feeders – some back-feed capability is built into the LV network and can be enabled through link box switching etc – and so a fault on a feeder can have a direct implication for customer supply and SSEN's CI/CMLs. Since there is limited monitoring on the LV network, it is not always directly obvious that an issue is apparent or being caused by increased loading on an LV feeder. An LV feeder is considered to be overloaded if it is operating in excess of 100% of its rating, however, OHLs and cables are capable of operating in excess of their thermal rating for short periods of time, depending on load profile. A consistent thermal overload may impact joints or other equipment before there is an issue with the conductor itself and as such, a correct fault diagnosis due to overloading may not be made immediately.

5 RIIO-ED2 Load Forecast

In order to understand the future pathways for LCT demand on our HV and LV network, we have carried out extensive scenario studies – the Distribution Future Energy Scenarios (DFES). The basis for this work is National Grid's Future Energy Scenarios (FES) 2020. This framework comprises four potential pathways for the future of energy based on how much energy may be needed and from where it might come. The variables for the four scenarios are driven by government policy, economics and consumer attitudes related to the speed of decarbonisation and the level of decentralisation of the energy industry. We have worked closely with our partner Regen to develop the forecasts between 2020 and 2050 through enhanced engagement with the local authorities, local enterprise partnerships, devolved governments, community energy groups and other stakeholders.

A high granularity projection has been produced for LCT uptake in both the North and South SSEN licence areas; this has been done down to the level of secondary distribution transformers and to individual LV feeders. This level of granularity corresponds to post code or street level. A bottom-up assessment of local resources, constraints and market conditions has been carried out to develop the four scenario forecasts for each technology. Locational data and GIS analysis have been used to understand the potential for technologies to develop through geographical distribution, local attributes, and constraints. The key LCT expected to increase the electricity demand on LV network are electric vehicle chargers and electricity-fuelled heating technologies (air source and ground source heat pumps, hybrid heating and direct electric heaters).

Based on the enhanced stakeholder engagement feedback, we have chosen Consumer Transformation as a credible baseline scenario on which to base our maximum demand for projection for ED2. In order to protect customers against the costs of forecasting uncertainties, our ex-ante baseline funding only includes load related investment required in the first two years in the RIIO-ED2 period. Full details on our DFES methodology, stakeholder input and regulatory treatments of load related investment can be found in the ***Load Related Plan Build and Strategy (Annex 10.1)*** [5].

Detailed DFES datasets have allowed us to model the potential impact of demand and technology changes on the LV network and to understand the scale and range of network reinforcement needed during RIIO-ED2.

With 53,215km of LV circuits between our licence areas, we found it unviable, given our connectivity limitations, to model and technically assess our entire network. Therefore, we took the approach to identify areas or 'hotspots' of concern that see potential overloading issues in the ED2 period. With the baseline load calculated[6], we then proceeded to add the forecast demand of the DFES and modified scenario before studying our assets to identify future thermal constraints. Using the forecast load of the LV feeders, we checked this against the thermal rating of the first section of the distributer mains circuit. One key assumption at this stage was to use the winter cyclic rating of the cable or overhead line as LV demand is predominately domestic with higher, cyclic demands in the winter months.

From this hotspot analysis, we were able to identify the LV feeders that are expected to be overloaded throughout ED2 period. Table 2 and Table 3 show the number of feeders and constrained LV mains length that require intervention throughout ED2 in both licence areas. It should be noted that volumes are cumulative and reflect only LV mains feeders (i.e., LV service conductors are not included).

---

5 Load-related investment is explained in more details in ***SECTION D: (Chapter 10), Responding to the net zero Opportunity, (Annex 10.1), Load Related Plan Build and Strategy***

6 The methodology to identify hotspots is available in **Section D: Responding to the net zero opportunity -Annex 12.- Load Related Plan Build and Strategy**

	2024	2025	2026	2027	2028
Number of Feeders	654	1391	2050	2650	3008
Constrained LV mains (km)	29	73	90	116	131

Table 2 SEPD LV Feeders Constrained Volumes

	2024	2025	2026	2027	2028
Number of Feeders	251	584	874	1127	1229
Constrained LV mains (km)	15	34	52	67	73

Table 3 SHEPD LV Feeders Constrained Volumes

6 Summary of Options Considered

This section sets out the investment options that are being proposed to manage the LV circuits asset class in ED2 to mitigate thermal constraints for LV circuits. It describes the holistic approach taken to ensure investment options are chosen which are both least regret and represent best value for money for network customers.

