SP Energy Networks 2015–2023 Business Plan

Updated March 2014

Annex

Asset Health and Criticality Strategy

SP Energy Networks

March 2014

SP ENERGY NETWORKS

Asset Health & Criticality Strategy

March 2014

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17th March 2014	1	Gerard Boyd	First Issue

1. Scope

This annex outlines our methodology for evaluating asset health and criticality including a detailed description of the IT solutions used to derive Health Index and Criticality Index scores. The output from this modelling has also been summarised for each applicable asset category.

2. Table of linkages

The calculation of Health & Criticality Indices is key to our Non-Load investment plans and the results from this modelling feature heavily in the expenditure section of the main business plan document and the Expenditure narrative.

Document	Chapter / Section
Main Plan	Expenditure summary
Expenditure Annex	Whole document

3. Introduction

This annex provides a detailed description of our methodology for the calculation of Health Index and Criticality Index measures. The purpose of Health & Criticality Indices is to obtain an approximation of the probability and consequence of asset failure. These two factors multiplied together produce an estimate of the risk, which can be used to prioritise and optimise investment.

4. Methodology

4.1. Health Index

Health Index is a measure of asset condition that is applied to a subset of our asset base. The evaluation methodology varies depending on the asset type however at a generic level Health Indices will match the following descriptions:-

HI Category	Description
HI1	New or as new
HI2	Good or serviceable condition
HI3	Deterioration requires assessment and monitoring
HI4	Material deterioration, intervention requires consideration
HI5	End of serviceable life, intervention required

Asset Health is determined using a number of factors:

- *• Design Standards — acceptability to the current specification*
- *• Deterioration — range of decay from 'None' to 'Major' and which may include specific indicators (such as dissolved gas analysis results, inspections or maintenance data)*
- *• Operational Issues — operational restrictions, fault levels, safe working procedures*
- *• Vicinity and Location — indoor/outdoor*
- *• Fault Rate — tolerance of rate within the asset base compared with others*
- *• Critical Issues -identified critical defect*
- *• Maintenance Spares — availability and suitability of parts and expertise*

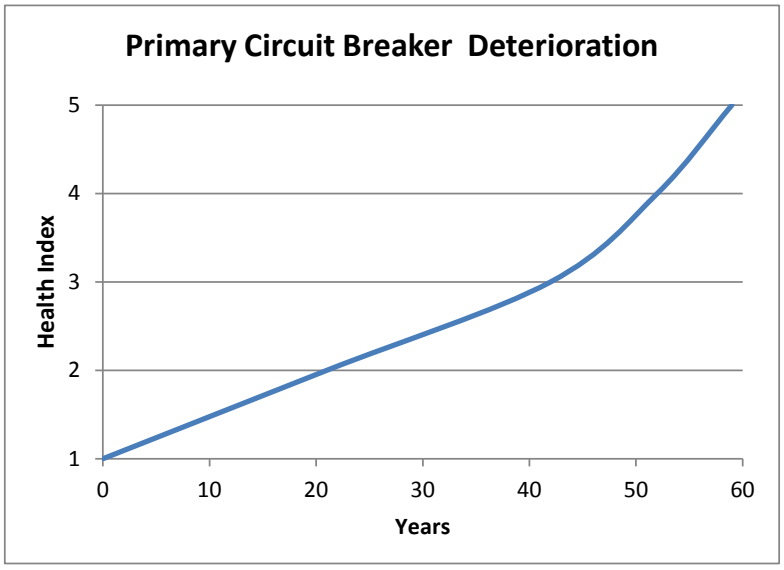
We currently use our HI methodology for the following classes of assets:-

- *• 11kV (ground mounted), 33kV and 132kV switchgear*
- *• 11kV (ground mounted), 33kV and 132kV transformers*
- *• LV, 11kV, 33kV and 132kV wood poles*
- *• 132kV overhead line conductor*
- *• 132kV overhead line towers*

We are continuing to develop the use of the HI methodology for other asset classes and in developing our ED1 plan, we have applied it to substation buildings and structures.

4.2. Deterioration Modelling

In addition to the assessment of current asset health it is also necessary to predict the future health index of our assets. For each asset category a separate deterioration curve is applied, the end point is determined by the expected asset life and the shape of the curve by the deterioration trend for that asset category. A sample deterioration curve is shown below:-



Our health and criticality modelling also takes account of assets which are in better or worse condition than their age would suggest and models their future condition accordingly.

4.3. Criticality Index

Criticality Index is a measure of the Consequence of Failure (COF) for assets within the same asset category, and it also provides a relative comparison of the Consequence of Failure for assets across different asset categories (if a common currency is utilised). Most importantly however, it provides a method for an organisation to prioritise work activities and investments.

A framework that defines asset criticality has been defined by the Health & Criticality Working Group. It was decided that criticality would be split into four main categories which combine to give an overall view of asset criticality. For each asset, the overall consequence of failure is defined as the sum of the individual categories. These individual categories include:

- *Safety – Valuation of Fatalities, Major and Minor Injuries.*
- *Network Performance – Impacts on Distribution assets including CML valuation.*
- *Environmental – Valuation of contamination and fugitive emissions arising from oil & SF6.*
- *Financial consequence of repair/replacement – Cost to return network to normal.*

The average consequence of each asset category is shown below, expressed in pounds.

HI_CRITERIA_ID	Average Consequence of Failure (SPD £)	Average Consequence of Failure (SPM £)
LV POLE	8,450	8,740
HV SWG PRIMARY	49,198	31,295
HV SWG DISTRIB	22,996	16,112
HV GM TRANSFORMER	15,963	13,170
HV POLE	8,166	6,941
EHV SWG	145,482	63,199
EHV TRANSFORMER	79,800	115,425
EHV OIL CABLE	42,396	19,307
EHV POLES	39,132	14,387
132kV CIRCUIT BREAKERS	-	59,241
132kV TRANSFORMERS	-	96,801
132kV GAS CABLE	-	111,283
132kV OIL CABLE	-	90,991
132kV TOWERS	-	60,148
132kV LINES	-	60,552

The criticality can vary between licences due to differences in customer density, network design and proximity to watercourses.

