# St Andrews Primary Reinforcement

## ED2 Engineering Justification Paper

**ED2-LRE-SPD-012-CV1-EJP**

| Issue | Date | Comments |
|---|---|---|
| Issue 0.1 | Jan 2021 | Issue to internal governance and external assurance |
| Issue 0.2 | Apr 2021 | Reflecting comments from internal governance |
| Issue 0.3 | May 2021 | Reflecting external assurance feedback |
| Issue 1.0 | Jun 2021 | Issue for inclusion in Draft Business Plan submission |
| Issue 1.1 | Oct 2021 | Reflecting updated DFES forecasts |
| Issue 1.2 | Nov 2021 | Reflecting updated CBA results |
| Issue 2.0 | Dec 2021 | Issue for inclusion in Final Business Plan submission |

| | | | |
|---|---|---|---|
| **Scheme Name** | St Andrews Primary Reinforcement | | |
| **Activity** | Primary Reinforcement | | |
| **Primary Investment Driver** | Thermal and Voltage Constraints | | |
| **Reference** | ED2-LRE-SPD-012-CV1 | | |
| **Output** | Load Index | | |
| **Cost** | £11.244m | | |
| **Delivery Year** | 2023-2028 | | |
| **Reporting Table** | CV1 | | |
| **Outputs included in ED1** | ~~Yes~~/No | | |
| **Business Plan Section** | Develop the Network of the Future | | |
| **Primary Annex** | Annex 4A.2: Load Related Expenditure Strategy: Engineering Net Zero<br>Annex 4A.6: DFES | | |
| **Spend Apportionment** | **ED1** | **ED2** | **ED3** |
| | **£m** | **£11.244m** | **£m** |

SP ENERGY NETWORKS

# Technical Governance Process

Project Scope Development

# IP1(S)

To be completed by the Service Provider or Asset Management. The completed form, together with an accompanying report, should be endorsed by the appropriate sponsor and submitted for approval.
IP1 – To request project inclusion in the investment plan and to undertake project design work or request a modification to an existing project
**IP1(S) – Confirms project need case and provides an initial view of the Project Scope**
IP2 – Technical/Engineering approval for major system projects by the System Review Group (SRG)
IP2(C) – a Codicil or Supplement to a related IP2 paper. Commonly used where approval is required at more than one SRG, typically connection projects which require connection works at differing voltage levels and when those differing voltage levels are governed by two separate System Review Groups.
IP2(R) – Restricted Technical/Engineering approval for projects such as asset refurbishment or replacement projects which are essentially on a like-for-like basis and not requiring a full IP2
IP3 – Financial Authorisation document (for schemes > £100k prime)
IP4 – Application for variation of project due to change in cost or scope

## PART A – PROJECT INFORMATION

| | |
|---|---|
| Project Title: | **St Andrews Primary Reinforcement** |
| Project Reference: | **ED2-LRE-SPD-012-CV1** |
| Decision Required: | **To give concept approval to establish a new 33/11kV primary substation in Guardbridge.** |

**Summary of Business Need:**

St Andrews 33/11kV primary group supplies 9,003 customers in the Central & Fife region of SP Distribution. With the forecast uptake of Low Carbon Technologies (LCT), the group demand at St Andrews primary is forecast to exceed its firm capacity by the end of RIIO-ED2 period with risk of thermal overloading on St Andrews 33/11kV transformers and the 33kV circuits supplying the site. Network studies also show that step voltages, beyond EREC P28 compliance (RVC < -10%), may be observed, for planned or unplanned outages, at St Andrews primary due to forecast demand growth.

Half-hourly time-profile studies have been undertaken to quantify the hours at risk and to define the flexibility services that would be required to manage the constraint. Optioneering and design studies have been undertaken to assess the least cost technically acceptable solution.

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

Proposed works are:

1. Contract flexibility services to support the network during the project delivery.
2. Establish a new 33/11kV 32MVA primary substation in Guardbridge, which lies on the outskirts of St Andrews town
3. Procure flexibility services to manage the network risk through the delivery stage at a cost of £331k.
4. Continue annual tendering for flexibility in this area to minimise the network risk

The estimated cost for the above is £11.244m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

**Expenditure Forecast (in 2020/21)**

| Licence Area | Reporting Table | Description | Total (£m) | Incidence (£m) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 2023/24 | 2024/25 | 2025/26 | 2026/27 | 2027/28 |
| SPD | CV1 | Primary Reinforcement | **10.913** | 0.546 | 2.183 | 2.728 | 3.274 | 2.183 |
| SPD | CV1 | Flexible Service | **0.331** | 0.008 | 0.026 | 0.081 | 0.215 | - |
| SPD | **Total** | | **11.244** | **0.554** | **2.209** | **2.809** | **3.489** | **2.183** |

## PART B – PROJECT SUBMISSION

| | | | | | |
|---|---|---|---|---|---|
| Proposed by | Mark Friese | Signature | | Date: | 30/11/2021 |
| Endorsed by | Russell Bryans | Signature | | Date: | 30/11/2021 |

## PART C – PROJECT APPROVAL

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

Contents

# 1 Introduction

St Andrews demand group supplies 9,003 customers and is geographically located in the Central and Fife region of SP Distribution (SPD) licence area.

The group demand at St Andrews Primary is approaching the 21.6MVA firm capacity (FC) of the group. Our Baseline View projects a peak demand of 22.2MVA by 2028, with an expected uptake of up to 1,830 electric vehicles and 1,279 heat pumps by the end of the RIIO-ED2 period.

Network studies also show that step voltages, beyond Engineering Recommendation (EREC) P28 compliance (RVC < -10%), may be observed, for planned or unplanned outages, at St Andrews primary due to forecast demand growth.

In order to secure supplies within the group, meet the licence obligations under EREC P2/7, EREC P28 and to accommodate future demand growth within the area, it is proposed to:

1. Contract flexibility services to support the network during the project delivery.
2. Establish a new 33/11kV primary substation in Guardbridge, which lies on the outskirts of St Andrews town:
   - Install two new circuit breakers on the 33kV switchboard at Cupar Grid Supply Point (GSP)
   - Provide a dedicated connection to new Guardbridge 33/11kV substation by installing two new 33kV underground cable circuits with associated comms infrastructure from Cupar GSP to the Guardbridge site, located to the west of St Andrews
   - Commission two 33/11kV primary transformers
   - Install a nine panel 11kV switchboard
   - Provide interconnection to St Andrews primary through two ca. 5km 11kV circuits
3. Procure flexibility services to manage the network risk through the delivery stage at a cost of £331k.
4. Continue annual tendering for flexibility in this area to minimise the network risk

The estimated cost for the above is £11.244m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

Due to the complexity of the circuits and the overall project, it is proposed to start the works in 2023/24 and the release capacity of 32MVA will be claimed in 2027/28 at the end of the project. In order to reduce the risk of supply, it is proposed to contract flexibility services during the project delivery.

# 2 Background Information

## 2.1 Existing / Authorised Network

St Andrews Primary substation is served by two 21MVA, Bruce Peebles, 33/11kV transformers (1967). The HV group is fed from Cupar GSP via the 33kV network shown in Figure 1. Cupar GSP is interconnectable to Leven GSP via St Andrews T1 33kV circuit and with Abernethy in the Scottish Hydro Electric Power Distribution (SHEPD) licence area via Auchtermuchty and Newburgh primary substations.