Conventional (constructed) network solutions and flexibility services are alternative potential solutions to alleviate network thermal overloads.

Network Solutions increase network capacity but do not specifically aim to reduce peak demand. An example includes upgrading with larger cross-sectional area conductors.

Flexible Solutions aim to reduce peak demand, either by shifting energy consumption out of peak demand periods or by reducing energy consumption overall. Encouraging local generation of power to offset demand – particularly at times of peak – can also be an effective means of matching supply and demand and avoiding or postponing conventional circuit reinforcement. Demand side response, energy storage systems, time of use tariffs, hybrid heat pumps and smart electric vehicle charging schemes are all sources of flexibility service. In addition, energy efficiency approaches may also provide 'inactive' flexibility services although these approaches are still yet to be tested in real network scenarios, SSEN as well as other DNO's have trialled the use of such approaches through innovation projects such as SSEN's Solent Achieving Value through Efficiency (SAVE) Project.

6.1 Whole System Considerations

Additionally, we have considered the potential for using Whole System solutions (involving collaboration with third parties) to deliver this investment programme. We set out our assessment in Appendix 1. This follows our standardised approach for embedding Whole System considerations into our load and non-load investment decisions (in line with Ofgem's ED2 business plan guidance), as described in our ***Whole System (Annex 12.1)***.[7]

Our assessment enables us to take a proportionate consideration of Whole System options, based on the feasibility of such options existing and materiality of the costs involved.

In this case, our Whole Systems assessment finds that this programme is not expected to have any wider Whole System interactions and there are no feasible Whole Systems solutions.

6.2 Summary of Investment Options

Table 4 below provides a high-level summary of the investment options under consideration along with the advantages and disadvantages associated with each. A more detailed description of each option is subsequently provided.

[7] Our approach to Whole Systems is presented in more detail in our ***Whole System Annex 12.1***.

Option	Description	Advantages	Disadvantages	Result
1. Load Transfer (Do Minimum)	No investment; utilise network back-feed capability when required to provide additional capacity	– Short-term expenditure reduction – No civil cost required	– Risk of EREC P2/7 non-compliance – Accelerate deterioration of asset health and lifespan – Limited spare capacity for additional load – Increased network losses – Increase in required switching actions to enable back-feed	Not progressed to CBA
2. Install LV monitors to monitor demand	Monitor demand on existing feeders to allow a more informed investment decision to be made	– Increased efficiency – Lowered carbon emissions – Lower expenditure – Lower civil costs required	– Additional LV monitor procurement, installation and operational costs – Data processing required to analyse monitoring data	Not progressed to CBA
3. Conductor Upgrade	Replace existing conductor with higher rated conductor	– Improved network reliability from new feeder – Readiness to accommodate desired network capacity without delays – Maximum improvement in asset lifetime – Compliance with Losses strategy minimum design (for cables)	– High expenditure – Potential disruption to network stakeholders – Civil costs required – Additional carbon footprint	Taken forward to CBA

Option	Description	Advantages	Disadvantages	Result
4. Deploy flexibility services and conductor reinforce	The procurement of flexibility services from network customers to defer feeder uprating	– Defer expenditure required to upgrade the circuit – Increased efficiency – Reduces the risk associated with increased maintenance – Supports development of third-party flexibility markets and transition to DSO	– The flexibility market on LV Level is still uncertain – The price point for flexibility services is often uncompetitive when compared to conventional solutions – Limited market liquidity in various regions of SSEN network	Taken forward to CBA

Table 4 Summary of Investment Options for LV feeders

6.3 Detailed Option Analysis

6.3.1 Option 1: Load Transfer (Do-Minimum)

Estimated Cost: £0k

Under the Do Minimum option, there is no investment taking place. Inspection and maintenance activities continue as normal as per the relevant policies. No innovation or flexibility considered, and back-feeding is performed only as needed/possible.

The additional load that may otherwise cause the conductors to be thermally constrained will be shifted to/supplied from other adjacent feeders via normal open points (NOPs), provided there is sufficient spare capacity on these back-feeds.