4.3.1. Safety Scoring

Our safety scoring utilises a generic evaluation of probability of fatality, major injury and minor injury for each asset class. This is then multiplied by an evaluation of the economic impact of these events as published by the Health and Safety Executive (HSE). These scores are then modified up or down depending on the public exposure of each individual asset. In order to provide our submission only system derived information was used and as such we evaluated the number of connected customers within a set radius of each substation. We have also updated our inspection question sets to provide a view on land usage which when captured in corporate systems will provide a more accurate measure of public/staff exposure.

4.3.2. System Scoring

System scoring is calculated through two separate methodologies, the first covers assets whose failure would result in a direct loss of supply to customers the second covers assets whose failure would result in an increased risk of loss of supply but no direct consequence (n-1 assets).

- *Direct loss of supply*

The system criticality for these assets is calculated using the expected impact on Customer Interruptions (CI) and Customer Minutes Lost (CML) through the Interruptions Incentive Scheme (IIS). For each asset the number of connected customers is evaluated and multiplied by the CI rate to calculate a CI impact. An outage duration is then applied (based on the average time to restoration within the same geographical area) to this volume of customers to provide a CML impact. When combined, these scores provide the system score for direct loss of supply assets. It is worth noting that the number of connected customers is simplistic at the moment as providing an actual volume of customers likely to be affected would require extremely complex logic rules and linkage to our Distribution management system PowerOn.

- *N-1 assets*

The failure of any single N-1 asset is unlikely to result in the loss of supply to customers however it does increase the risk of loss of supply in the event of additional failures on the network. To capture the risk associated with these events, we have calculated the impact associated with the Value of Lost Load (VoLL) for each asset. To do so the MW loading of each site has been incorporated into our database and an assumed loading per customer applied to evaluate a theoretical number of customers. The CI/CML impact is then evaluated as per the direct loss of supply methodology however a multiplier has been applied to account for the fact that there is only an increased probability of customers being affected.

4.3.3. Environmental Scoring

The environmental criticality of an asset has been evaluated based on the cost implications of contaminants that are used as insulating mediums for electrical apparatus. The two most commonly used contaminants are SF^6 and oil.

- *Oil clean-up – The clean-up costs for the spillage of insulating oil can vary significantly from site to site and from event to event. To capture the consequence of oil spillage, the volume of oil contained within each asset was extracted from our corporate systems. This was then multiplied by a standard cost of clean-up per litre (derived from historic invoices). In addition to the volume of oil, the proximity to bodies of water can have a significant impact on clean-up costs. From our ESRi system a spatial query was carried out to determine the distance from each substation to the nearest watercourse. This information was used to increase the impact of environmental scoring based on proximity.*

- *SF6 CO2 implications – The carbon cost equivalent was evaluated for each asset that contained SF6. This was based on the volume of SF6 multiplied by the carbon cost per kg of SF6*

4.3.4. Financial Scoring

The financial score is based on the costs associated with restoring an asset to working service following a failure. This is split into replacement costs and repair costs which are then weighted by the frequency with which an asset is likely to be replaced or repaired. This data has been sourced from actual repair and replacement data.

4.3.5. Criticality Index 1-4 bandings

To allocate a Criticality Index for each asset the overall criticality is calculated for each asset within that asset category. An average criticality score can then be derived for each asset category and assets are allocated a Criticality Index based on their deviation from the average.

Criticality Index	Description	Definition
C1	'Low' criticality	<75% of the Average Overall Consequence Of Failure
C2	'Average' criticality	75%-125% of the Average Overall Consequence Of Failure
C3	'High' criticality	125%-200% of the Average Overall Consequence Of Failure
C4	'Very High' criticality	>200% of the Average Overall Consequence Of Failure

E.g. Primary circuit breaker average criticality is derived then each primary circuit breaker is categorised based on its overall criticality compared with the average criticality for primary circuit breakers.

4.4. Criticality movements over time

We have not made any assumptions on how asset criticality is likely to change over time, with the exception of changes due to planned investment. This is due to the fact that the main drivers for asset criticality remain relatively static over time (e.g. volume of oil contained within an asset) or are difficult to forecast reliably (e.g. changes in land usage).

4.5. Overall Risk

In order to provide a measure of overall risk the probability of failure associated with each Health Index score was multiplied by the consequence of failure to provide an overall risk metric. This is illustrated below.

11kV Secondary Switchgear – 2023 With Intervention
(Asset volume by HI & CI)

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	2549	1173	226	295	863	**5106**
CI2	2927	864	320	287	764	**5162**
CI3	1474	518	299	181	511	**2983**
CI4	348	145	36	41	185	**755**
Total HI	**7298**	**2700**	**881**	**804**	**2323**	14006

