Scottish & Southern
Electricity Networks

RIIO-ED2 Engineering Justification Paper (EJP)

EHV and 132kV Underground Cables

Investment Reference No: 313_SSEPD_NLR_EHV_132kV_UG

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Investment Summary Table

Table 1 below provides a high level summary of the key information relevant to this Engineering Justification Paper (EJP) and the non-load related management of our EHV and 132kV underground (UG) cables.

Table 1: Investment Summary

Name of Programme	EHV and 132kV Underground Cables
Primary Investment Driver	Non Load – Reliability
Investment Category	313_SSEPD_NLR_EHV_132kV_UG
Output Type	EHV_132kV_UG
Cost (£m)	26.2
Reporting Table	CV7: Asset Replacement CV8: Refurbishment – No Secondary Deliverable Improvement (SDI) CV9: Refurbishment SDI

Spend Apportionment	**Licenced Area**	**ED1 (£m)**	**ED2 (£m)**	**ED3+ (£m)**
	SEPD	-	23.3	-
	SHEPD	-	2.9	-

RIIO-ED2 Spend (£m) – EHV Underground Cable

	Area	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
CV7 Asset Replacement (£m)	**SEPD**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	SHEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CV8 Refurbishment – No SDI (£m)	**SEPD**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	SHEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CV9 Refurbishment - SDI (£m)	**SEPD**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	SHEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

RIIO-ED2 Volumes – EHV Underground Cable

	Area	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
CV7 Asset Replacement (km)	**SEPD**	8.3	8.3	0.0	0.0	0.0	**16.7**
	SHEPD	0.5	0.5	2.4	0.0	0.0	**3.4**
CV8 Refurbishment – No SDI (#)	**SEPD**	3.0	3.0	3.0	3.0	3.0	**15.0**
	SHEPD	0.0	1.0	0.0	1.0	0.0	**2.0**
CV9 Refurbishment – SDI (km)	**SEPD**	9.0	9.0	9.0	9.0	9.0	**45.0**
	SHEPD	0.0	0.0	0.0	0.0	0.0	**0.0**

RIIO-ED2 Spend (£m) – 132kV Underground Cable							
CV7 Asset Replacement (£m)	Area	2024	2025	2026	2027	2028	Total
	SEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CV8 Refurbishment – No SDI (£m)	SEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CV9 Refurbishment - SDI (£m)	SEPD	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
RIIO-ED2 Volumes – 132kV Underground Cable							
CV7 Asset Replacement (km)	Area	2024	2025	2026	2027	2028	Total
	SEPD	0.0	0.0	0.0	0.0	0.0	**0.0**
CV8 Refurbishment – No SDI (#)	SEPD	2.0	2.0	2.0	2.0	2.0	**10.0**
CV9 Refurbishment – SDI (km)	SEPD	9.0	9.0	0.0	0.0	0.0	**18.0**

1 Executive Summary

The Primary Investment Driver described within this Engineering Justification Paper (EJP) is the condition or health of our EHV and 132kV underground (UG) cable network. Without further intervention is these asset categories during RIIO-ED2 we expect to see an increase in costly cable faults, which will significantly impact both the reliability and affordability of the distribution network for our network customers.

Our document ***Safe and Resilient*** (Annex A_07.1) describes our approach to determine the Non-Load baseline for capital expenditure. This encompasses capital investment to address assets in poor health deemed to be at or near their "end of life".

This EJP includes the investment proposed within our EHV and 132kV UG cables within the CV7a (Asset Replacement), CV8 (Refurbishment – no SDI), and CV9 (Refurbishment – SDI). This includes three main cable types: solid (non-pressurised) cable, gas filled cable, and oil filled cable.

The replacement programme for oil filled cables has been included within the environmental investment scope, so additional volumes of EHV and 132kV UG cable overlay are identified and justified for replacement based on the environmental impact of the assets. As such, these environmentally based additions and disposals will not be accounted for within this EJP or the accompanying CV7a tables.

Following the optioneering and analysis set out in this paper, the proposed scope of works is the replacement of **20.1km** "end of life" EHV and 132kV UG cable in the Southern Electric Power Distribution PLC (SEPD) licence area and **3.4km** of EHV UG cable in Scottish Hydro Electric Power Distribution PLC (SHEPD).

In addition, **63km** of oil filled cable will be refurbished over the course of RIIO-ED2 (CV9), and **25** CV8 refurbishments will be undertaken in SEPD and **2** in SHEPD.

The resultant cost to deliver the investment described above during RIIO-ED2 has been calculated to be **£26.2m.**

2 Introduction

This Engineering Justification Paper (EJP) describes our proposed non-load related investment plan for the EHV (33kV & 66kV) and 132kV UG cable asset categories during RIIO-ED2. The Primary Investment Driver described within this EJP is the health or condition of our UG cable network. This is reflected in the UG cable faults and the resulting network outages faced by our network customers.

These asset categories cover three main cable types: solid cables (non-pressurised), gas filled cables, and oil filled cables. This document includes the replacement and refurbishment investment that is required to manage the condition of each of these cables cables.

Section 3 of this EJP provides useful background information on our EHV & 132kV cable network and explains the importance of this asset category for our electricity distribution network and our network customers. Since the UG cable network is largely inaccessible for routine inspection, it is challenging to directly determine the condition of each circuit. For this reason, it is necessary to consider fault trend data in order to determine the likely condition of our UG cable network and to determine where our circuits are approaching end of life.

In addition, to further understand the requirement to replace our EHV & 132kV UG cable, asset age profiling has been conducted, which provides useful insight into overall volumes of cable that will need to be overlaid (i.e. replaced) in RIIO-ED2 and in upcoming price controls

Section 3 of the EJP then goes on to describe the primary and secondary investment drivers for investment in this asset category and the corresponding areas of the Business Plan Data Tables (BPDTs) which are used to capture the costs required to address these drivers for investment.

Section 4 describes our stakeholder engagement activities which have informed our proposed intervention strategy for our UG cable network during RIIO-ED2.

Section 5 then details the intervention options that will be available to us during RIIO-ED2 to address the primary and secondary investment drivers. The advantages and disadvantages of each intervention option is described in this section along with a conclusion on which we intend to take forward for RIIO-ED2.

Section 6 provides the results of our detailed analysis and the resulting cable costs and volumes that we are proposing for RIIO-ED2. This includes a description of the justification for the intervention volumes we are proposing for both our licenced areas. Finally, the deliverability and the cost efficiency of the of the proposed volumes are discussed within this section of the EJP.

Section 7 provides a brief conclusion to this EJP and summarises the key findings of our assessment of the intervention requirement during RIIO-ED2 on our EHV & 132kV UG cable network. This is followed by an Acronym table and an Appendix of the relevant polices and standards that should be considered alongside this EJP.

3 Background Information

This section of the report provides background information which has been used to inform the non-load related investment strategy for EHV and 132kV UG cable assets. This includes a description of the assets under consideration and their primary and secondary investment drivers, details on the problems related to fluid-filled cables and the approach used to identify those that will require replacement or refurbishment during RIIO-ED2.

3.1 Introduction to the Asset Category

Within SHEPD, the volume of 33kV cable is 1,641km, versus 5,123km of overhead lines. The cable proportion is therefore significant, comprising 24% of our overall 33kV circuits. Similarly, within SEPD there is 2,238km of 33kV cable and 3,375km of 33kV overhead line, meaning that cable represents around 40% of our 33V network.

In SEPD, there is 216km of UG cable at 66kV, compared to 6km of overhead line; whilst at 132kV there is 493km of 132kV UG cables, versus 1,887km of overhead line, i.e. 132kV UG cable represents around 21% of the 132kV network.

Table 2 below shows the quantity of EHV and 132kV UG cable assets within both SEPD and SHEPD licence areas:

Table 2: SSEN EHV & 132kV Underground Cables by Type

	SHEPD			SEPD		
Cable Type	**Volume (km)**	**# Circuits**	**Average Age**	**Volume (km)**	**# Circuits**	**Average Age**
33 kV Non-Pressurised	1568	650	12	1565	377	26
33 kV Oil Filled	63	30	56	674	277	52
33 kV Gas Filled	10	6	50	0	0	0
66 kV Non-Pressurised	0	0	0	125	21	17
66 kV Oil Filled	0	0	0	75	13	49
66 kV Gas Filled	0	0	0	16	5	74
132 kV Non-Pressurised	0	0	0	202	63	20
132 kV Oil Filled	0	0	0	292	91	50
132 kV Gas Filled	0	0	0	0	0	0

Clearly, our EHV & 132kV UG cable network makes up a significant proportion of our total network and is responsible for distributing a significant amount of energy to our network customers. As such, it is critical that the health of these assets is well maintained during RIIO-ED2.

Cross-linked polyethylene (XLPE) is used for all new or replacement EHV & 132kV UG cable circuits which falls into the solid or 'non-pressurised' category. Cables can be laid direct into the ground or within ducts. Where required cable tunnels may also be used, especially in relation to railway crossings and bridges.

Poor performing and ageing cable assets can reduce the quality of supply for consumers and customers and lead to both safety and environmental consequences for network customers and our employees if not managed effectively.

In addition, whilst cable failures are relatively rare, when they do occur, they can take longer to repair than OHL faults and therefore lead to reduced performance for longer periods of time. There is also an increased risk of longer interruptions and an increased likelihood of additional faults on the asset, which will reduce the resilience of the network and performance against IIS targets.

There are particular challenges associated with our gas and oil filled cables. For example, leaks within our gas filled cable can be difficult to find, especially if damage is caused to the sheath away from any known joint bay locations. Furthermore, the supplies of cable accessories are limited to a small number of companies in the UK. The lead time for joints can be up to 6 months and the number of qualified jointers is very limited. Replacement joints that meet our specifications can also be very expensive and challenging to source.