Whilst this option avoids conventional investment, it could accelerate the deterioration of feeder health, particularly under new, likely more onerous, cyclic load patterns as EV and heat pump uptake increases. It also increases the likelihood of faults and other events that may occur due to overloading.

This option could lead to asset failure in some cases which can have both safety, environmental and financial consequences. Also a reduction in the quality of supply for network customers, with significant increases in customer interruptions (CIs) and customer minutes lost (CMLs).

6.3.2 Option 2: Install LV monitors in local secondary substation to monitor demand

Estimated Cost: £0k

This option could be used to monitor any feeders which are known to experience occasional overloading and allow a more informed decision to be made on the investment option to follow i.e. flexibility or asset reinforcement. This option would allow us to avoid any unnecessary expenditure if the overload is not as severe or does not materialise.

LV monitors provide up to ten-minute interval readings of load current per phase of each feeder connected to a transformer. The LV data analysis will inform on the severity and frequency of overloading, allowing an informed CAPEX investment decision to be made.

Additional benefits of LV monitoring equipment:

- Provides efficient network visibility and utilisation which supports wider strategic work.
- Informs SSEN of network areas that are off supply. There is currently no way of knowing when a feeder is off supply unless a customer calls us directly.
- Reduces CI/CMLs.

Our LV monitoring strategy[8] will facilitate the roll out of LV monitors on all LV assets expected to be utilised at 80% or more of nameplate rating. This option will enable us to manage the uncertainty of LV feeders loading over the coming years which will ultimately facilitate the transition to electrification of heat and transport in a measured way. There will be less and/ or deferred CAPEX costs, improved network visibility (which has benefits for other SSEN business areas), and more benefits to customers. However, spare network capacity is not guaranteed.

6.3.3 Option 3: Conductor upgrade

Estimated Cost: £22.8 million

This option is to reinforce only all 203 km constrained LV conductors with a higher rated circuit. This will increase network capacity, enhance network reliability, and facilitate the transition to electrification of transport and heat. It will also support SSEN's losses strategy[9] which has mandated a minimum LV cable size for new/replacement assets to minimise losses.

We have made the decision to reinforce all LV main constrained sections with the maximum size cable (300mm^2 Wavecon) to provide better network capacity, reliability, and value for money for customers in the long run. The marginal cost of installing larger conductor or cable is less than the marginal benefit associated with losses reduction and with the potential future costs of further upgrade – particularly for underground cables where the cost and inconvenience of excavation and installation can be significant. This supports our 'once touch to net zero' approach. The full reinforcement of LV feeders will also be coordinated with any wider substation works in the area if required, such as the replacement of the substation transformer or protection equipment.

Despite the benefits this option provides, this option increases the investment cost needed; potential disruption to our customers and stakeholders due to the requirement for an increased amount of civil work. Furthermore, this option does not align with our business plan ambition and DSO objectives. There is also the potential risk of deliverability challenges due to high work volumes.

---

[8] LV Monitoring Strategy is described in more details in Section B: IT and Digitalisation - Annex 5 - Digital Investment Plan Strategic Annex

[9] SSEN Distribution's RIIO-ED1 Losses Strategy, March 2021 Losses Strategy (ssen.co.uk)

6.3.4 Option 4: Deploy flexibility services and reinforce

Estimated Cost: £19 million

In this option, deployment of LV flexibility where feasible ahead of network reinforcement is considered.

A key investment option is the procurement of flexibility services which is in line with SSEN's Flexibility First approach. This approach is considered as a key enabler of our aspiration to further develop distribution system operation (DSO) capability. These flexibility services will be procured to defer or avoid the need to carry out costly network reinforcement and investment in network assets.

In some cases, flexibility procurement will be useful to maintain network loading to an acceptable level and thus sustain the designed lifespan of feeders to prevent rapid deterioration and either defer or avoid conventional reinforcement or asset replacement. Flexible services have the potential to defer a significant number of asset replacements from RIIO-ED2 to RIIO-ED3, delivering value for money for network customers. Furthermore, flexibility procurement has the following potential for load and non-load related purposes:

- Reduces the rate of asset degradation by reducing peak network loading (thermal strain) on high-risk assets.
- Allows DNOs to secure the network prior to planned outage events, in some cases avoiding the need for mobile diesel generation support.

