Scottish & Southern Electricity Networks

RIIO-ED2 Engineering Justification Paper (EJP)

Stokenchurch 33/11kV Primary Substation

Investment Reference No: 51/SEPD/LRE/STOK

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Definitions and Abbreviations

Acronym	Definition
AIS	Air-insulated Switchgear
ASCR	Aluminium Conductor Steel Reinforced
BSP	Bulk Supply Point
CBA	Cost Benefit Analysis
CBRM	Condition Based Risk Management
CEM	Common Evaluation Methodology
CI	Customer Interruptions
CML	Customer Minutes Lost
CT	Consumer Transformation
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
EJP	Engineering Justification Paper
ESA	Electricity Supply Area
EV	Electric Vehicle
FCO	First Circuit Outage
FES	Future Energy Scenarios
GIS	Geographic Information System
GM	Ground Mounted
GSP	Grid Supply Point
HI	Health Index
IDP	Investment Decision Pack
LCT	Low Carbon Technology
LEP	Local Enterprise Partnership
LI	Load Index
LRE	Load Related Expenditure
LW	Leading the Way
NPV	Net Present Value
OHL	Overhead Line
PM	Pole Mounted
PV	Photovoltaics
RSN	Relevant Section of Network
SCO	Second Circuit Outage
SSEN	Scottish and Southern Electricity Network
SP	Steady Progression
ST	System Transformation
XLPE	Cross-linked Polyethylene

1 Executive Summary

Our proposed investment at Stokenchurch primary substation will mitigate asset overloading for investment of £3.07m during RIIO-ED2.

The primary investment driver for this scheme is thermal overloading due to demand growth. The overloading issue is apparent under two Distribution Future Energy Scenario (DFES) scenarios (Consumer Transformation and Leading the way) in the winter and under all the scenarios in spring/autumn requiring investment in ED2.

Accelerating progress towards a net zero world

The EJP considers a range of options to address the overloading issues experienced at Stokenchurch primary, setting out the options that have been considered and rejected prior to the CBA analysis, and the short list of those options included within the analysis, with a clear rationale for including or excluding each option.

The Cost Benefit Analysis results shown below demonstrates that the most cost-effective solution, that delivers the best value for consumers in terms of Net Present Value (£m) over 45 years, is option 4 which will initially use flexible services to defer conventional reinforcement followed by asset replacement.

Options	Net Present Value (NPV) After 45 Years (£k)	Investment (£k)
Option 2 – Replacement of the 33kV circuit and 33/11kV transformer with premium cost	-2,572	4,093
Option 3 – Addition of a third 33kV circuit and transformer	-4,253	4,457
Option 4 – Use of Flexible services to defer conventional reinforcement with standard cost	-1,464	3,074

Table 1 Option Summary

Following the optioneering and detailed analysis, as set out in this paper, the proposed scope of works for Option 4 is:

Asset	Volume	Costs
33kV OHL (Pole Line) Conductor) (km)	13.2	[redacted]
33kV UGC (non-pressurised)	5.04	[redacted]
33kV Transformer (GM)	2	[redacted]
Flexible Services	-	£44.1k
Total		**£3,074k**

Table 2 Investment Summary

This scheme delivers the following outputs and benefits:

- Uplift in network capacity from 9.8MVA to 30MVA to meet the needs of our customers.
- Improves the LI index from LI4 (without investment) to LI1 (with investment).
- Facilitates the efficient, economic, and co-ordinated development of our Distribution Network for Net Zero.

The cost to deliver the preferred solution is £3.07m and the works are planned to be completed in 2026. This EJP investment sits within our Net Zero Totex ask.

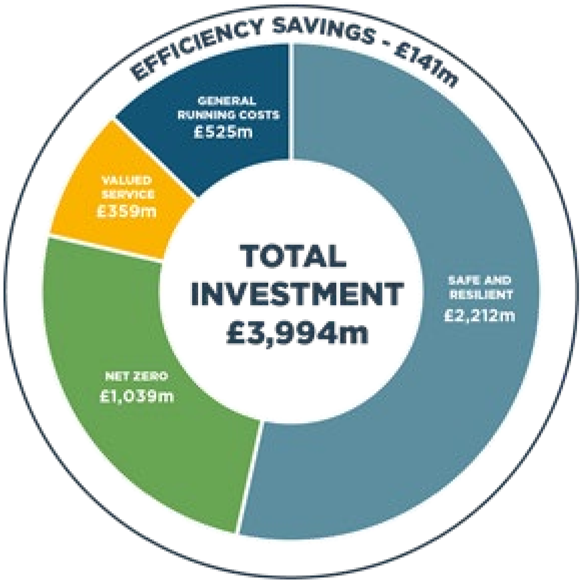


Figure 1: SSEN total investment cost within RIIO ED2

2 Investment Summary Table

Table 3 below provides a high level summary of the key information relevant to this Engineering Justification Paper (EJP).

Name of Programme (delete as appropriate)	Stokenchurch 33/11kV Transformer and 33kV circuits Reinforcement		
Primary Investment Driver	Load – Thermal overloading		
Scheme reference/mechanism or category	51/SEPD/LRE/STOK		
Output references/type	33/11kV transformers 33kV circuits		
Cost	£3.07m		
Delivery year	2025/26		
Reporting table	• CV1: Primary Reinforcement		
Outputs included in RIIO-ED1 Business Plan	No		
Spend apportionment	**ED1**	**ED2**	**ED3+**
	£0	£3.07m	£0

Table 3: Investment Summary

3 Introduction

Our ***Load Related Plan Build and Strategy (Annex 10.1)***[1] 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'.

Section 4 of this Engineering Justification Paper (EJP) describes our proposed load related investment plan for the reinforcement of Stokenchurch Primary Substation in RIIO-ED2. The primary driver considered within this paper is thermal overloading at the primary substation due to forecast demand growth from our Stakeholder supported Distribution Future Energy Scenario (DFES).

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

This EJP provides high-level background information for this proposed scheme explaining the existing network arranges, the load growth forecasts through the Distribution Future Energy Scenarios (DFES) and setting out the need for this project. The Detailed Analysis section of the EJP describes the network studies undertaken, detailing the results which further justify the need of the proposed investment.

