SP Energy Networks 2015–2023 Business Plan

Updated March 2014

Annex

Protective Equipment and Supporting Systems Strategy

SP Energy Networks

March 2014

SP ENERGY NETWORKS

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Protective Equipment and Associated Systems Strategy

March 2014

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1. Scope

This Annex covers our strategy for asset replacement, refurbishment and repair activities during the ED1 period associated with protection systems installed in SPD and SPM networks as well as other assets which play a major role in the protection of the network.

2. Table of linkages

This strategy supports our ED1 Business Plan. For ease of navigation, the following table links this strategy to other relevant parts of our plan.

Document	Chapter / Section
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Expenditure Supplementary Annex Section 8.3.5
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Expenditure Supplementary Annex Section 8.3.6
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Expenditure Supplementary Annex Section 8.3.7
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Cost Benefit Analysis – SPEN Reference 9
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Operational IT and Telecoms Strategy – SPEN Section 4.1
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – Operational IT and Telecoms Strategy – SPEN Section 6.2
SP Energy Networks Business Plan 2015-2023 Annexes	Annex C6 – SP Manweb Company Specific Factors – SPEN Section B3

3. Introduction

This annex details the asset replacement, refurbishment and repair activities during the ED1 period associated with protection systems installed in SPD and SPM networks as well as other assets which play a major role in the protection of the network. Together these assets function to ensure our compliance with associated statutory obligations and maintain the integrity and safety of electrical plant and circuits when faults on the network occur. Overhead Head and Underground Pilot cables assets detailed in this annex are widely used throughout SPD and SPM for protection applications but also carry other services essential to the continued operation of the network such as SCADA and telephony.

Asset Refurbishment, Replacement and Repair Activities detailed in the annex include;

- *Protection and Control Equipment Modernisation*
  - HV Protection
  - EHV Protection
  - 132kV Protection
- *Overhead Line Pilot Cables Modernisation*
  - Fibre Modernisation
  - Hardex Modernisation
- *Underground Pilots Modernisation and Repairs*
  - 11kV Pilots
  - 33kV &132kV Pilots
- *Fault Throwers*
- *Battery and Charger Systems Modernisation*
  - HV Substation Battery Systems
  - EHV Substation Battery Systems
  - 132kV Substation Battery Systems

Associated Investment is detailed in the table below.

Table 1:ED1 Investment in Modernisation and Repair activities

Asset Modernisation and Repairs	SPD	SPM
	£m	£m
Protection Refurbishment	8.1	14.1
Fault Throwers replacement	0.5	
Battery Replacement	1.0	3.5
OHL Pilots Modernisation	0.4	1.5
UG Pilots Modernisation	6.2	7.4
UG Pilots Repairs	2.2	4.8

There are elements of expenditure in this annex which relate to the SPM special factors case, details of which are contained within **Annex C6 – SP Manweb Company Specific Factors – SPEN**.

4. Protection and Control Modernisation

4.1. Asset Overview and Investment Drivers

Protection modernisation investment will increase in ED1 due to asset condition & obsolescence driven by the rapid development of protection technology and short life expectancy of some types of electronic components. Protection modernisation activity is also driven by plant replacement programmes as SPs policy is to align plant and protection modernisation wherever possible.

Protection and Control equipment installed in our substations is necessary to ensure compliance with our statutory obligations to maintain the integrity and safety of electrical plant and circuits. Protection systems detect faults on the network and clear them by operating substation circuit breakers designed to interrupt fault energy. Without protection equipment in good working order, network faults would not be promptly disconnected resulting in avoidable fault energy release which causes damage to equipment and potentially extreme danger to the public. Other issues caused by inadequate protection include, degraded network performance and stability and increased interruptions to customers. Control Equipment within Substations such as Frequency Load Shedding and Automatic Voltage Control systems also plays vital role in ensuring that the network stability is retained and customer supply voltages remain within statutory limits respectively.

Overall investment in protection modernisation during the ED1 period is shown in the table below.

Table 2:ED1 Protection Modernisation Investment

Protection Refurbishment	SPD	SPM
	£m	£m
HV Protection Refurbishment	3.1	4.2
EHV Protection Refurbishment	5.0	5.5
132kV Protection Refurbishment	0.0	4.4

4.2. Asset Management Strategy

Protection and Control Equipment Modernisation standalone investment activities have been identified for equipment nearing end of life not included in the main scope of plant replacement activities. Forecasts for protection equipment asset replacement plans follow a “type” based approach where the risk associated with an asset and its modernisation priority is primarily driven from the main protection relay / control component and focuses on key factors such as reliability, supportability, compliance with policy and maintenance requirements.

Modernisation priorities are driven not only from SPEN experience and as found condition information but also information from the wider industry, primarily ENA Defect Reporting Systems. Similarly our ability to support equipment is gauged by not only our own expertise and available spares but also available manufacturer support and the ability to substitute existing systems for modern equivalents.

Assets where modernisation is classified as High Priority/Very High Priority or likely to escalate to this risk level within the next price control period will be targeted for replacement in ED1. The highest replacement priority assets identified include electro-mechanical relays which have been installed in great volumes historically and 1st generation electronic relays which have a short design life. The strategy to for electro-mechanical relays assets installed in large volumes is to modernise a proportion of the asset base and retain useful spares to aid the support for asset which remain on the system. Synergies with other capital programmes and access to the network will greatly influence the assets which are targeted.

