Scottish & Southern Electricity Networks

RIIO ED2 Engineering Justification Paper (EJP)

Protection Systems

Investment Reference No: 424/SSEPD/NLR/PROTECTION

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Executive Summary

This paper sets out the justification to refurbish protection schemes by replacing the associated obsolete protection relays and hence meet our obligations under the “Electricity Safety, Quality and Continuity Regulation 2002” (ESQCR).

This will improve network reliability by reducing maloperation of protection which results in unnecessary customer interruptions. They are also critical in reducing the probability of harm following human and livestock interaction with our live network and as such form a critical part to ensuring safety to the general public.

The proposals were derived based on stakeholder engagement workshops conducted over 5 sessions during the years 2019 and 2020. The outputs were conditioned further by verifying additional data such as maloperation reports and failures contributed by protection directly or indirectly.

The cost to deliver the preferred option stands at **£25.07m**. This cost is based on previous expenditure for similar tasks and predicted spread over the ED2 period. The projects and programmes would be delivered as an continuous programme of works throughout the RIIO-ED2 period

In addition to improved network reliability, several benefits relating to the RIIO-ED2 business goals will also be realised:

- Transforms legacy protection systems to intelligent devices thus enhancing our vision of achieving swift progress towards a smarter electricity system to meet our customers’ expectations
- Enables the Open Data vision “for modernising the UK energy system via an integrated data and digital strategy”
- Introduces new security measures on Layer 1 & 2 Non-Core OT devices of the Purdue model to manage the increasing level of threats waiting for Critical National Infrastructure (CNI).

1 Introduction

This paper sets out our proposal to undertake protection scheme refurbishment works during the RIIO-ED2 period. Protection solutions are designed to balance sensitivity and stability. They are critical in reducing the probability of harm following human and livestock interaction with our live network and as such form a critical part to ensuring safety to the general public. Protection systems must rapidly disconnect faulty sections of our network and must limit areas of disconnection to only the faulty sections. Protection systems must keep the network stable during transient events such as the Aug-2019 Under Frequency tripping which rapidly disconnected load to maintain the frequency and prevented total system collapse.

The improvement works are required to ensure our HV, EHV and 132kV circuits and substations are resilient, flexible and provide improved customer service. Protection solutions have been maintained to offer its best service during ED1 and proactive upgrades have been completed on identified protection assets that can potentially fail.

2 Background Information

This section of the report provides additional background information which has been used to inform the non-load related investment for Protection related assets. This includes a description of the assets under consideration, the relevant SSEN and industry policies, and the approach used to identify those that will require replacement during RIIO ED2.

2.1 Protection Systems

A basic principle of our Network design is that every item of equipment or circuit is covered by at least two independent protection devices with the second device only operating in the event of the failure of the first device to clear the fault. Often the backup protective device is provided by a separate relay located upstream of the primary protective device. This requires co-ordination in terms of current settings and/or time settings on the protective relays. The co-ordination and equipment types are standardised (known as Protection Schemes) which minimise complexity, whilst the settings allow the flexibility to cater for local conditions.

Excess current is the main fault as this leads to heating and thermal damage when allowed to occur unchecked for any significant time. Voltage and frequency variations, either above or below the allowable range, need to be controlled as these anomalies also damage equipment. Excess voltage can cause breakdown of insulation whilst under voltage can result in equipment maloperation. These problems are especially significant for motors and electronic equipment. Under and over frequency are unsafe conditions for transformers and motors; with transformer over fluxing and motor overspeed being the main problems.

Excess current can occur between phases (overcurrent) or from one phase to earth (earth fault). The basic Protection Schemes to detect and prevent these faults are termed overcurrent and earth fault protection respectively with the latter particularly relying on a defined earth return path.

Faults can be transient or permanent; with the majority being transient faults such as a result of conductor clashes in high winds or wind-blown debris or lightning strikes and hence more associated with overhead lines. Permanent faults usually occur as a result of some insulation breakdown or other electrical or mechanical damage and are more associated with transformers, motors and switchgear but can also be due to underground cables or broken conductors and insulators on overhead lines.

The protection schemes, some with delayed auto-reclose on overhead lines, and the co-ordination of times and current levels, are the methods by which the network discriminates between temporary and permanent faults.

The goal of auto-reclose is to automatically restore the supply as quickly as possible following the clearance of a temporary non-damaging fault. At the same time, the protection scheme must ensure that any permanent fault is disconnected as quickly as possible and remains permanently disconnected to eliminate any hazardous conditions arising from genuine permanent faults.

A permanent fault is indicated by the sustained overcurrent or overvoltage which exceeds the circuit or equipment rating. The hazards are excessive current and/or voltage which are both life-threatening and destructive to equipment.

Protection schemes employ a variety of techniques to achieve these twin goals of fault discrimination and clearance. The basic overcurrent and earth fault schemes are enhanced through the use of directional, distance and unit protection schemes. Dedicated applications are used for busbar, transformer, and rotating machine protection.

At low voltages, fuses are the predominant protection device. At HV and above, every piece of equipment and every feeder circuit on our network is monitored by a network of current and voltage measuring devices (CT's and VT's). These provide real time data to protective relays which interpret the signals and can respond accordingly to any faults by tripping off equipment and circuits when the current and/or voltage exceed the design limits or equipment ratings.

If protection systems fail, then a fault on the network will not be cleared locally. When a fault is cleared by a device further upstream, then an increased number of customers are affected unnecessarily. The time to clear the fault is increased, which increases the risk of severe damage to our Network and increases risk to others who may have inadvertently come into contact with our Network. Alternatively, a maloperation of a protection system may disconnect sections of our Network, and our customers, when no fault actually exists.

2.2 Approach in ED1

Our approach planned for ED1 was to only upgrade protection solutions along with a primary asset replacement of circuit breakers or transformers. This approach had served us well for many years since protection relays had a similar lifespan to the associated primary asset. However, the change from electro-mechanical relays to electronic relays, whilst bringing many benefits, has also resulted in a much shorter lifespan for protection relays. In the ED1 period, we started to see an increased number of maloperations of particular types of Intelligent Electronic Devices (IEDs) and we took the decision to start a replacement programme out with the cycle of primary asset replacement. In addition, the ongoing change from analogue to digital communications has resulted in a number of protection systems requiring targeted refurbishment to ensure reliable operation.