CI 1	CI 2	CI 3	CI 4
12,084	16,112	20,139	32,223

HI 1	HI 2	HI 3	HI 4	HI 5
0.00090	0.00107	0.00151	0.00314	0.00627

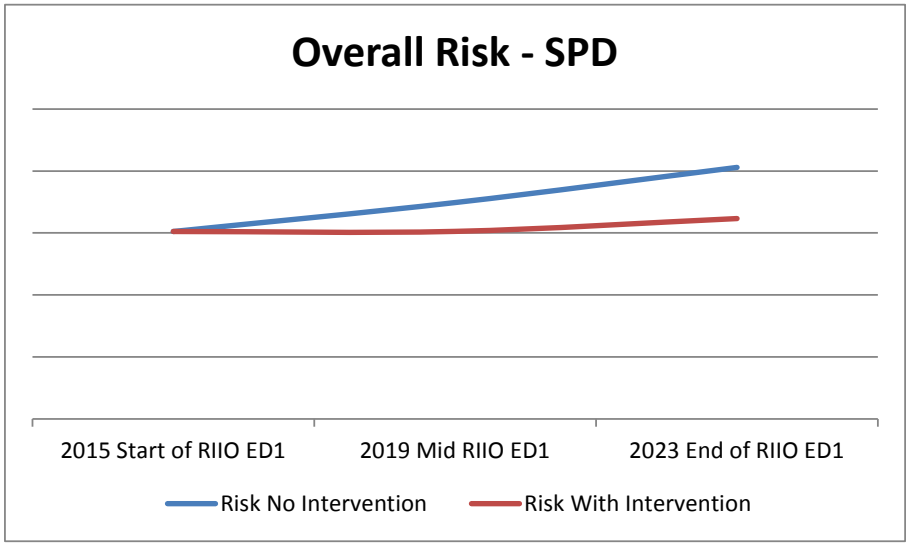
11kV Secondary Switchgear – 2023 With Intervention
(Asset Risk by HI & CI and totalled)

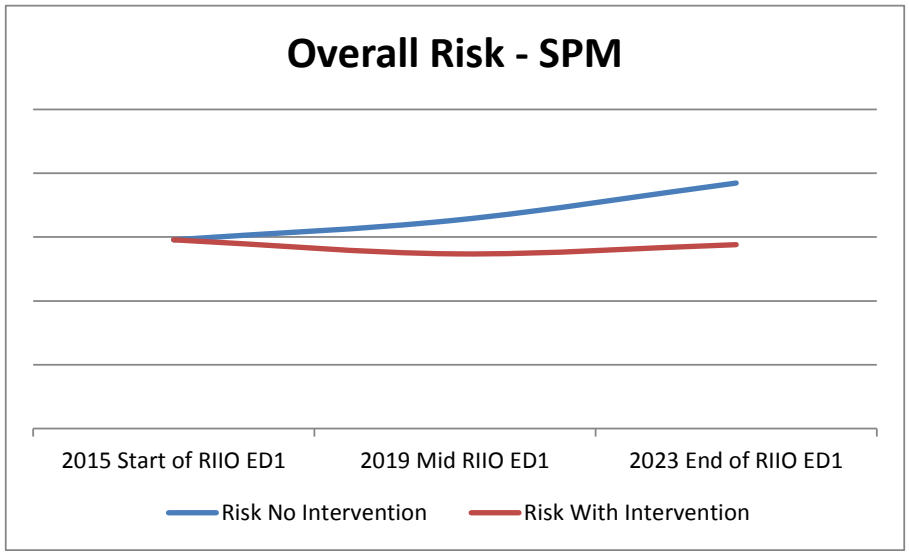
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	27,737	15,117	4,112	11,182	65,424	**123,572**
CI2	42,466	14,847	7,763	14,505	77,225	**156,806**
CI3	26,732	11,126	9,067	11,435	64,565	**122,925**
CI4	10,098	4,983	1,747	4,144	37,400	**58,372**
Total HI	**107,033**	**46,074**	**22,688**	**41,266**	**244,614**	461,674

This overall risk score was calculated for each Health Index asset and for the following scenarios:-

- *Starting point of RIIO ED1*
- *2019 excluding planned investment*
- *2023 excluding planned investment*
- *2019 including our planned investment*
- *2023 including out planned investment*

The overall risk for each asset category can be summated to provide an overall risk for our health index asset categories:-





5. IT solution

5.1. Health Index

We have developed a reporting tool that extracts data from SAP and ESRI to determine the Health Index and the Health Index movements for each asset category. This reporting tool utilises a series of logic rules in order to evaluate the Health Index of an asset before and after replacement, the logic rules are based on our own Health Index methodology documents:

- *SPEN ASSET-01-019*
- *SPEN SWG-02-007 - Switchgear Assessment (6kV, 11kV & 33kV)*
- *SPEN SWG-02-008 – Assessment of the operational adequacy of 132kV, 275kV and 400KV Switchgear*
- *SPEN TRAN-02-002 - Assessment of the operational adequacy of Transformers & Reactors (33kV & Above)*

When an asset is added, refurbished or disposed of, updates are received from the project managers undertaking these projects which detail the changes made. These changes are then reflected into the asset registers on our corporate data register systems. Only movements that have been captured in our corporate systems are recorded and claimed as valid Health Index changes. This ensures that we have a complete audit trail from the claimed outputs to our corporate IT systems.

5.2. Probability of Failure

In addition to our Health Index methodology we have also derived the probability of failure associated with each Health Index category. This has been based on annual Nafirs data and related back to health index where possible. It is worth noting that the results vary slightly between licensees and between asset categories and this is largely down to variations in make/model and/or environmental factors (e.g. indoor vs. outdoor, weather patterns). The results are shown below:-

	SPD				
HI_CRITERIA_ID	HI 1	HI 2	HI 3	HI 4	HI 5
LV POLE	0.000601	0.002104	0.00297	0.006188	0.012375
HV SWG PRIMARY	0.001181	0.000934	0.001319	0.002747	0.005494
HV SWG DISTRIB	0.000991	0.001241	0.001752	0.00365	0.0073
HV GM TRANSFORMER	0.000189	0.001913	0.0027	0.005625	0.01125
HV POLE	0.001121	0.002019	0.00285	0.005938	0.011875
EHV SWG	5E-07	0.001105	0.00156	0.00325	0.0065
EHV TRANSFORMER	5E-07	0.00952	0.01344	0.028	0.056
EHV OIL CABLE	5E-07	0.000106	0.00015	0.000313	0.000625
EHV POLES	0.0000	0.00085	0.0012	0.0025	0.005