Section 5 provides an exhaustive list 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 6, 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. This section also describes how we have established the cost efficiency of the plan with reference to the unit costs that have been chosen.

Finally, **Section 7** of this EJP also sets out the deliverability of the plan for RIIO-ED2 and this proposed investment.

4 Background Information

4.1 Existing Network Arrangement

Stokenchurch Primary is located within Buckinghamshire in the SEPD licence area. This substation is supplied from the High Wycombe BSP. Stokenchurch primary currently supplies 4,501 customers via 11kV circuits. The 2019/20 peak demand was 9.2MW.

Stokenchurch Primary is currently fed from High Wycombe BSP via a 33kV ring connecting Stokenchurch, Watlington, Nuffield and Chisbridge Primaries. The 33kV circuits between High Wycombe and Stokenchurch and High Wycombe and Chisbridge have winter ratings of 24.1MVA. The two 33/11kV Stokenchurch primary transformers are rated at 7.5MVA (9.8MVA winter rating), which limits the FCO capacity at Stokenchurch Primary to 9.8MVA in winter and 7.5MVA in spring / autumn. A schematic of the Stokenchurch 33kV network is shown in the figure below.

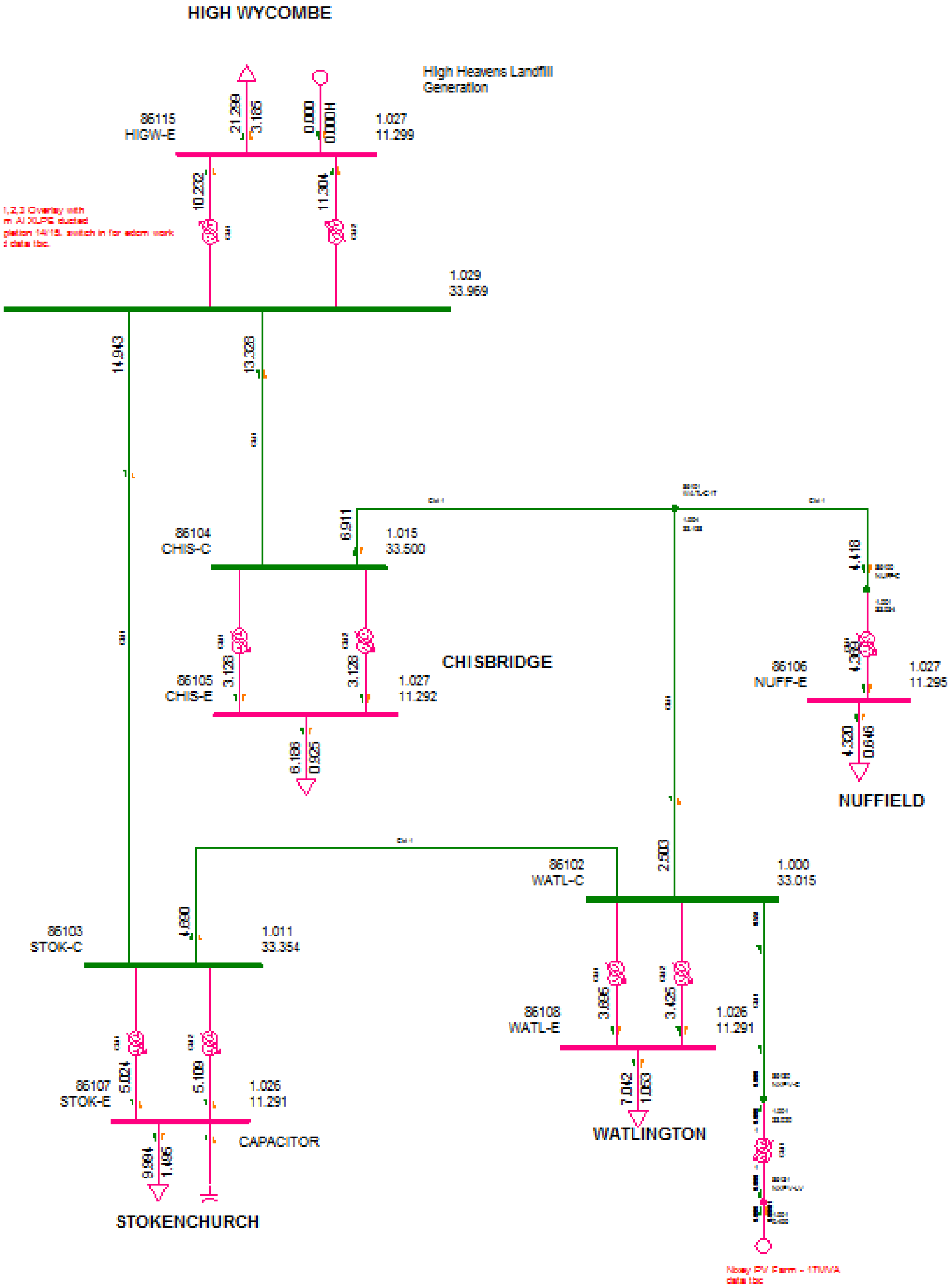


Figure 2: Stokenchurch Network Arrangement SLD

Figure 3: Stokenchurch Primary Substation

Given the forecasted demand presented in the Distribution Future Energy Scenarios, the existing 33kV ring network and the 33/11kV transformers at Stokenchruch primary will not have enough thermal capacity to supply the ED2 demand. It is anticipated that these assets will become overloaded and if no intervention is carried out there is a risk of asset failure and the interruption of supply to customers.

The existing 33/11kV transformers both have a health index of HI3. These assets are forecasted to progress to HI4 by the end of the RIIO ED2 price control period. There are currently no plans to replace these assets under the non-load work stream. However, as discussed in the optioneering section of this paper, the preferred option to resolve the over loading issues identified will seek to replace these assets. This solution will therefore bring a secondary benefit of mitigating any risk associated with asset deterioration and poor health.