In ED1 we commenced condition-based protection replacement programmes, focusing on certain failing protection relays like SEPAMs, Microphase, AEG, and K-Series. These programmes are nearing completion.

The industry currently has no consistent method to produce a health index for Protection and Control Assets as defined for Primary Assets. Problems have been identified in defect management of these assets and we are seeking to develop a condition-based maintenance strategy rather than time based. The Collaborative Energy Portfolio (CEP) Project has been proposed in ENA by SSEN and is now being developed as a joint project sponsored by SSEN, UKPN and Northern PowerGrid[1]. This CEP project is set for Sep-2022 delivery with the governance managed by UKPN, with SSEN and Northern Power grid offering financial and technical support only.

[1] CEP029 - Operational Technology Asset CNAIM and Defect Management

The objectives are as follows: " *1) Achieve a common methodology across all utilities on scoring the health index acceptable by the regulator and 2) Enable DSO readiness by upgrading legacy operational technology devices*". The deliverables of this project will be producing an Engineering Recommendation document to support the implementation of the findings of the project along with an online/offline tool with pre-defined scoring implementation.

Another industry wide challenge is the availability of skilled protection engineers within UK and EU. It has proven to be difficult to recruit and retain protection engineers. In ED1, we have stepped up our internal training to develop protection skills within our business and we have established a pipeline programme to develop protection engineers.

ED1 has also seen a transformational change start in our Network. With increased Distributed Energy Resources, Fault current doesn't just flow from source to load anymore, as the sources are increasing on the load or customer side. This, combined with high fault currents, makes the protection setting calculation process cumbersome and demands the need for wide area protection coordination. The present way of calculating protection settings and grading checks over one or two zones is no longer showing the full picture. In ED1 we started to address this issue by procuring the necessary setting calculation tools. To extract the full value of these tools we need to develop our connectivity model where the system impedances and especially the parameters like zero sequence impedances, transformer vector details, distributed energy data along with accurate network representations are shared between multiple tools. This challenge is proposed to be addressed in ED2[2] to ensure system is ready to cope with much wider power flow and fault current flow disruptions that awaits during Flexibility implementation and DSO migration.

Many sites are operating with protection relays with electro-mechanical timers. These timers have little flexibility and do not interact correctly with modern automation schemes. This sometimes results in automations schemes failing to operate correctly and our customers experiencing unnecessary interruptions.

Some assets are at an age where some software platforms are obsolete or approaching obsolescence. If type faults occur, spares cannot be easily sourced, and this leads to circuit unavailability. These replacements were time consuming and cause a business risk if not proactively managed. One prime example is the P122 IEDs Intelligent Electronic Devices which are modern protection relays with less than 10-year lifetime but are recommended by the vendor to be removed and replaced. It's not the relay cost, but the outage and the replacement programme costs which become the challenge in such scenarios.

[2] 21/SSEPD/IT-ASSET/CONNECTIVITY++

3 Stakeholder Engagement

In preparation for SSEN's 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 ***Enhanced Engagement (Chapter 3)***.

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 ***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 SSEN 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.
- SSEN needs 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.
- SSEN needs 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 SSEN's proposed approach of prioritising assets with a higher likelihood of failure as part of ***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.

4 Introduction to The Investment Under Consideration

This section of the EJP provides an introduction to the investment under consideration including a description of the asset category itself and the primary and secondary investment drivers which lead to the need to invest in this asset category.

4.1 Primary investment drivers and associated CV tables

This Engineering Justification Paper (EJP) is intended to inform the proposed interventions of SSEN's Protection System assets **for non-load related purposes** during RIIO ED2.

This primarily relates to the health of each protection asset. A key part of the calculation of Asset Health is the consideration of certain factors about the protection assets. These factors include the following:

- **Defects –** most defects on protection relays are notified via the National Equipment Defect Reporting scheme (NEDeRS) operated by the ENA. This provides a means of assessing known defects with particular relay types.
- **Condition –** condition data is captured during routine inspection and maintenance. Much of the condition data is visual only, such as cracks in the plastic housing of test blocks. Maintenance records also identified issues with insulation integrity or operating tolerance of relays.
- **Self-monitoring capability** – many relays have in-built monitoring which will raise an alarm if the relay recognises that it has a fault. Self-monitoring is highly desirable and reduces the risks associated with continued use of the relay.
- **Availability of Support** – where a manufacturer remains able to support and repair a relay, the risk of ownership is reduced.
- **Availability of Spares** – we hold a stock of strategic spare relays to allow rapid replacement of relays found to be faulty. Once we run out of spares, and we are no longer able to purchase a like-for-like replacement, then the risk of retaining the protection relay increases.
- **Asset age and obsolescence –** the age of each relay type, in comparison to the design life suggested by the original manufacturer. Where a design life was not available, we have assumed 40 years for electro-mechanical relays and 25 years for an electronic relay. Where available, manufacturers often suggested a shorter design life.
- **Fault rate –** the number of faults caused by, or failed to clear by, each relay type.

4.2 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).

- **CV8 – Refurbishment (Non-SDI):** The refurbishment of network assets due to the health and criticality of each asset.

The costs and volumes associated with each CV table and the corresponding asset category depend upon the investment strategy and options that are chosen for each primary and secondary investment driver.

4.3 Asset Health Index

Our Asset Health Index (AHI) matrix table was created in-house due to lack of industry standard model. Every protection relay type which we have in service on our network was scored against the factors listed in section 4.1.

The scoring was completed by subject matter experts from SSEN as well as from key suppliers of protection equipment. The process followed is described further in section 6. The outcomes of the workshops with key stakeholders are shown in Appendix 2. The AHI process identified the protection relays that need to be replaced and over what timeframe.

The AHI covered the Cost Benefit assessments indirectly having considered all the factors listed in section 4.1.

4.4 Fault Thrower Replacements

Fault throwers are a type of switchgear installed as part of a protection scheme. Fault throwers are used as part of transformer protection at sites which are remote from their source circuit breakers. When protection schemes detect a fault in the transformer, they need to send a trip signal to all associated circuit breakers to stop the flow of fault current. Where the associated circuit breaker is remote from the transformer, it is necessary to send an intertrip signal to the remote site or to use a fault thrower.