Other protection and control assets with manageable medium replacement priority classifications may change to High / Very High replacement priority within the ED1 period as support is withdrawn or defects emerge, this is difficult to predict particularly for modern electronic relays with a short design life, however programmes will always be adjusted to ensure that highest risk equipment is targeted.

A capital investment requirement has also been identified for reactive protection modernisation investment. This investment is required to reactively repair or replace protection equipment that fails in service. Though proactive investment activities aim to remove problematic protection prior to failure, experience suggests that some protection equipment can fail unpredictably and mitigation is required to ensure critical systems are retained in a functional condition.

SPs preferred approach is to align all protection and control modernisation with plant modernisation works wherever possible. When plant replacement work is being completed on the network, local protections and control equipment will be replaced and SPEN will target the modernisation of remote end protection equipment where equipment is obsolete or problematic. Outages on the network for the plant modernisation are good opportunities to make use of to complete this work. Often remote end equipment modernisation is driven out of necessity when switchgear and associated local end protection is replaced due to the type of protection deployed on the network and the interaction between local and remote protection equipment.

Investment requirements are minimised since our policy is to replace the protection equipment components on the panel when it is in reasonably good condition. It is only instances where the protection panel's condition has deteriorated that panel replacement works will also be considered.

4.3. ED1 Standalone Modernisation Activities

Protection replacement activities carried out in isolation of other capital works will focus on the reduction of legacy electronic relays on the power system which lack watchdog facilities as well as other electronic relays types with known defects and support issues. As these electronic devices age, evidence suggests that failure rates will increase, this is in part due to failure modes such as the degradation of electronic components.

Where associated devices form the main protection element and fail, safety will be comprised, so it is essential that investment is made to mitigate risk. The level of investment forecast for risk mitigation is based on current information. If bath tub curve failure modes are experienced for electronic relays early in the ED1 period, investment in this area will need to increase to mitigate associated risk; this scenario is not reflected in current programmes. As electronic relays have shorter design life than legacy electro-mechanical devices, investment levels for standalone modernisation are expected to increase in ED2 as current installed base ages.

Expectant increases in electronic relay failure rates coupled the company having no means of knowing about associated failure outside of maintenance testing or failure of device to operation for a fault in the case of relays without watchdog facilities; represent an unacceptable risk in the system. Other strategies in place include the replacement of electronic devices with known defects where there are large installed bases in order to lower overall risk by reducing populations of problematic relay types.

D.C surge proof intertripping relays heavily utilised on SPD transformer feeders are currently obsolete and have major limitations such having no monitoring facilities for either the relays or the pilot cables they utilise. As a result, faults can fail to be cleared correctly due to a non visible failure of either the pilot cables or the intertripping relays. Some of these devices have failed in services and have been replaced. Consequently this equipment has been classified as a very high priority for replacement in ED1 and will be replaced with modern equipment with watchdog and basic pilot monitoring capabilities. The replacement of this equipment which also enables dedicated battery chargers provided solely for the dc surge proof intertrip systems to be removed. Replacement will be carried out both as a standalone activity and where opportunities exist with other capital works.

Other protections which will be targeted in ED1 as standalone activities include obsolete NVD protection installed on SPD networks which has used to detect earth faults on an unearthed delta-connected network. These devices have been unreliable and have caused mal-operations in service which has disconnected customer supplies unnecessarily. In addition these devices have no watchdog facilities and are unsupportable by SPEN leading to their very high modernisation priority during the ED1 period.

Problematic legacy voltage control equipment with reliability issues will be replaced in ED1 as a continuation of a DPCR5 programme. Replacement voltage control equipment will be capable of interfacing with the SCADA systems or other devices which can dynamically adjust voltage control regimes.

The ability to adjust voltage set points dynamically on voltage control schemes, whether manually via control or automatically will help the business deal with the dynamic effects associated with areas with large penetrations of embedded generation. It is not possible to adjust voltage set points on legacy voltage control systems without physical changes being applied on site.

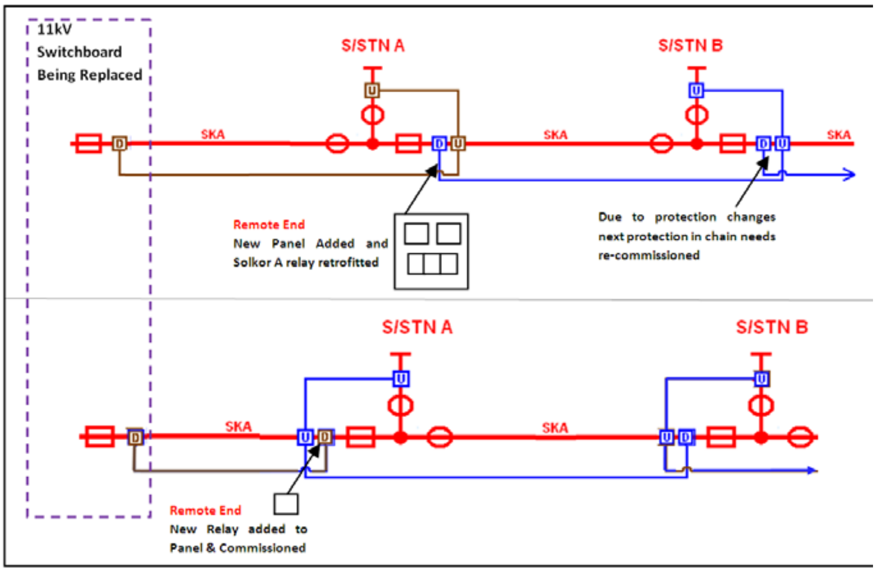
Other standalone control equipment modernisation activities include replacement of obsolete, unsupportable frequency load shedding equipment.