4.2 Local Energy Plan

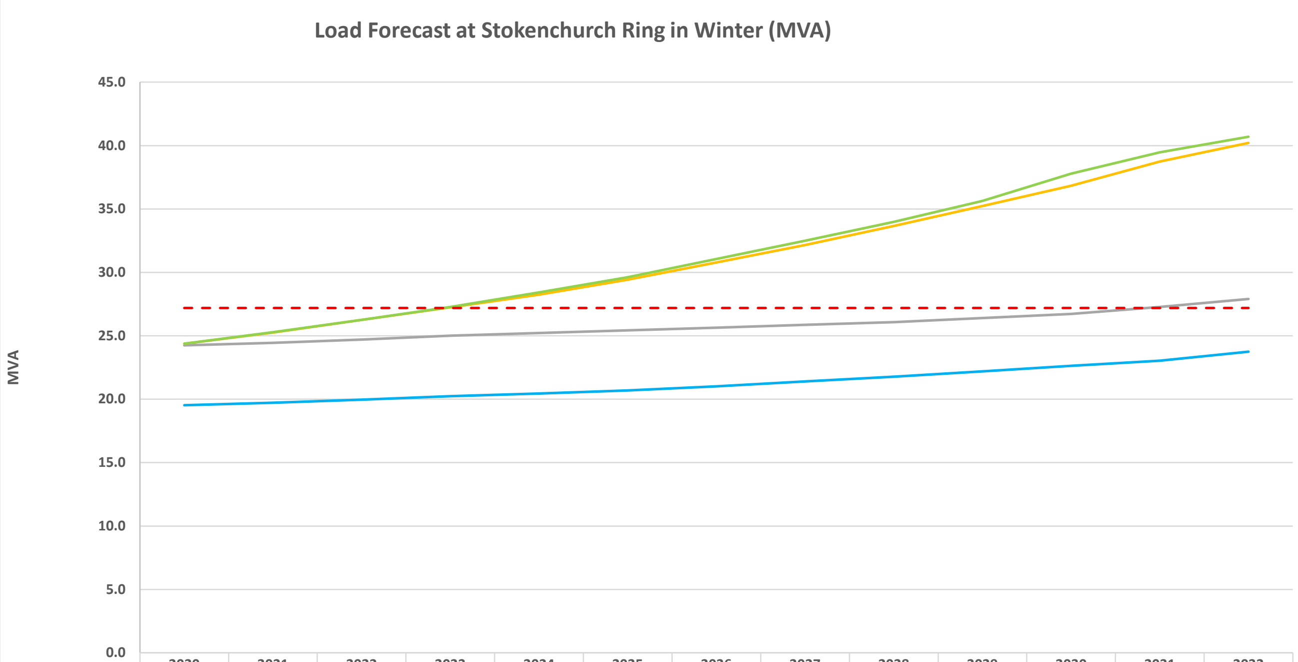
In 2019, Buckinghamshire council declared a climate emergency and acknowledged the need for Climate Change Strategy which has not yet been published as it is in the draft phase. However, the council has agreed to:

- Recognise that the rate of climate change is a global emergency.
- Recognise that, although the UK constitutes 1% of global carbon emissions, it must nevertheless play its part in leading the way in promoting change both in the UK itself and, importantly, globally.
- Note the significant progress that Buckinghamshire County Council has made to date in addressing climate change.

- Agree that the new Buckinghamshire Council should consider addressing climate change as a key issue.
- Acknowledge the net-zero 2050 UK target, as contained in the 2008 Climate Change Act (as amended).
- Commission a carbon audit pre assessment to gain an insight into the Council's carbon usage.
- Recommend that Cabinet should further consider this issue, including what proposals, ahead of vesting day, the authority could implement to support this agenda. These proposals to include using the carbon audit gap analysis report to inform the policy decisions of the new Buckinghamshire Council once it is established next April (2020).

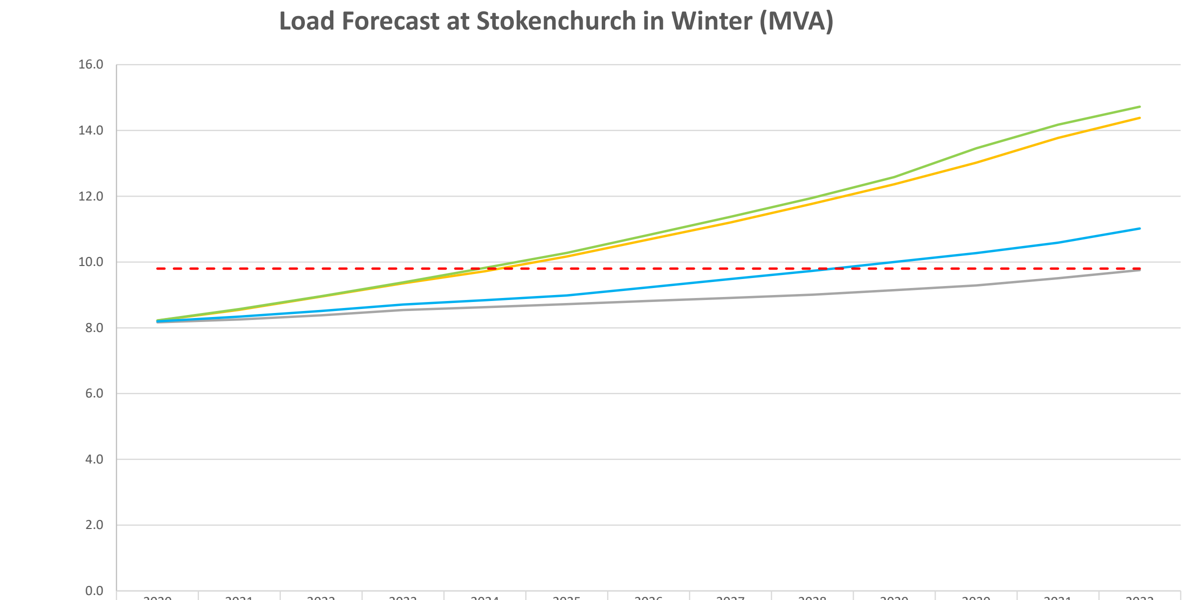
4.3 Demand and Generation Forecast for Stokenchurch Primary