A fault thrower connects the incoming circuit (usually 33kV or above) directly to earth – creating a circuit earth-fault and causing a high fault current to flow. This high fault current is seen by the protection associated with the source circuit breaker and causes the source circuit breaker to trip. A fault thrower operation causes a high rise-of-earth-potential, introducing a safety hazard, and causes stress on the network by forcing high fault currents. We therefore only deploy fault throwers as a last resort protection, and we remove them when the opportunity arises.

Intertrip signals require a communications link. As part of our ED2 business plan, we are providing new communications links to primary and grid substations as part of our OTN Rollout (422_SSEPD_OT_OTN Rollout). We are also refurbishing protection schemes where protection relays are no longer reliable. Where a site has fault throwers and we are providing a new communications route and we are refurbishing protection, then we will also dismantle the fault throwers and replace them with an intertripping scheme. All costs associated with the replacement of the fault thrower are included within the protection refurbishment.

5 Summary of Options Considered

This section of the report sets out the investment options that are considered when managing Protection Systems. As described below a holistic approach is taken to ensure 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 no additional investment (Do Nothing) to the full replacement of each protection system. By analysing all the investment drivers in a holistic manner for each individual project, we arrive at the optimal investment decision which avoids unnecessary spend and stranding of network assets.

5.1 Summary of Options

Table 2 below provides a high-level summary of the 4 investment options under consideration along with the advantages and disadvantages associated with each. A more detailed description of each option is then provided within the proceeding sub-sections.

Table 2: Summary of Protection Investment Options

Option	Description	Advantages	Disadvantages	Result
1. Do Nothing	No upfront action taken to improve condition of the protection assets under pre-defined Risk and Health scoring. Maintenance and Inspection activities continue as normal with reactive replacement of protection assets following failure and replacement continuing aligned with primary assets.	No additional cost	Risk of reduction in quality of supply, network safety, and environmental impact Increased risk of complete asset failure Increased risk of failing to clear a fault and impacting on life and property.	Not Considered
2. Refurbishment	Refurbishment of all protection schemes at AHI 4/5 by replacing obsolete components (relays).	Rapidly removes all protection systems at risk of failure from the network.	Huge volume of work which is not deliverable in terms of resources nor system outages. Risks inefficient expenditure if new relays removed within a few years.	Not Considered
3. Targeted Refurbishment	Refurbishment of protection schemes at AHI 4/5 by replacing obsolete components (relays) which are unlikely to be replaced by primary asset works within next ten years.	Removes all protection systems at risk of failure in a controlled timescale.	High risk protection relays remain on the Network for up to ten years.	Considered
4. Replacement	Complete replacement of protection systems at AHI 4/5	Establishes protection systems in best possible condition.	Considerable increase in cost and outage duration with little tangible improvement in AHI.	Not Considered

5.2 Option 1: Do-Nothing

In this option a decision is made to assess the risk associated with each protection asset in its current condition in conjunction with the risk with the associated primary asset. Protection systems are already included as a factor in the assessment of Asset Health of switchgear. This assessment may drive the early replacement of the switchgear and the protection along with it. But it is not possible for poor protection condition alone to trigger the replacement of the primary asset. This option therefore would not address the situation with the life of the primary asset and the associated protection are not synchronised, as is becoming the norm with the transition to the use of IEDs.

Whilst this option avoids additional CAPEX investment, it does not address the risk of our protection assets. For end-of-life assets this option is likely to lead to asset failure which can have both safety, environmental and financial consequences and a reduction in the quality of supply for network customers.

For this reason, during RIIO-ED2 the do-nothing option is limited to assets which remain below the Health Score criteria described within SSEN asset management policies. All other assets will require additional investment to manage the risk of asset failure within acceptable levels.

5.3 Option 2: Refurbishment

This option involves the refurbishment of all protection systems identified at Asset Health Index 4 or 5 by replacing the particular protection relays which drive the condition score. Generally, the panels, instrument transformers and wiring would remain, with only essential modifications being made.

This option would not consider the remaining life of the associated primary plant and hence may result in protection replacement in ED2, with the protection being replaced again in ED3 in conjunction with the primary asset.

The volume of work required under this option is not considered to be achievable given the required number of system outages and skilled protection engineers. For these reasons, the full refurbishment option is not considered practical in ED2.

5.4 Option 3: Targeted Refurbishment

The work content in individual projects is the same as described in option 2 for refurbishment. However, with this option, no work will be carried out on any protection assets which are likely to be replaced under a primary asset project in ED2 or ED3. Generally, this means that protection assets will not be replaced where the associated switchgear has an asset health of 4 or 5. The harder element to predict is if the primary asset may be replaced under a load-based reinforcement project. All sites presently in load reinforcement plans have been removed from the scope of this option, but this exercise will need to be repeated on a site-by-site basis as detailed designs are created. It is likely that load projections will change over ED2 resulting in some schemes coming in, or going out, of scope for protection refurbishment under this option.

We believe this option represents an appropriate balance of cost and risk.

5.5 Option 4: Replacement

This option involves the total replacement of the protection system, including panels, switches and wiring. The option does not generally include the replacement of instrument transformers, which tend to be embedded in the primary asset.

Although this option would leave protection systems in the best possible condition, with wiring the same age as the relays, it would involve replacing components which have a very low failure rate. The wiring and switches can generally be visually inspected, allowing good monitoring of condition. Typically, a complete rewiring of a protection scheme would result in a much longer system outage requirement and an increased cost.

There may be a small number of protection schemes which require several relay replacements, which may have a shorter outage requirement if a new panel is built offline and then swapped into place. However, such instances are unusual and would still tend to rely on existing cabling between the panel and the switchgear.

The extra cost, and outage time, for a complete protection system replacement is not considered further.

6 Detailed Analysis

This section of the report describes the investment strategy that SSEN have chosen for Protection Systems for RIIO ED2. This strategy has been informed by both stakeholder engagement and wider RIIO ED2 strategies.