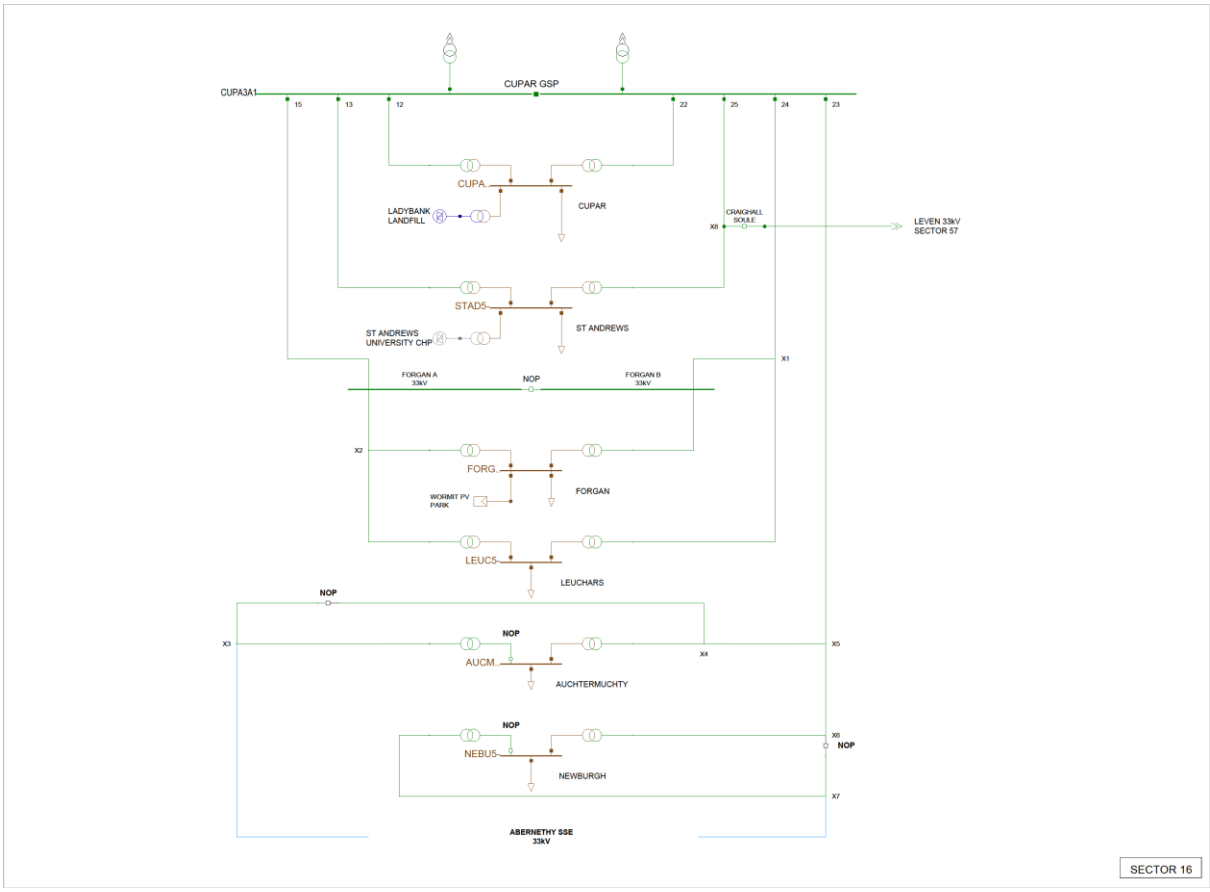


*Figure 1. Existing 33kV Network*

## 2.2 Group Demand & Security of Supply

The maximum demand at St Andrews primary was 19.9MVA in 2018; which places the group in a class 'C' of supply as per EREC P2/7 and must be secured for a first circuit outage (FCO). Based on measured data, this area of network would be unable to accommodate any sustained growth without exceeding the 21.6MVA FCO capacity of the St Andrews group.

## 2.3 Embedded Generation

Embedded generation connected to the network is shown in Table 2.1.

*Table 2.1. Embedded generation connected to St Andrews primary*

| Primary | Voltage (kV) | Site | Capacity (MW) | Type | Status |
|---|---|---|---|---|---|
| St Andrews | 11 | St. Andrews University | 0.50 | CHP | Connected |
| | 11/LV | Embedded generation (<1MW) | 0.62 | Onshore Wind/Solar | Connected |

## 2.4 Fault Levels

Studies indicate that with the authorised customer connections there are no fault level issues at St Andrews primary.

# 3 Needs Case

Our Baseline View forecasts a peak demand by 2028 of 22.2MVA, with an expected uptake of up to 1,830 electric vehicles and 1,279 heat pumps. This exceeds the St Andrews primary firm capacity of 21.6MVA within the RIIO-ED2 period.

Network studies also show that step voltages, beyond Engineering Recommendation (EREC) P28 compliance (RVC < -10%), may be observed, for planned or unplanned outages, at St Andrews primary due to forecast demand growth.

The present level of utilisation at St Andrews constrains routine operational activities. For example, there are now limited opportunities to take 11kV half-bar outages to undertake routine maintenance or reconfiguration works. The present level of loading risks exceeding the emergency ratings of the 11kV back feeds.

## 3.1 Forecast Demand

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

### 3.1.1 Distribution Future Energy Scenarios

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

The peak demand forecast based on the SPD Distribution Future Energy Scenarios, including authorised connections are depicted in Figure 2. The anticipated total electric vehicle and heat pump uptakes based on the future energy scenarios are depicted in Figure 3.

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

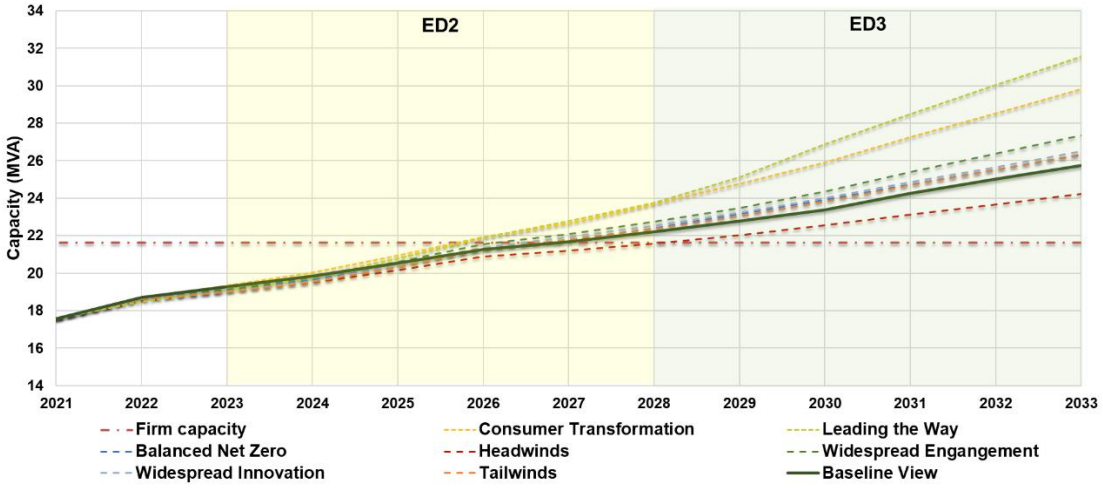


*Figure 2. Demand (MVA) forecast for St Andrews demand group*

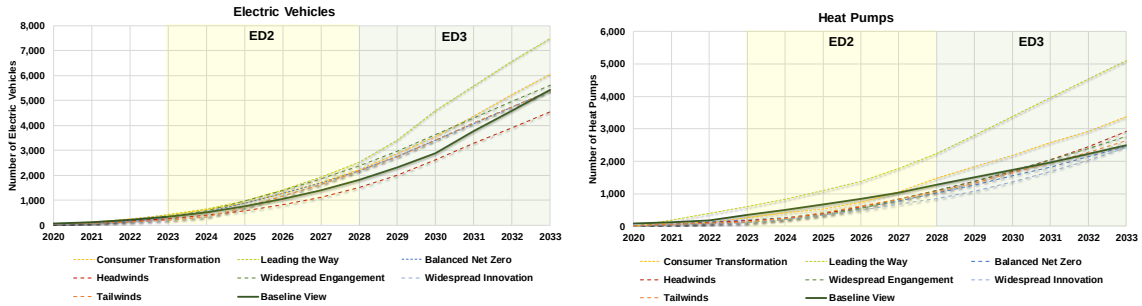


*Figure 3. Forecast Electric Vehicle and Heat Pump uptakes for St Andrews demand group*

### 3.1.2 Baseline View

For the St Andrews group demand, the forecast demand growth under our Baseline scenario, along with the firm capacity and utilisation through to RIIO-ED3 period is shown in Table 3.1.