Figure 3 below shows the demand projections in MVA of Stokenchurch-Watlington-Chisbridge 33kV ring network for all forecast scenarios in Winter. Figure 5 shows the demand projections for Stokenchurch primary in winter and Figure 6 the same for spring / autumn. For Stokenchurch primary the FCO firm capacity is 9.8MVA in Winter and 7.5MVA in Spring/Autumn. In this case, the demand forecast in the Consumer Transformation (CT) and Leading the Way (LW) DFES secarios show that under a First Circuit Outage (FCO) conditions the existing equipment will be overloaded and therefore, not in complicance with P2/7 in 2023/24 for the winter period. In the Spring/Autumn period, the stokenchurch FCO limit is exceeded for all DFES scenarios during the RIIO ED2 price control period. The 33kV ring circuit will also experience overloading from 2023 as depicted in figure 4.



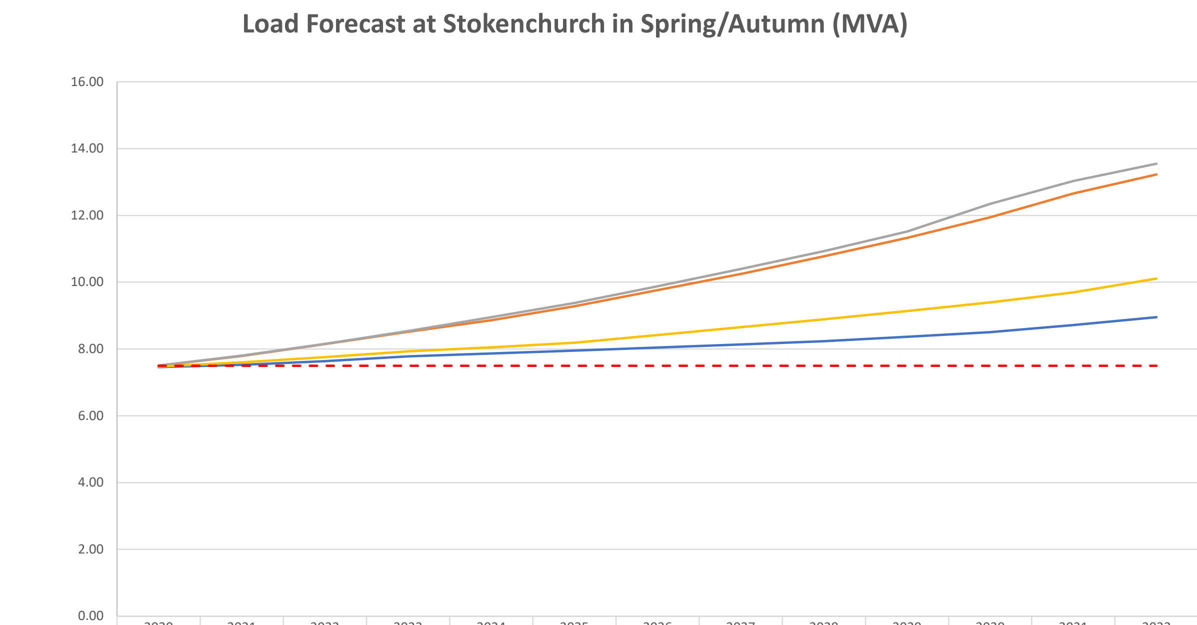
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	24.2	24.4	24.7	25.0	25.2	25.4	25.6	25.9	26.1	26.4	26.7	27.3	27.9
CT	24.4	25.3	26.3	27.2	28.2	29.4	30.8	32.2	33.7	35.2	36.8	38.7	40.2
LW	24.4	25.3	26.3	27.3	28.4	29.6	31.1	32.5	34.0	35.6	37.8	39.5	40.7
ST	19.53	19.71	19.96	20.23	20.45	20.69	21.02	21.40	21.78	22.19	22.63	23.04	23.75
FCO Limit	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2

Figure 4: Stokenchurch 33kV Ring Winter Peak Demand Growth



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.3	9.5	9.8
CT	8.2	8.5	8.9	9.4	9.7	10.2	10.7	11.2	11.8	12.4	13.0	13.8	14.4
LW	8.2	8.6	9.0	9.4	9.8	10.3	10.8	11.4	12.0	12.6	13.5	14.2	14.7
ST	8.19	8.34	8.51	8.71	8.84	8.98	9.23	9.48	9.73	10.00	10.27	10.59	11.02
FCO Limit	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8

Figure 5: Stokenchurch winter peak demand growth.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP	7.46	7.52	7.63	7.78	7.86	7.95	8.04	8.13	8.23	8.36	8.51	8.72	8.95
CT	7.50	7.79	8.15	8.52	8.86	9.28	9.76	10.24	10.78	11.33	11.94	12.66	13.23
LW	7.50	7.80	8.16	8.54	8.95	9.38	9.88	10.39	10.93	11.52	12.35	13.03	13.55
ST	7.48	7.60	7.75	7.93	8.05	8.19	8.42	8.65	8.89	9.14	9.40	9.69	10.11
SCO Limit	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5

Figure 6: Stokenchurch Spring / Autumn peak demand growth.

While the plot above shows that during Spring/Autumn Stokenchurch primary substation is overloaded from 2020, this overloading is fairly marginal. In this case for the years leading up to ED2, this overloading will be managed via operational control to mitigate the risk of equipment failure and subsequently loss of supply. It is proposed to address the overloading issue during the RIIO ED2 price control period and implement a permanent solution to alleviate the overloading experienced at Stokenchurch primary substation.

Peak demand is expected to increase at Stokenchurch primary by approximately 2MVA from 2020/21 to 2027/28 when following the CT scenario in winter. The projected primary demand of 11.2MVA is split below by demand type. The chart shows the largest impact on demand in the area is from heat pumps and EVs, equating to 18.7% and 16.7% of the overall projected demand.