	SPM				
HI_CRITERIA_ID	HI 1	HI 2	HI 3	HI 4	HI 5
LV POLE	0.000166	0.001913	0.0027	0.005625	0.01125
HV SWG PRIMARY	0.001081	0.000786	0.001109	0.002311	0.004623
HV SWG DISTRIB	0.000901	0.001067	0.001506	0.003137	0.006274
HV GM TRANSFORMER	0.000161	0.000708	0.001	0.002083	0.004167
HV POLE	0.000589	0.00212	0.002993	0.006234	0.012469
EHV SWG	0.000501	0.001063	0.0015	0.003125	0.00625
EHV TRANSFORMER	0.004561	0.00969	0.01368	0.0285	0.057
EHV OIL CABLE	5.05E-05	0.000106	0.00015	0.000313	0.000625
EHV POLES	0.000422	0.000895	0.001263	0.002632	0.005263
132 CIRCUIT BREAKERS	0.003521	0.00748	0.01056	0.022	0.044
132 TRANSFORMERS	0.006801	0.01445	0.0204	0.0425	0.085
132 GAS CABLE	8.05E-05	0.00017	0.00024	0.0005	0.001
132 OIL CABLE	5.05E-05	0.000106	0.00015	0.000313	0.000625
132 TOWERS	2.98E-05	6.23E-05	8.8E-05	0.000183	0.000367
132 LINES	0.000134	0.000283	0.0004	0.000833	0.001665

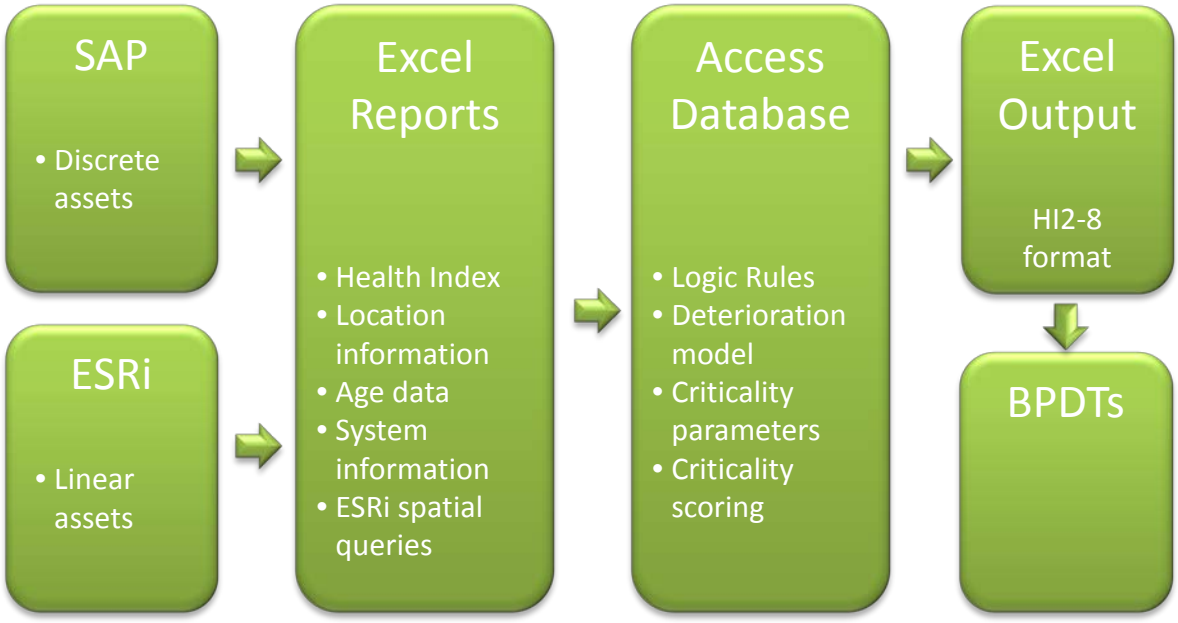
5.3. Criticality Index

In order to report asset health and criticality as per the requirements set out within the RIIO ED1 Business Plan Data Tables (BPDT) it is necessary to know both the Health Index and Criticality Index for each individual asset covered by Health Index reporting. This becomes a data intensive task particularly when considering high volume assets like wood poles and/or HV switchgear. Our initial submission in July 2013 was created in a spreadsheet model utilising extracts from our SAP and ESRi Corporate systems and although capable of providing accurate outputs was time consuming to refresh or modify.

To provide a more complete view of asset health & criticality across our asset base we have developed an interim database solution, which is capable of providing a view of Health & Criticality for the following assets:-

Asset Category	Methodology changes	Criticality Provided July 2013
LV OHL Support	Safety based on generic score plus on site locational risk assessment.	No
HV Switchgear (GM) - Primary		Yes
HV Switchgear (GM) - Distribution		Yes
HV Transformer (GM)		Yes
HV OHL Support - Poles	Safety based on generic score plus on site locational risk assessment.	No
EHV Switchgear (GM)	N-1 System methodology developed	Yes
EHV Transformer	N-1 System methodology developed	No
EHV UG Cable (Oil)		No
EHV OHL Support - Poles	Safety based on generic score plus on site locational risk assessment.	No
132kV CBs	N-1 System methodology developed	No
132kV Transformer	N-1 System methodology developed	No
132kV UG Cable (Gas)		No
132kV UG Cable (Oil)		No
132kV OHL Support - Tower		No
132kV OHL Fittings and Conductors (Tower Lines)		No

A high level functional diagram of the database is shown below with further detail on the calculation methodology available in section 9 of this document:-



The database alleviates the issues associated with data handling and also provides us with a mechanism to adjust the parameters associated with calculating criticality (e.g. coastal proximity multipliers for oil clean up). The database is designed to accept specific formats of extract reports from SAP and ESRi which can then be tied to specific assets through global asset identifications numbers.