*Table 3.1. Baseline View forecast*

| Year | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forecast Demand (MVA) | 17.6 | 18.7 | 19.3 | 19.9 | 20.5 | 21.3 | 21.7 | 22.2 | 22.8 | 23.4 | 24.3 | 25.0 | 25.7 |
| Firm Capacity (MVA) | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 | 21.6 |
| Utilisation (%) | 81 | 87 | 89 | 92 | 95 | 98 | 100 | 103 | 105 | 108 | 112 | 116 | 119 |
| Load Index | LI2 | LI2 | LI2 | LI2 | LI4 | LI3 | LI4 | LI5 | LI5 | LI5 | LI5 | LI5 | LI5 |

## 3.2 Network Impact Assessment

Detailed network studies covering network intact and outage (N-1) conditions and fault level assessments were carried out for the 33kV network fed from the St Andrews group considering the different demand forecast scenarios.

The network thermal constraint during the most onerous outage was identified and time profile-based simulations (17,520 half-hourly simulations/year) were performed considering the historical half hourly measured Supervisory control and data acquisition (SCADA) data at primary substation overlaid with the DFES demand forecasts for each year through the RIIO-ED2 price control period. These studies

identify the risk in terms of the thermal capacity exceedances with the forecast demand, the anticipated annual hours at risk and risk window of the constraint. The half-hourly studies performed for years starting from 2023 through 2028 determined the risk hours and the capacity required to overcome the constraint by using flexibility services.

### 3.2.1 Thermal Constraints

Table 3.2 shows the identified thermal constraints on the 33/11kV network level.

*Table 3.2. Thermal constraints at 33/11kV level*

| Network Item | Voltage | Outage |
|---|---|---|
| St Andrews T1 | 33/11kV | N-1 |
| St Andrews T2 | 33/11kV | N-1 |
| Cupar GSP to St Andrews primary No.1 cct | 33kV | N-1 |
| Cupar GSP to St Andrews primary No.2 cct | 33kV | N-1 |

### 3.2.2 Voltage Constraints

Table 3.3 shows the step voltage results for the loss of the No.1 circuit between Cupar GSP and St Andrews primary. EREC P28 – Issue 2 (2019) requires that step voltage change is limited to -10% for very infrequent events[1]. Therefore, with a forecast -13% step voltage change, St Andrews primary requires intervention before the end of RIIO-ED2, to remain EREC P28 compliant.

*Table 3.3. Voltage step change results for the Baseline View 2028 forecast*

| Busbar | Pre-fault Voltage (pu) | Post-fault Voltage (pu) | Voltage Step Change (%) |
|---|---|---|---|
| St Andrews 11kV | 1.0003 | 0.8608 | -13.9 |

### 3.2.3 EREC P2/7 – Security of Supply

St Andrews primary substation has a forecast peak demand of 22.2MVA by the end of RIIO-ED2 which puts the group in class 'C' of supply as per EREC P2/7. A class 'C' must secure the following minimum demand for a first circuit outage (FCO):

- Smaller of group demand minus 12MW; and 2/3 of group demand;
- Group demand must be met within 3 hours.

St Andrews group demand has an FCO security of 21.6MVA. Therefore, this site is predicted to be non-compliant under EREC P2/7 by the end of the RIIO-ED2 price control period; consequently, investment is required.

### 3.2.4 Flexibility Services

As the present level of utilisation at St Andrews constrains routine operational activities, there are limited opportunities to take 11kV half-bar outages to undertake routine maintenance or reconfiguration works. In order to manage the network risk on the 11kV network, our assessment indicates that the risk of thermal overload on the 33/11kV St Andrews primary transformers and 33kV circuits and security of supply constraints in the group starts from the year 2023/24 throughout to the year 2028 for the most onerous scenario including an additional 5% for the asset protection margin. This is shown in Table 3.4. The detailed results from the half hourly profile-based simulations are furnished in Appendix 1.

[1] Very Infrequent events are defined as no more than 1 event in 3 calendar months and no more than 1 event is permitted per day, consisting of up to 4 RVCs, each separated by at least 10 minutes with all switching completed within a two-hour window.

*Table 3.4. Network annual hours at risk and flexible capacity tendered in Spring 2021*

| Year | 2023/24 | 2024/25 | 2025/26 | 2026/27 | 2027/28 |
|---|---|---|---|---|---|
| **Annual hours at risk (Hrs)** | 25 | 55 | 122 | 244 | 427 |
| **Required Flexible Capacity (MW)** | 0.95 | 1.36 | 1.87 | 2.45 | 3.13 |

# 4 Optioneering

Table 4.1 shows a summary of the options considered for this reinforcement. The baseline option represents the lowest cost conventional option.

*Table 4.1. Longlist of solution options*

| # | Options | Status | Reason for rejection |
|---|---|---|---|
| (a) | Do nothing | Rejected | Not compliant with security of supply requirements as per EREC P2/7 and EREC P28. |
| (b) | Intervention plan using only Energy Efficiency | Rejected | Discounted due to lower cost effectiveness (peak MW reduction per £) and the number of individual interventions required across the wide area supplied by this network. |
| (c) | Establish a new primary substation in Guardbridge and utilise flexibility services to manage network constraints until delivery. | Shortlisted as **Baseline** option in Detailed Analysis | |
| (d) | Establish a new primary substation in West St Andrews and utilise flexibility services to manage network constraints until delivery. | Shortlisted as **Option 1** in Detailed Analysis | |
| (e) | Install STATCOM to maintain step voltage within EREC P28 limits and utilise flexibility services to defer a new primary into RIIO-ED3 | Shortlisted as **Option 2** in Detailed Analysis | |
| (f) | Install STATCOM to maintain step voltage within EREC P28 limits | Rejected | Rejected as it does not resolve thermal constraints. Not compliant with security of supply requirements as per EREC P2/7. |
| (g) | Real Time Thermal Rating | Rejected | Rejected as it does not resolve the voltage constraints and the capacity release is not sufficient to remain compliant with EREC P2/7. |

# 5 Detailed Analysis & Costs

## 5.1 Proposed Option (Baseline) – Establish a New Primary Substation in Guardbridge

The proposed option for this scheme is to establish a new primary substation in Guardbridge, which lies on the outskirts of St Andrews town, and utilise flexibility services to manage network constraints until delivery. Table 5.1 shows the scheme summary.

*Table 5.1. Proposed option summary*

| Category | Scheme Name | Scheme Summary | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| Conventional / Innovation | St Andrews Primary Reinforcement | Establish a new primary substation in Guardbridge with 11kV interconnection to St Andrews Primary | 11.244 | - |
| | | Utilise flexibility services to manage network constraints until delivery | | |

The new primary will be called "Guardbridge Primary S/S". The proposed location of the site is adjacent to Eden Estuary Centre, shown as a blue circle in Figure 4. The identified site provides a strategic location for forecast LCT growth and known future development plans in the area. We are aware of multiple future development plans for the area, and that as part of Tay City Deal programme, St Andrews University has been awarded funding to develop the "Eden Campus" in Guardbridge. The University have funding in place to create an innovation hub, which includes a sustainable site with solar farm, biomass, battery technology and EV chargers, bringing significant investment to the local community.