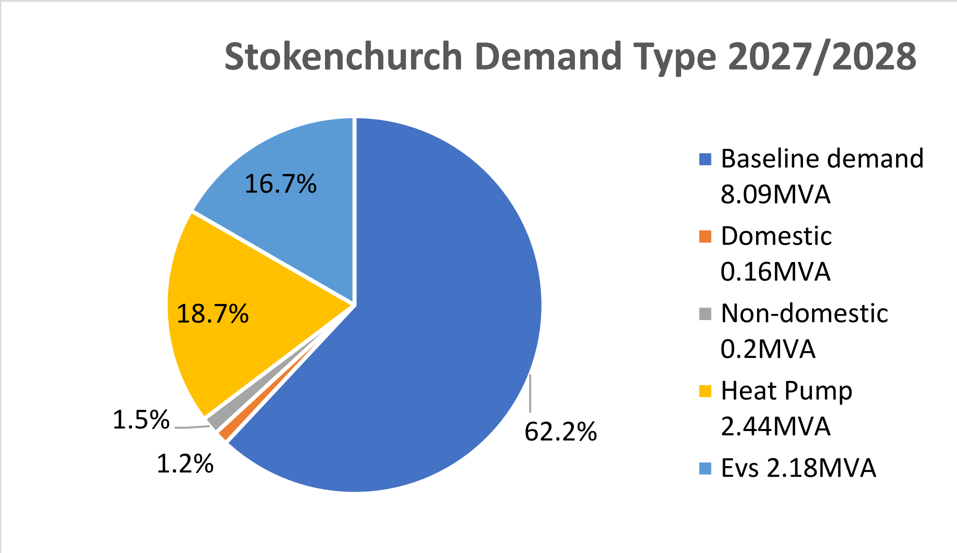


Figure 7: Stokenchurch Demand Type 2027/2028

4.4 Thermal Flow Analysis

Under FCO conditions, the remaining in service 33kV circuit and 33/11kV transformer at Stokenchurch primary will become over loaded. The result of the thermal analysis, representative of the year 2028, are shown below.

Demand Group	Season	Group Class	Contingency	Loaded Circuit / Transformer	Loading (MVA)	FCO Available Capacity (MVA)	% Loading
Stokenchurch Primary T1 & T2	Winter	B	Fault on Stokenchurch Primary T1	Stokenchurch Primary T2	10.8	**9.8**	**110**
Stokenchurch Primary T1 & T2	Winter	C	Fault on HIGW-C to STOK-C 33kV circuit	HIGW-C to CHIS-C 33kV circuit	35	**27.2**	**129**
Stokenchurch Primary T1 & T2	Winter	C	Fault on HIGW-C to CHIS-C 33kV circuit	HIGW-C to STOK-C 33kV circuit	34.1	**27.2**	**125**

Table 4 First Circuit Outage (FCO) Analysis in 2027/28 – CT scenario

Reinforcement is required due to thermal overload and subsequently P2/7 non-compliance under FCO conditions. The results of the load flow analysis show that the Stokenchurch primary transformers are loaded to 110% of the equipment rating under N-1 conditions and the 33kV circuits are loaded to (worse case) 129% of the circuit rating under N-1 conditions.

4.5 Voltage Level Assessment

The voltage assessment shows that the voltage at the 33kV and 11kV busbars remain within statutory limits, therefore reinforcement is not required based on voltage.

4.6 Fault Level Analysis

Fault levels remain within the existing switchgear ratings.

4.7 Network Analysis Summary

The analysis above has shown that intervention to reinforce Stokenchurch primary substation and the surrounding 33kV ring circuit, will be required within RIIO-ED2. The DFES forecasted increase in demand, and in turn the increased reliance on the network will overload the network under FCO conditions subsequently causing non-compliance with P2/7.

5 Optioneering

This section of the report sets out the investment options that are considered when resolving overload issues. As described below a holistic approach is taken to ensure investment options which are both least regrets and represents best value for money for network customers are identified.

5.1 Whole System Considerations

We have additionally 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 3. 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)***.

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.

5.2 Summary of Options

The table below provides a high-level summary of the 4 investment options under consideration along with the advantages and disadvantages associated with each. A more detailed description of each option is then provided within the proceeding sub-sections.

Option	Description	Advantages	Disadvantages	
Option 1 - Do Minimum	Monitor demand development.	Low cost and workload.	Does not provide a long tern solution Reinforcement may still be required.	Considered but not progressed to CBA
Option 2 – Replacement of 33kV circuits and 33/11kV Transformers	The replacement of the full overloaded equipment including: • 2 x 33/11kV transformers • 8.68km 33kV circuit between High Wycombe and Stokenchurch 6.51km 33kV circuit between High Wycombe and Chisbridge Primary.	Increase network capacity and resilience. Reduce environmental impact. Some non-overloaded assets may also need to be replaced in-line with the new equipment. In this case, oil filled cable should be replaced with XLPE cable.	Can incur long outages if replacement cannot be built offline.	Progressed to CBA Analysis
Option 3 – Addition of a third 33kV circuit and a third 33/11 kV transformer at	When overloaded equipment has already reached maximum rating, new equipment will be added into existing network. This involves:	Increase network resilience. Shorter outage time. Long term benefit.	Additional land purchase maybe required. Can incur large civil costs;	Progressed to CBA Analysis

Stokenchurch Primary	• a new 33/11kV transformer at Stokenchurch • a new 8.68km 33kV circuit between High Wycombe and Stokenchurch • a new 6.51km 33kV circuit between High Wycombe and Chisbridge Primary new switchgear at High Wycombe, Chisbridge and Stokenchurch		Required new control strategy.	
Option 4 - Flexibility Solution	Flexible service contracts to reduce peak demand and defer capital investment	Relatively low cost. Defers need for network reinforcement.	Amount of flexibility depends on location-specific resources and interests. CAPEX may still be required.	Progressed to CBA Analysis

Table 5: Summary of Options

5.3 Detailed Option Analysis

5.3.1 Option 1: Do-Minimum

Estimate Cost: £0k

The load development at Stokenchurch Primary will be monitored under this option to determine when reinforcements would be required. Load transfers have been considered for this option however there isn't sufficient capacity in adjacent substations. In addition, transferring load does not address the circuit overload of this meshed network of substations. This option is therefore P2/7 non-compliant.