Leaks in our oil filled cable can be found more readily when compared to gas cables. However, suppliers are also limited to a small number of companies in the UK. The lead time for joint is around 3-4 months. Again, the joints can be very expensive with limited jointers qualified to undertake the work. The oil pressure on any oil filled cable sections must also be maintained. As such, various auxiliary equipment is required to allow the oil pressure and level within these cables to be monitored and topped up if required. Obviously, any cable faults or leaks from existing joints will have a serious environmental consequence in addition to the cost and network reliability implications.

Repeated cable repairs carried out on aged cable sections tend to only produce short duration solutions, with further repairs required a few years later. Repairing cable that has already faulted and been repaired is usually more difficult and time consuming then on cable without a fault history, resulting in increased duration for loss of supply.

In total there is **3,881km** of EHV UG cable in our network with an estimated Modern Equivalent Asset Value (MEAV) of **£1,115 million** (m). Note that this calculation assumes that oil and gas filled cables have unit MEAV of a solid cable.

Similarly, there **is 493km** of 132kV UG cable in our network with an estimated Modern Equivalent Asset Value (MEAV) of **£1,249m** (note that this calculation assumes that oil and gas filled cables have unit MEAV of a solid cable).

3.2 Fluid Filled Cables

All Fluid filled cables (FFCs) are being phased out of use on the GB distribution networks and will ultimately be replaced by non-pressurised XLPE cables as standard.

FFCs include both, gas filled, and oil filled cable, both of which can develop leaks over time due to either ageing or third party damage. Any leaks must be fixed promptly to prevent asset failure, and in the case of oil filled cable to avoid environmental damage to the surrounding area.

Figure 1 to Figure 3 show examples of the condition of cables found whilst performing repairs on the SEPD network.

Following the repair of the cable in Christchurch, it was noted that the section of cable that was repaired was in poor condition and very fragile. Numerous repairs had already been undertaken along the length of this section so in effect repairs were carried out on top of previous repair attempts. It was advised that it may not be possible to maintain the integrity of the cable for much longer. As such, an overlay was strongly recommended to avoid future costly faults. This issue was directly related to the age and general condition of the cable. This provides an example of the challenges associated with ageing FFCs on our network.

Figure 1: Leak identified on 132kV FFC in Fleet, on the SEPD network

Figure 2: Rodent damage to outer sheath of 132kV FFC in Fleet, on the SEPD network

Figure 3: Previous repair can to FFC in Christchurch showing signs of leakage

3.2.1 Gas Filled Cables

This section describes the gas filled cables owned and maintained by both SEPD and SHEPD.

SEPD Gas Filled Cables

The majority of gas filled cables on our network were installed in the 1940s and 1950s. The asset base is therefore approaching end of life, and the cable type has become obsolete in recent years and is no longer installed on the networks. There have been a number of significant failures on the remaining gas cable on the SEPD network throughout RIIO-ED1, verifying that these cables have reached end of life and are performing poorly.

There are relatively low volumes of this cable type left on the network and there are programmes running in RIIO-ED1 to remove the remaining volumes and replace them with non-pressurised cable. These programmes will run into the RIIO-ED2 non-load investment and have been informed by in house knowledge of the performance of the cable and experience with repairing the circuits.

SEPD has a 66kV network in the west London area and some of these circuits include gas-filled cables which have serious operational and maintenance issues, and the worst performing circuits need to be replaced to ensure security of supply is maintained. All schemes for replacement of gas-filled cables have been completed except for two, North Hyde to Vicarage Farm Road circuits and the North Hyde to Osterley circuit.

These circuits will need to be replaced in RIIO-ED2 as they are continually being topped up and repair work usually takes several months and costs upwards of £0.5m. We only have 40m of gas cable for use on fault repairs and diversions and this is no longer made. Joints have long lead times, and transition joints are not generally available. Furthermore, manufacturers have very few jointers able to work on gas-filled cables.

Gas leakages have required the following gas bottle changes in the last three years (January 2017 to January 2020):

Table 3: Gas bottle changes related to leakages on 66kV gas circuits

Circuit	Number of bottles
North Hyde – Vicarage Farm Road 1	96
North Hyde – Vicarage Farm Road 2	15
North Hyde – Osterley	48

This is reflected within our Condition Based Risk Modelling (CBRM) of our EHV UG cable (gas) asset category as per the Common Network Asset Indices Methodology (CNAIM) v2.1. This is illustrated in Figure 4 below which shows the three circuit listed above within the Health Index (HI5) category both at the start of RIIO-ED2 and at the end of RIIO-ED2 without further intervention.

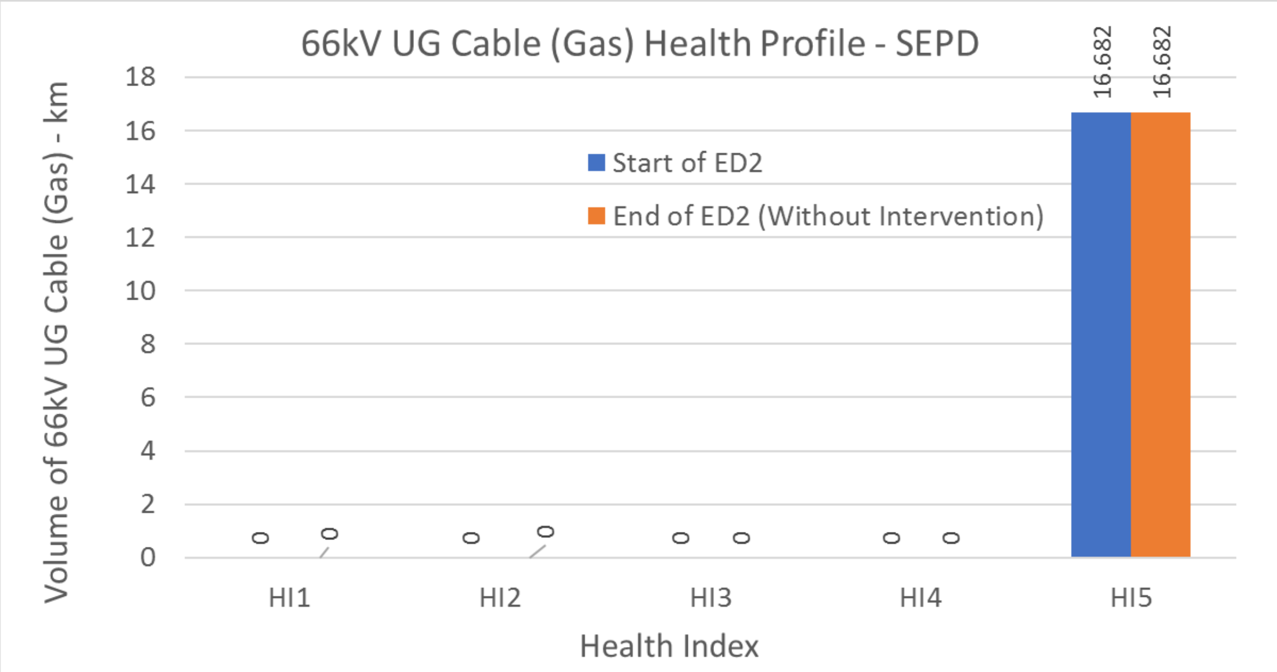

Figure 4: 66kV UG Cable (Gas) Health Profile (SEPD)

As such, the replacement of these cables can be justified through based the CBRM outputs, the condition assessment, the lack of spares and the diminishing availability of special skills required to repair these gas cables. The proposal for replacement of the 66kV gas filled cables will result in:

- Complete replacement of all SEPD's gas-filled cables, removing existing issues with maintenance and spares;
- Removal of the high risk of double circuit outages and possible extreme reliability impacts on customers;
- Large reduction in future repair costs; and will
- Provide increased 66 kV transfer capacity between North Hyde and Ealing GSPs and improved operational flexibility increasing security of supply.

Our Gas filled cables are not covered under the RIIO-ED2 environmental related investments unlike the oil-filled cable investments, as the insulating gas used is inert and is not seen to pose an environmental damage in the event of leakages.

SHEPD Gas Filled Cables

The gas filled cables on the SHEPD network were installed in the 1960s. The asset base is therefore approaching end of life, and the cable type has become obsolete in recent years and is no longer installed on the networks. One of the four remaining Gas filled cable circuits has recently failed. Hayton – Willowdale No.2 circuit has failed due to leaking gas, resulting in the network being forced to operate on a back-feed.

This represents a considerable risk to the continuity of supply to the affected customers, and due to the redundant components used in the gas filled cable, combined with the scarcity of skilled technical resource to work on these cables it is considered appropriate that the affected circuit and the adjacent circuit (Hayton – Willowdale No.1, which resides in the same trench work) are overlaid during RIIO-ED2.

The twin gas filled circuits represent a total cable overlay of around 1.5km. The project design will be initiated in the remainder of RIIO-ED1 and is proposed for completion by the end of 2026.

The overlaying of the twinned Hayton – Willowdale gas filled circuits, will leave two remaining gas filled 33Kv circuit in SHEPD (Persley – Hayton No.1, Persley – Hayton No.2) it is expected that these circuits will be overlaid in RIIO-ED3, with preliminary planning works being conducted in RIIO-ED2.

3.2.2 Oil Filled Cable Assessment

As previously described, we intend to phase out all our oil-filled cable and replace this will solid XLPE cable (non-pressurised). There are several drivers for this direction of travel including the cost and complexity of maintaining oil-filled cable circuits. However, the primary driver for this investment is the environmental impact and damage that can be caused when an oil-filled cable or joint fails.

Given that the primary investment driver for our oil-filled cable is an environmental one, we have decided that all oil-filled cable overlays will be funded via the environmental section of our RIIO-ED2 business plans.