The new primary will enable a portion of demand to be offloaded from St Andrews primary and so prevent thermal overloading and ensure the voltage step is EREC P28 compliant.

The new primary will be supplied from Cupar GSP as the closest GSP by installing two new circuit breakers on the 33kV switchboard at Cupar GSP and two new 33kV underground cable circuits with associated comms infrastructure from Cupar GSP to the Guardbridge site, located to the west of St Andrews. The new 33kV circuits are shown in green in Figure 4. The proposed 33kV network configuration is shown in Figure 5. The new primary will have two 33/11kV 32MVA transformers in order to ensure suitable capacity is available for forecast demand growth. The voltage and thermal constraints identified on the St Andrews 11kV network will be mitigated by transferring 5.8MVA of demand from the existing sites. To achieve this, two circuit breakers will be made available on the new Guardbridge primary switchboard and two 11kV interconnectors will be established from the new Guardbridge primary to interconnect into the St Andrews Primary 11kV network. The new 11kV circuits are shown in red in Figure 4.

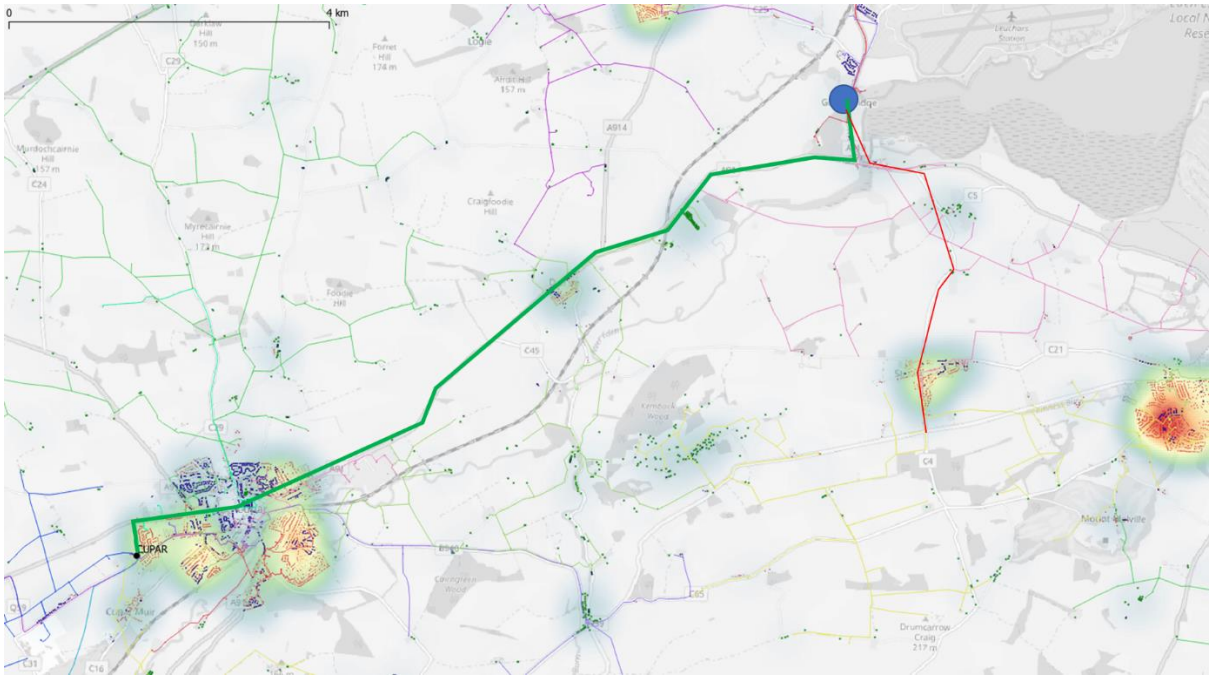


*Figure 4. Geographical location of Guardbridge primary*

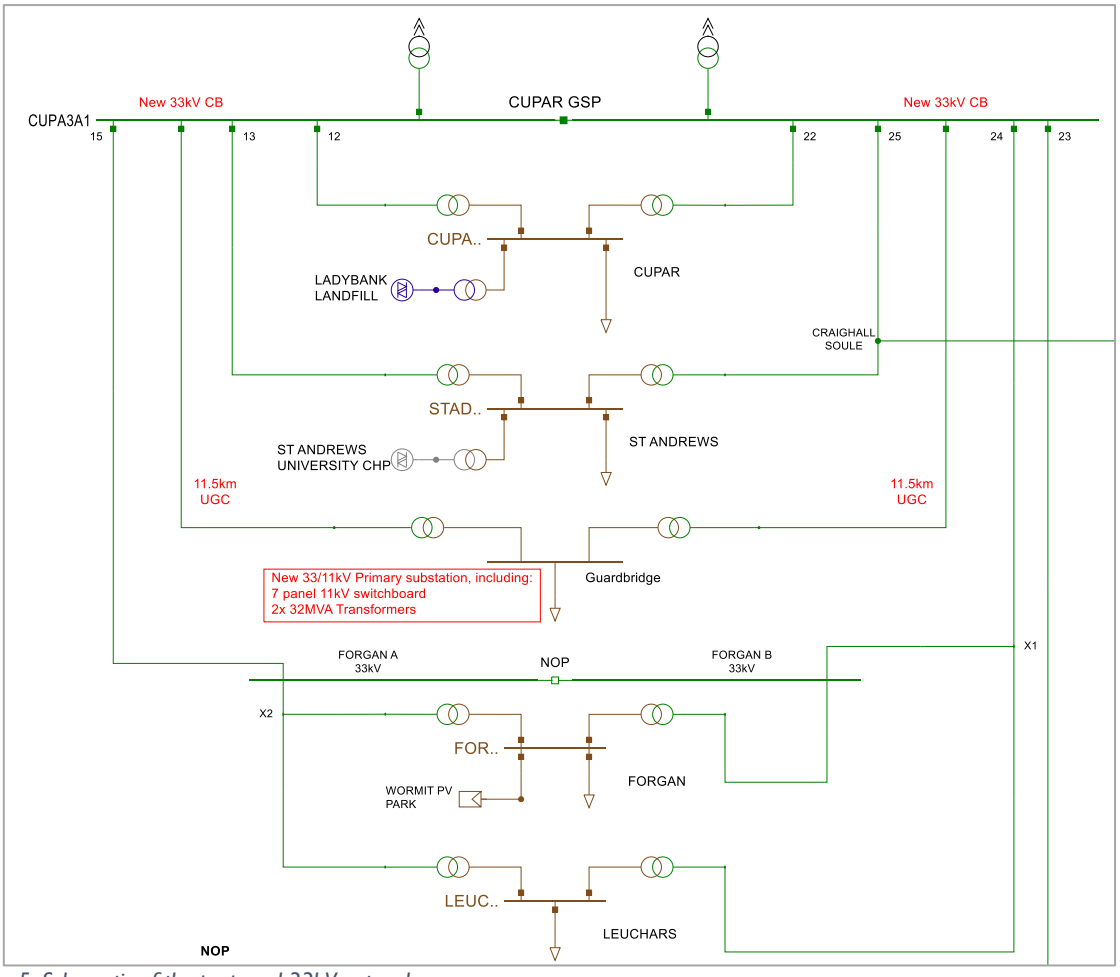


*Figure 5. Schematic of the proposed 33kV network*

Based on the response to the flexibility tender run in Spring 2021, flexibility as a viable option to delay reinforcement has been discounted (see section 5.3). However, in order to facilitate market growth, manage network constraints during project delivery and enable network outages, the total of 7.9MW of capacity has been accepted between 2023-2027, which is shown in Table 5.2. The cost of flexibility services has been added to the proposed solution.