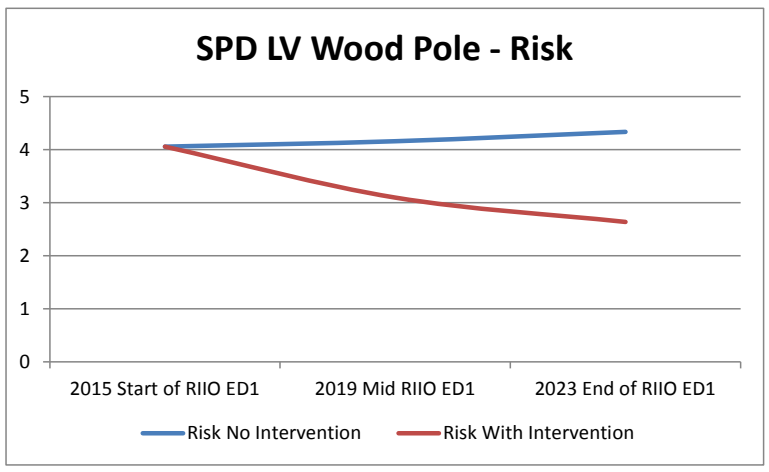
The impacts of planned interventions were applied in excel with the following allocation methodologies:-

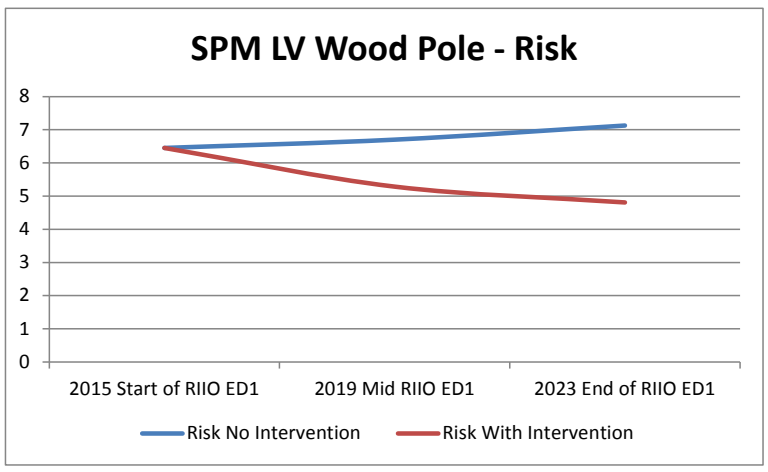
- *132kV and 33kV Plant – individual sites identified and their corresponding HI & CI movements mapped against the CI/HI profile.*
- *Remaining assets – HI movements identified and CI movements applied proportionate to the CI 1-4 population.*

6. Outputs

This section details the outputs from our health & criticality modelling for the RIIO ED1 period by asset category. Included for each asset category is a risk profile as outlined in section 4.e of this document and the detailed Health Index & Criticality Index movements associated with planned asset replacement and refurbishment activity taking place over the course of RIIO ED1.

6.1. LV Wood Poles





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	3154	1600	2339	1250	12539	**20882**
CI2	5259	2486	3430	1700	18945	**31820**
CI3	788	254	354	175	2766	**4337**
CI4	896	277	381	198	2596	**4348**
Total HI	**10097**	**4617**	**6504**	**3323**	**36846**	61387

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	11601	5785	7722	4086	30109	**59303**
CI2	9834	4858	6629	3357	22904	**47582**
CI3	2471	1102	1496	705	5737	**11511**
CI4	1868	941	1225	589	4538	**9161**
Total HI	**25774**	**12686**	**17072**	**8737**	**63288**	127557

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	7749	-1004	-1042	-969	-5045	**-311**
CI2	11561	-1559	-1527	-1317	-7622	**-464**
CI3	1505	-159	-158	-136	-1113	**-61**
CI4	1481	-174	-170	-153	-1044	**-60**
Total HI	**22296**	**-2896**	**-2897**	**-2575**	**-14824**	-896

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	15743	-2440	-2420	-2224	-9562	**-903**
CI2	12508	-2050	-2077	-1826	-7273	**-718**
CI3	2970	-465	-469	-384	-1822	**-170**
CI4	2405	-397	-384	-321	-1441	**-138**
Total HI	**33626**	**-5352**	**-5350**	**-4755**	**-20098**	-1929

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	10903	596	1297	281	7494	**20571**
CI2	16820	927	1903	383	11323	**31356**
CI3	2293	95	196	39	1653	**4276**
CI4	2377	103	211	45	1552	**4288**
Total HI	**32393**	**1721**	**3607**	**748**	**22022**	60491

SPM 2023 with Intervention

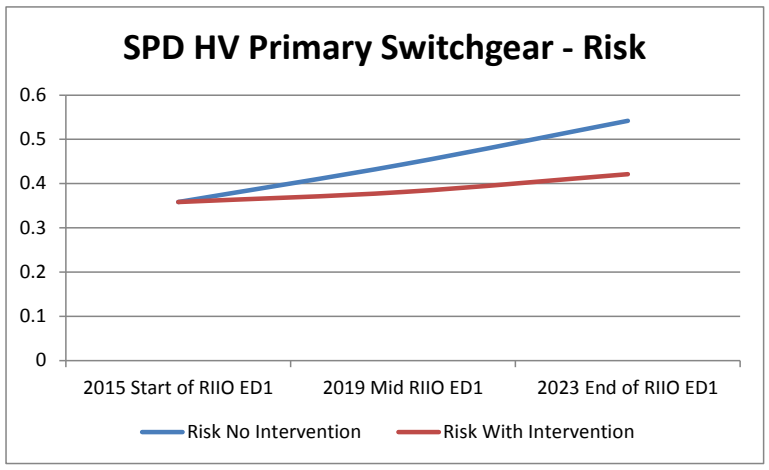
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	27344	3345	5302	1862	20547	**58400**
CI2	22342	2808	4552	1531	15631	**46864**
CI3	5441	637	1027	321	3915	**11341**
CI4	4273	544	841	268	3097	**9023**
Total HI	**59400**	**7334**	**11722**	**3982**	**43190**	125628