However, there will be an on-going need to refurbish and maintain our remaining oil-filled circuits. The costs associated with this are captured within the CV31, CV8 and CV9 refurbishment tables within Ofgem's Business plan Data Tables (BPDTs).

This includes CV31 Repair and Maintenance activities such as the oil that is pumped into the pressurised oil filled UG cables to bring a circuit back up to pressure from a lower pressure level and to sustain a circuit fluid pressure from reaching Pressure emergency (Pe) level prior to jointing or repair of a leak.

The CV8 (Refurbishment – no SDI) activities include the replacement of the pressurising equipment valves and/or gauges and the replacement of pressurising equipment pipework and/or tanks, whilst our CV9 (Refurbishment – SDI) activities include the replacement of cable joints and terminations (including sealing ends), remaking existing joints and terminations in situ, and the re-engineering of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system

3.2.3 Age Profile

Figure 5 to Figure 7 shows the Age Profiles for our EHV UG cables for both SEPD and SHEPD. These show the number of assets installed within both licence areas during each decade. This is provided for information purposes only and cannot be used in isolation to justify investment in the asset category. However, there is a close correlation between age and asset health.

Furthermore, these Age Profiles do demonstrate the variance in the rate at which the network was built over time. This variance can result in sudden increases or decreases in future investment to manage these historic ageing assets. Sudden rates of change in volumes and associated investment can be partially managed via the development of long-term overlay programmes that help to smooth spikes and troughs in annual volumes enabling more effective resource management and the efficient delivery of overlay.

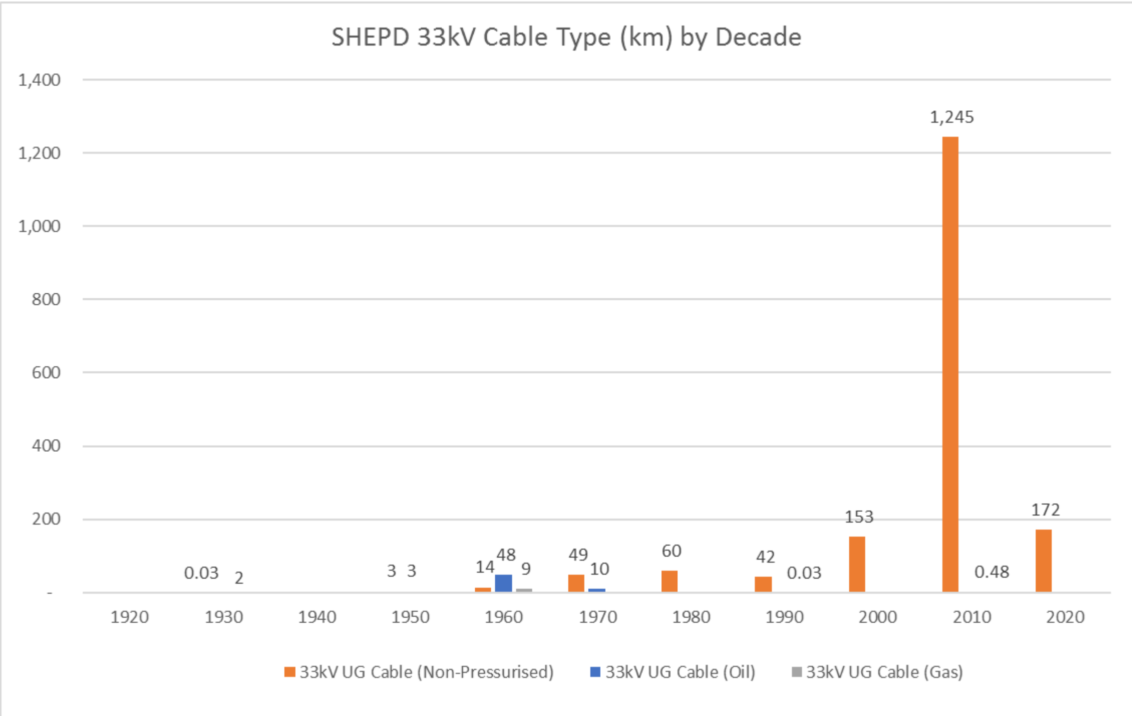

Figure 5: Age Profile for 33kV Underground Cable SHEPD

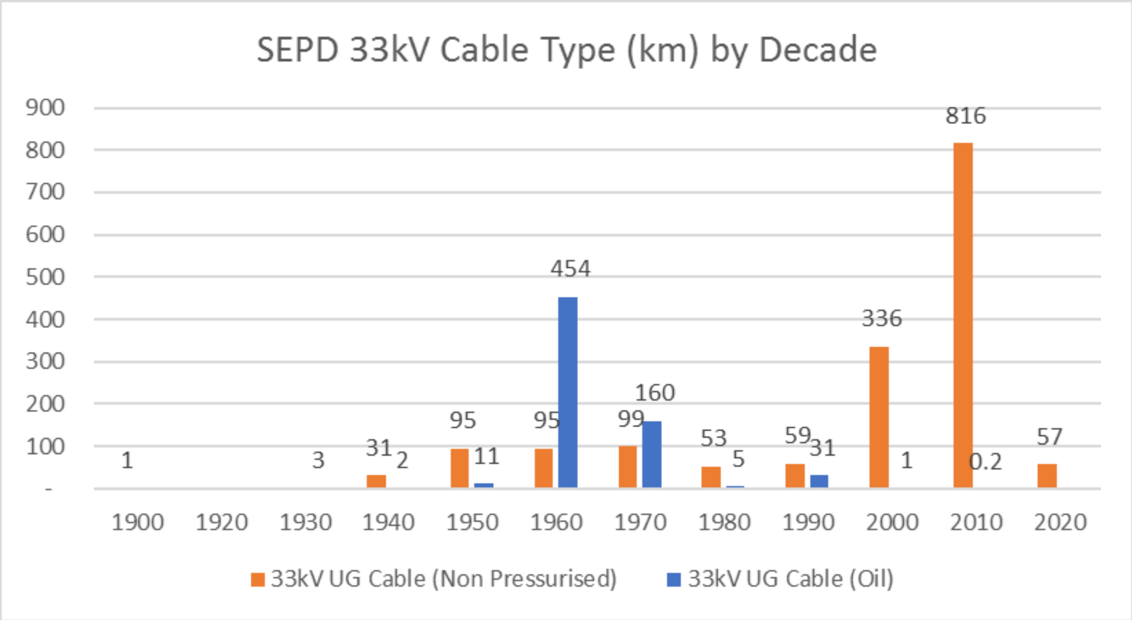

Figure 6: Age Profile for 33kV Underground Cable SEPD

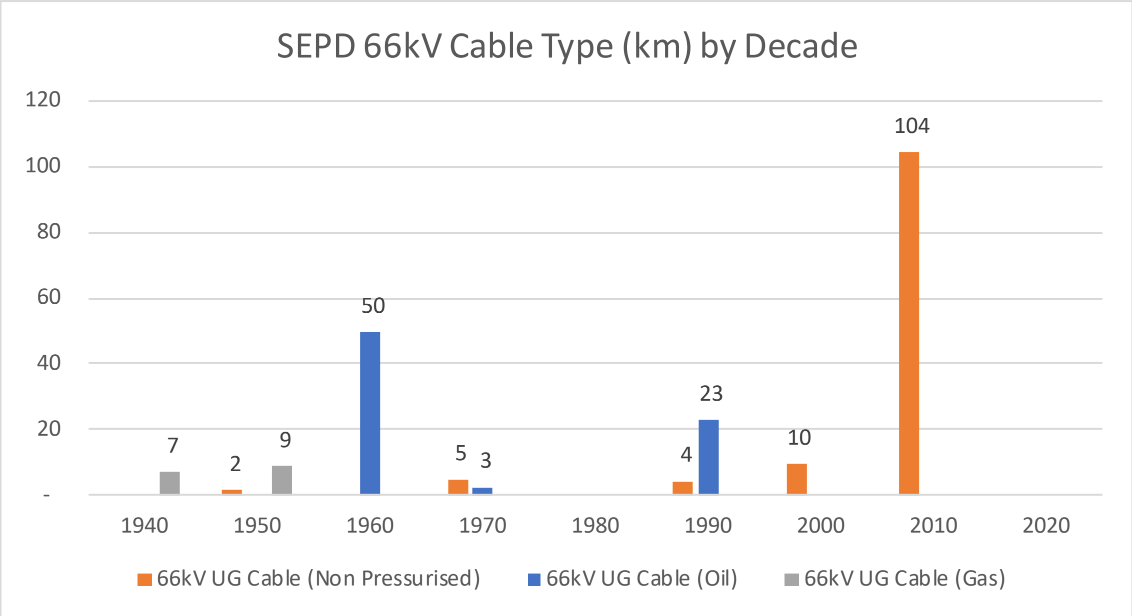

Figure 7: Age Profile for 66kV Underground Cable SEPD

Similar to the above, Figure 8 shows the age profile for 132kV FFC and Non-Pressurised UG cables in SEPD. Note that almost all 132kV gas filled UG cable has now been replaced on the SEPD network. As seen, the majority of our remaining oil-filled cable was installed in the 1960s, whereas the majority of our non-pressurised cable was installed post 2000. As such, our 132kV Non-Pressurised UG cable is on the whole well within its useful lifetime.