Flexibility at LV can significantly reduce the winter peak demand growth that is driven by the uptake of LCTs. We have assessed the impact of five different sources of flexibility including:

1. Domestic SMART Charging
2. Domestic Vehicle to Grid
3. Flexible Heat from Domestic Heat Pumps
4. Time of Use Tariffs uptake arising from Ofgem's Access and Charging Significant Code Review
5. Energy Efficiency interventions[10]

LV flexibility sources have been modelled by means of a reduction in the peak demand at each LV asset (i.e. LV feeder or secondary transformer) with anticipated LCT uptake. However, the LV flexibility services to be procured in ED2 are expected to include domestic vehicle to grid and flexible heat from domestic heat pumps[11].

The aggregate volumes of LV Flexibility are driven by the growing numbers of LCTs over time together with the assumed participation rates. It is anticipated that we will procure 11 MVA by end of RIIO-ED2 to defer reinforcement of 40km of LV cables. The domestic demand reduction/shift during peak time at LV level from LV flexibility deployment will have incremental benefits on upstream assets loading (i.e. secondary transformers loading, etc…)

From the LV flexibility assessment, it was found that 2515 LV feeders in SEPD and 937 LV feeders in SHEPD are still expected to be overloaded during RIIO-ED2 and procurement of LV flexibility is unlikely to be feasible to address thermal constraints. Therefore, it is proposed to reinforce 108 km of LV mains in SEPD and 56 km of LV mains in SHEPD, with the maximum size cable (300mm^2 Wavecon).

We will perform analysis for all schemes, and for LV feeders which are identified as having potential for Flexible Solutions, we will carry out Flexibility market tests to establish the cost, location and technical capabilities of the available flexibility.

If the market test is successful, a flexibility solution will be employed offering value to both us, and our customers in terms of investment deferral and optionality. Should the market test fail or only partially succeed

[10] The Energy Efficiency initiative is considered in separate CVP which includes all relevant costs. More details are available in RIIO-ED2 Business Plan- ***DSO Strategy (Annex 11.1) Appendix F - Delivering Value through Flexibility***

[11] The impact of flexibility services on LV peak demand are presented in more details in RIIO-ED2 Business Plan - ***DSO Strategy (Annex 11.1) Appendix F - Delivering Value through Flexibility***

in identifying the required Flexibility, we will use the CEM Framework or alternative CBA mechanism to assess the optimal, secondary solution for the location in question, be that be a further market test for full Flexibility, accelerating the Conventional solution or a Hybrid Scheme.

It is expected that our Energy Efficiency Accelerator and Local Market Stimulation Consumer Value Propositions (CVP) will directly stimulate and improve the levels of Flexibility available at LV in areas of network need. The implementation of these CVPs gives us greater confidence of the viability in deploying Flexibility across a wider sample of LV schemes.

Further details of our approach to flexibility and our CVPs can be found in the Flexibility Appendix to our ***DSO Strategy (Annex 11.1) Appendix F - Delivering Value through Flexibility*** [12].

[12] RIIO ED2 Business Plan, ***DSO Strategy (Annex 11.1) Appendix F - Delivering Value through Flexibility***

7 Cost Benefit Analysis

This section provides an overview of the results from the Cost Benefit Analysis (CBA). A detailed exercise has been undertaken to support the investment strategy that is described within this EJP. A CBA has been undertaken to determine how we should invest in our load related HV and LV portfolio in ED2.

7.1 CBA of Investment Options

Ofgem's RIIO-ED2 standard CBA template has been used to assess costs and benefits of the secondary reinforcement investment options for HV/LV assets portfolio for each license area. Four CBA options have been considered:

Option 1: Reinforcement without flexibility services

In this option, network reinforcement is only considered, and no flexibility services are used.

Option 2: Deploy flexibility services – Central Price

This option considers the deployment of LV flexibility services where feasible ahead of network reinforcement at a central price. At this stage however, the LV flexibility services market is considered immature and an unproven long-term solution which requires further development. The market procurement cost is based on a previous analysis of activity on flex platforms. The value used is:

- LV Flexibility Service Fee[13]: £48 / kW / year

We have made the additional assumption that dynamic LV Flexibility would be paid a service fee.