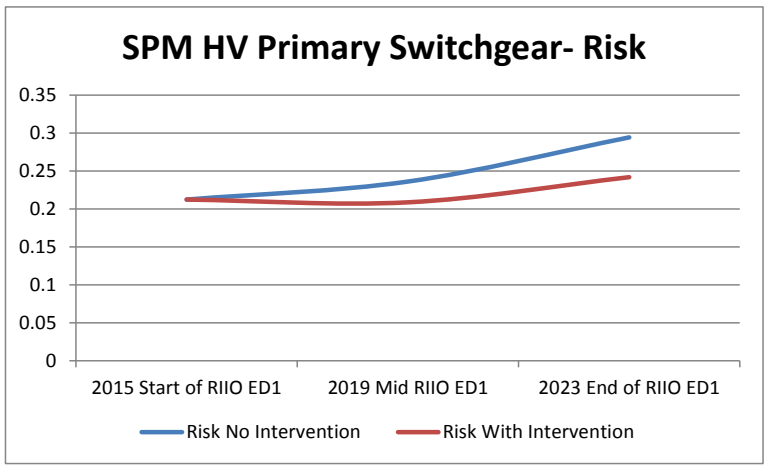
Interventions

We have three investment programmes that will impact on the health & criticality of LV wood pole assets.

- *ESQCR Low Ground Clearance – Replacement of wood poles or conductor where existing poles do not meet HSE requirements for the distance between conductors and the ground and/or other structures and obstacles. Will result in the removal of HI5 poles and the addition of HI1 poles*
- *LV Modernisation – Modernisation of our existing LV overhead lines that will result in a range of HI movements and the addition of HI1 poles. Not all poles are expected to be HI5 as modernisation will be targeted at villages or circuits.*
- *LV Undergrounding – Will result in the removal of LV poles with no corresponding addition.*

6.2. HV Primary Switchgear





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	357	452	410	292	483	**1994**
CI2	267	312	249	237	322	**1387**
CI3	82	181	165	76	168	**672**
CI4	54	150	123	83	75	**485**
Total HI	**760**	**1095**	**947**	**688**	**1048**	4538

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	558	653	597	420	353	**2581**
CI2	437	434	373	191	188	**1623**
CI3	111	215	195	98	127	**746**
CI4	104	123	129	65	100	**521**
Total HI	**1210**	**1425**	**1294**	**774**	**768**	5471

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	165	103	126	-229	-165	**0**
CI2	111	84	103	-187	-111	**0**
CI3	58	27	33	-60	-58	**0**
CI4	26	29	36	-65	-26	**0**
Total HI	**360**	**243**	**298**	**-541**	**-360**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	148	73	126	-199	-148	**0**
CI2	78	33	57	-90	-78	**0**
CI3	53	17	29	-46	-53	**0**
CI4	42	11	20	-31	-42	**0**
Total HI	**321**	**134**	**232**	**-366**	**-321**	0

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	522	555	536	63	318	**1994**
CI2	378	396	352	50	211	**1387**
CI3	140	208	198	16	110	**672**
CI4	80	179	159	18	49	**485**
Total HI	**1120**	**1338**	**1245**	**147**	**688**	4538

SPM 2023 with Intervention

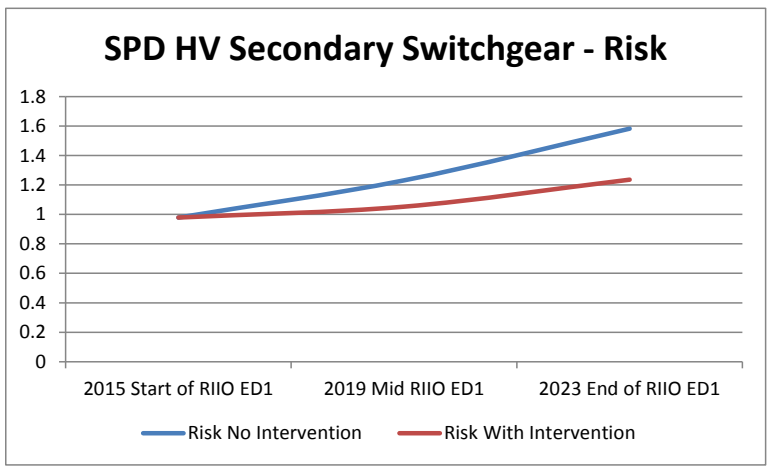
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	706	726	723	221	205	**2581**
CI2	515	467	430	101	110	**1623**
CI3	164	232	224	52	74	**746**
CI4	146	134	149	34	58	**521**
Total HI	**1531**	**1559**	**1526**	**408**	**447**	5471

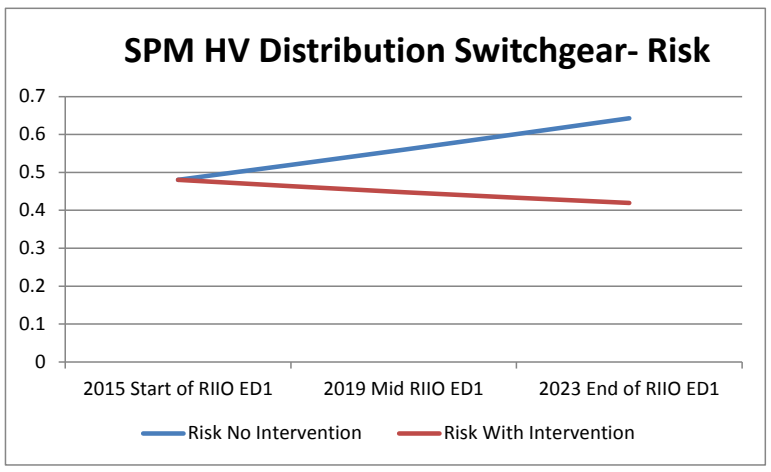
Interventions

We have three investment programmes that will impact on the health & criticality of HV Primary Switchgear assets.