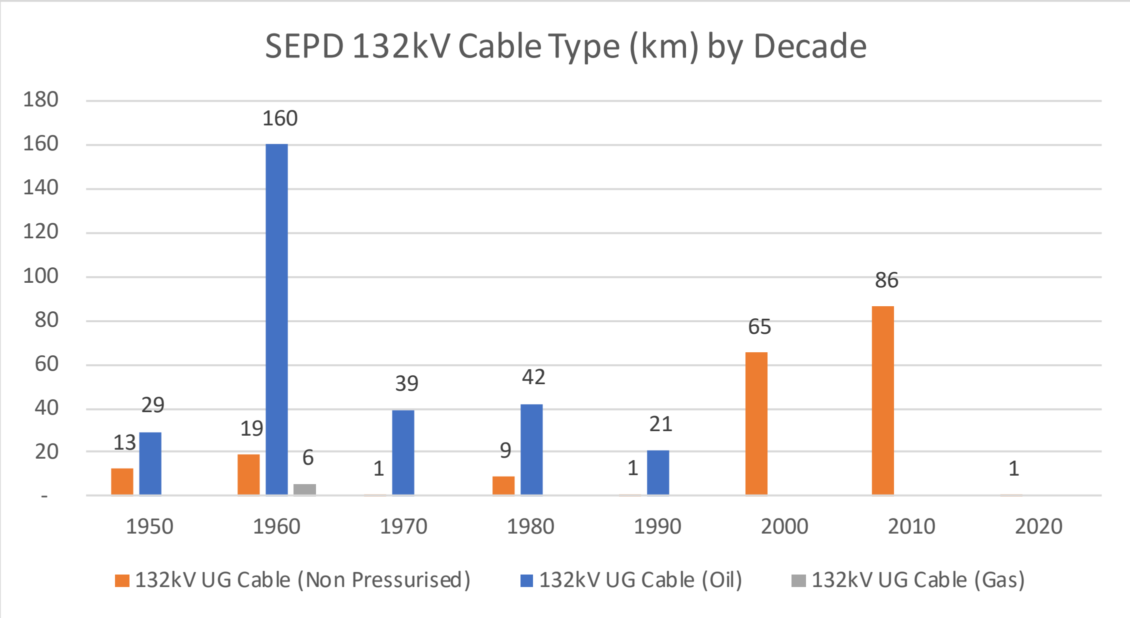

Figure 8: Age Profile for 132kV Underground Cable SEPD

3.3 Condition Based Risk Management (CBRM)

During RIIO-ED1, we have built our Condition Based Risk Management (CBRM) models to inform the risk (health and criticality) associated with each of our NARMs asset categories. These CBRM models are based upon the Common Network Asset Indices Methodology (CNAIM) v2.1 developed by the Energy Network Association (ENA) and member Distribution Network Operators (DNOs).

The CNAIM has been developed to allow a Risk Score to be calculated for each network asset which consists of both the Health and Criticality scoring. This information informs the replacement strategy for each qualifying asset category and to help DNOs to prioritise investment into assets based upon both the Probability of Failure (POF) and Consequence of Failure (COF) for both the DNO and network customers. The information provided by CBRM data is key to the CV7 Asset Replacement and CV8/CV9 Refurbishment strategy for each qualifying asset category. A more detailed description of the outputs from CBRM is provided below.

The Health Index is a key output of the CBRM policy. This measure provides a view on the condition of the asset relative to its Normal Expected Life. The normal expect life for EHV and 132kV UG cable assets is shown in Table 4 below, reproduced from CNAIM v2.1.

Table 4: Normal Expected Life of EHV and 132kV underground cable assets

Asset Register Category	Sub-Division	Normal Expected Life (years)
33kV UG Cable (Non Pressurised)	Aluminium Sheath	100
	Lead Sheath	100
33kV UG Cable (Oil)	Aluminium Sheath	75
	Lead Sheath	80
33kV UG Cable (Gas)	Aluminium Sheath – Aluminium Conductor	65
	Aluminium Sheath – Copper Conductor	70
	Lead Sheath	75
66kV UG Cable (Non Pressurised)	Aluminium Sheath	100
	Lead Sheath	100
66kV UG Cable (Oil)	Aluminium Sheath	75
	Lead Sheath	80
66kV UG Cable (Gas)	Aluminium Sheath – Aluminium Conductor	65
	Aluminium Sheath – Copper Conductor	70
	Lead Sheath	75
132kV UG Cable (Non Pressurised)	Aluminium Sheath	100
	Lead Sheath	100
132kV UG Cable (Oil)	Aluminium Sheath	75
	Lead Sheath	80
132kV UG Cable (Gas)	Aluminium Sheath – Aluminium Conductor	65
	Aluminium Sheath – Copper Conductor	70
	Lead Sheath	75

The Health Index (HI) ranges from HI1 to HI5, where HI1 is like new and HI5 is at 'end-of-life'. To calculate the initial Health Index for each asset, a Duty Factor and Location Factor are combined to account for the specific environment in which that asset operates. This is then combined with a Measured and Observed condition factor which can be ascertained from inspection and maintenance routines. These are used to calculate the final Health Index for each asset.

3.4 Primary Investment Drivers

As discussed, this EJP is intended to inform the proposed non-load related interventions of our EHV and 132kV UG cable assets during RIIO-ED2. This primarily relates to the condition of each asset as tracked by our Condition Based Risk Management (CBRM) models, but also includes the following:

- **Defects –** these are captured during routine inspection and maintenance or on-line monitoring. Defects can include degrading insulation, insulation faults under operational stress or defects introduced during transportation or installation. The data is assessed separately from the CBRM scoring and should be considered alongside the asset risk scores. Inspections are currently only carried out on oil filled cables.
- **Condition –** condition data is captured during routine inspection and maintenance and uploaded for inclusion within the CBRM modelling of asset Health, Criticality, and Risk. This condition data primarily includes partial discharge monitoring of the cable insulation, cable joints and the terminations.
- **Asset age and obsolescence –** the age of each of the EHV and 132kV UG cable assets and the associated accessories (joints, terminations, cleats etc) will also determine the investment option that is selected. Fluid Filled Cables were installed from the 1940's to 1998. Cables generally have a very high electrical reliability but can suffer from fluid leaks generally on the accessories or when the lead sheath fatigues and cracks, which can arise especially in older assets.
- **Environmental –** the cable type (e.g. oil filled) of the UG cable assets may be a primary driver for replacement, especially if there are oil leakage issues associated with the cable. Oil leakage is believed to mainly be linked to pressure, which can be monitored, and refurbishment could be used to reduce pressure. Additionally, consideration should be taken of the location and surrounding environment of the cable, such as the proximity to potable water bore holes or other water sources.
- **Fault rate –** The number and trend of faults caused by the failure of each cable section or circuit. As the condition of a cable is closely reflected within the number and frequency of faults, analysis of fault trends can inform the asset replacement strategy and volumes for our EHV and 132kV UG cables.
- **Catastrophic Failure –** A cable without defects may fail due to damage or theft, resulting in the requirement to replace or repair the cable circuit or section of cable.
- **Operational Difficulties –** Approximately 60% of our fluid filled cable is in the carriageway of major roads. This results in high repair costs and the need for road or lane closures in very busy areas.

Corresponding Ofgem CV Tables:

The primary investment drivers described above correlate to the following Cost and Volumes (CV) tables within the RIIO-ED2 Business Plan Data Tables (BPDT).

- **CV7a – Asset Replacement:** The replacement or overlay of any 'end-of-life' (as recorded within our CBRM cable models) EHV & 132kV UG cable sections or circuits with solid XLPE Non-Pressurised cable.
- **CV8 – Refurbishment (No SDI):** Our Non SDI related refurbishments of our EHV and 132kV UG cables includes the replacement of the pressurising equipment valves and/or gauges and the replacement of pressurising equipment pipework and/or tanks.
- **CV9 – Refurbishment (SDI):** Our SDI related refurbishments of our EHV and 132kV UG cables includes the replacement of cable joints and terminations (including sealing ends), remaking existing joints and terminations in situ, and the re-engineering of pressurising system equipment with the objective of reducing the normal operating fluid pressure in the cable system
- **CV26 – Faults:** This captures the costs associated with responding and rectifying any faults on our EHV and 132kV cables including the leak repair of any failing joints.

- **CV31 – Repair & Maintenance:** Repair and maintenance activities on our EHV and 132kV cables include diagnostic testing such as partial discharge monitoring, sheath repairs, top up of oil or gas, and resealing tanks etc.

The CBRM models maintained by us provide a Health, Criticality, and Risk score for each individual asset. The risk score (asset health and criticality) attributed to each asset by the CBRM models is a key metric that will trigger a need for investment into this asset category. This is calculated using a variety of asset-specific data which include basic parameters in addition to the observed and measured condition of each asset.

3.5 Secondary Investment Drivers

Whilst this investment pack is intended to inform the management of 33kV, 66kV and 132kV UG cable given the primary investment drivers described above, the investment options described within this EJP also take into account **several secondary investment drivers** that may influence the final investment option that are chosen.

It is important to ensure that these secondary investment drivers are also considered carefully alongside the primary drivers to identify potential efficiencies and to prevent double counting within our RIIO-ED2 business plans.

This includes the analysis of future network trends to ensure sustainable investment decisions are identified which represent best value for money for our network consumers and customers, whilst enabling the transition to Net Zero.

The secondary investment drivers which influence this EJP and the investment options that are chosen include quality of supply, future load growth, and network automation. These secondary drivers correlate to the following additional CV tables within the BPDT:

- **CV1 – Primary Reinforcement:** This table funds the load related investment required in our 33kV & 132kV UG cables as informed by our load related business plans and our Distribution Future Energy Scenarios (DFES).
- **CV22 – Environmental Reporting:** The table captures the costs associated with the replacement of our oil-filled cables where the investment is justified against a reduction in the environmental impact of these asset (reduction in oil leaks).
- **CV15 – Quality of Supply:** The replacement, refurbishment of network assets specifically to improve customer quality of supply. This can include investment in network automation to improve IIS performance.