5.3.2 Option 2: Asset Replacement

Estimated Cost: £4,093k

The overloaded equipment at Stokenchurch Primary is the 33/11kV Transformers which are currently rated at 9.8/7.5/7.5MVA. It is possible to replace these transformers with two units that are rated at 30/15MVA from SSE existing suppliers. As a result, the FCO limit of the substation will increase from 9.8MVA in winter to 30MVA.

The following 33kV circuits will also become overloaded:

- 33kV circuit between High Wycombe and Stokenchurch, this is an 8.68km circuit, consisting of two sections:
    - 2.04km cable section rated at 27.2/24.1MVA
    - 6.64km overhead line section rated at 30.7/28.5MVA.
    - The existing circuit route leaves Stokenchurch via overhead line, across fields to the east for 6.64km until just before Lane End road where it becomes underground cable for 2km, following roadways to High Wycombe BSP.
    - Overload is 34.1MVA, therefore the cable and overhead line sections will require replacing. It should also be noted that the existing cable is oil filled and will be replaced by XLPE cable.

- 33kV circuit between High Wycombe and Chisbridge Primary, this is a 6.51km circuit consisting of 4 sections:
    - 0.52km cable section rated 37/32.7MVA.
    - 0.36km cable section rated 28.9/25.6MVA.
    - 4.28km overhead line rated 30.7/28.5MVA.
    - 1.35km cable section rated 27.2/24.1MVA.
    - Overload is 35MVA, therefore the cable and overhead line sections will require replacing. It should also be noted that the existing cable is oil filled and will be replaced by XLPE cable.

Implementing this solution will resolve the overloading issue and bring the load index of Stokenchurch primary substation from LI4 by the end of ED2 to LI1. It should be noted that while the current circuit comprises of 4.27km of cable, due to cable trench route requirements it is anticipated that replacement of this cable section will require 5.04km of underground cable. The total capital expenditure for this project is £4,093k which accounts for the replacement of the 2 x 33/11kV transformers, replacement of 5.04km of underground cable and replacement of 10.92km of overhead line.

5.3.3 Option 3: Add New Assets

Estimated Cost: £4,457k

The proposed solution for Stokenchurch Primary is to install a new 33kV circuit from High Wycombe to Stokenchurch (as a backup circuit), with associated switchgear rearrangement to increase the capacity of the ring circuit. The existing two transformers at Stokenchurch will be replaced with new ones, which are rated at 30/15MVA, to avoid expanding existing substation site. The new 33kV circuit would be underground cable so the cable route will be different to the existing OHL arrangement, a potential cable route is shown below, which is 10.8km in length. The 33kV cable route would need to cross the M40.
The additional circuit and upgraded transformers will give a new FCO capacity at Stokenchurch of 39.8MVA in winter, and 22.5MVA in Summer.

Figure 8: Proposed Cable Route

Implementing this solution will resolve the overloading issue and bring the load index of Stokenchurch primary substation from LI4 by the end of ED2 to LI1. The estimated capital cost for this solution is £4,457k which accounts for replacement of the 2 x 33/11kV transformers, 10.8km of 33kV underground cable, 1 x 33kV circuit breaker at High Wycombe BSP and 1 x 11kV breaker at Stokenchurch primary substation.

5.3.4 Option 4: Flexible Solution

Estimated Cost: £3,074k

Options 2 and 3 were fed into the Ofgem CBA to determine the preferred option. As shown in Table 4, Option 2 provides a better NPV value and was hence chosen to feed into the Common Evaluation Model (CEM) CBA to assess if there are benefits in deferring it to a future year. The CEM framework would evaluate options around timing of network investments, in particular taking into account:

- the range of different options available (e.g., reinforcing the network, using flexibility, or doing nothing);
- the time periods in which actions can be taken; and
- the existence of uncertainty, and the impact of incremental information which becomes available over time.

The table below shows that the peak demand at Stokenchurch Primary exceeds the FCO rating for approximately 3.5 hours in 2023/24, increasing in later years. Flexibility services could be used to reduce the peak demand forecast and defer conventional reinforcement.

In line with our Flexibility First Approach, the Stokenchurch project is technically compatible with a Flexibility Solution. In this case flexibility will allow us to defer the need for a conventional solution by two years, as such SSEN 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 SSEN and our customers in terms of investment deferral and optionality. Should the market test fail or only partially succeed in identifying the required Flexibility, SSEN will utilise the CEM Framework to assess the optimal, secondary solution for this location, be that be a further market test for full Flexibility, accelerating the Conventional solution or a Hybrid Scheme.

Further detail of our Flexibility First approach and assessment methodology can be found in our ***DSO Strategy (Annex 11.1), Appendix F - Delivering Value through Flexibility.***