- *Primary Circuit Breaker (CB) replacement – If the fixed portion of a primary CB is in poor condition and/or there is no suitable modern retrofit options of the moving portion we will replace the CB. Results in the removal of HI5 CBs and the addition of HI1 CBs*
- *Primary CB Retrofit – If there is a suitable retrofit option for the moving portion of a CB we will replace the moving portion and refurbish the fixed portion. Results in the movement of HI4s to HI2s*
- *Primary CB refurbishment – Refurbishment of Primary CBs will result in the movement of HI4s to HI3s*

6.3. HV Secondary Switchgear





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	2908	3897	443	689	2272	**10209**
CI2	2326	2648	473	669	1967	**8083**
CI3	1160	1128	215	227	822	**3552**
CI4	259	653	99	110	644	**1765**
Total HI	**6653**	**8326**	**1230**	**1695**	**5705**	23609

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	1858	1173	200	332	1609	**5172**
CI2	2094	864	284	323	1420	**4985**
CI3	1089	518	265	204	941	**3017**
CI4	278	145	32	46	333	**834**
Total HI	**5319**	**2700**	**781**	**905**	**4303**	14008

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	813	0	325	-325	-813	**0**
CI2	706	0	316	-316	-706	**0**
CI3	295	0	107	-107	-295	**0**
CI4	231	0	52	-52	-231	**0**
Total HI	**2045**	**0**	**800**	**-800**	**-2045**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	917	0	37	-37	-917	**0**
CI2	810	0	35	-35	-810	**0**
CI3	537	0	23	-23	-537	**0**
CI4	190	0	5	-5	-190	**0**
Total HI	**2454**	**0**	**100**	**-100**	**-2454**	0

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	3721	3897	768	364	1459	**10209**
CI2	3032	2648	789	353	1261	**8083**
CI3	1455	1128	322	120	527	**3552**
CI4	490	653	151	58	413	**1765**
Total HI	**8698**	**8326**	**2030**	**895**	**3660**	23609

SPM 2023 with Intervention

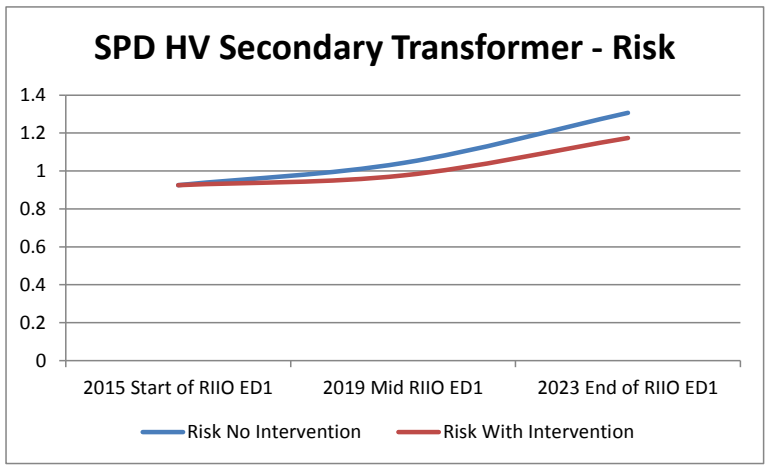
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	2775	1173	237	295	692	**5172**
CI2	2904	864	319	288	610	**4985**
CI3	1626	518	288	181	404	**3017**
CI4	468	145	37	41	143	**834**
Total HI	**7773**	**2700**	**881**	**805**	**1849**	14008

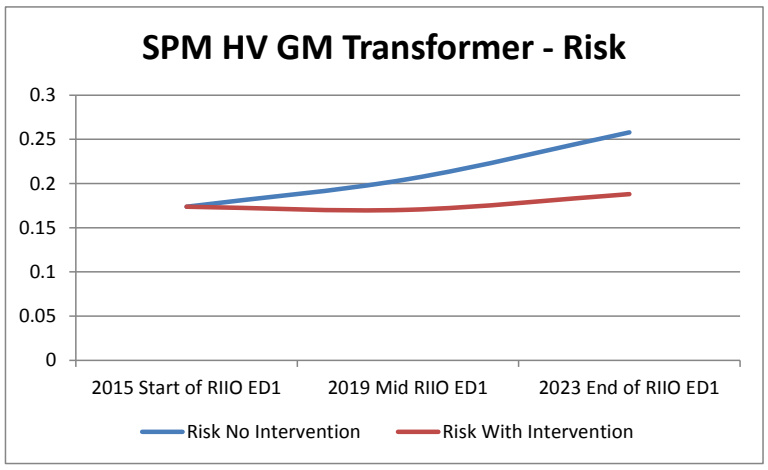
Interventions

We have two investment programmes that will impact on the health & criticality of HV Secondary Switchgear assets.