4.4. ED1 Modernisation Driven by other Investment Activities

Protection modernisation activities at secondary substations are largely driven from the requirement to do remote end protection works associated with 11kV panel board changes in urban unit protected areas. This activity is applies predominately to SPM switchgear modernisation activities but also to small volumes of switchgear modernisation in SPD where unit protection is installed. This work enables protection identified with a Medium/High modernisation priority asset to be removed from the system. This protection modernisation work is unavoidable as modern 11kV unit protection will be provided on the new switchgear panels installed and the remote ends need to be replaced to form a functional protection.

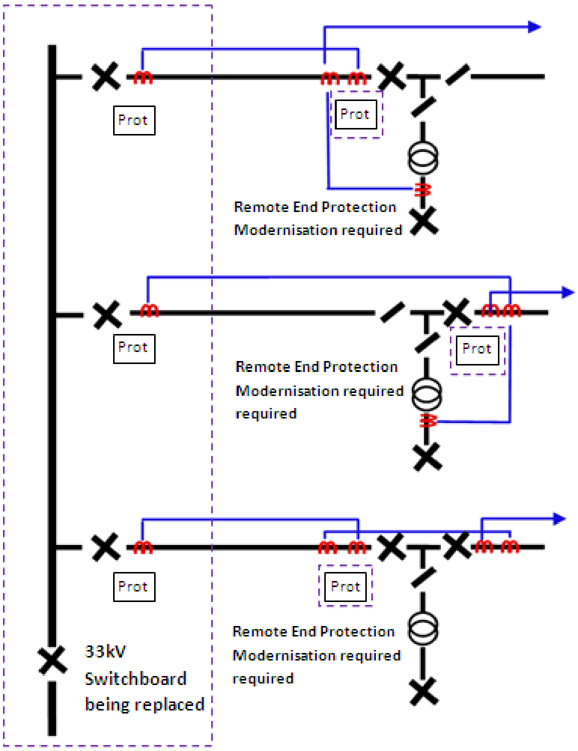
The scope of work at the remote end is dependent on whether the remote substation transformer is in the same zone of protection as the CB on the 11kV board being replaced or is outside of this zone of protection as per the diagram below. This scope of associated protection modernisation does not allow for battery system replacement or full multi-core renewal. Where battery systems are found in poor condition, these will be replaced as part of battery systems modernisation programme.

Figure 1: 11kV Panel Board Replacement– Remote End Protection Modernisation Requirements



In SP-M, a 33kV board and associated protection replacement will necessitate remote end protection modernisation works. The scope of the remote end protection works is dependent upon the network arrangement and type of protection deployed as illustrated in the diagram below which shows feeder remote end types where remote end protection works are required.

Figure 2: SP-M 33 kV Panel Board Replacement Activities – Remote End Protection Modernisation

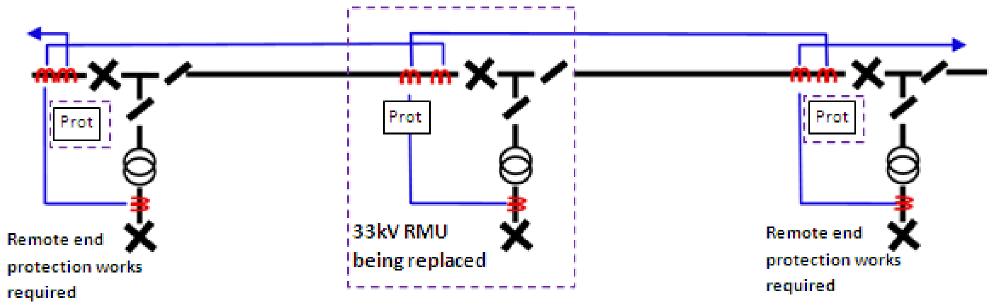


Where the remote end is equipped with electronic unit protection, the panels will be fairly modern and protection modernisation works will be limited to measurer replacement and panel modification. Distance Protection is typically deployed as the replacement solution for these applications as current unit protections had a bespoke backup voltage compensated over current protection function. In order to facilitate this change 33kV VT installations are required, investment will be made to equip associated sites where they are not currently installed but required. The associated electronic unit protection devices targeted are classified as High Modernisation Priority and will begin to be targeted as a standalone activity in isolation of this activity towards the end of ED1.

Where the remote end is equipped with legacy electro-mechanical unit protection, protection modernisation works will be required when the 33kV board is replaced. Where the remote substation transformer is within the zones of protection, all associated remote end protection will be modernised. Where the remote substation transformer is out of the associated zone of protection, it is possible to do minimum protection works (measurer replacement and panel alterations only) as long as the panel condition is adequate to be modified. The legacy unit protection devices being targeted as part of this activity are classified as High Modernisation Priority; modernisation will help reduce the risk associated with their large installed asset base.

Similar considerations exist where 33kV Ring Main Units (RMUs) within a string of RMUs and associated local end protection are being replaced where remote end protection modernisation works will be required. Normally there will be one remote RMU where the associated transformer is within zone of associated protection and one remote RMU where the associated transformer outside of the zone of associated protection as per the figure below.