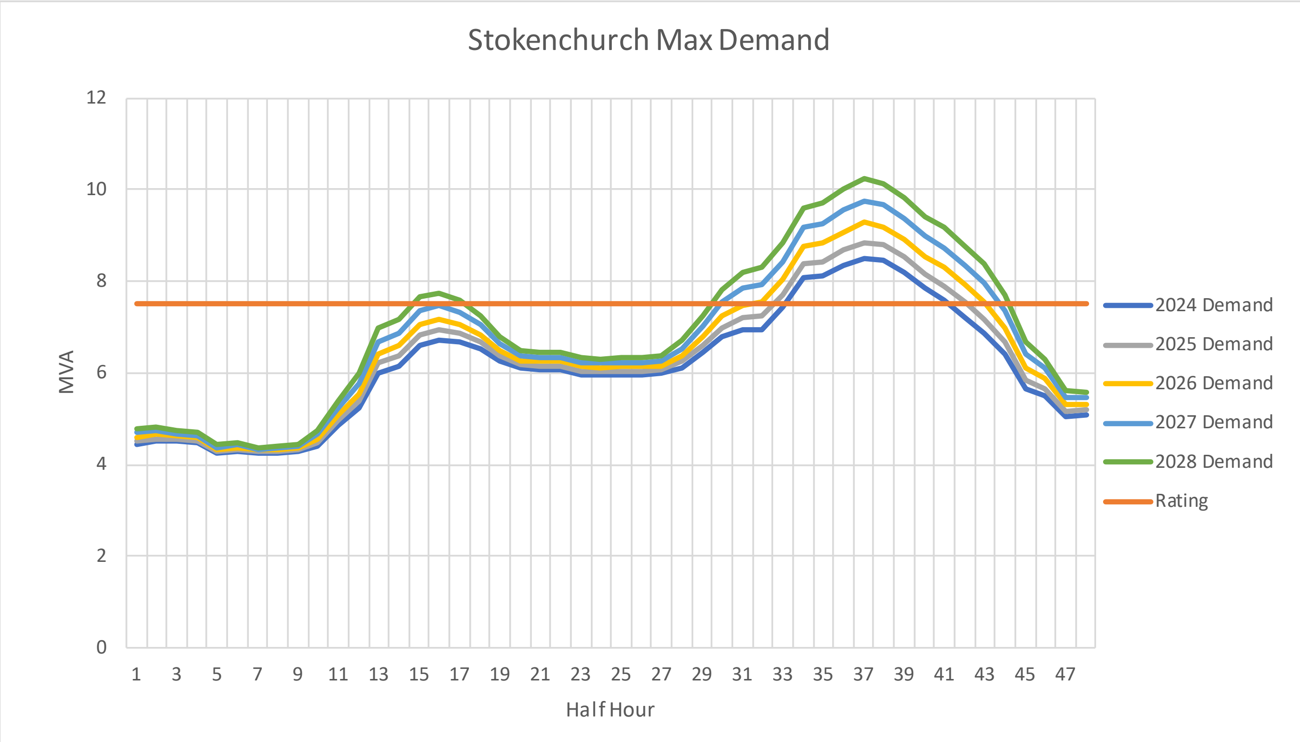


Figure : Stokenchurch spring / autumn demand 2027 without flexibility services.

The MW exceedance, the daily and annual overload hours (Table 6) and the flexibility unit costs of £150 per MW per hour and £150 per MWh were used as input parameters in the CEM CBA model (full details of the flexibility methodology can be found in the ***Load Related Plan Build and Strategy (Annex 10.1)***.

	2023	2024	2025	2026	2027	2028
Hrs/day required	1.0	1.3	3.5	5.2	7.3	7.7
Days/yr required	64	192	192	192	192	256
Av MVA	0.38	0.67	1.93	3.2	4.61	4.68
MWh	12.3	85.7	650	1589.2	3243.8	4591.3

Table 6: Estimated dispatch requirements for flexibility solution using CT scenario.

The CEM model outcome shows that, under both the CT and LW scenarios, there is a positive benefit of deferring reinforcement by 2 years. As a result, it is proposed in this case to defer reinforcement until 2026, utilising flexible service to mitigate the overloading at Stokenchurch and the surrounding network. Following which replacement of the assets will be carried out (option 2).

Cumulative benefit of deferral (excluding benefit from further deferral, but including multi-year discount)		**Defer by 1 year(s) to 2025**	**Defer by 2 year(s) to 2026**	**Defer by 3 year(s) to 2027**
[1] under CT	*£0*	£54,411	£71,575	-£157,085
[2] under LW	*£0*	£51,809	£53,070	-£239,595
[3] under SP	*£0*	£60,034	£115,167	£165,260
[4] under ST	*£0*	£60,034	£115,167	£165,260

Figure 9: Net benefit of deferring reinforcement.

6 Cost Benefit Analysis (CBA)

This section provides an overview of the results from the Cost Benefit Analysis (CBA). This detailed exercise has been undertaken to support the investment strategies discussed within this EJP.

6.1 CBA of investment options

Ofgem's RIIO-ED2 standard CBA template was used to assess costs and benefits of the conventional options. Capital reinforcement costs, CI/CML penalties, network losses and other societal benefits are the key parameters used in the CBAs of the three options progressed. The customer interruptions / customer minutes lost (CI/CML) were calculated based on the potential overload and the probability of a failure.

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

CBA Results

The CBA results below, demonstrate that the most cost-effective solution is option 4 'Flexible Solution', as it has the least NPV against the required investment and enable phasing of the project to ensure deliverability.

6.2 Cost Benefit Analysis Comparisons

The table below summarises the CBA outcome for all the options considered to resolve the thermal constraints at Stokenchurch primary. The result of the CBA show that option 4 is the preferred solution due the lower NPV compared to the other options.

Options	NPV After 45 Years (£k)	Total Investment Cost (£k)
Option 2 – Replacement of 33kV circuits and 33/11kV Transformers with premium cost	-2,572	4,093
Option 3 – Addition of a third 33kV circuit and a third 33/11 kV transformer at Stokenchurch Primary	-4,253	4,457
Option 4 – Flexible Solution with standard cost	-1,464	3,074

Table 7: CBA results summary

Options	Unit	2024	2025	2026	2027	2028	ED3+	Total £k
Option 2 – Replacement of 33kV circuits and 33/11kV Transformers with premium cost	**£k**	4,093	0	0	0	0	0	4,093
Option 3 – Addition of a third 33kV circuit and a third 33/11 kV transformer at Stokenchurch Primary	**£k**	4,457	0	0	0	0	0	4,457
Option 4 – Flexible Solution standard cost	**£k**	5.5	38.6	3,030	0	0	0	3,074

Table 8 Summary of cost

6.3 Options Summary

The options were assessed with standard pricing and premium pricing. The concept of premium pricing has been developed by the Commercial and Deliverability workstream to provide a way to capture the cost of delivering a project earlier than is feasible to help with deliverability of the plan. The premium cost has been based upon tender returns for representative model projects across a variety of asset categories. The premium cost is the difference between evaluated tender rates for lowest submitted tender and highest submitted tenders. In this EJP, the premium price relates to 33kV OHL works and attracts a 17% uplift on the lowest submitted tender. For cable works, we have undertaken a bottom up analysis of a representative sample of ED1 projects to calculate the premium cost, which is the difference between the internal and external delivery rates of historic cable projects.