When selecting the investment option for each individual project the following factors and secondary investment drivers are also considered to ensure the optimal solution is identified which best represents value for money for network consumers and customers:

- **Inability to Secure Spare Components:** Certain types of cable accessories such as cable joints for gas filled cables can be difficult to obtain and the lead time can be long. Also, the number of qualified jointers is limited for both gas and oil filled cables. There are currently enough spare parts available to repair gas filled cables in the short term, but ultimately, they will need to be replaced.
- **Online Monitoring:** A large percentage of the EHV & 132kV UG cables installed on the network were commissioned many years ago. As such, it is common that the cables will not be supported with online monitoring. Cables may also have insufficient sensors to carry out robust testing. The condition and even type of some cables may not be known due to gaps in some of the GIS data.

- **Telecommunications:** There may be an opportunity to lay an integrated fibre with a cable or a fibre alongside the cable as part of the cable replacement to provide functions such as differential protection or control. Existing fibre may not have this functionality but incorporating this new functionality into existing circuits could enable smart grids functions or facilitate new generation to be connected to the network.
- **Number of Customers and Network Outages:** When assessing the investment options available it is also important to consider the number and severity of network outages that have been incurred during previous years. This will inform the criticality of each circuit and inform the most appropriate investment solution. For example, a more redundant or resilient solution could be selected compared with like for like replacement depending on how critical a fault on the circuit would be. Due to network resilience, faults on EHV or 132kV cables do not typically lead to customers off supply, unless it is a second circuit outage
- **Network Load Forecast**: Future network trend analysis must also be carried out for each individual project to determine if sustained load growth can be expected for the cable circuit in question. If load growth can be proven with a reasonable level of confidence, a solution may be chosen which is not like-for-like, but one which can facilitate the future load growth that has been forecast. Similarly, the asset may be decommissioned if it can be demonstrated that other network assets can accommodate the forecasted network demand.
- **Network Losses**: The impact on network losses should also be taken into consideration. For example, if a larger cross-sectional area cable has a lower full lifecycle cost, then this solution should be considered for cable replacement, rather than simply a like for like replacement.

4 Stakeholder Engagement

In preparation for our RIIO-ED2 business plans several stakeholder engagement exercises have been undertaken to better understand what will be important to our network customers during RIIO-ED2 and to ensure the views of our stakeholders are reflected in the cost and volumes we are proposing for each asset category in line with our document: ***Enhanced Engagement Strategy (Annex 3.1) .***

Below is a summary of the key outcomes from this engagement from some of our critical stakeholders. The summary below provides details of our stakeholder feedback on our document; ***Safe and Resilient (Annex 7.1)*** and their views on the importance of improving network reliability.

Consumer Feedback

- 88% of stakeholders in SEPD and 72% in SHEPD either agreed or strongly agreed with our asset management proposal to target assets with the highest probability of failure for ED2.
- 71% consumers thought it was very important that we are committed to reliability, which was the second highest priority for them (after affordability).
- In terms of reliability, domestic and SME customers' top priorities were 'Restoring the electricity supply as quickly as possible in the event of a power cut' (particularly for those aged 65+ or in vulnerable situations) and 'Keeping my power on with minimal power cuts'.

Local Authority and Government

- Stakeholders strongly urged us to strike a balance between maintain a reliable network by simply fixing older assets now and replacing assets (at a higher cost now) so that the network is ready for future use.
- We need to ensure reliability and disruptions are minimised, suggesting proactive actions such as providing generators during bad weather and new technologies to 'master' the network.
- Resilience partnerships are a good start for mitigating issues.

Community Energy Groups and Interest Groups

- Both old and new communities need to be resilient - must ensure the transition does not leave people behind.
- We need to think about current and future populations in areas now in order to plan its investments most effectively.

Summary of Findings

A wide range of stakeholders confirmed that they stakeholders strongly support our proposed approach of prioritising assets with a higher probability and consequence of failure as part of the document; ***Safe and Resilient (Annex 7.1)***. In addition, stakeholders also highlighted that network reliability was a high priority, greater than sustainability but below value for money.

Stakeholders communicated that reliability is expected as they depend on electricity for so many things in everyday life, and this is increasing, for example, with more households working from home and the electrification of heating and transport. These expectations and views validate Ofgem's IIS targets and Guaranteed Standards, so on this basis we have set our ambition to meet these levels of network performance.

5 Summary of Options Considered

This section of the report sets out the investment options that are considered when managing our EHV and 132kV UG Cables. As described below a holistic approach is taken to ensure that investment options which are both least regrets, and represent best value for money for network customers, are identified.

The investment options described below range from reactive cable repair during faults to the full replacement of our EHV and 132kV UG cable circuits. By analysing all the primary and secondary investment drivers in a coordinated manner for each individual project, we can arrive at the optimal investment decision which avoids unnecessary spend and risks the future stranding of network assets. The options described below are chosen with the aim of achieving an optimal balance between maintenance, refurbishment, and replacement throughout RIIO-ED2 to minimise the cost of managing this asset category.

5.1 Summary of Options

Table 5 below provides a high-level summary of the 7 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.

Table 5: Summary of EHV and 132kV Underground Cable Investment Options

Option	Description	Advantages	Disadvantages	Result
1. Reactive Replacement of Faulted Cable Section	Post-fault replacement of cable section with like for like section.	Allows the cable to be repaired and returned to service quickly without the need for extensive replacement works	A temporary solution which is triggered by a circuit outage and potential disruption to customers. Introduces additional joints to the cable circuit which increase the likelihood of future faults.	**To be undertaken during fault repair and captured in CV26.**
2. Rationalisation of Circuit	It is possible that when the original circuit has come to the end of its life a replacement circuit may not be required. In this case the original circuit is disconnected, and the cable is left in the ground.	CAPEX may be reduced, as less expenditure is required.	Overall, capacity will be lost from the network so potentially less ability to future-proof. Rationalisation may reduce security of supply.	To be considered during RIIO-ED2 but is not an option that is quantified within this EJP.

Option	Description	Advantages	Disadvantages	Result
3. Enhanced Monitoring	Enhanced monitoring to better understand the condition of our UG cable network. This valuable data can inform the optimal time to intervene upon an ageing circuit.	May be cost effective for certain cable types and circuits which are showing signs of ageing or supply many customers. Can prevent the early overlay of healthy circuits or circuits that would be better deferred till later years.	Additional equipment will be required, which may have a CAPEX implication when deploying monitoring systems. Alternatively, more operational testing and monitoring will be used, which will increase OPEX.	To be considered during RIIO-ED2 on a case by case basis. Any associated costs will be captured in CV30 and CV31.
4. Fluid Leak Repair	For oil or gas filled cables, this involves identification of the leak by tagging the cable, followed by repair of the leaking section or joint.	No large upfront CAPEX in replacing the cable. Reduced carbon cost as the existing cable remains. Allows the existing circuit to be repaired and returned to service quickly	May be a missed opportunity to replace a fluid-filled cable and prevent further leaks. Lack of parts or companies to carry out repairs may mean this option is not suitable for all cable types.	**To be undertaken during fault repair and captured in CV26.**
5. Proactive Replacement of Section	Proactive replacement of cable section – may be hydraulic, solid or gas – with like for like section. This may be carried out due to condition, monitoring information, criticality data, fault history etc.	Cable is left in situ – no need to replace. No large upfront CAPEX in replacing the cable. Reduced carbon cost as the existing cable remains.	May be a missed opportunity to replace a fluid-filled cable and prevent further leaks. Depending on the age of the cable, full lifecycle cost may be minimised by replacing entire circuit rather than specific sections.	**To be taken forward during RIIO-ED2 within CV7a**
6. Proactive Replacement of Circuit with Larger Diameter Cable	Replacement of the entire aged circuit with a larger diameter/higher rated modern cable. The cost of the cable only represents a relatively small proportion of the total cost of overlay. Using a cable with a larger diameter than the original cable therefore represents a fairly small increase in cost whilst providing several benefits.	Lower full lifecycle cost than maintaining older faulting cables. Losses will be even lower and/ or more load will be accommodated providing future proofing for the net zero transition. Lower electrical loading results in lower thermal loading.	The CAPEX of the cable will be slightly higher than for overlaying cable with the equivalent rating of the original cable.	**To be taken forward during RIIO-ED2 within CV7a**

Option	Description	Advantages	Disadvantages	Result
7. Replacement with Innovative Low Loss Cable	Deployment of novel and innovative cable technologies when overlaying a cable that is in poor health or condition, which can improve both electrical losses and the voltage drop along the length of the circuit.	May lead to a reduction in electrical losses, reducing both carbon emissions and consumer energy bills. Can enabler longer UG cable circuits due to better voltage drop performance.	Likely to have a higher cable CAPEX due to novel technology. An unproven business case not widely deployed or tested in the field with lower Technology Readiness Level (TRL).	New cable technologies to be monitored during RIIO-ED2. Not currently built into RIIO-ED2 business plans.

5.2 Option 1: Reactive Replacement of Faulted Cable Section

If a cable fails during operation our faults team respond as quickly as possible to locate and repair the fault to minimise the disruption to our network customers whether there is an outage associate with the cable fault or not. Once the fault is located the ground around the fault is excavated to expose the failed cable. The cable is then cut back on either side of the point of failure, whether that be due to a fault on the cable itself or a failed historic joint, and new section of cable is jointed in to replace this section.

Whilst this allows us to return the circuit to operation as quickly as possible it does not address the underlying cause of the fault if the rest of the circuit is also in bad health or condition. It also introduced two new joints to the circuit which are weak points and can increase the likelihood of future faults.

The cost and volumes associated with this activity are captured within the CV26 Faults table within Ofgem's BPDT pack. As such, this option does not impact the volumes presented within this EJP with records the proactive CV7a asset replacement activity planned for RIIO-ED2.