*Table 5.2. Accepted flexible capacity from the flexibility tender run in September 2020*

| Year | 2023/24 | 2024/25 | 2025/26 | 2026/27 | 2027/28 |
|---|---|---|---|---|---|
| **Accepted Flexible Capacity (MW)** | 1.27 | 1.01 | 1.25 | 1.60 | - |

Table 5.3 shows a summary of reinforcement costs and volumes for the proposed scheme under RIIO-ED2.

*Table 5.3. Proposed option summary of reinforcement costs and volumes*

| Asset Description | Volumes | Prime Costs (£m) | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| 6.6/11kV OHL (Conventional Conductor) | 10 | 0.254 | 0.254 | - |
| 6.6/11kV UG Cable | 13 | 1.527 | 1.527 | - |
| 6.6/11kV CB (GM) Primary | 7 | 0.194 | 0.194 | - |
| 33kV UG Cable (Non Pressurised) | 23 | 4.591 | 4.591 | - |
| 33kV CB (Gas Insulated Busbars)(ID) (GM) | 2 | 0.334 | 0.334 | - |
| 33kV Transformer (GM) | 2 | 0.790 | 0.790 | - |
| Batteries at 33kV Substations | 1 | 0.009 | 0.009 | - |
| Pilot Wire Underground | 23 | 2.548 | 2.548 | - |
| Civil Works at 33 kV & 66 kV Substations | | 0.285 | 0.285 | - |
| Wayleaves/Easements/Land Purchase | | 0.154 | 0.154 | - |
| Other Costs (Identify Below) | | 0.227 | 0.227 | - |
| Flexibility Services | | 0.331 | 0.331 | - |
| Total Costs | | 11.244 | 11.244 | - |
| Identify activities included within other costs (please provide high-level detail of cost areas) | | | | |
| Planning and design (£50k) | | | | |
| RTU/SCADA (£10k) | | | | |
| 33kV telecoms upgrade (£10k) | | | | |
| Remote end protection (£42k) | | | | |
| Environmental consideration (£115k) | | | | |

Due to the complexity of the circuits and the overall project, it is proposed to start the works in 2023/24 and the release capacity of 32MVA will be claimed in 2027/28 at the end of the project. In order to reduce the risk of supply, it is proposed to contract flexibility services during the project delivery.

## 5.2 Option 1 – Establish a New Primary Substation in West St Andrews

This option considers the establishment of a new 33/11kV 32MVA primary substation in west St Andrews with 11kV interconnection to St Andrews primary. Table 5.4 shows the scheme summary. This option would enable 32MVA additional network capacity. It will enable 5.8MVA of demand to be offloaded from St Andrews primary and so prevent thermal overloading and ensure the voltage step is EREC P28 compliant. In order to facilitate market growth, manage network constraints during

project delivery and enable network outages, the total of 7.9MW of capacity has been accepted between 2023-2027 following the latest tender in Spring 2021. The cost of flexibility services has been added to this option.

However, due to predicted load growth in Guardbridge, the location does not provide a good strategic location for the future load growth. Therefore, this option is rejected based on cost and the location of future load growth.

*Table 5.4. Option 1 summary*

| Category | Scheme Name | Scheme Summary | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| Conventional | St Andrews Primary Reinforcement | Establish a new primary substation in west St Andrews with 11kV interconnection to St Andrews Primary | 11.586 | - |
| | | Utilise flexibility services to manage network constraints until delivery | | |

Table 5.5 shows a summary of reinforcement costs and volumes for Option 1 under RIIO-ED2. Option 1 33kV network configuration in shown Figure 6.

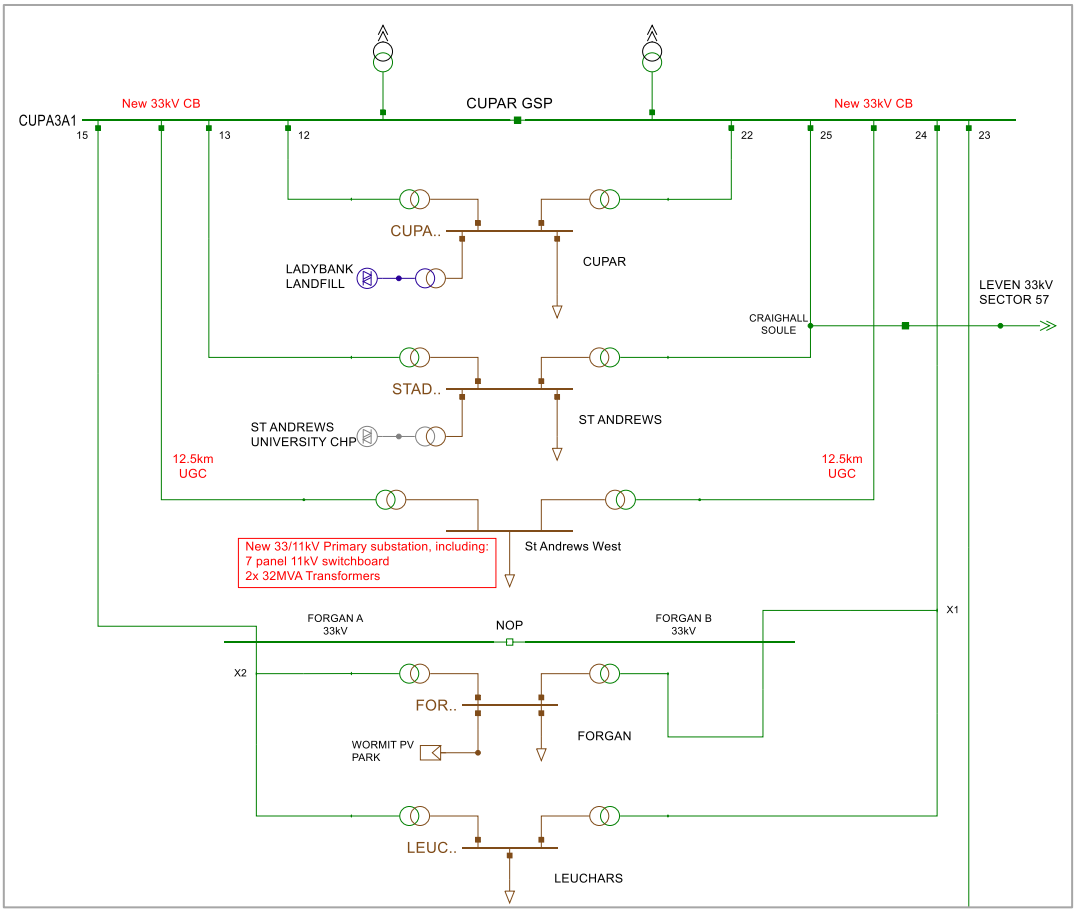


*Figure 6. Schematic of Option 1 33kV network*

*Table 5.5. Option 1 summary of reinforcement costs and volumes*

| Asset Description | Volumes | Prime Costs (£m) | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| 6.6/11kV UG Cable | 13 | 1.527 | 1.527 | - |
| 6.6/11kV CB (GM) Primary | 7 | 0.194 | 0.194 | - |
| 33kV UG Cable (Non Pressurised) | 25 | 4.990 | 4.990 | - |
| 33kV CB (Gas Insulated Busbars)(ID) (GM) | 2 | 0.334 | 0.334 | - |
| 33kV Transformer (GM) | 2 | 0.790 | 0.790 | - |
| Batteries at 33kV Substations | 1 | 0.009 | 0.009 | - |
| Pilot Wire Underground | 25 | 2.769 | 2.769 | - |
| Civil Works at 33 kV & 66 kV Substations | | 0.241 | 0.241 | - |
| Wayleaves/Easements/Land Purchase | | 0.163 | 0.163 | - |
| Other Costs (Identify Below) | | 0.237 | 0.237 | - |
| Flexibility Services | | 0.331 | 0.331 | - |
| Total Costs | | 11.586 | 11.586 | - |
| Identify activities included within other costs (please provide high-level detail of cost areas) | | | | |
| Planning and design (£50k) | | | | |
| RTU/SCADA (£10k) | | | | |
| Remote end protection (£42k) | | | | |
| 33kV telecoms upgrade (£10k) | | | | |
| Environmental consideration (£125k) | | | | |

## 5.3 Option 2 – Flexibility Services and STATCOM

Option 2 for this scheme is to defer the reinforcement with the combination of:

- Utilisation of flexibility services and
- Installation of a STATCOM.