Figure 3: SP-M 33 kV Panel Board Replacement Activities – Remote End Protection Modernisation Requirements



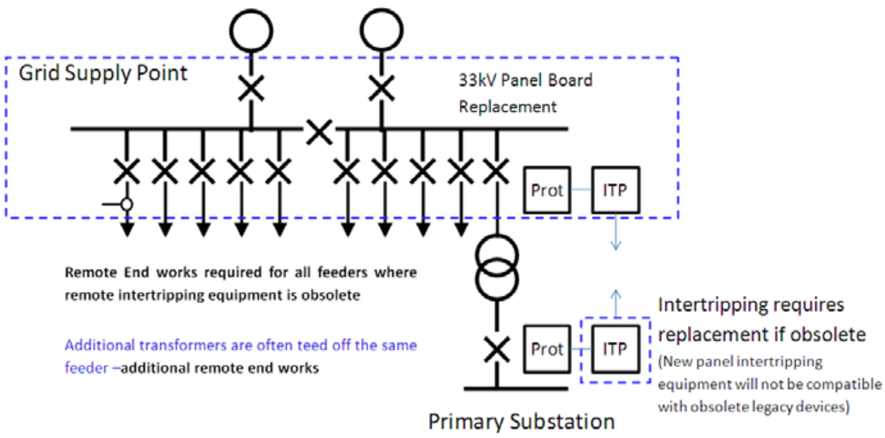
As with 33kV panel board replacements, where the remote substation transformer is within the zone of protection, all remote end protection will be replaced. Where the remote substation transformer is out of the associated zone of protection minimum protection works (measurer replacement and panel alterations only) will be possible if the associated panel's condition is adequate to be modified.

Where modernisation of electo-mechanical protections completed, investment is sometimes necessary to up-rate battery systems due to increases in standing loads, this investment will be made as part of the battery modernisation activity.

In SP-D a 33kV board and associated local protection replacement will necessitate remote end protection modernisation works, usually in the form of the replacement of remote end intertripping equipment.

The remote end intertripping replacement will be required if the current local and remote end intertripping equipment is obsolete. Obsolete equipment will not be compatible with the modern equivalent intertripping equipment fitted when the panel board is replaced. Where obsolete intertripping equipment is installed, the intertripping equipment on all associated feeder remote ends will be required.

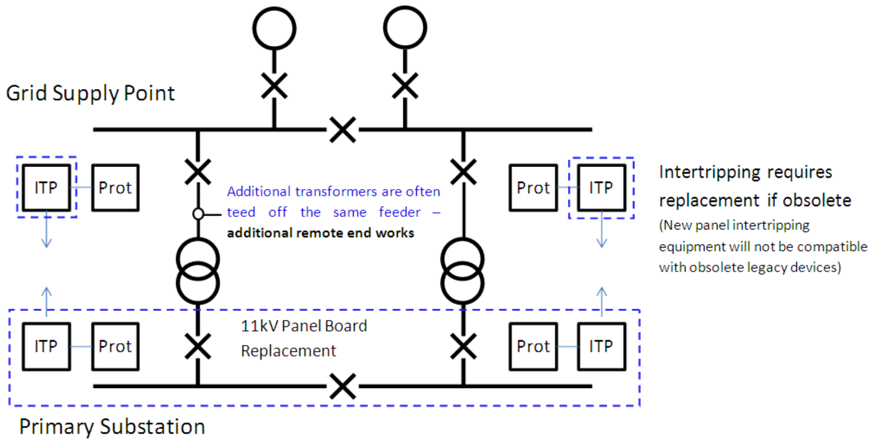
Figure 4: SP-D 33kV Panel Replacement - Associated Remote End works



The diagram above shows the scope of remote end work associated with a 33kV Board replacement. Wherever intertripping equipment is being replaced, DC intertripping equipment will be installed if suitable galvanic pilots are available. Where suitable pilots are not available but a suitable shared service provision on the communication networks, digital/VF intertripping equipment will be used. On some feeders there is more than one remote end to be modernised as transformers have been teed off the original feeders, in such cases panel modifications with be required at all remote ends if the intertripping equipment is obsolete.

As with SPM investment where electo-mechanical protections are modernisation it is sometimes necessary to up-rate battery systems, associated investment will be made as part of the battery modernisation activity.

Figure 5: SP-D 11kV Panel Replacement - Associated Remote End works



Similarly in SP-D an 11kV board change will necessitate remote end protection modernisation works, in the form of the replacement of remote end intertripping equipment. The diagram above shows the scope of remote end work associated with an 11kV Board replacement.

In SPD fault thrower replacement activities will drive protection equipment investment as intertripping equipment is installed as a replacement solution. Protection modernisation in SPM changes will be driven from other investment activities in addition to plant modernisation such as the Hardex replacement programmes with is discussed in this annex. Where the Hardex alterative communications solution is not a galvanic pilot, then the associated legacy unit protections will be modernised with equipment capable of utilising available communications bearers.

The protection and control modernisation in SPM is also driven by the RTU replacement activity detailed in **Annex C6 – Operational IT and Telecoms Strategy – SPEN**, section 4.1. The replacement of the legacy RTUs in SPM will necessitate the replacement of measurement / control units installed at SPM Grid and Primary substations. This work will be required due the incompatibilities between these legacy measurement devices essential for visibility of dynamic network behaviour and voltage boost/voltage reduction facilities and modern industry control equipment such as RTU which will not support bespoke legacy protocols without development investment. The devices have a short design life and will be replaced with a modern equivalent which will be easier to support through this investment activity.