5.3 Option 2: Rationalisation of Circuit

By analysing the surrounding network and considering the change in network loading that can be expected over the ED2 period, we can identify if there is a long term need for a cable that has reached the end of its useful life or that requires repairing.

If there is no sustained need for the cable due to low network loading or changes in the network configuration, decommissioning can be considered, particularly if there is spare capacity available on other local circuits that can be utilised. It may also be possible to reduce the size of the cable; for example, replace the existing cable with a lower cross-sectional area cable, although highly unlikely in the current growth market.

Network analysis would be needed to perform contingency analysis to ensure that the cable is not required under any potential scenario. This option should only be pursued if the future scenarios are clearly showing that the capacity will not be needed, with the implications of the uptake of Low Carbon Technologies (LCTs) accounted for. It is not anticipated that significant volumes of cable will qualify for removal / rationalisation during ED2.

If this option is chosen, the existing poor health or condition cable will be de-energised and disconnected from the network. It is not common for the cable to be remove from the ground after it is disconnected as there is little need for it to be removed and this would be expensive.

5.4 Option 3: Enhanced Monitoring

Enhanced monitoring of our EHV & 132kV UG cables has also been considered for RIIO-ED2 to allow us to better understand the condition and performance of our cables. The costs associated with enhanced monitoring fall under the CV30 (Inspection) data tables. Two examples of potential monitoring that have been considered are described below:

1. **Solid Cables - Partial Discharge Monitoring**: Partial discharge provides the main opportunity to detect insulation defects. On-line partial discharge monitoring can be used to provide continuous measurements, which gives increased information regarding degradation or deterioration of the insulation. Cable accessories for new cables are particularly important to monitor as these are more prone to problems due to installation and operational stress.

2. **Oil Filled Cables - Enhanced Leak Detection**: leak detection has traditionally been carried out using cable freezes or the Capenhurst hydraulic method. For cable freezes, the fluid in the cable is frozen and the pressure is monitored at each end of the circuit. Monitoring the pressure drop can indicate the presence of a leak. In the Capenhurst method, the position of the leak can be estimated by measuring the flow of fluid through the cable. PFT (Perfluorocarbon Tracer) is a new detection method, based on introducing a small amount of PFT into the degassed cable fluid of the leaking cable. The tracer is then detected by a mobile unit. This should enable fluid filled cable leaks to be detected faster and with increased cost efficiency.

The online partial discharge monitoring may deliver benefits on older circuits that are reaching their approximate expected lifetime. This would allow us to better understand the true condition of these cables and schedule overlays at the most cost-effective time. However, it can be difficult to carry out these measurements in situ once the cable has been installed. For new cable circuits, methods of monitoring the cable during the cable's lifetime should be established as part of the project assessment.

We do not have any current plans to deploy online partial discharge monitoring across all of our solid EHV & 132kV UG cable circuits. However, we will continue to assess the financial viability of this investment option and re-consider it if a clearer business case is identified.

5.5 Option 4: Fluid Leak Repair

Option 4 considers the repair of a leak, which is likely to be via a cable accessory (cable joint etc). This option involves identification of the leak followed by repair of the leaking section and is only valid for Oil or Gas-filled cables.

This is likely to be an attractive solution if the leak or joint failure is the only primary driver, and in the event that there are no secondary drivers. However, if, for example, the health score of the cable is also high, there may be a case to replace the cable section with new cable or consider replacing the entire cable with a solid cable. If there are other secondary drivers, such as likely high LCT growth for the circuit and/ or the cable losses are high, then there could be a case to replace the cable with a higher capacity and/or lower loss cable.

Some circuits have repetitive fluid leaks due to poorly made joints or ground movement. These joints can be refurbished and the plumbs on to the end of the copper joint sleeve can be reinforced with fibre glass wraps to further strengthen the new plumbs and prevent future leaks.

We will continue to repair leaking joints on our oil and gas filled cable during RIIO-ED2. The costs associated with this are captured within both the CV26 Faults and CV31 Repair and Maintenance data tables.

5.6 Option 5: Proactive Replacement of Section

Proactive replacement of our UG cable is also an important investment option undertaken when a cable or circuit is deemed to be in poor health or condition and the on-going fault repair costs are unacceptable; therefore, not representing value for money for our customers. Often, rather than replacing an entire UG circuit, a smaller section of the circuit is overlayed. This option is chosen when a problem section of a wider circuit has been identified and a targeted investment is cost effective and is expected to significantly reduce the number of future faults on that circuit.

To do this, historical fault data can be plotted to identify the location of each fault and the proximity of these faults to one another. Clusters or closely located faults indicates that the condition of the circuit has degraded faster in one section of the cable than others. In these situations, a targeted overlay can significantly improve the performance of the circuit at a much lower cost than full circuit overlay. This option will be undertaken during RIIO-ED2 and the volumes associated with this will be captured in CV7a Asset Replacement.

5.7 Option 6: Proactive Replacement of Circuit with Larger Diameter Cable

This option consists of the full replacement of an existing EHV or 132kV UG cable circuit with an entirely new cable. There are various sub options available within this option as described below.

If it is deemed that the most efficient solution is to replace the cable circuit, a project-specific study will be required to determine which design approach should be taken. The following areas should be considered:

- **Cable cross section** – the size of the cable will impact both its thermal rating (and hence ability to connect demand and generation) and the technical losses. A larger cross-sectional area will reduce the losses associated with the circuit, delivering both financial and carbon savings for our customers.
- **Reliability/Resilience** – opportunities to increase the reliability and/or resiliency should be considered. This could include diversification of cable routes, maximising cable separation, cable protection etc.
- **Bonding and Laying** – there are various options in the cable installation that can be flexed, such as direct burying or laying in ducts, bonding type, laying configuration (flat or trefoil) etc. All these aspects should be considered when selecting the design of the new cable circuit.
- **Cable Monitoring** – replacing a complete circuit provides an opportunity to provide sensors or in-line monitoring which can assist in cable asset management and reducing cable failure.
- **Cable protection, control, telecoms** – replacing a complete circuit provides an opportunity to provide a fibre or fibres along with the cable, to provide control as part of a smart grids scheme, future proof the cable control or to provide differential protection etc.

When designing a new cable circuit, secondary drivers are likely to be important. For example, if load growth or LCT uptake is potentially likely across the cable circuit in question, then it may be beneficial to design the circuit to have a larger cross-sectional area, to enable future proofing and also to reduce technical losses. During RIIO-ED2 we will actively look to deploy larger cross-section area cable to both improve technical losses and to protect our network against future load growth.

As such, this investment option will be taken forward during RIIO-ED2 and the costs associated with it are captured within CV7a Asset Replacement.

5.8 Option 7: Replacement of Complete Cable Circuit with Innovative Low Loss Solution

If full replacement of the entire UG cable circuit is deemed to be the most cost-effective option, then alternative cable technology can be considered. There are several novel cable technologies in development that promise improved cable performance when compared to the business as usual (BaU) solutions.

For example, technology is in development which offers a significant reduction is electrical losses when compared to the current technology. Others claim improvement in the voltage drop along the length of the cable allowing us to build longer cable feeders without the need for additional substations and wider reinforcement.

However, the precise cost and performance of this technology is not fully understood and as such is not ready for full BaU deployment. As such, this option has not been included in the baseline of the RIIO-ED2 business plan. However, we will continue to monitor advancements during RIIO-ED2 and may take the decision to deploy any new cable technologies is a proven business case is identified.

5.9 Investment Options taken forward for RIIO-ED2

To summarise, we intend to take forward Option 1, Option 4, Option 5, and Option 6 during RIIO-ED2.

The costs associated with Option 1 (reactive replacement of faulted cable) will be captured during RIIO-ED2 within the CV26 Faults table in the BPDT pack.

Option 4 (Fluid Leak Repair) will be required during RIIO-ED2, the costs of which will be captured within CV26 Faults and CV31 Repair and Maintenance depending upon the specific circumstances of the leaking fluid filled cable section. Various refurbishment activities are also required to prevent fluid leaks, the costs of which are included within CV8 and CV9 as per Sections 6.2.2 and 6.2.3.

Meanwhile, the costs and volumes associated with Options 5 & 6 are captured within CV7a Asset Replacement. These costs and volumes are presented within Section 6.2.1 of this EJP.

Option 2 (circuit rationalisation) we be considered during RIIO-ED2 but due to the nature of this option there are no corresponding volumes at this stage.

After consideration, we have not chosen to take forward Option 3 and Option 7. However, we will continue to assess the business case for these options during RIIO-ED2 and they will be reconsidered if a more proven business case becomes clearer.

6 Detailed Analysis

This section of the report describes the detailed analysis that has been undertaken for our EHV and 132kV UG cable assets for RIIO-ED2**.** This includes the cost and volumes that are required during RIIO-ED2 to manage these asset categories.

6.1 Age Based Replacement Schedule

Figure 9 to Figure 12 show the replacement schedules that correspond to the age of the EHV and 132kV UG cables on the SEPD and SHEPD networks and the expected average lifespan.