This option would defer a requirement for a new primary to RIIO-ED3 which has been included in the cost benefit analysis.

Table 5.6 shows the scheme summary. This option is rejected based on cost.

*Table 5.6. Option 2 summary*

| Category | Scheme Name | Scheme Summary | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| Innovation | St Andrews Primary Reinforcement | Install ±10MVAr STATCOM to maintain step voltage within EREC P28 limits<br>Utilise flexibility services to defer a new primary into RIIO-ED3 | 4.212 | - |

### 5.3.1 Reinforcement Deferral via Flexibility Services

Based on the response to the flexibility tender run in Spring 2021, flexibility as an option to delay reinforcement has been considered in this option. The total of 11.06MW of received flexible capacity has been considered between 2023-2028 which is shown in Table 5.7. The cost of flexibility services has been added to this option.

*Table 5.7. Option 2 flexible capacity from the flexibility tender run in Spring 2021*

| Year | 2023/24 | 2024/25 | 2025/26 | 2026/27 | 2027/28 |
|---|---|---|---|---|---|
| **Received Flexible Capacity (MW)** | 1.15 | 1.59 | 2.23 | 2.96 | 3.13 |

### 5.3.2 STATCOM – Dynamic Voltage Support

To mitigate the voltage issues in the group, it is proposed to install a new reactive support device at the existing St Andrews 33/11kV substation. Studies have been undertaken to assess a wide range of options and static/dynamic voltage support. St Andrews is identified as the most suitable location for fast-acting dynamic MVAr support in the form of a ±10MVAr STATCOM to manage voltage step issues. This option will mitigate voltage step issues in the group through RIIO-ED2 and RIIO-ED3.

The Option 2 33kV network configuration in shown Figure 7 and Table 5.8 shows a summary of reinforcement costs and volumes for Option 2 under RIIO-ED2.

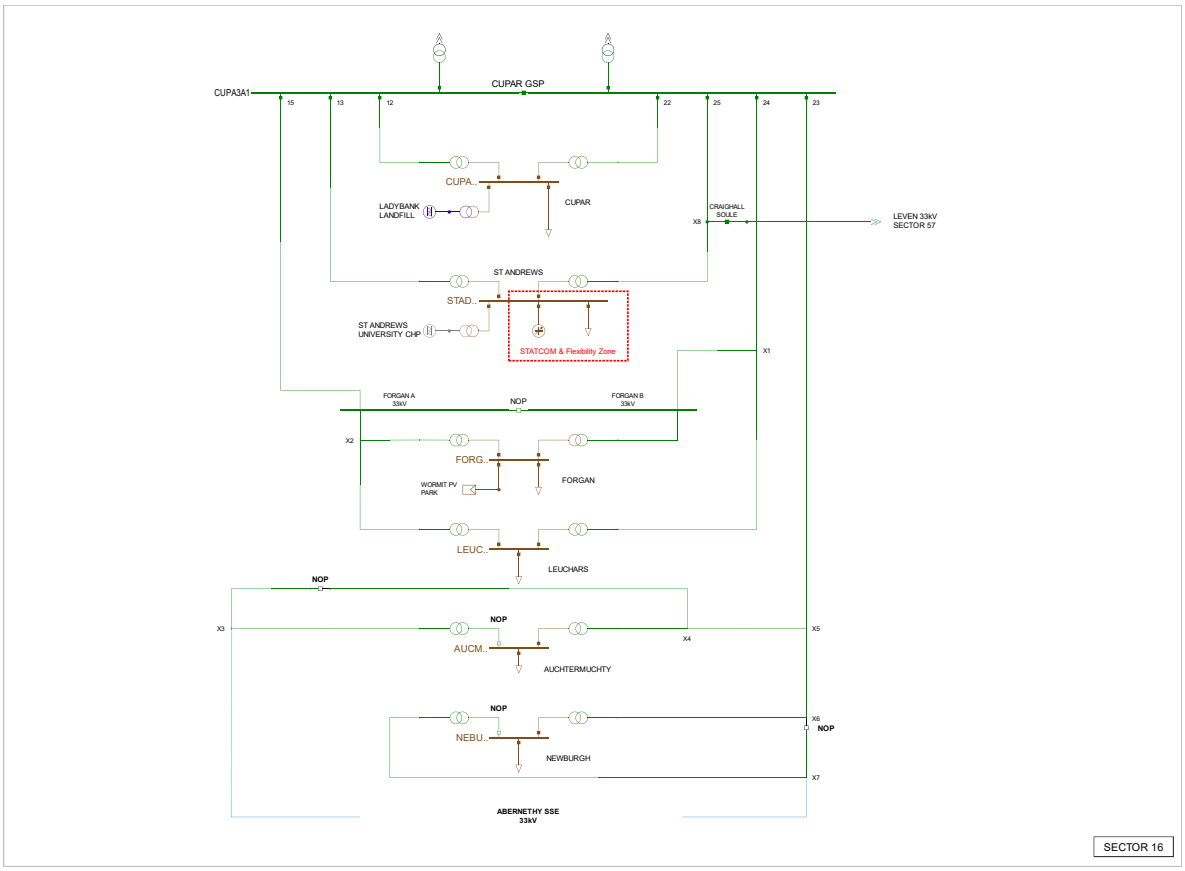


*Figure 7. Schematic of Option 2 33kV network*

*Table 5.8. Option 2 summary of reinforcement costs and volumes*

| Asset Description | Volumes | Prime Costs (£m) | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| 6.6/11kV CB (GM) Primary | 7 | 0.194 | 0.194 | - |
| 33kV UG Cable (Non Pressurised) | 1 | 0.200 | 0.200 | - |
| Pilot Wire Underground | 1 | 0.111 | 0.111 | - |
| Civil Works at 33 kV & 66 kV Substations | | 0.357 | 0.357 | - |
| Wayleaves/Easements/Land Purchase | | 0.050 | 0.050 | - |
| Other Costs (Identify Below) | | 2.570 | 2.570 | - |
| Flexibility Services | | 0.731 | 0.731 | - |
| Total Costs | | 4.212 | 4.212 | - |
| **Identify Activities Included Within Other Costs** | | | | |
| Planning and design (£50k) | | | | |
| Installation of +/-10MVAr STATCOM (£2.5m) | | | | |
| Environmental consideration (£10k) | | | | |
| 33kV telecoms upgrade (£10k) | | | | |

## 5.4 Options Cost Summary Table

Summary of the costs for each of the evaluated options is presented in Table 5.9.

*Table 5.9. Cost summary for considered options*

| Options | Option Summary | RIIO-ED2 Cost (£m) |
|---|---|---|
| Baseline | Establish a new primary substation in Guardbridge and utilise flexibility services to manage network constraints until delivery. | 11.244 |
| Option 1 | Establish a new primary substation in West St Andrews and utilise flexibility services to manage network constraints until delivery. | 11.586 |
| Option 2 | Install STATCOM to maintain step voltage within EREC P28 limits and utilise flexibility services to defer a new primary into RIIO-ED3 | 4.212* |

*Note: This option would defer a requirement for a new primary to RIIO-ED3 of £10.913m which has been included in the cost benefit analysis.