Options 2 attract premium costs due to having to be delivered in the first year in ED2. Option 2 shows a better NPV value over 45 years compared to Option 3. If Option 2 is to be delivered at a later year in ED2, only standard costs are incurred and these are reflected in the costing for Option 4. The CBA outcome shows that the use of flexible services to defer conventional reinforcement until 2025 would allow adequate phasing of the project in relation to the full RIIO ED2 programme of works. Therefore, Option 4 is the preferred solution.

6.4 Costing Approach

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)***[2]. 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.

Unlike asset replacement, large load projects will include more unique and site-specific costs for example civils, waterway, road or rail crossings and local planning considerations. Through detailed bottom up project assessment, we have identified projects that are impacted by Regional and Site factors driving additional costs.

Category	Sub-category	Unit Cost (£k)	Unit	Asset Count	Predominant Costing Approach	Cost £k
Transformer	33/11kV transformers	[redacted]	#	2	ED1 6yr average actual unit rates	[redacted]
Overhead Line	33kV OH Line (pole conductor)	[redacted]	km	13.2	ED1 6yr average actual unit rates	[redacted]
Cable	33kV UG Cable (Non-Pressurised)	[redacted]	km	5.04	ED1 6yr average actual unit rates	[redacted]
					Project Total	**3,030.0**

Table 9 Preferred option Cost breakdown

The costs breakdown above is reflective of the physical asset costs only. The cost for the use of flexible services to defer the reinforcement until 2026 will be in addition of this. Based on the assessment of flexibility it is estimated that cost for procuring flexible services (Availability and utilisation) will be £44.1k. Thi s will bring the total project cost to £3,074k.

7 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

[2] Link to ***Cost Efficiency (Annex 15.1)***.

- We have engaged 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

The table below sets out the revised investment phasing based on the outcome of our deliverability assessment:

	2024	2025	2026	2027	2028
Revised Investment Phasing			x		

Table 10 Investment phasing on deliverability assessment

This investment scheme is part of the wider load-related investment portfolio in RIIO-ED2. SSEN has 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.
In RIIO-ED1, SEPD have delivered a number of 33kV and 11kV OHL projects using internal workforce. The experience and skills acquired from these projects lay the foundation for the delivery of the proposed option within this paper.

8 Conclusion

This Engineering Justification Paper (EJP) provides relevant information in relation to the load related investment at Stokenchurch primary substation and the Stokenchurch 33kV ring network in RIIO-ED2.

The thermal overloading of the two 33/11kV transformers at Stokenchurch and the 33kV circuits under FCO conditions is triggered by increase in demand across Consumer Transformation and Leading the Way DFES scenarios during the ED2 price control period. The current load index of the substation is LI2 but will increase to LI4 by the end of the RIIO ED2 price control period if no network reinforcement is implemented.

The following options were considered in the Ofgem's standard CBA and the CEM flexibility CBA

- Option 1: Do Minimum by load monitoring/transfer.
- Option 2: Reinforcement through asset replacement.
- Option 3: Reinforcement through the addition of new assets.
- Option 4: Flexible Solution followed by asset replacement.

Option 4 is the preferred option due to its superior NPV value as well as enabling the phasing of works to ensure the project can be delivered effectively. As a result of this option the load index for the Stokenchurch substation will now be LI1 compared to LI4 if no network reinforcement is carried out.

Appendix 1. Relevant Policy, Standards, and Operational Restrictions

The policies, manuals and standards and operational restrictions relevant to the content of this paper.

Policy Number	Policy Name / Description
TG-NET-OHL-010	Load Ratings of Overhead Lines – Data Sheet
TG-NET-OHL-012	Short Circuit Ratings of Overhead Lines – Data Sheet
TG-NET-OHL-104	Electrical Constants for Overhead Lines- Data Sheet
TG-NET-CAB-009	Load Ratings of LV to 33kV Underground Cables – Design Data
TG-NET-CAB-010	Electrical Constants for LV to 33 kV Underground Cables- Data Sheet
TG-NET-CAB-011	Short Circuit Ratings of 6.6kV to 33kV Underground Cables - Design Data

Table 11 Relevant documents

Appendix 2. Assumptions

CI/CML Tables

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	24.38	25.26	26.25	27.24	28.25	29.43	30.79	32.15	33.66
Firm Capacity	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
Difference	0	0	0	0.044	1.05	2.23	3.59	4.95	6.46
Customer No. 1% Growth	10443	10547	10653	10759	10867	10976	11085	11196	11308
MW per customer	0	0	0	0	0	0.0002	0.0003	0.0004	0.0006
No. Faults per Year	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Final Input									
CI	0	0	0	-693	-700	-707	-714	-721	-728
CML	0	0	0	-124696	-125943	-127203	-128475	-129759	-131057

Table 12:CI/CML for Do Minimum Option.

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	24.38	25.26	26.25	27.24	28.25	29.43	30.79	32.15	33.66
Firm Capacity	44	44	44	44	44	44	44	44	44
Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer No. 1% Growth	10443	10547	10653	10759	10867	10976	11085	11196	11308
MW per customer	0	0	0	0	0	0	0	0	0
No. Faults per Year	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Final Input									
CI	0	0	0	0	0	0	0	0	0
CML	0	0	0	0	0	0	0	0	0

Table 13: CI/CML for Asset Replacement

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	24.38	25.26	26.25	27.24	28.25	29.43	30.79	32.15	33.66
Firm Capacity	95	95	95	95	95	95	95	95	95
Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Customer No. 1% Growth	10443	10547	10653	10759	10867	10976	11085	11196	11308
MW per customer	0	0	0	0	0	0	0	0	0
No. Faults per Year	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Final Input									
CI	0	0	0	0	0	0	0	0	0
CML	0	0	0	0	0	0	0	0	0

Table 14: CI/CML for Add New Asset

Appendix 3: 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 ***Whole Systems (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 15 below outlines our Whole Systems CBA test for Stokenchurch 33/11kV Primary Substation.

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?
Stokenchurch 33/11kV Primary Substation	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 15 Whole Systems CBA test for Stokenchurch 33/11kV Primary Substation

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.