4.5. ED1 Protection Modernisation Summary

The table below shows the volume of protection modernisation works planned during the ED1 period.

Protection Equipment Category includes;

- *Feeder Protection Equipment*
- *Transformer Protection Equipment*
- *Busbar Protection Equipment*
- *Protective Intertripping Equipment*

Control Equipment Category includes;

- *Automatic Voltage Control Equipment*
- *Control & Measurement Units*
- *Frequency Load Shedding Equipment*

Table 3: ED1 Protection Modernisation Activities

Standalone Modernisation Activity			ED1 Volume
SPD	EHV Protection and Control	Protection Equipment	592
		Reactive Equipment	40
	HV Protection and Control	Protection Equipment	253
		Control Equipment	96
		Reactive Modernisation	40
SPM	132kV Protection and Control	Protection Equipment	157
		Control Equipment	4
		Reactive Modernisation	24
	EHV Protection and Control	Protection Equipment	298
		Control Equipment	111
		Reactive Modernisation	24
	HV Protection and Control	Protection Equipment	530
		Control Equipment	666
		Reactive Modernisation	32

5. Overhead Line Pilot Cables

Overall investment in OHL pilots during the ED1 period is shown in the table below.

Table 4:ED1 Overhead Line Pilot Modernisation Investment

Asset Modernisation	SPD	SPM
	£m	£m
OHL Pilots	0.4	1.5

5.1. Fibre Optical Asset Overview and Investment Drivers

Fibre pilots installed on SPM 132kV lines and some 33kV circuits form the backbone of the telecoms network and support high bandwidth services. These services include all SCADA traffic from all primary substations which we have the ability to remotely control downstream of the associated circuit. Service requirements imposed on these assets are set to increase over the ED1 period due to migration to industry standard control protocols and other service requirements reinforcing the importance of ensuring their integrity. Overhead fibre is also installed on both SPD and SPM networks also service SCADA and Protection applications associated with circuits where they are installed.

The fibre installed on the network is a mix of optical ground wire (OPGW) and Optical Phase Conductor (OPPC) where the fibre in contained with the conductor or earth wires but also in the form of fibre wrapped on conductors or earth wires and fibre under slung under the line (ADSS).

Experience of the legacy fibre wrap installed on the network to date indicates an asset life not exceeding 20 years. Programmes are required to replace fibre wrap before the assets fail in service due to the importance of the traffic they carry, known failure modes and operational difficulties returning asset to service due to system access. ADSS has been installed on only a few circuits in SPD but there are issues with current installations which have required a series of ongoing repairs.

5.2. Fibre Management Strategy and ED1 Programme Details

We plan to replace our remaining (about 3km) of degraded fibre wrap on 33kV circuit which forms a highly important core communications infrastructure link in SPM. We will have mitigated all of other de-graded fibres wrap assets on 132kV towers at this point. The replacement of this core telecoms network asset is planned early in the ED1 period. Due to the bandwidth requirements of the core system only a bearer which can transport high bandwidth is suitable, therefore a replacement fibre optic cable is required. An underground fibre has been identified as the replacement solution due to the criticality of the asset, the life expectancy of the existing fibre and condition of overhead line.

In SP-D, we plan to replace degraded 17km All-dielectric self-supporting (ADSS) fibre asset mid-period of ED1 to ensure continuity of associated services.

In addition to the circuits that will be specifically targeted, SPEN have forecast the need to reactively modernise sections of fibre on other circuits in SPD and SPM as faults occur. This modernisation work tends to be difficult and often requires temporary ground deploy of fibre due to importance of the services associated and operational difficulties of returning the asset to service due to system access.

5.3. Hardex Asset Overview and Investment Drivers

Hardex is galvanic pilot commonly deployed on 33kV overhead line OHL or mixed underground (UG) and OHL circuits in SPM. This asset forms an integral part of the unit protection schemes deployed to detect and clear faults from associated circuits. A photo of a 33kV line upon which Hardex cable is installed is shown in the figure below. In addition to supporting protection applications, Hardex cables also support services such as SCADA and telephony.

Figure 6: Hardex on a 33kV Overhead Line

Hardex cable is no longer manufactured. All efforts to date to find a suitable replacement have been met with failure due to the high tensile strength, insulation levels and features that allow it to be strung on long spans of overhead line without comprising safety and line resilience.

When Hardex faults occur, protection on the system is depleted and risk can only be mitigated in short time scales by temporary pilot deployment / temporary way-leaves or repairs using spare cable. The only spare cable that remains to repair Hardex if it is damaged is a very limited stock of good condition cable recovered from overhead lines targeted in DPCR5.

Recovery of Hardex from existing installations in condition adequate to be used as spare stock is problematic as much of the existing assets are have deteriorated after years in service and the process of removal further degrades the asset as it has been installed at tension for many years. This asset is therefore an operational risk, ranked highly on the company risk register.

The insulation resistance of a number of Hardex circuits has degraded to levels where protection performance is affected and action needs taken. The main risk overall is that any adverse weather conditions or alternations to the overhead line as part of refurbishment work may damage the Hardex which cannot be readily repaired and this will expose the network to risk of protection mal-operation.

5.4. Hardex Management Strategy and ED1 Programme Details

SPEN strategy is to reduce the quantity of Hardex on the systems over an extended period. During DPCR5, we have planed and deployed radio solutions and underground galvanic pilot to replace the Hardex on circuits where only short cable sections are required.