Option 3: Deploy flexibility services – Low Price

Deploys flexibility services where feasible ahead of network reinforcement (Low Price £36/kW/year)

Option 4: Deploy flexibility services – Lowest Price

Deploys flexibility services where feasible ahead of network reinforcement (Lowest Price £24/kW/year)

Sensitivities on these prices (Option 3 and Option 4) have been undertaken due to the emerging nature of the flex markets and the potential volatility in prices.

Further information on our CBA approach is set out within our ***Cost Benefit Analysis Process (Annex 15.8)***.[14].

7.2 Cost Benefit Analysis Results

The CBA results in Table 5 and Table 6, demonstrate that the most cost-effective solution is option 4 'Deploy flexibility services - Lowest Price' for both licensed areas, as it has the least NPV against the required investment. The total investment reduces by 19% due to flexibility deployment during RIIO-ED2, while providing efficient and enduring long-term security of supply as we move towards a Net Zero network. In addition, it achieves our aspiration to fully develop distribution system operation (DSO) capabilities. Similarly, option 2 and option 3, have better NPV than option 1 and reduce the total investment needed by 13% and 16% respectively during RIIO-ED2. Meanwhile, in Option 2, the cost of LV flexibility is calculated using the same market procurement price (LV Flexibility Service Fee of £48/kW/year). Therefore, to ensure consistency with market prices, option 2 is the preferred solution to address the LV feeder thermal constraint issue.

---

13 LV flexibility service fee is paid to flexibility providers for making their capability available to respond and for actual delivery.

14 RIIO ED2 Business Plan, our ***Cost Benefit Analysis Process (Annex 15.8)***.

Options	Net Present Value (NPV) After 45 Years (£m)	Investment (£m)
Option 1: Reinforcement without flexibility services	-33.16	62.7
Option 2: Deploy flexibility services - Central Price	-23.26	56.2
Option 3: Deploy flexibility services - Low Price	-22.58	54.9
Option 4: Deploy flexibility services - Lowest Price	-21.90	53.5

Table 5 SEPD CBA Comparison

Options	Net Present Value (NPV) After 45 Years (£m)	Investment (£m)
Option 1: Reinforcement without flexibility services	-9.18	17.13
Option 2: Deploy flexibility services - Central Price	-5.25	13.6
Option 3: Deploy flexibility services - Low Price	-5.21	13.5
Option 4: Deploy flexibility services - Lowest Price	-5.16	13.4

Table 6 SHEPD CBA Comparison

Deploying flexibility has significant potential to reduce investment needs, unlocking savings for consumers. The scale of these savings has been estimated below in Table 7 which shows the amount of asset reinforcement cost we have avoided during the ED2 period as a result of using flexibility schemes.

Capex Savings in ED2	Option 2: Flex Cost-Central Price	Option 3: Flex Cost – Low Price	Option 4: Flex Cost – Lowest Price
SEPD (£m)	10.10	10.80	11.51
SHEPD (£m)	4.01	4.06	4.11
SSEN (£m)	14.11	14.86	15.61

Table 7 Capex Savings Estimation of Flexibility Deployment

For LV flexibility to be deployed as a credible investment option there needs to be a substantial improvement in both the market liquidity and the threshold price for each of the services. Increased levels of flexibility will be possible when it can be procured at a lower price such that it represents value for money when compared to conventional solutions. Our current modelling approach to Flexibility viability at LV Feeder level has been conservative and we recognise there are likely to be significant benefits from the ability in delaying investment decisions through the use of flexibility which is not captured in our current methodology. As flexibility markets evolve and increased fluidity in service availability is seen, we expect an increase in the number of schemes utilising flexibility and the attributable benefits which are achieved.

7.3 Preferred Option Summary

Option 2 is the preferred option to deliver our secondary reinforcement investment plan for our LV feeder portfolio. It is proposed to reinforce 165km of constrained LV main sections with the maximum size cable (300mm^2 Wavecon), and will procure 11MVA of flexibility services, to mitigate overloading and provide spare capacity for LCT uptake by end of RIIO-ED2.