6.1 Volume of Protection Systems requiring intervention

The lessons learned during ED1 protection programmes have supported us to take a proactive approach during ED2 that will offer best value in terms of alignment with primary asset replacement programmes, supporting flexibility, providing intelligence data and increasing security. To attain a realistic replacement and refurbishment programme a new Heath Index methodology was created that will consider various factors of a protection solution. The approach we have taken is detailed below:

- Use our established AHI scoring matrix
- List all of the different types of protection relay in service
- Vendors and lead protection engineers score relay types in matrix
- Combine scores to calculate AHI for each relay type (see Appendix 2)
- Sort listed relays into AHI scores
- Remove the AHI 4 and 5 protection relays already planned for primary asset replacement
- Prioritise works based on criticality

6.2 Cost Benefit Analysis

No Cost Benefit Analysis has been completed for these works. We have taken the approach of establishing a process similar to CBRM to calculate an Asset Health Index for protection assets to improve the management of these critical systems.

6.3 Proposed RIIO ED2 Investment

As previously described, the primary investment driver detailed within this EJP is the management of protection assets for non-load related purposes, specifically asset Health and Criticality. This correlates to the CV8 (Refurbishment) tables within Ofgem's BPDTs. The following subsections show both the costs and volumes that are proposed for RIIO ED2 for each of these CV tables.

6.3.1 CV8 Refurbishment (Non-SDI)

Table 3 and

Table 4 show the volumes and costs associated with the refurbishment of the primary switchgear asset category for both SHEPD and SEPD. These costs and volumes have been determined by SSEN's ***Safe and Resilient (Annex 7.1)*** for this asset category and the feedback SSEN has gathered from the RIIO ED2 stakeholder engagement activities.

Table 3: CV8 Refurbishment (non SDI) Protection Volumes for RIIO ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Protection Systems (SHEPD)	#	86	129	129	258	258	859
Protection Systems (SEPD)	#	192	288	288	575	575	1,917
Total	#	278	416	416	833	833	2,776

Table 4: CV8 Refurbishment (non SDI) Protection Cost for RIIO ED2

Asset Category	Unit	2024	2025	2026	2027	2028	Total
Protection Systems (SHEPD)	£m	£0.84	£1.27	£1.27	£2.53	£2.53	£8.44
Protection Systems (SEPD)	£m	£1.66	£2.49	£2.49	£4.99	£4.99	£16.63
Total	£m	£2.51	£3.76	£3.76	£7.52	£7.52	£25.07

6.4 Unit costs

Unit costs have been used to calculate the overall cost of the protection refurbishment programme. The unit costs have largely been based on manufacturers list prices and the actual costs of similar works in ED1. Works will be delivered by a combination of in-house and external resource.

Asset Category	Unit Cost	**Notes on Cost Confidence**
Hardware Costs		
Basic Multifunction Relay / Bay Controller	[redacted]	Average of prices from approved suppliers
Distance Relay	[redacted]	
Transformer Differential Relay	[redacted]	
Line Differential Relay	[redacted]	
Combined Differential + Distance	[redacted]	
Busbar Protection Relay	[redacted]	
Sundry Equipment **(test blocks, wiring)**	[redacted]	Estimate only
Relay Panel Front Sheet **(EHV circuits)**	[redacted]	Based on quotation during ED1
Install & Commissioning Costs	[redacted]	
In-House Bay Refurbishment	[redacted]	Estimate only
External Bay Refurbishment	[redacted]	Estimate only
Fault Thrower Replacement	[redacted]	This represents uplift on works included within 422_SSEPD_OT_OTN Rollout). Proportion of costs with assumption of two fault throwers per site
Additional OT Panel per end	[redacted]	Additional panel required for diversity
Additional Diverse Access Bearer	[redacted]	On sites where diverse communications not already available

Teleprotection Interfaces	[redacted]	
Intertrip Relays	[redacted]	From approved relay list
OT Panel Installation Costs	[redacted]	From 422_SSEPD_OT_OTN Rollout
Protection Install & Commission	[redacted]	Actual cost from ED1

6.5 Deliverability and Risk of Proposed Volumes

Our deliverability strategy ***Ensuring Deliverability and a Resilient Workforce (Chapter 16)*** describes our approach to evidencing the deliverability of our overall plan as a package, and its individual components. Testing of our EJPs has prioritised assessment of efficiency and capacity, and this has ensured that we can demonstrate a credible plan to move from SSEN's ED1 performance to our target ED2 efficiency. We have also demonstrated that SSEN's in house and contractor options can, or will through investment or managed change, provide the capacity and skills at the right time, in the right locations. This assessment has been part of the regular assessment of our EJPs, IDPs and BPDTs, and we will further refine our bottom-up efficiencies and work plan phasing for our final submission in December through the ongoing development of our ED2 Commercial & Deliverability Strategy and engagement with our supply chain.

Our deliverability testing has identified a major strategic opportunity which is relevant to all EJPs.

- In ED2 SSEN will change the way Capital Expenditure is delivered, maximising synergies within the network to minimise disruptions for our customers. This is particularly relevant for a Price Control period where volumes of work are increasing across all work types.
- The principle is to develop and deliver Programmes of work, manage risk and complexity at Programme level and to develop strategic relationships with our Suppliers and Partners to enable efficiency realisation.
- The Commercial strategy will explore the creation of Work Banks (WB) and identify key constraints. The Load work will be the primary diver for a WB, supplemented by Non-Load work at a given Primary Substation. This approach will capitalise on synergies between the Load and Non-Load work, whereby the associated downstream work from a Primary Substation will maximise outage utilisation, enabling the programme to touch the network in a controlled manner with the objective of touching the network once. Where there is no Primary Load scheme to support the Non-Load work, these will be considered and packaged separately, either insourced or outsourced dependant on volume, size and complexity.
- Transparency with the Supplier in terms of constraints, challenges, outage planning and engineering standards will capitalise on efficiencies, supported by a robust contracting strategy.

The specific considerations for deliverability based on the scope of this EJP are detailed below:

- We do not presently have sufficient protection engineers to deliver the proposed workload. We have however established training pipelines to develop this essential skillset. It takes several years to develop protection engineers. For this reason, the phasing of protection refurbishment across ED2 is not even. In the first year of ED2, we have assumed project delivery using our existing resources only, with increases in subsequent years as new engineers become available.
- Works will be coordinated with Substation Scada upgrades (420_SSEPD_OT_SCADA) and substation communication improvements (422_SSEPD_OT_OT2_OTN_ROLLOUT) to allow us to take full advantage of the additional functionality available from IEDs.