During ED1, we plan to replace 25 Hardex circuits, including 79.1km on circuits where overhead line investment is also planned and radio solutions are not feasible. Aligned to this work, we also plan to install 16.5km UG fibre cable on circuits which include an underground 33kV cable section.

Active equipment will be established to manage the services on the new assets. The incremental costs for the installation of fibre on these overhead lines and installation of underground fibre on associated cable sections is captured in this investment plan (OHL Pilots and UG Pilots respectively).

The Hardex galvanic pilot is currently an active part of the protection scheme; therefore the protection will also require replacement when a fibre is installed and associated costs have been included as part of protection modernisation activity.

Work in this area set to ramp up after the BT21CN mitigation programme completes. Hardex circuits where associated mitigation solutions are of high cost have not been included in ED1. As the telecoms infrastructure grows over the ED1 period it is likely that synergies will emerge to mitigate these remaining assets at lower cost, therefore these circuits will be targeted in ED2.

6. Underground Pilot Cables

There is a large installed asset base of underground pilots in both SP-D and SP-M. There are dedicated pilots with small numbers of cores for protection applications which are essential to ensuring clearance in faults in design clearance times. There are also telecoms pilots that carry essential services such as SCADA and may also provide channels for protection signalling.

When pilots used by discriminative protection applications degrade beyond an adequate condition, associated protection schemes are likely to fail to operate correctly which may cause danger to the public and/or increased interruptions to customer's supplies.

During ED1 we plan to modernise pilot assets which have degraded to ensure continued operation. Pilots found to be in poor condition and have had previous repairs, shall have sections overlaid to reduce future repair costs and avoid further deterioration of the assets.

Telecoms Pilots are integral to provision of essential services such as SCADA for network management. With the anticipated increase in operational communications bandwidth requirements during ED1 and beyond, we plan to proactively modernise degraded UG copper pilots sections to remove the risk associated with these assets and restore condition.

Overall investment in UG pilots during the ED1 period is shown in the table below. This includes investment in UG Pilot sections associated with the Hardex removal programmes outlined in the previous section.

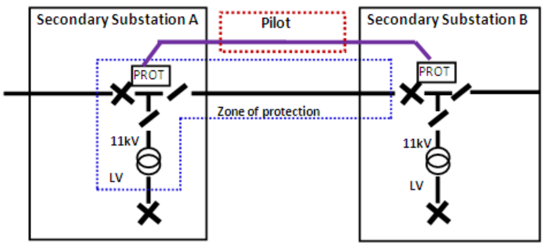
Table 5:ED1 Underground Pilot Modernisation and Repairs Investment

Asset Modernisation and Repairs	SPD	SPM
	£m	£m
UG Pilots Modernisation	6.2	7.4
UG Pilots Repairs	2.2	4.8

6.1. 11kV networks UG Pilots Cables Overview and Investment Drivers

We have a large number of 3 Core pilot cables which solely support 11kV protection applications in SPM urban networks and a smaller number of these assets in 11kV networks protected with unit protection in SPD. These assets directly contribute to network performance which is approximately 400% better than the national average (SPM - Nafirs Tables).

Figure 7: SPD 11kV Pilot Example



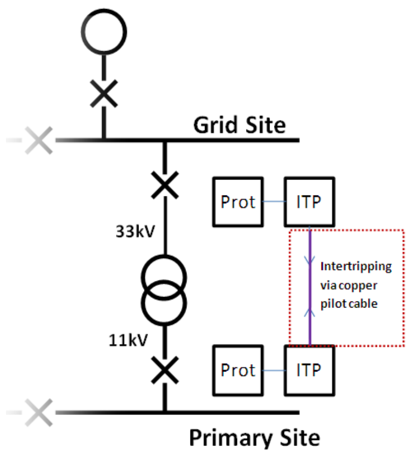
6.2. 11kV networks UG Pilots Management Strategy and ED1 Programme

During ED1, we plan to repair degraded and faulted pilot assets. 11kV protection pilots tend to be shorter than 800m each and there is little in the way of choice of alternative communications bearers. The cables are usually buried at much shallower depths than telecoms cables and 33kV protection cables, therefore repairs are almost always more straightforward, less costly and almost always the best solution to ensure continued operation of assets.

During ED1, we expect to carry out 320 simple repairs in SPM. We also expect to replace 48 short pilot sections (about 2.4km in total) where there has been a need to carry out repeated repairs on a single cable due to degradation or where there are significant access issues to repair faults. A CBA is attached at (**Annex C6 – Cost Benefit Analysis – SPEN**, Reference 9).

6.3. 33kV & 132kV UG Pilot Cables Overview and Investment Drivers

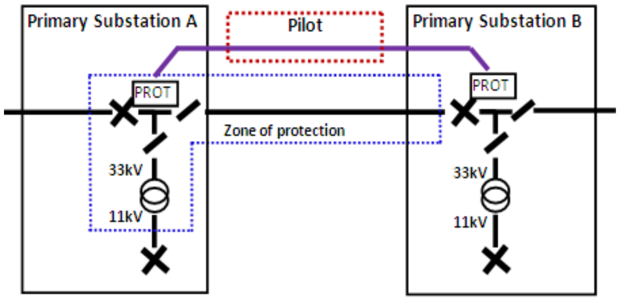
Figure 8: SPD 33kV Pilot Example



Pilots associated with 33kV networks in SP-D and 33kV and 132kV networks in SPM include dedicated 4 core pilots for protection applications and telecoms pilots used for protection and SCADA applications. Pilots used for protection applications, are essential to meeting statutory faults clearance obligations.