It is critical to note that we will review each scheme for the potential application of flexible services and should markets mature in this area there is increasing likelihood of our ability to defer a much larger percentage of schemes. However, due to the infancy of LV flexibility and the need for further development we are taking a moderate view of roll-out capability at this stage.

8 Summary of Costs and Volumes

Our RIIO-ED2 Business Plan costs are derived from our outturn RIIO-ED1 expenditure. We have modified costs per activity, capturing and reporting those adjustments in our cost-book. By tying our costs back to reported, outturn, real life data this approach provides multiple data points on which both the Regulator and we can benchmark cost efficiency. It provides a high level of cost confidence in our Business Plan cost forecast for RIIO ED2. Through our benchmarking analysis, we recognised that not all Non-Load related RIIO-ED1 actual unit costs sit within the upper quartile efficiency band. Where this is the case, we have applied a catch-up efficiency to those cost categories.

Further detail on our unit cost approach, cost efficiency and cost confidence for RIIO-ED2 can be found within our ***Cost Efficiency (Annex 15.1)***[15]. Following our draft Business Plan, we have continued to develop project scopes and costs, utilising valuable stakeholder feedback. We have included developments of our Commercial Strategy within the updated project scope and delivery strategy.

This section of the report provides an overview of the volumes and costs associated with the proposed LV feeder investment approach in ED2.

8.1 SEPD Costs and Volumes

Table 8 and Table 9 provide details costs and volumes for LV feeder investment in the SEPD licence area of SSEN for ED2. The LV main cable unit cost has been derived from ED1 six years average unit cost in addition to 2.5% efficiency. The average unit cost per km for LV main cable is [redacted].

Asset Reinforcement	2024	2025	2026	2027	2028	Total
OHL (km)	0	0	0	0	0	0
Cable (km)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 8 SEPD LV Feeder Asset Reinforcement Volumes

Asset Reinforcement	2024	2025	2026	2027	2028	Total
OHL (£m)	0	0	0	0	0	0
Cable (£m)	2.27	2.99	2.99	2.99	1.67	12.92

Table 9 SEPD LV Feeder Asset Reinforcement Costs

As mentioned previously, it is the intention to replace existing OHLs with cable with 300mm^2 Wavecon cable to offer better network capacity, reliability, and value for money for customers. In ED2, SEPD will reinforce 2515 sections of LV mains, totalling approximately 108km at a cost of £12.92million.

For LV flexibility service procurement, we have taken guidance from recent LV flexibility tenders run by other UK DNOs and the assumed cost of this is £48/kW/year. Based on the number of feeders and the required flexibility capacity, the costs and volumes of LV flexibility for SEPD in ED2 is presented in Table 10 and Table 11.

15 Link to ***Cost Efficiency (Annex 15.1***.

Flexibility	2024	2025	2026	2027	2028
Length of feeders (km)	4	5	5	5	3

Table 10 SEPD LV Feeder Deferred Volumes

Flexibility	2024	2025	2026	2027	2028	Total
Capacity required (MVA)	0.1	0.1	0.8	2.4	3.1	6.48
Cost of procuring capacity (£m)	0.00	0.01	0.04	0.11	0.15	0.31

Table 11 SEPD LV Feeder Flexibility Costs

8.2 SHEPD Costs and Volumes

Table 12 and Table 13 provide costs and volumes for LV feeder investment in the SHEPD licence area of SSEN for ED2. The LV main cable unit cost has been derived from ED1 six years average unit cost in addition to 2.5% efficiency. The average unit cost per km for LV main cable is £99,300.

Asset Reinforcement	2024	2025	2026	2027	2028	Total
OHL (km)	0	0	0	0	0	0
Cable (km)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 12 SHEPD LV Feeder Asset Reinforcement Volumes

Asset Reinforcement	2024	2025	2026	2027	2028	Total
OHL (£m)	0.0	0.0	0.0	0.0	0.0	0.0
Cable (£m)	1.13	1.46	1.38	1.17	0.45	5.59

Table 13 SHEPD LV Feeder Asset Reinforcement Costs

As mentioned previously, it is the intention to replace existing OHLs with cable with 300mm^2 Wavecon cable to offer better network capacity, reliability, and value for money for customers. In ED2, SHEPD will reinforce 937 sections of LV mains feeder, totalling approximately 57 km at a cost of £5.59million.