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

# 6 Deliverability & Risk

## 6.1 Preferred Options & Output Summary

The adopted option is the baseline option to establish a new primary substation in Guardbridge, which lies on the outskirts of St Andrews town, and utilise flexibility services to manage network constraints until delivery.

## 6.2 Cost Benefit Analysis Results

A cost benefit analysis (CBA) was carried out to compare the NPV of the options discussed in the previous sections. Considering the lowest forecast capital expenditure, the proposed option has the highest total NPV against other options. The summary of the cost benefit analysis is presented in Table 6.1. The full detailed CBA is provided within 'ED2-LRE-SPD-012-CV1-CBA – St Andrews Primary Reinforcement'.

*Table 6.1. Cost benefit analysis results*

| Options considered | Decision | Comment | NPVs based on payback periods, £m (2020/21 prices) | | | |
|---|---|---|---|---|---|---|
| | | | 10 years | 20 years | 30 years | 45 years |
| Baseline – Establish a new primary substation in Guardbridge and flexibility services | **Adopted** | | | | | |
| Option 1- Establish a new primary substation in West St Andrews and flexibility services | Rejected | Discounted on NPV and the location of future load growth | -0.41 | -0.46 | -0.49 | -0.51 |
| Option 2 – Flexibility services and STATCOM to defer investment to RIIO-ED3 | Rejected | Discounted on NPV | -0.97 | -2.45 | -3.35 | -4.07 |

## 6.3 Cost & Volumes Profile

Table 6.2 shows the breakdown of expenditure for the proposed scheme (in 2020/21 prices) and the cost incidence (in 2020/21 prices) over the RIIO-ED2 period is shown in Table 6.3. The total cost of the proposed scheme is £10.913m and further £0.331m to procure future flexibility services in the group.

*Table 6.2: Summary of reinforcement costs and volumes*

| Asset Description | Volumes | Prime Costs (£m) | RIIO-ED2 Contribution (£m) | Customer Contribution (£m) |
|---|---|---|---|---|
| 6.6/11kV OHL (Conventional Conductor) | 10 | 0.254 | 0.254 | - |
| 6.6/11kV UG Cable | 13 | 1.527 | 1.527 | - |
| 6.6/11kV CB (GM) Primary | 7 | 0.194 | 0.194 | - |
| 33kV UG Cable (Non Pressurised) | 23 | 4.591 | 4.591 | - |
| 33kV CB (Gas Insulated Busbars)(ID) (GM) | 2 | 0.334 | 0.334 | - |
| 33kV Transformer (GM) | 2 | 0.790 | 0.790 | - |
| Batteries at 33kV Substations | 1 | 0.009 | 0.009 | - |
| Pilot Wire Underground | 23 | 2.548 | 2.548 | - |
| Civil Works at 33 kV & 66 kV Substations | | 0.285 | 0.285 | - |
| Wayleaves/Easements/Land Purchase | | 0.154 | 0.154 | - |
| Other Costs (Identify Below) | | 0.227 | 0.227 | - |
| Flexibility Services | | 0.331 | 0.331 | - |
| Total Costs | | 11.244 | 11.244 | - |
| Identify activities included within other costs (please provide high-level detail of cost areas) | | | | |
| Planning and design (£50k) | | | | |
| RTU/SCADA (£10k) | | | | |
| 33kV telecoms upgrade (£10k) | | | | |
| Remote end protection (£42k) | | | | |
| Environmental consideration (£115k) | | | | |

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

| Total Investment | Total (£m) | Incidence (£m) | | | | |
|---|---|---|---|---|---|---|
| | | 2023/24 | 2024/25 | 2025/26 | 2026/27 | 2027/28 |
| CV1 (Primary Reinforcement) | **10.913** | 0.546 | 2.183 | 2.728 | 3.274 | 2.183 |
| CV1 (Flexible Service) | **0.331** | 0.008 | 0.026 | 0.081 | 0.215 | - |
| Total Cost | **11.244** | **0.554** | **2.209** | **2.809** | **3.489** | **2.183** |

## 6.4 Risks

The main delivery risks are the land for the new primary and cable route. We would mitigate these risks by seeking alternatives for the primary location and engaging with local authorities.

There is a risk that the contracted flexibility services will not materialise. In order to overcome this risk, we will continue to tender for flexibility services for this location.

## 6.5 Outputs Included in RIIO-ED1 Plans

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

## 6.6 Future Pathways – Net Zero

### 6.6.1 Primary Economic Driver

The primary drivers for this investment are insufficient thermal headroom, security of supply risk and EREC P28 compliance. The investment does not have a strong reliance on environmental benefits.

### 6.6.2 Payback Periods

The CBA indicates that for the proposed option demonstrates better NPV results in all assessment periods (10, 20, 30 & 45 years) against other options. As the intervention is forecast to carry at least a 45-year asset life expectancy, the CBA at this time justifies the intervention. Consumers will also benefit from reduced network risk immediately on completion of the project.

### 6.6.3 Sensitivity to Future Pathways

The network capacity and capability that result from the proposed option is consistent with the network requirements determined in line with the section 9 of the Electricity Act and Condition 21. Additionally, the proposed option is consistent with the SPEN's Distribution System Operator (DSO) Strategy and Distribution Future Energy Scenarios.

Table 6.4 shows electric vehicle and heat pump uptakes across a range of future pathways and Table 6.5 shows the sensitivity of the proposed solution and Table 6.6 shows the sensitivity of the proposed RIIO-ED2 expenditure against the full ranges of Net Zero complaint future pathways other Climate Change Committee (CCC) scenarios.

*Table 6.4: Electric Vehicle and Heat Pump uptakes across a range of future pathways*

| End of RIIO-ED2 | SPEN | DFES | | | CCC | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline | System Transformation* | Consumer Transformation | Leading the Way | Balanced Net Zero Pathway | Headwinds | Widespread Engagement | Widespread Innovation | Tailwinds |
| **EVs** | 1,830 | | 2,241 | 2,533 | 2,195 | 1,512 | 2,388 | 2,175 | 2,175 |
| **HPs** | 1,279 | | 1,488 | 2,247 | 1,017 | 1,095 | 1,101 | 858 | 1,066 |

*Note: We have excluded System Transformation from our future pathways assessment as it does not meet interim greenhouse gas emission reduction targets.

*Table 6.5: Sensitivity of the proposed solution against future pathways*

| | RIIO-ED1 | | | | RIIO-ED2 | | | | | RIIO-ED3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Solution Requirements** | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
| Baseline | | | | | F | F | F | F | $R^1$ | | | | | |
| Consumer Transformation | | | | | F | F | F | $R^1$ | | | | | | $R^2$ |
| Leading the Way | | | | | | | F | $R^1$ | | | | | $R^2$ | |
| Balanced Net Zero Pathway | | | | | F | F | F | F | $R^1$ | | | | | |
| Headwinds | | | | | F | F | F | F | $R^1$ | | | | | |
| Widespread Engagement | | | | | F | F | F | F | $R^1$ | | | | | |
| Widespread Innovation | | | | | F | F | F | F | $R^1$ | | | | | |
| Tailwinds | | | | | F | F | F | F | $R^1$ | | | | | |

F – Utilise accepted flexibility services
$R^1$ – Establish a new primary substation in Guardbridge with two 11kV circuits to St Andrews
$R^2$ – Additional 11kV circuit to St Andrews

The proposed solution is robust across the range of future pathways. The selected solution is required under all scenarios. The timing of this requirement is only slightly sensitive to uptake rates but is found to be required under all scenarios within the RIIO-ED2 period.