- It is intended to deliver a proportion of the work programme in-house. In the event that our training pipelines are unsuccessful, we already have framework contractors in place who are able to deliver this type of work. The use of contractors would generally increase the unit costs.
- System interfaces for controls, Network operation and SCADA

At the time of writing our ED1 business plan, we did not intend to undertake any protection refurbishment separately from Primary Asset replacement works. As explained earlier, we have had to start a refurbishment programme and over the last two years of ED1 we will be refurbishing over 500 units per annum using a mixture of in-house and contract resource.

7 Conclusion

This Engineering Justification Paper set out the need for refurbishment of protection systems due to our commitment to “Electricity Safety, Quality and Continuity Regulation 2002” (ESQCR).

We have developed a programme of protection system refurbishment over the ED1 period as a result of increased failures of electronic relays and failures in the compatibility of legacy relays with modern communications systems or automation systems. We have developed an Asset Health Index for protection relays to provide structure to our plans.

In order to establish the protection refurbishment programme, we have created a training pipeline for protection engineers which will continue to deliver new talent as we progress into ED2.

We will refurbish over 3,500 protection systems in the ED2 period by replacing the protection relay which is the main component of the protection system. The listing of sites and programmes proposed for works is included in Appendix 1.

8 Acronym Table

Acronym	Description
AAAC	All Aluminium Alloy Conductors
ACB	Air Circuit Breaker
ACSR	Aluminium Conductor Steel Reinforced
AIB	Air Insulated Busbar connected
AVC	Auto Voltage Control
BaU	Business as Usual
BPDT	Business Plan Data Table
Cad Cu	Cadmium Copper
CapEx	Capital Expenditure
CB	Circuit Breaker
CBRM	Condition Based Risk Methodology
CBA	Cost Benefit Analysis
CCA	Chromated Copper Arsenate
CEG	Customer Engagement Group
CI	Customer Interruption
CML	Customer Minutes Lost
CMR	Continuous Maximum Rating
CMZ	Constraint Management Zone
CNAIM	(DNO) Common Network Asset Indices Methodology
CO_2e	Carbon Dioxide equivalent (can be suffixed by t (tonnes))
CoF	Consequence of Failure
Consac	Underground Cable type, Paper insulation with Aluminium Sheath
CRC	Charge Restriction Condition
CV	Cost and Volume
DFES	SSEN's Distribution Future Energy Scenarios
DGA	Dissolved Gas Analysis
DIN	Dangerous Incident Notification
DNO	Distribution Network Operator
DP	Degree of Polymerisation
DPCR5	Distribution Price Control Review for five years from 1 April 2010 to 31 March 2015
DSI	Death or Serious Injury
DSO	Distribution System Operator
DTI	Department of Trade and Industry

EHV	Extra High Voltage, Voltages > 22kV and < 132kV , in SSEN these assets are usually 33kV and 66kV.
EJP	Engineering Justification Paper
ENA	Energy Networks Association
EQ	Equation
ESQCR	Electricity, Safety, Quality and Continuity Regulations
EU	European Union
FFA	Furfuraldehyde
FFC	Fluid Filled Cable
GB	Great Britain
GIB	Gas Insulated Busbar connected
GM	Ground Mounted
GRP	Glass Reinforced Plastic
HI	Health Index
HSE	Health and Safety Executive or Health, Safety and Environment
HM	Her Majesty or His Majesty
HV	High Voltage, Voltages > 1kV and < 22kV , in SSEN these assest are usually 6.6kV and 11kV.
ID	Indoor
IIS	Interruption Incentive Scheme
IR	Insulation Resistance
kV	Kilovolt
LCT	Low Carbon Technology
LV	Low Voltage, Voltages < 1kV, in SSEN these assest are usually ~400V.
LV UGB	Low Voltage Underground Board (Link Box)
LTA	Lost Time Accident
MEAV	Modern Equivalent Asset Value
MMI	Maximum and Multiple Increment
MR	Monetised Risk
MVA	Megavolt Ampere
NaFIRS	National Fault and Interruption Reporting Scheme
NARA	Network Asset Risk Annex
NARM	Network Asset Risk Metric
NAW	Network Assets Workbook
NEDeRs	National Equipment Defect Reporting Scheme
NPV	Net Present Value
OD	Outdoor

OEM	Original Equipment Manufacturer
Ofgem	Office of Gas and Electricity Markets
OHL	Overhead Line
OpEx	Operational Expenditure
PCB	Polychlorinated Biphenyls
PESC	Postsecondary Electronic Standards Council
PILC	Paper Insulated Lead Covered
PM	Pole Mounted
PoF	Probability of Failure
PSI	Planned Supply Interruption
PVC	Polyvinyl Chloride
RIG	Regulatory Instructions and Guidance
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
RMU	Ring Main Unit
SDI	Secondary Deliverable Intervention
SEPD	Southern Electric Power Distribution PLC
SF6	Sulphur Hexafluoride
SHEPD	Scottish Hydro Electric Power Distribution PLC
SLC	Standard Licence Condition
SOP	Suspension of Operational Practice
UGC	Under Ground Cable
VoLL	Value of Lost Load
VSL	Value of Statistical Life
WM	Wall Mounted

9 Appendix 1: Listing of Protection Refurbishment Works

Appendix 1, Table 1 SEPD Protection Projects

Substation	No. of AHI 4 to 5 relays	Cost per Site
ACTL - ACTON LANE SS	14	[redacted]
ALDERSHOT SS	45	[redacted]
ALTON	41	[redacted]
BOURNEVALLEY SS	61	[redacted]
BRDE - BATH ROAD EAST SS	14	[redacted]
BROMHAM SS - BROM	7	[redacted]
CANB - CANAL BANK SS	12	[redacted]
CHICHESTER SS	47	[redacted]
CHIPPENHAM	23	[redacted]
CHUR - CHURCH ROAD SS	13	[redacted]
CODFORD SS	12	[redacted]
COKES LANE	14	[redacted]
COXMOOR WOOD SS	20	[redacted]
DENHAM	29	[redacted]
DRAYTON SS	50	[redacted]
EALI - EALING SS	30	[redacted]
FELT - FELTHAM SS	22	[redacted]
FERNHURST SS	35	[redacted]
FLEET SS	47	[redacted]
GROVE SS	13	[redacted]
HAVANT SS	38	[redacted]
HUNSTON SS	23	[redacted]
HURSTSBORNE TURRANT SS	4	[redacted]
KIDDINGTON SS	19	[redacted]
LALEHAM	10	[redacted]
LEAFIELD SS	23	[redacted]
LOUDWATER S/S	23	[redacted]
LYNES COMMON SS	17	[redacted]
LYTCHETT SS	42	[redacted]
MANCHESTER ROAD SS	26	[redacted]
MILTON SS	23	[redacted]
NETLEY COMMON SS	52	[redacted]
NORRINGTON SS	45	[redacted]
PORTLAND SS	8	[redacted]
REDHILL SS	30	[redacted]
SALISBURY SS	40	[redacted]
SOUTHAMPTON - SS	42	[redacted]
STRATTON SS	38	[redacted]
WEST GRAFTON SS	6	[redacted]
WINCHESTER SS	36	[redacted]