For LV flexibility service procurement, we have taken guidance from recent LV flexibility tenders run by other UK DNOs and the assumed cost of this is £48/kW/year. Based on the number of feeders and the required flexibility capacity, the costs and volumes of LV flexibility for SHEPD in ED2 is presented in Table 14 and Table 15.

Flexibility	2024	2025	2026	2027	2028	Total
Length of feeders (km)	4	4	4	4	1	17

Table 14 SHEPD LV Deferred Volumes

Flexibility	2024	2025	2026	2027	2028	Total
Capacity required (MVA)	0.10	0.13	0.56	1.77	2.11	4.67
Cost of procuring capacity (£m)	0.00	0.01	0.03	0.09	0.10	0.22

Table 15 SHEPD LV Feeder Flexibility Costs

9 Deliverability and Risk

Between our draft and final Business Plans we have carried out a more detailed deliverability assessment of our overall plan as a package and its component investments. Using our draft Business Plan investment and phasing as a baseline we have followed our deliverability assessment methodology. We have assessed any potential delivery constraints to our plan based on:

- In-house workforce capacity and skills constraints based on our planned recruitment and training profile and planned sourcing mix as well as the efficiencies we have built into our Business Plan ***(detailed in our Workforce Resilience Strategy in (Annex 16.3)*** and ***Cost Efficiency (Annex 15.1)***
- Assessment of the specific lead and delivery timelines for the asset classes in our planned schemes
- We have evaluated our sourcing mix where there were known delivery constraints to assess opportunities to alleviate any constraints through outsourcing
- We have engaged our supply chain detailed in our ***Supply Chain Strategy (Annex 16.2)*** to explore how the supply chain could support us to efficiently deliver greater volumes of work and how we could implement a range of alternative contracting strategies to deliver this
- We have also engaged with the supply chain on the delivery of work volumes that sit within Uncertainty Mechanisms to ensure we have plans in place to deliver this work if and when the need arises
- Specific to load schemes: We have carried out flexibility assessments at all voltage levels in order to understand when we can defer reinforcement through paying for flexibility services, therefore ensuring our investment profile is deliverable and at the lowest cost to consumers see ***Flexibility within Load Related Plan Build and Strategy (Annex 10.1***)
- We have assessed the synergies between our planned load, non-load and environmental investments to most efficiently plan the scheduling of work and minimise disruption to consumers
- Based on our assessment of delivery constraints and potential solutions to resolve them, we have revised our investment phasing accordingly to ensure our Business Plan is deliverable, meets our consumers' needs and is most cost efficient for our consumers

This investment scheme is part of the wider load-related investment portfolio in RIIO-ED2. We have developed a strategy to deliver a much larger volume of work in comparison with the level of investment in ED1. We have engaged with our supply chain to negotiate the most effective unit costs and we have taken measures to ensure we secure a future workforce with the right skills and competencies to deliver capital projects in ED2.

10 Conclusion

The purpose of this Engineering Justification Paper (EJP) is to set out the overarching investment strategy that SSEN intends to take during RIIO ED2 for the load related investment of LV feeders.

To address thermal capacity constraints due to LCT uptake during RIIO-ED2 price control period, conventional and flexible solutions are considered as potential interventions that will depend upon the attributes of each LV circuit project requiring investment (rate of load growth, flexible market availability, etc.). During RIIO ED2 a detailed Cost Benefit Analysis (CBA) will be used on a case-by-case basis to identify which option represents best value for money for network customers and can be considered least regret.

As described within this EJP, a holistic approach has been taken to establish the LV feeder investment strategy. This included a hot spot analysis of SSEN's existing LV feeder assets, future network trend analysis and careful consideration of the financial, safety, and environmental implications of each investment option. From CBA results, 'Option 2: Deploy flexibility services where feasible ahead of network reinforcement - Central Price' is the preferred solution to manage LV feeders secondary reinforcement during RIIO-ED2. It is proposed to reinforce total of 165 km of constrained LV cable and overhead line sections with higher rated conductors and procure 11 MVA for an LV flexibility service fee of (£48/kW/year). Any further investment to be required is to be delivered by our load related uncertainty mechanism.

The strategy described in this EJP have been assessed against RIIO-ED2 strategies as follows: meeting license obligations, steady performance, and leading reliability.