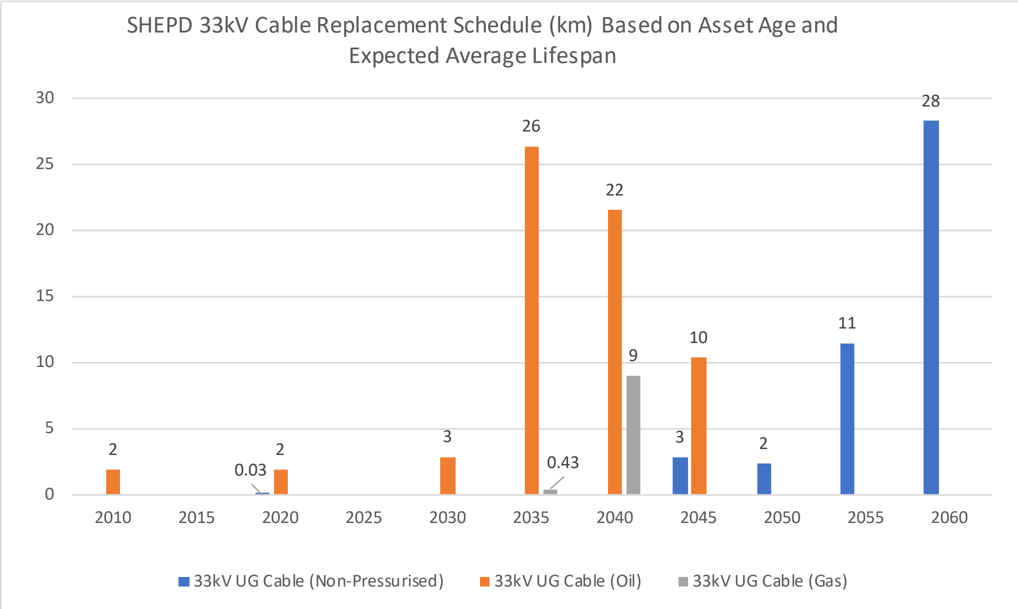

Figure 9: Replacement Schedule for 33kV UG Cable by Type SHEPD, Expected Life: Gas 75 years, Non-Pressurised 90 years

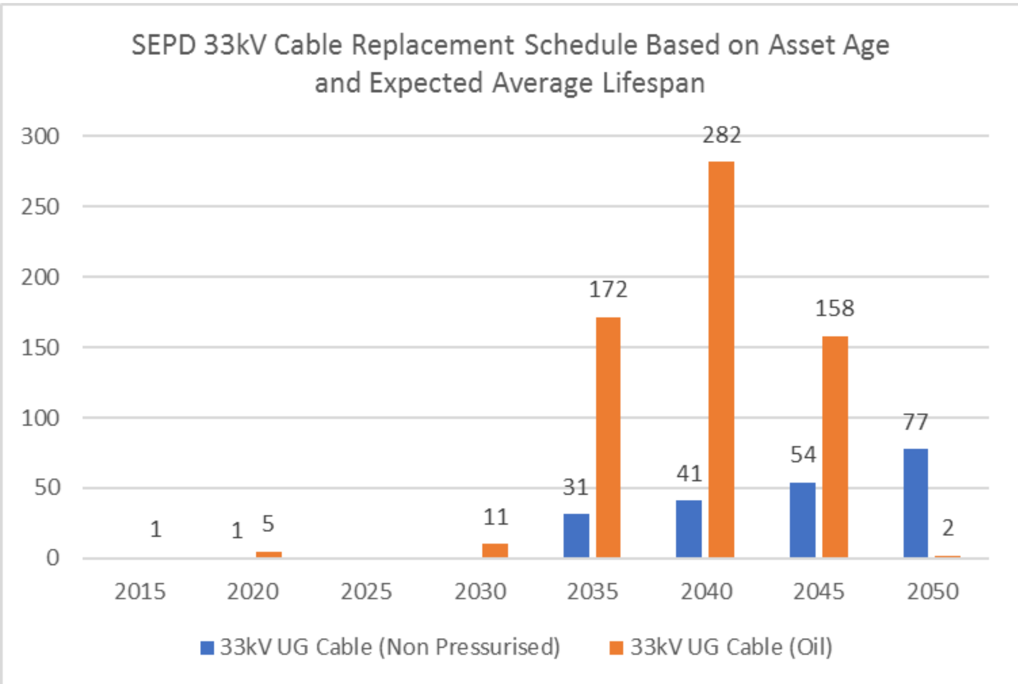

Figure 10: Replacement Schedule for 33kV UG Cable by Type SEPD, Expected Life: Oil 80 years, Non-Pressurised 90 years

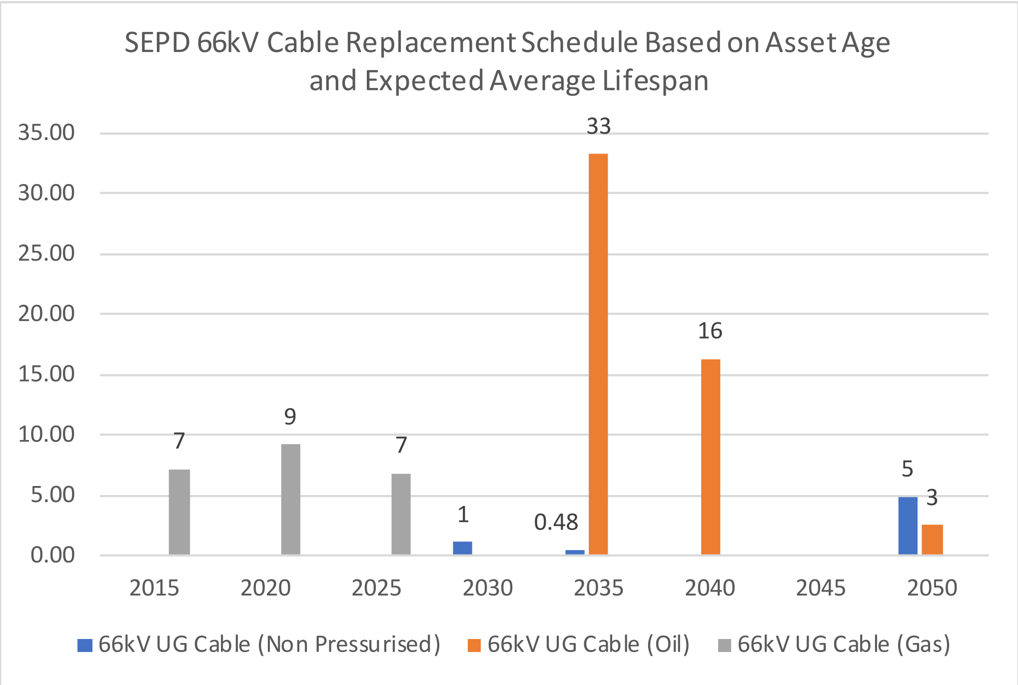

Figure 11: Replacement Schedule for 66kV UG Cable by Type SEPD, Expected Life: Oil 80 years, Non-Pressurised 90 years

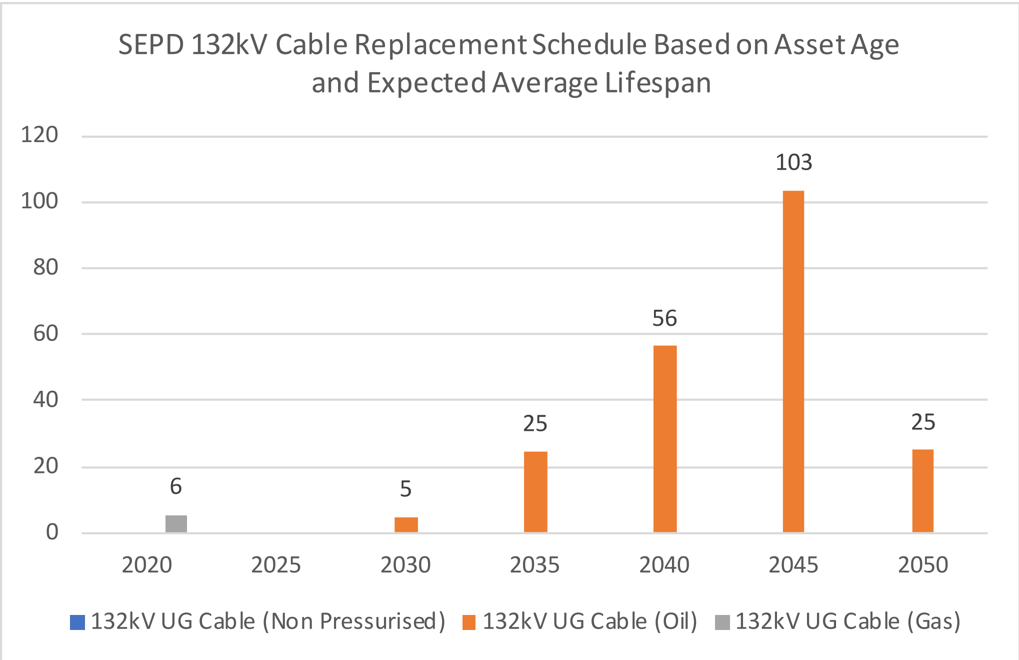

Figure 12: Replacement Schedule for 132kV UG Cable by Type SEPD, Expected Life: Oil 80 years, Gas 75 years, Non-Pressurised 90 years

Note that the last of the 132kV gas filled UG cable on the network was removed and replaced with non-pressurised cable in March 2020.

6.2 Proposed RIIO-ED2 Investment

The following subsections show the cost and volumes associated with CV7a Asset Replacement, CV8 Refurbishment (no SDI) and CV9 Refurbishment (SDI) for EHV & 132kV UG cable.

6.2.1 CV7a Asset Replacement

Table 6 shows the additions and disposals for SHEPD. We have identified both non pressurised and oil cable that require overlay. As per the table below both will be replaced with non-pressurised cable.

Table 6 and Table 9 show the proposed costs and volumes for the replacement or overlay of our existing EHV (33kV and 132kV) UG cable. This includes both the additions and disposals that have been identified for RIIO-ED2. There is no 132kV cable overlay required for RIIO-ED2 based upon our condition scoring.

Table 6 shows the additions and disposals for SHEPD. We have identified both non pressurised and oil cable that require overlay. As per the table below both will be replaced with non-pressurised cable.