WINTERBOURNE ABBAS SS	19	[redacted]
WOOTON BASSETT SS	15	[redacted]
WOOTTON COMMON SS	54	[redacted]
	1,182	[redacted]

Appendix 1, Table 2 SHEPD Protection Projects

Substation	No. of AHI 4 to 5 relays	Cost per Site
ABERFOYLE PRIMARY	5	[redacted]
ABOYNE PRIMARY	3	[redacted]
ACHILTIBUIE PRIMARY	2	[redacted]
AIRD PRIMARY	4	[redacted]
ALYTH PRIMARY	5	[redacted]
ARDERSIER PRIMARY	10	[redacted]
ARDMORE GRID	2	[redacted]
ARISAIG PRIMARY	3	[redacted]
ARNISH	5	[redacted]
ASHLUDIE PRIMARY	7	[redacted]
BALALDIE PRIMARY	4	[redacted]
BALLATER PRIMARY	7	[redacted]
BALLIEKINE PRIMARY	2	[redacted]
BALLURE PRIMARY	5	[redacted]
BALMEDIE PRIMARY	5	[redacted]
BANCHORY PRIMARY	2	[redacted]
BARCALDINE PRIMARY	5	[redacted]
BARVAS PRIMARY	6	[redacted]
BEINN GHLAS WINDFARM	2	[redacted]
BETTYHILL PRIMARY	2	[redacted]
BLAIRLINNANS PRIMARY	1	[redacted]
BOAT OF GARTEN PRIMARY	9	[redacted]
BONSKEID PRIMARY	1	[redacted]
BRAE PRIMARY	1	[redacted]
BUCKIE PRIMARY	8	[redacted]
BURGAR HILL PRIMARY	5	[redacted]
BURGHMUIR PRIMARY	6	[redacted]
CALLANDER PRIMARY	8	[redacted]
CALLANISH PRIMARY	4	[redacted]
CARNOCH REGULATOR	2	[redacted]
CLAYHILLS PRIMARY	14	[redacted]
COLDBACKIE PRIMARY	1	[redacted]
COLL PRIMARY	3	[redacted]
CONNEL PRIMARY	4	[redacted]

CORRAN PRIMARY	3	[redacted]
COSHIEVILLE PRIMARY	3	[redacted]
COUPAR ANGUS PRIMARY	6	[redacted]
CRAIGINCHES PRIMARY	9	[redacted]
CRINAN PRIMARY	1	[redacted]
CULLODEN PRIMARY	10	[redacted]
CUMMING STREET PRIMARY	4	[redacted]
DALCROSS PRIMARY	11	[redacted]
DALNEIGH PRIMARY	9	[redacted]
DALWHINNIE PRIMARY	5	[redacted]
DERVAIG PRIMARY	4	[redacted]
DORNOCH PRIMARY	5	[redacted]
DRIMORE PRIMARY	3	[redacted]
DRUMNADROCHIT PRIMARY	4	[redacted]
DRYMEN PRIMARY	4	[redacted]
DUNBLANE PRIMARY	10	[redacted]
DUNOON GRID	1	[redacted]
DUNOON PRIMARY	9	[redacted]
DUNVEGAN GRID / PRIMARY	4	[redacted]
DYCE NORTH PRIMARY	13	[redacted]
EDAY PRIMARY	3	[redacted]
EDZELL PRIMARY	1	[redacted]
ELGIN GRID	6	[redacted]
ELGIN PRIMARY	14	[redacted]
ELLON PRIMARY	7	[redacted]
FIRTH PRIMARY	5	[redacted]
FLOTTA PRIMARY	1	[redacted]
FORRES PRIMARY	25	[redacted]
FOYERS PRIMARY	3	[redacted]
FYVIE PRIMARY	2	[redacted]
GISLA PRIMARY	2	[redacted]
GLENDEVON PRIMARY	4	[redacted]
GLENEAGLES PRIMARY	11	[redacted]
GLENSANDA PRIMARY	2	[redacted]
GOURDIE PRIMARY	5	[redacted]
GRANTOWN PRIMARY	7	[redacted]
GREYFRIARS PRIMARY	8	[redacted]
GUTCHER PRIMARY	3	[redacted]
HARBOUR PRIMARY	9	[redacted]
HATTON PRIMARY	5	[redacted]
HAYTON PRIMARY	6	[redacted]
HILTON PRIMARY	11	[redacted]
HUNTLY PRIMARY	9	[redacted]
INSCH PRIMARY	6	[redacted]