In six of the eight scenarios this solution is expected to cater for capacity requirements until beyond RIIO-ED3. Under the two highest uptake scenarios an additional 11kV circuit may be required toward the end of RIIO-ED3.

*Table 6.6: Sensitivity of the proposed RIIO-ED2 expenditure*

| | Baseline | Uncertain |
|---|---|---|
| **RIIO-ED2 Expenditure (£m)** | 11.244 | N/A |
| **Comment** | Proposed option | Under higher uptake scenarios additional 11kV circuit may be required in RIIO-ED3 |

### 6.6.4 Asset Stranding Risks & Future Asset Utilisation

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

### 6.6.5 Losses / Sensitivity to Carbon Prices

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

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

During the evaluation of the options associated with the proposed scheme, we have embedded within the CBA, where data are available, an assessment of the embodied carbon and the associated carbon cost to inform our NPV evaluation. The mass of carbon dioxide emitted (CO2e) during the manufacture of the main equipment deployed to deliver this scheme is estimated to be 638 tonnes. The monetised embodied carbon value associated with this emission is £38.7k. It should be noted that the embodied carbon evaluation undertaken has only considered the manufacture and supply of materials. Further collaborative industry-wide work is planned for the RIIO-ED2 price review period to better understand the overall embodied carbon values including, for example installation and commissioning services, decommissioning and disposal activities as well as refurbishment opportunities. More information regarding this can be found in Section 3.1.2 of our Environmental Action Plan[2].

### 6.6.6 Whole Systems Benefits

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

[2] Annex 4C.3: Environmental Action Plan, SP Energy Networks, Issue 2, 2021.

## 6.7 Environmental Considerations

### 6.7.1 Operational and Embodied Carbon Emissions

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

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

As network losses currently account for 95% of our BCF, even a marginal improvement in the efficiency of a transformer can bring a significant reduction in lifetime losses and the resulting carbon emissions. Therefore, it is important that efficiency criteria inform the decision-making process.

### 6.7.2 Supply Chain Sustainability

For us to take full account of the sustainability impacts associated of the St Andrews Primary Reinforcement programme, we need access to reliable data from our suppliers. The need for carbon and other sustainability credentials to be provided now forms part of our wider sustainable procurement policy.

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

### 6.7.3 Resource Use and Waste

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

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

### 6.7.4 Biodiversity / Natural Capital

The construction of a new primary substation has the potential to impact on natural capital and biodiversity. In particular, the positioning of the substation will result in the loss of a small area of grassland. We will minimise the area of land take required and will minimise disturbance to soils and vegetation during construction. We will replace and enhance the existing habitat, working with relevant stakeholders to identify the measures required to achieve a net gain in biodiversity and wider ecosystem services.

### 6.7.5 Preventing Pollution

SPEN will always follow all relevant waste regulations and will make sure that special (hazardous) waste produced or handled by our business is treated in such a way as to minimise any effects on the environment.

### 6.7.6 Visual Amenity

SPEN continually seeks to reduce the landscape and visual effects of our networks and assets but recognises that the nature of our substations makes it challenging to minimise their visual impact. Our use of underground cables instead of overhead lines helps to minimise our overall visual impact.

### 6.7.7 Climate Change Resilience

In addition to our efforts to minimise our direct carbon emissions in line with our Net Zero ambitions, we are also conscious of the need to secure the resilience of our assets and networks in the face of a changing climate. We have also modified our policy on vegetation control in the face of higher temperatures and longer growing seasons.

## 7 Conclusion

St Andrews demand group supplies 9,003 customers and is geographically located in the Central and Fife region of SP Distribution (SPD) licence area.

The group demand at St Andrews Primary is approaching the 21.6MVA firm capacity (FC) of the group. Our Baseline View projects a peak demand of 22.2MVA by 2028, with an expected uptake of up to 1,830 electric vehicles and 1,279 heat pumps by the end of the RIIO-ED2 period.

Network studies also show that step voltages, beyond Engineering Recommendation (EREC) P28 compliance (RVC < -10%), may be observed, for planned or unplanned outages, at St Andrews primary due to forecast demand growth.

To accommodate the demand growth, improve security of supply and alleviate voltage step issues in the St Andrews group, the proposed solution is to establish a new primary substation in Guardbridge, which lies on the outskirts of St Andrews town, with 11kV interconnection to St Andrews Primary and utilise flexibility services to manage network constraints until delivery.

The estimated cost for the above is £11.244m (in 2020/21 prices) with 100% contribution to be included in the RIIO-ED2 load related expenditure.

It is recommended to continue annual tendering for flexibility in this area to minimise the network risk.

Due to the complexity of the circuits and the overall project, it is proposed to start the works in 2023/24 and the release capacity of 32MVA will be claimed in 2027/28 at the end of the project.

# 8 Appendices

## Appendix 1. System Study Results

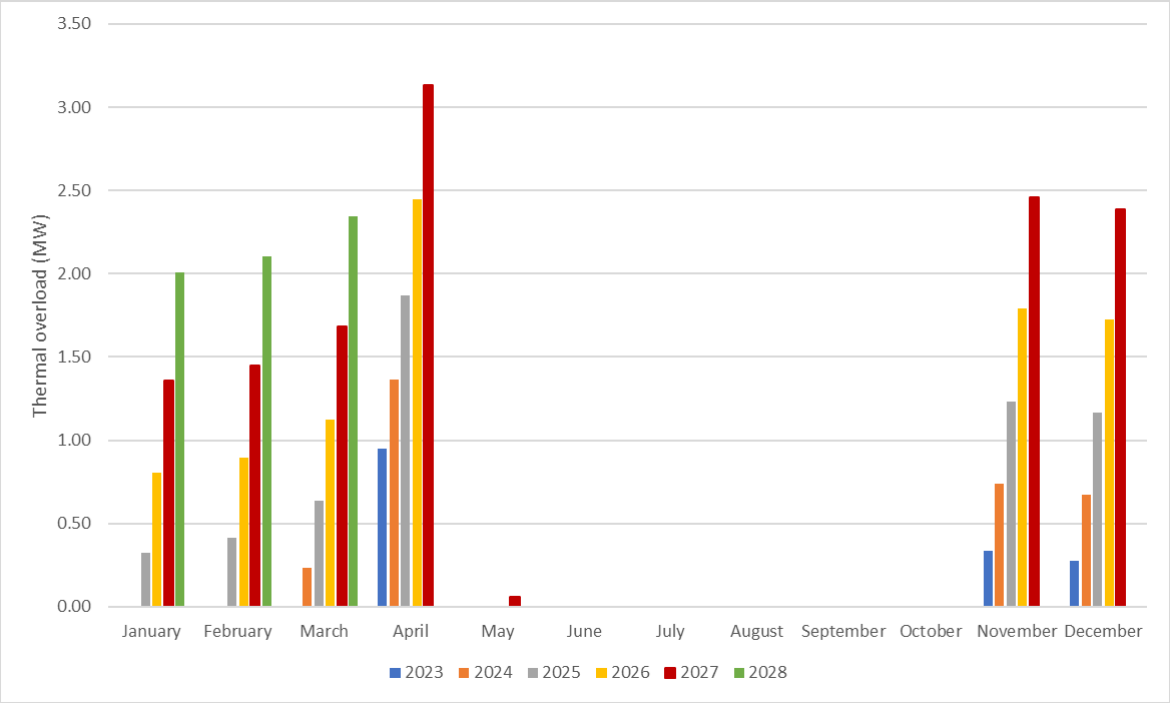


*Figure 8. Monthly maximum overload on 33/11kV St Andrews transformer*