Table 6: SHEPD CV7a EHV Underground Cable Addition Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Addition Volumes							
33kV UG Cable (Non Pressurised)	km	0.5	0.5	2.4	0.0	0.0	**3.4**
Disposal Volumes							
33kV UG Cable (Non Pressurised)	km	0.0	0.0	1.9	0.0	0.0	**1.9**
33kV UG Cable (Oil)	km	0.0	0.0	1.5	0.0	0.0	**1.5**

Table 7: SHEPD CV7a EHV Underground Cable Costs for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Non Pressurised)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
33kV UG Cable (Gas)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 8 shows the addition and disposal volumes associated with SEPD's 66kV UG cable. As below, the volumes correspond to the disposal of 16.7km of gas cable which will be replaced with non-pressurised cable.

Table 8: SEPD CV7a EHV & 132kV Cable Additions Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Addition Volumes							
66kV UG Cable (Non Pressurised)	km	8.3	8.3	0.0	0.0	0.0	**16.7**
Disposal Volumes							
66kV UG Cable (Gas)	km	8.3	8.3	0.0	0.0	0.0	**16.7**

Table 9: SEPD CV7a EHV & 132kV Cable Additions Costs for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
66kV UG Cable (Non Pressurised)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
66kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6.2.2 CV8 Asset Refurbishment (no SDI)

Table 10 to Table 13 shows the costs and volumes associated with the CV8 asset refurbishment of our remaining oil filled cable for both SHEPD and SEPD during RIIO-ED2. This investment does not apply to both the gas and non-pressurised cable.

Table 10: SHEPD CV8 EHV Underground Cable Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	#	0.0	1.0	0.0	1.0	0.0	**2.0**

Table 11: SHEPD CV8 EHV Underground Cable Costs for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 12: SEPD CV8 EHV & 132kV Underground Cable Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	#	3.0	3.0	3.0	3.0	3.0	**15.0**
132kV UG Cable (Oil)	#	2.0	2.0	2.0	2.0	2.0	**10.0**

Table 13: SEPD CV8 EHV & 132kV Underground Cable Costs for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6.2.3 CV9 Asset Refurbishment (SDI)

Table 14 to Table 15 shows the costs and volumes associated with the CV9 asset refurbishment of our remaining oil filled cable for SEPD during RIIO-ED2. This investment does not apply to both the gas and non-pressurised cable.

Table 14: SEPD CV9 EHV & 132kV Underground Cable Volumes for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	km	8.0	8.0	8.0	8.0	8.0	**40.0**
66kV UG Cable (Oil)	km	1.0	1.0	1.0	1.0	1.0	**5.0**
132kV UG Cable (Oil)	km	9.0	9.0	0.0	0.0	0.0	**18.0**

Table 15: SEPD CV9 EHV & 132kV Underground Cable Costs for RIIO-ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
33kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
66kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132kV UG Cable (Oil)	£m	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6.3 Unit Cost Efficiency

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.

Following on from our draft Business Plan, we have continued to develop project volumes and costs, utilising valuable stakeholder feedback. We have included developments of our Commercial Strategy within the updated project scope and delivery strategy.

This analysis has produced the following unit costs for our EHV & 132kV UG cables (Table 16 to Table 18):

Table 16: SSEN RIIO-ED2 CV7a Unit Costs for EHV and 132kV Underground Cables

Asset	SEPD (£k)	SHEPD (£k)
33kV UG Cable (Non Pressurised)	[redacted]	[redacted]
66kV UG Cable (Non Pressurised)	[redacted]	[redacted]
132kV UG Cable (Non Pressurised)	[redacted]	[redacted]

Table 17: SSEN RIIO-ED2 CV8 Unit Costs for EHV and 132kV Underground Cables

Asset	SEPD (£k)	SHEPD (£k)
33kV UG Cable (Oil)	[redacted]	[redacted]
132kV UG Cable (Oil)	[redacted]	[redacted]

Table 18: SSEN RIIO-ED2 CV9 Unit Costs for EHV and 132kV Underground Cables

Asset	SEPD (£k)	SHEPD (£k)
33kV UG Cable (Oil)	[redacted]	[redacted]
66kV UG Cable (Oil)	[redacted]	[redacted]
132kV UG Cable (Oil)	[redacted]	[redacted]

6.4 Deliverability of Proposed Volumes

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 documents: ***Workforce Resilience Strategy (Annex 16.3)*** and ***Costs and Efficiency*** (***Chapter 15).***

- 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 ***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
- 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

Table 19 below shows a comparison of the EHV and 132kV UG cables replaced within the first 5 years of RIIO-ED2 compared to our proposal for RIIO-ED2. Overall, our RIIO-ED2 volumes represent a 72.2% decrease compared to the volumes that have been delivered in the first 5 years of RIIO-ED1.

Table 19: RIIO-ED1 volumes (first 5 years) and RIIO-ED2 volumes

Licenced Area	Cable Type	ED1 Additions (first 5 years) (km)	ED2 Additions (km)	Percentage Change
SEPD	33kV Non-Pressurised	44.8	0	-100%
	66kV Non-Pressurised	8.8	16.7	89.8%
	132kV Non-Pressurised	0.5	0	-100%
SHEPD	33kV Non-Pressurised	18.9	3.4	-82.0%
Total Volume (Additions)		**72.9**	**20.1**	**-72.4%**

7 Conclusion

The Primary Investment Driver described within this Engineering Justification Paper (EJP) is the condition or health of our EHV and 132kV underground (UG) cable network. Without further intervention is these asset categories during RIIO-ED2 we expect to see an increase in costly cable faults, which will significantly impact both the reliability and affordability of the distribution network for our network customers.

Our document ***Safe and Resilient (Annex 7.1)*** describes our approach to determine the Non-Load baseline for capital expenditure. This encompasses capital investment to address assets in poor health deemed to be at or near their "end of life".

This EJP includes the investment proposed within our EHV and 132kV UG cables within the CV7a (Asset Replacement), CV8 (Refurbishment – no SDI), and CV9 (Refurbishment – SDI). This includes three main cable types: solid (non-pressurised) cable, gas filled cable, and oil filled cable.

Seven investment options have been considered within this EJP as solutions to the non-load related primary investment drivers for our EHV and 132kV UG cables. The viability of each of these options will depend upon the specifics of each cable project requiring investment.

The options considered for RIIO-ED2 are listed below. In summary Option 1, Option 4, Option 5, and Option 6 have been shortlisted for investment during RIIO-ED2. The other investment options will continue to be monitored during RIIO-ED2 and will be reconsidered if a clearer business case is established for these.

- **Option 1: Reactive Replacement of Faulted Cable Section**
- Option 2: Rationalisation of Circuit
- Option 3: Enhanced Monitoring
- **Option 4: Fluid leak Repair**
- **Option 5: Proactive Replacement of Section**
- **Option 6: Proactive Replacement of Circuit with Larger Diameter Cable**
- Option 7: Replacement of Complete Circuit with Innovative Low Loss Cable

In total, **20.1 km of EHV & 132kV UG cable** has been identified for replacement during RIIO-ED2. An additional **63km** has been proposed for refurbishment (CV9) and a total of **27** refurbishments (CV8). This investment represents a total spend of **£26.2m** throughout RIIO-ED2.

Out with this investment there is a significant volume of oil filled EHV and 132kV UG cable that will be replaced with non-pressurised cable during RIIO-ED2. However, the cost and justification for this investment is captured within our RIIO-ED2 environmental business plans given that the primary driver for investment is to minimise the environmental impact of these assets.

8 Appendix 1: Acronym Table

Acronym	Description
BaU	Business as Usual
BPDT	Business Plan Data Table
CapEx	Capital Expenditure
CBRM	Condition Based Risk Methodology
CI	Customer Interruption
CML	Customer Minutes Lost
CNAIM	(DNO) Common Network Asset Indices Methodology
CO_2e	Carbon Dioxide equivalent (can be suffixed by t (tonnes))
CV	Cost and Volume
DFES	SSEN's Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DPCR5	Distribution Price Control Review for five years from 1 April 2010 to 31 March 2015
DSO	Distribution System Operator
EHV	Extra High Voltage, Voltages > 22kV and < 132kV , in SSEN these assets are usually 33kV and 66kV.
EJP	Engineering Justification Paper
ESQCR	Electricity, Safety, Quality and Continuity Regulations
EU	European Union
FFA	Furfuraldehyde
FFC	Fluid Filled Cable
GB	Great Britain
HI	Health Index
HSE	Health and Safety Executive or Health, Safety and Environment
IIS	Interruption Incentive Scheme
kV	Kilovolt
MEAV	Modern Equivalent Asset Value
MVA	Megavolt Ampere
NARM	Network Asset Risk Metric
Ofgem	Office of Gas and Electricity Markets
OpEx	Operational Expenditure
PoF	Probability of Failure
RIIO	Ofgem's price control framework first implemented in 2013
RIIO-ED1	First price control for Electricity Distribution companies under the RIIO framework from 1 April 2015 to 31 March 2023

RIIO-ED2	Second price control for Electricity Distribution companies under the RIIO framework from 1 April 2023 to 31 March 2028
SEPD	Southern Electric Power Distribution PLC
SHEPD	Scottish Hydro Electric Power Distribution PLC
TRL	Technology Readiness Level
UG	Underground

9 Appendix 2: Relevant Policies and Standards

The policies, manuals and standards which govern the management of our EHV (33kV & 66kV) & 132kV UG cables are listed below in Table 20

Table 20: EHV and 132kV underground cables relevant documents

Policy Number	Policy Name / Description
MA-NET-NPL-001	Investment Management Framework
ST-NET-ENG-010	SSEN Distribution Network Investment Strategy RIIO-ED1
TG-NET-CAB-020	Technical Guidance for Managing the Replacement of Fluid Filled Underground Cable Networks
TG-NET-CAB-032	Asset Management of Fluid Filled Cable