INVERARNIE PRIMARY	3	[redacted]
KAMES PRIMARY	3	[redacted]
KEPCULLOCH PRIMARY	7	[redacted]
KERRY FALLS PRIMARY	2	[redacted]
KILLIN TOWN PRIMARY	3	[redacted]
KILNINVER PRIMARY	2	[redacted]
KINGUSSIE PRIMARY	11	[redacted]
KIPPEN PRIMARY	6	[redacted]
KISHORNHILL PRIMARY	1	[redacted]
KYLE PRIMARY	2	[redacted]
LAXAY PRIMARY	4	[redacted]
LETHEN PRIMARY	5	[redacted]
LIMEHILLOCKS PRIMARY	4	[redacted]
LOCHALINE PRIMARY	1	[redacted]
LOCHDONHEAD	3	[redacted]
LOCHEARNHEAD PRIMARY	4	[redacted]
LOCHGILPHEAD PRIMARY	10	[redacted]
LOWER OLLACH PRIMARY	2	[redacted]
LYNDHURST PRIMARY	12	[redacted]
LYNESS PRIMARY	3	[redacted]
MACHRIE PRIMARY	2	[redacted]
MALLAIG PRIMARY	3	[redacted]
MARKETHILL PRIMARY	1	[redacted]
MARNOCH PRIMARY	6	[redacted]
MAUD PRIMARY	7	[redacted]
METHLICK PRIMARY	9	[redacted]
MID YELL PRIMARY	2	[redacted]
MIDMAR PRIMARY	1	[redacted]
MILTON OF CRAIGIE PRIMARY	1	[redacted]
MINTLAW PRIMARY	7	[redacted]
MOSSAT PRIMARY	5	[redacted]
NAIRN CENTRAL PRIMARY	9	[redacted]
NAIRN GRID	13	[redacted]
NEW PITSLIGO PRIMARY	5	[redacted]
NEWTONHILL PRIMARY	13	[redacted]
NINEWELLS PRIMARY	4	[redacted]
NOSTIE BRIDGE PRIMARY	6	[redacted]
OLDMELDRUM PRIMARY	5	[redacted]
OTTER FERRY PRIMARY	3	[redacted]
PARK PRIMARY	2	[redacted]
PETERHEAD GRANGE GRID	7	[redacted]
PETERHEAD GRANGE PRIMARY	13	[redacted]

PETERHEAD NORTH STREET PRIMARY	7	[redacted]
POLLACHAR PRIMARY	3	[redacted]
PORTREE PRIMARY	18	[redacted]
PORTSOY PRIMARY	3	[redacted]
QUOICH PRIMARY	1	[redacted]
RAIGMORE PRIMARY	12	[redacted]
REDFORD PRIMARY	2	[redacted]
REDGORTON PRIMARY	6	[redacted]
ROUSAY PRIMARY	4	[redacted]
SALEN 2 PRIMARY	4	[redacted]
SANDBANK PRIMARY	6	[redacted]
SANDWICK PRIMARY	1	[redacted]
SCALLOWAY PRIMARY	4	[redacted]
SHAPINSAY PRIMARY	3	[redacted]
SKULAMUS PRIMARY	4	[redacted]
ST CYRUS PRIMARY	4	[redacted]
ST FILLANS GRID	1	[redacted]
ST MARY'S PRIMARY	4	[redacted]
STOCKINISH PRIMARY	3	[redacted]
STORR LOCHS PS	1	[redacted]
STRACHUR PRIMARY	1	[redacted]
STRATHDON PRIMARY	3	[redacted]
STRICHEN PRIMARY	5	[redacted]
STROMNESS PRIMARY	1	[redacted]
STRONSAY PRIMARY	3	[redacted]
SUMBURGH PRIMARY	5	[redacted]
TAIN PRIMARY	9	[redacted]
TARBERT PRIMARY	5	[redacted]
TAYNUILT PRIMARY	2	[redacted]
TORRYBURN PRIMARY	4	[redacted]
TUMBLIN PRIMARY	3	[redacted]
TUMMEL BRIDGE PRIMARY	10	[redacted]
TURRIFF PRIMARY	12	[redacted]
UIG PRIMARY	3	[redacted]
UNST PRIMARY	3	[redacted]
VOE PRIMARY	5	[redacted]
WATERLOO PLACE PRIMARY	14	[redacted]
WHITEHOUSE PRIMARY	4	[redacted]
WHITESTRIPES PRIMARY	7	[redacted]
WHITING BAY PRIMARY	3	[redacted]
WILLOWDALE GRID	4	[redacted]
	835	[redacted]

Appendix 1 Table 3 SEPD Protection Programmes

	Total Number of Relays /Schemes	Proposed for Replacement	Cost per Unit	Total Cost
Fault Thrower Replacements	54	24	[redacted]	[redacted]
11kV SEPAM replacements		30	[redacted]	[redacted]
K - Relay replacements - 22kV	95	95	[redacted]	[redacted]
K - Relay replacements - 33kV	392	392	[redacted]	[redacted]
K - Relay replacements - 66kV	37	37	[redacted]	[redacted]
K - Relay replacements - 132kV	157	157	[redacted]	[redacted]
Total		**735**		[redacted]

Appendix 1 Table 4 SHEPD Protection Programmes

	Total Number of Relays /Schemes	Proposed for Replacement	Cost per Unit	Total Cost
Fault thrower replacement		24	[redacted]	[redacted]
Old Eclipse Boards – Add Watchdog Alarms				[redacted]
Total		**24**		[redacted]

10 Appendix 2: Fault Thrower Replacement Sites

Appendix 2 Table 1 SEPD Fault Thrower Replacement Sites

Type	Substation	Code
PRIMARY	BROMHAM	BROM
GRID	CHICHESTER	CHHE
PRIMARY		
GRID	DENHAM	DENH
GRID	FERNHURST	FERN
PRIMARY	FIVE OAKS	FIVO
PRIMARY	GODALMING	GODA
GRID	LYTCHETT	LYTC
GRID	SALISBURY	SALI
GRID	STRATTON	STRA
PRIMARY		
GRID	UPTON	UPTO
PRIMARY		
GRID	WEST GRAFTON	WGRA
GRID	WINCHESTER	WINC

Appendix 2 Table 2 SHEPD Fault Thrower Replacement Sites

Type	Substation	Code
PRIMARY	BALLATER	806
PRIMARY	CRAIGAGOUL	381
PRIMARY	DALRULZION	259
PRIMARY	MALLAIG	731
PRIMARY	MARYTON	084
PRIMARY	NEWTONHILL	914
PRIMARY	OBAN	307
PRIMARY	OLDMELDRUM	921
PRIMARY	PITLOCHRY	263
PRIMARY	SANDAY	685
PRIMARY	STRACHUR	382
PRIMARY	UIG	640

11 Appendix 3: Protection Relay Types in SSEN and associated AHI

Final Relay HI Score Guide
1 - Nearly new and can be retained for over 15 years with regular maintenance
2 - No concerns for next 10 years
3 - Needs monitors or alarms to warn in the next two to three years
4 - Needs replacement at the earliest
5 - Proven to fail already - Urgent fix required or project already in place for replacements