In SPD, where pilots are utilised to protect primary transformer circuits failures can lead to destructive failure of transformers due to non clearance of faults. It is therefore essential that the condition of these assets is maintained.

Figure 9: SPM 33kV Pilot Example



In SP-M there are separate dedicated protection pilots and telecoms pilot assets. Telecoms pilots are predominantly used for SCADA applications but are also used to host some protection applications. The SP-M 33kV Network is largely interconnected and can only be adequately protected from common fault conditions by the use communications assisted protection schemes. SP-M 132kV protection applications also utilise UG pilot cables for unit protection and essential intertripping applications.

Without these discriminative protection schemes and functional pilots, dangerous occurrences can arise. In SP-M networks can become unearthed under fault conditions in violation of ESQC regulations and associated incidents can result in the disconnection of larger volumes of customers due to the interconnected nature of the network and the potential for cascaded tripping.

Tests have shown the insulation resistance has degraded on many protection pilot assets, some to levels where protection operation would be affected if called to operate; these are repaired as quickly as possible and investment will be recorded as fault repair costs.

There are pilots (low insulation resistance) in areas such as city centres and busy roadways where access is difficult (both in terms of street access and cable depths) and repairs are costly. Pilots further degrade when their insulation is in a poor condition.

6.4. 33kV &132kV UG Pilot Cables Management Strategy and ED1 Programme

SPEN has recognised the need to proactively modernise degraded pilots sections in order to restore their condition.

Increases in service bandwidth requirements for network applications will continue during ED1 but degraded assets will be unable to deliver additional bandwidth requirements until their condition is restored.

SPEN will analyse degraded / faulted Pilots before repairs are carried out with particular consideration given to areas when repair costs estimated to be high and the associated risk of failure to network integrity. Action taken will be decided on as basis of cost and network requirements for the asset. The following options will be considered and the best option identified;

- *Arrange for faults to be located and repaired as soon as possible*
- *Schedule short section replacement if appropriate*
- *Transfer to alternative bearer if capacity available*
- *Schedule modernisation of Pilot Asset or seek alternative bearer solution*

During fault repair activities, SPEN will complete pilot modernisation where appropriate in the form of short section (~100m) replacements on pilots which have multiple faults / recurring faults and poor as found condition.

During the ED1 Period we expect to:

1. *Make 164 pilot repairs in SPD and 262 pilot repairs in SPM.*
2. *Make short section repairs to approximately 6.8km of pilot cable (70 circuits) in SPD and approximately 8.8km of pilot cable (90 circuits) in SPM.*
3. *Replace approximately 8.1km of worst condition pilot cable sections per annum in SPD and 6.2km of worst condition pilot cable sections per annum in SPM.*

Currently in SPM there are separate protection and telecoms pilot assets, some of which follow the same cable routes and interconnect the same sites. All proactive investment in replacement assets will look how to best service the requirements of all applications that use telecoms / protection pilots. Typically only on circuits where pilot degradation has prevented requirements from being serviced by all existing infrastructure will proactive modernisation be considered.

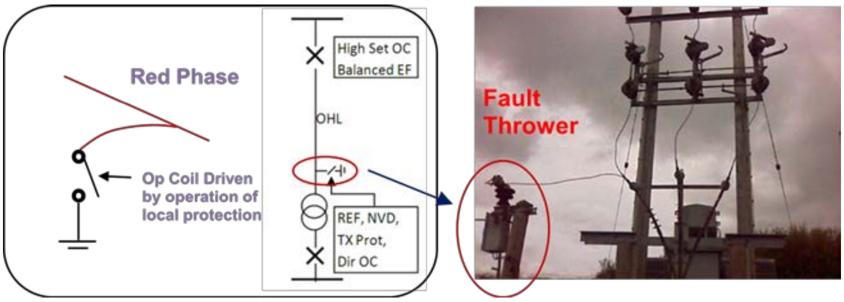
7. Other Activities

7.1. Fault Throwers Asset Overview and Investment Drivers

Fault throwers have historically been widely installed on the end of 33kV overhead line transformer feeders in SP-D to aid fault clearance. This solution is also in use in SP-M but it has not been widely deployed due to the network design. These devices were installed at a time where no adequate or cost effective communications circuits were available for protection signalling.

On detection of a local fault condition, fault throwers put a fault on the network which can be detected and cleared by equipment circuit breaker at the remote end site, Mal-operation of Fault Throwers can result in extensive equipment damage and extreme danger to the public as system faults remain un-cleared. Many of these devices have degraded over time and cannot be supported due to lack of expertise and spares availability. Proactive investment is required to mitigate the associated risk when devices degrade and cannot be supported.

Figure 10: Fault Throwers on 33kV Transformer Feeders



Overall investment in Fault Throwers during the ED1 period is shown in the table below. This includes only investment in switchgear solutions as costs associated with protection and communications is included in relevant tables.

Table 6:ED1 Fault Thrower Replacement Investment

Fault Throwers Replacement	SPD	SPM
	£m	£m
New Switchgear Solutions	0.5	

7.2. Fault Throwers Management Strategy and ED1 Programme Details

There are approximately 138 fault throwers on the 33kV Network in SPD and 27 33kV fault throwers on the Network in SPM. During ED1 we plan to remove 46 units from the SPD network and 2 units from the SPM network. SPEN solutions for the removal of fault throwers include installation of new 33kV pole mounted switchgear and the provision of intertripping schemes and communications. All useful spares will be recovered to manage the remaining asset base. Fault throwers removal will also be targeted on sites where intertripping services can be cost effectively be provisioned on communications infrastructure.