The total cost of £19 million to deliver the proposed load-related LV feeders portfolio needed during RIIO ED2. The delivery of the proposed investment strategy will be a key in enabling the achievement of our strategic ambition to facilitate the connection of 1.3m EVs and 800,000 heat-pumps by 2028. As well as releasing capacity and enabling the connection of LCT, our investments will also provide further benefits to consumers. These include a positive impact on long-term network reliability associated with the number and duration of supply interruptions.

The delivery of this scheme will be measured throughout RIIO-ED2 by the volumes delivered, and the reduction of CIs/CMLs.

To protect our customers against costs from forecast uncertainties, we have taken the decision that our ex-ante baseline funding only includes the LV circuit load related investment required in the first two years in the RIIO-ED2 period. Of the £19million total expenditure on LV circuits, £7.8million is included in our ex-ante baseline TOTEX proposal and we anticipate that £11.2million will be provided-for through an appropriately designed and implemented load-related expenditure Uncertainty Mechanism.

Appendix 1: Whole Systems consideration

In augmenting our decision-making processes to consider Whole System solutions, we have introduced an assessment to identify where a Whole Systems CBA would be a useful decision-making tool for ED2 load and non-load schemes. While our work with the ENA to undertake Whole Systems CBAs is ongoing, we have introduced the 'Whole Systems CBA test' to identify where a scheme may be suitable for a Whole Systems CBA to be conducted. Where a Whole Systems CBA is determined to be a useful decision-making tool, these would be conducted in addition to the standard Ofgem CBA and/or SSEN's flexibility CBA. We have introduced this test in line with Ofgem's expectations for "proportionality when submitting a Whole System CBA. For example, smaller or simple projects following the standard CBA template, whereas larger or more complex projects requiring bespoke analytical approaches" (Ofgem BPG, section 4.28, p.34).

The 'Whole Systems CBA test' involves assessing each investment scheme of over £2m (the threshold to develop an EJP for load and non-load investments) against 5 tests. These 5 tests help determine whether a Whole Systems CBA is a useful decision-making tool based on the characteristics of the scheme, including whether it will have wider cross sector or societal impacts.

Details on each of the tests are provided in case study 6 in our ***Whole System (Annex 12.1)***. Tests 1-3 are aligned with the ENA's guidance for Whole System CBA tests. We have added Tests 4 and 5 to clarify whether a Whole Systems CBA is required based on the materiality / proportionality of the investment (Test 4) and whether a flexibility CBA only is sufficient (Test 5). Table 16 below outlines our Whole Systems CBA test for LV circuits.

Scheme	Test 1: Are there Whole Systems interactions, or is there potential for it?	Test 2: Could a Whole Systems CBA drive you to make a different decision?	Test 3: Is a Whole Systems CBA reasonable?	Test 4 - Is the project valued at over £2m?	Test 5 - Is the investment plan related to procuring flexible solutions only?
SSEN's LV circuits Reinforcement	No – We consider there to be limited potential for Whole Systems interactions with third parties to deliver this investment programme, and accordingly we do not consider there to be potential for Whole Systems solution(s).	No – As noted under Test 1 we do not consider there to be potential for Whole Systems solution(s) in this case.	No – As noted under Test 1 we do not consider there to be potential for Whole Systems solution(s) in this case.	Yes	No

Table 16 Whole Systems CBA test for SSEN's LV Circuits Reinforcements

As the result of tests 1, 2 and 3 above is "No", a Whole Systems CBA is not required for this investment. It is not expected to have any wider Whole System interactions or potential Whole Systems solutions.

Appendix 2: Relevant Policy, Standards, and Operational Restrictions

The policies, manuals and standards and operational restrictions which govern the management of LV feeders are listed below in Table 17.

Policy Number	Policy Name / Description
	ENA Engineering Recommendation P2, Issue 7, 2019
PR-NET-NPL-010	Planning Standards for 11 kV and 6.6 kV Distribution Networks
PR-NET-NPL-001	Planning Standards for Low Voltage Distribution Network
ST-NET-ENG-010	SSEN Distribution Network Investment Strategy RIIO-ED1
	SSEN Distribution's RIIO-ED1 Losses Strategy, March 2021

Table 17 LV Feeders relevant documents