PROTECTION RELAY HEALTH INDEX (HI) ASSESSMENT		
Relay model	Make	Final Relay HI
2B3	Reyrolle	5
2DCC	Reyrolle	5
2DCC03	Reyrolle	5
2TJM10	Reyrolle	5
4C21	Reyrolle	5
7SD60	Siemens	4
7SR220	Siemens	1
7SR242	Siemens	1
AEG SD14E	AEG	4
AKA2	AEI	4
AKC2		4
AKH3		3
ARGUS 7SR 11	Reyrolle	1
ARGUS 8	Reyrolle	1
B3	Reyrolle	5
B69	Siemens	2
Basler		3
BD		3
BE181	Basler	4
BSE		2
C21	Reyrolle	5
CAG14	GEC /EE	5
CAG17	GEC /EE	5
CAG19	GEC /EE	5
CAG33	GEC /EE	5
CAG34	GEC /EE	5
CAG37	GEC /EE	5
CDAG31	GEC /EE	5
CDAG51	GEC /EE	5
CDD21	GEC /EE	5
CDG SPEC	GEC /EE	5
CDG11	GEC /EE	5

CDG12	GEC /EE	**5**
CDG31	GEC /EE	**5**
CDG51	GEC /EE	**5**
CDG61	GEC /EE	**5**
CGD31	GEC /EE	**5**
DAD	Reyrolle	**5**
DB M200	Reyrolle	**5**
DBA	AEI	**5**
DBA2	AEI	**5**
DBM4	GEC /EE	**5**
DS4		**2**
DT2		**4**
DUOBIAS M	Reyrolle	**4**
FAC	GEC /EE	**4**
FAC14	GEC /EE	**4**
FSL		**2**
FTG	GEC /EE	**5**
FV2		**5**
GF3	Reyrolle	**4**
HO2		**5**
HOA2		**5**
KAVR100	GEC /EE	**5**
KAVR159	GEC /EE	**5**
KBCH120	GEC /EE	**5**
KCEG130	GEC /EE	**5**
KCEG140	GEC /EE	**5**
KCEG142	GEC /EE	**5**
KCGG120	GEC /EE	**5**
KCGG122	GEC /EE	**5**
KCGG130	GEC /EE	**5**
KCGG140	GEC /EE	**5**
KCGG141	GEC /EE	**5**
KCGG142	GEC /EE	**5**
KVTR100	GEC /EE	**4**
LFZP112	Alstom / GE	**4**
LFZP122	Alstom / GE	**4**
MBCH12	Alstom / GE	**4**
MBCI	Alstom / GE	**4**
MBCZ	Alstom / GE	**4**
MCAG14	Alstom / GE	**3**
MCAG19	Alstom / GE	**3**
MCAG34	Alstom / GE	**3**
MCAG39	Alstom / GE	**3**
MCBI02/TRANSLAY	Alstom / GE	**5**

MCGG22	Alstom / GE	**5**
MCGG42	Alstom / GE	**5**
MCGG52	Alstom / GE	**5**
MCGG62	Alstom / GE	**5**
MCGG82	Alstom / GE	**5**
METI31	Alstom / GE	**5**
MFAC	Alstom / GE	**3**
MFAC14	Alstom / GE	**3**
MFAC34	Alstom / GE	**3**
MHOA4		**2**
MHR4	Reyrolle	**5**
MICOMP443	GEC /EE	**2**
MICRO Ph	GEC /EE	**4**
MVAA11	GEC /EE	**2**
MVAG31	GEC /EE	**4**
MVAG34	GEC /EE	**4**
MVAJ25	GEC /EE	**2**
MVTP31	GEC /EE	**2**
MVTR51	GEC /EE	**5**
MVTR52	GEC /EE	**5**
MVTR59	GEC /EE	**5**
MVTT	GEC /EE	**4**
MVTT14	GEC /EE	**3**
MVTU18	GEC /EE	**5**
MVUA	GEC /EE	**5**
MVUA11	GEC /EE	**5**
NSD570	ABB	**1**
Ohmega311	Reyrolle	**2**
OPTIMHO		**2**
P121	Alstom / GE	**1**
P122	Alstom / GE	**1**
P123	Alstom / GE	**1**
P127	Alstom / GE	**1**
P141	Alstom / GE	**1**
P142	Alstom / GE	**1**
P143	Alstom / GE	**1**
P143IM	Alstom / GE	**1**
P443	Alstom / GE	**1**
P445	Alstom / GE	**1**
P521	Alstom / GE	**1**
P542	Alstom / GE	**1**
P741	Alstom / GE	**1**
P742	Alstom / GE	**1**
P923	Alstom / GE	**1**

PBD2	Reyrolle	**4**
PBO	Reyrolle	**5**
PBO2	Reyrolle	**5**
PBOA	Reyrolle	**5**
PG2	Reyrolle	**5**
PG3	Reyrolle	**5**
QUADRAMHO	GEC	**4**
RSG2		**2**
S01-137DC		**2**
Schweizer 321s	SEL	**2**
SD14E		**3**
SHPM101		**2**
Solkor N	Reyrolle	**2**
SolkorRf	Reyrolle	**3**
SSM3V	AEI	**5**
SSRR3V	AEI	**5**
T4DA1		**3**
TDS		**3**
TEB DDB1	Easun Reyrolle	**3**
THR 3PE1	Reyrolle	**5**
TJEV	Reyrolle	**5**
TJM10	Reyrolle	**4**
TJV	Reyrolle	**5**
TRANSLAYS	GEC	**5**
VAG	GEC /EE	**5**
VAG70	GEC /EE	**5**
VAR101	GEC /EE	**5**
VAR102/3	GEC /EE	**5**
VAR21	GEC /EE	**5**
VAR22	GEC /EE	**5**
VAR42	GEC /EE	**5**
VAR51	GEC /EE	**5**
VAT	GEC /EE	**5**
VAT11	GEC /EE	**5**
VAT21	GEC /EE	**5**
VAU	GEC /EE	**5**
VMG	GEC /EE	**5**
VTX	GEC /EE	**5**
VTX31	GEC /EE	**5**
CMU31	GEC/EE	**4**
NPO	Reyrolle	**3**
GCM05	Alstom / GE	**1**
P12x Series 1	Alstom / Schneider	**3**
Solkor R	Reyrolle	**3**