In addition to sites where intertripping services can be cost effectively provided on SPEN networks, sites where switchgear and transformer replacement activities are taking place will be targeted in ED1 as work will be already be underway at associated sites and there will be outage availability to remove fault throwers from the system. Where intertripping solutions are not possible, a 33kV switchgear solution will be installed.

The overall scope of works associated with the removal of fault throwers can be seen in the table below.

Table 7: ED1 Fault Thrower Replacement Activities

Fault Throwers Modernisation (33kV Switch Other Category)		ED1 Volume
SPD	Fault Throwers Removed	46
	33kV Switchgear Solution	16
	Intertripping / Communications Solution	30
SPM	Fault Throwers Removed	2
	Intertripping / Communications Solution	2

7.3. Battery Systems Asset Overview and Investment Drivers

Battery Systems are a critical component of the protective equipment within substations used to promptly disconnect faults from the network. If tripping batteries are not in good working order, the disconnection of faults from the network cannot be completed at associated network site. Accordingly fault clearance is dependent upon the operation of backup systems at other network sites, which will take much longer and may cause equipment damage, potentially extreme danger to the public and wider interruptions to customer supplies.

It is common for Grid and Primary substations to have multiple Battery and Charger Systems as equipment contained within often has different supply requirements. Batteries performance deteriorates rapidly as they approach their end of life, and they need be replaced before they fail due to their criticality. We also plan to replace obsolete, unsupportable battery chargers and to modernise chargers to ensure continued performance where possible.

Investment in Battery Systems during the ED1 period is shown in the table below.

Table 8: ED1 Battery Systems Modernisation Investment

Asset Modernisation	SPD	SPM
	£m	£m
HV Battery Replacement	0.2	1.3
EHV Battery Replacement	0.8	1.1
132kV Battery Replacement	0.0	1.1

7.4. Battery Systems Management Strategy and ED1 Programme Details

Investment in end of life batteries modernisation as a standalone activity with be driven by battery set asset life expectancy, battery system condition and switchgear modernisation works, in addition to the activities planned as part of the black start resilience initiatives.

Batteries are deployed in many SP-M and some SPD secondary substations for D.C. tripping requirements, some systems also support small standing loads. The majority of these sites are equipped with Valve Regulated Lead Acid (VRLA) Batteries and Chargers. Investment programmes include replacement of low cost short asset life VRLA Batteries (maximum replacement intervals range from 6-10 years dependant on type) and the replacement of legacy (Wet) Planté and NiCd Cells. New Chargers and VRLA batteries will replace of a number of (Wet) Battery systems if the charger condition has also degraded. Small volumes of VRLA chargers with support and reliability issues will also be targeted for replacement during ED1.

Modernisation activities will target batteries at SPD Primaries and SPM Grid and Primary Sites in line with Asset Management Replacement Policies. These batteries are typically much lower duty requirements than those being up-rated in the black start resilience enhancement activities and will be delivered as under this capital programme. Chargers which are unreliable or unsupportable will be replaced. Battery and Charger Systems will also be replaced due to adequacy issues, such as instances where standing loads are added to sites (e.g. remote end protection updates) and existing battery systems are not designed to meet associated duty requirements. Chargers with known type issues in SPM Grid and Primary Sites will have charger components modernised and smoothing circuits added to charger outputs to ensure that equipment remains reliable and the any sensitive equipment connected will not be damaged if a battery faults occurs.

Other investment in Battery and Charger Assets is driven by Plant replacement activities in line with the supply requirements of new equipment installed on the site. We plan to ensure that as much standby resilience as it practical for the installation is provided. High standing load duty requirements make it difficult to ensure 72hrs standby for all applications therefore each system installed also be equipped and installed with a controller which will disconnect selected, less essential D.C. loads in emergency conditions such as a blackout.

Battery Systems installed at Grid sites will be scoped as part of the capital project associated, factoring in the duty requirements of the new equipment to be installed on the site and overall resilience solution for the associated site.

The summary of Battery and Charger Modernisation work planned for ED1 is shown in the table below.

Table 9: Battery and Charger Modernisation Activities during the ED1 period

		Item	ED1 Volume
SPD	Primary Substation	New Batteries and Chargers installed (as part of Switchgear replacement initiatives)	33
		New Batteries and Chargers installed (based on condition/adequacy)	80
		Battery sets Replaced (based on life expectancy)	44
	Secondary Substation	New Batteries and Chargers installed (based on condition)	59
		Battery Sets Replaced (based on life expectancy)	432
SPM	Grid Substation	New Batteries and Chargers installed (as part of Switchgear replacement initiatives)	34
		New Batteries and Chargers installed (based on condition/adequacy)	14
		Chargers refurbishment / modernisation	32
		Battery sets Replaced (based on life expectancy)	64
	Primary Substation	New Batteries and Chargers installed (as part of Switchgear replacement initiatives)	40
		New Batteries and Chargers installed (based on condition/adequacy)	18
		Chargers refurbishment / modernisation	100
		Battery sets Replaced (based on life expectancy)	477
	Secondary Substation	New Batteries and Chargers installed (based on condition/adequacy)	198
		Battery sets Replaced (based on life expectancy)	6672