- *Secondary Switchgear replacement – The replacement of Ring Main Units (RMUs) and Network circuit breakers. Results in the removal of HI5 assets and the addition of HI1 assets*
- *Ring Main Unit (RMU) refurbishment – Refurbishment of RMUs will result in the movement of HI4s to HI3s*

6.4. HV Secondary Transformers





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	724	2003	1413	1715	1167	**7022**
CI2	234	996	1117	1712	1072	**5131**
CI3	198	519	449	994	615	**2775**
CI4	77	333	222	388	310	**1330**
Total HI	**1233**	**3851**	**3201**	**4809**	**3164**	16258

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	883	1485	949	906	722	**4945**
CI2	531	677	567	813	764	**3352**
CI3	302	352	371	530	486	**2041**
CI4	126	204	143	217	243	**933**
Total HI	**1842**	**2718**	**2030**	**2466**	**2215**	11271

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	263	0	0	0	-263	**0**
CI2	241	0	0	0	-241	**0**
CI3	139	0	0	0	-139	**0**
CI4	70	0	0	0	-70	**0**
Total HI	**713**	**0**	**0**	**0**	**-713**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	275	233	234	-467	-275	**0**
CI2	291	210	209	-419	-291	**0**
CI3	185	136	137	-273	-185	**0**
CI4	93	56	56	-112	-93	**0**
Total HI	**844**	**635**	**636**	**-1271**	**-844**	0

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	987	2003	1413	1715	904	**7022**
CI2	475	996	1117	1712	831	**5131**
CI3	337	519	449	994	476	**2775**
CI4	147	333	222	388	240	**1330**
Total HI	**1946**	**3851**	**3201**	**4809**	**2451**	16258

SPM 2023 with Intervention

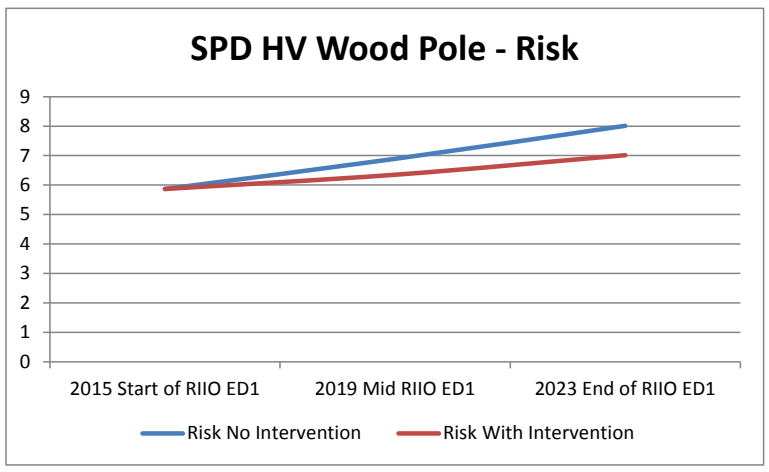
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	1158	1718	1183	439	447	**4945**
CI2	822	887	776	394	473	**3352**
CI3	487	488	508	257	301	**2041**
CI4	219	260	199	105	150	**933**
Total HI	**2686**	**3353**	**2666**	**1195**	**1371**	11271

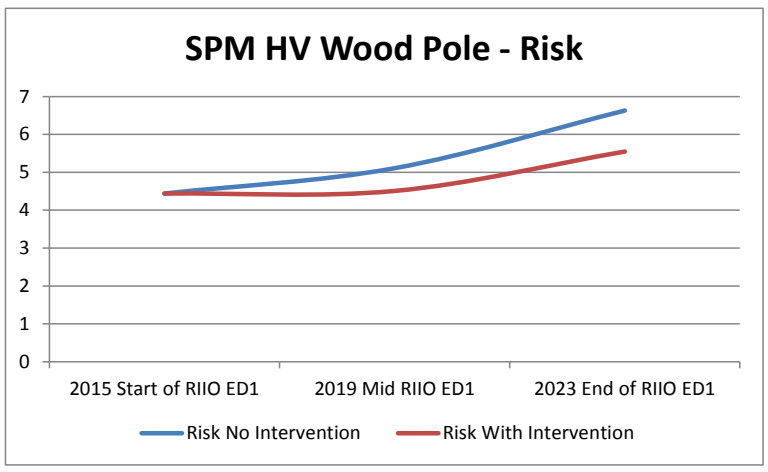
Interventions

We have three investment programmes that will impact on the health & criticality of HV Secondary Transformer assets.

- *Secondary Transformer replacement – The replacement of secondary transformers. Results in the removal of HI5 assets and the addition of HI1 assets*
- *Low Loss Transformer installation - Targeted replacement programme focusing on high loss pre 1961 transformers. Results in the removal of HI5 assets and the addition of HI1 assets*
- *Secondary transformer refurbishment – Refurbishment of existing secondary transformers utilising traveller units (Transformers that have been removed from site are refurbished in house and installed at another site at a later date). Results in the movement of HI3-4 assets to HI2-3 assets.*

6.5. HV Wood Pole





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	1308	3237	3656	1120	3774	**13095**
CI2	21741	33255	42251	21159	39490	**157896**
CI3	2197	3069	4102	2143	4648	**16159**
CI4	122	279	308	136	301	**1146**
Total HI	**25368**	**39840**	**50317**	**24558**	**48213**	188296

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	**0**
CI2	22722	24524	37338	28485	41829	**154898**
CI3	1688	1690	2378	1785	2875	**10416**
CI4	83	67	88	104	136	**478**
Total HI	**24493**	**26281**	**39804**	**30374**	**44840**	165792

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	2105	-688	-616	-361	-440	**0**
CI2	25606	-7072	-7114	-6813	-4607	**0**
CI3	2576	-653	-691	-690	-542	**0**
CI4	190	-59	-52	-44	-35	**0**
Total HI	**30477**	**-8472**	**-8473**	**-7908**	**-5624**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	**0**
CI2	27892	-7317	-7355	-6863	-6356	**1**
CI3	1839	-504	-468	-430	-437	**0**
CI4	83	-20	-17	-25	-21	**0**
Total HI	**29814**	**-7841**	**-7840**	**-7318**	**-6814**	1

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	3413	2549	3040	759	3334	**13095**
CI2	47347	26183	35137	14346	34883	**157896**
CI3	4773	2416	3411	1453	4106	**16159**
CI4	312	220	256	92	266	**1146**
Total HI	**55845**	**31368**	**41844**	**16650**	**42589**	188296

SPM 2023 with Intervention

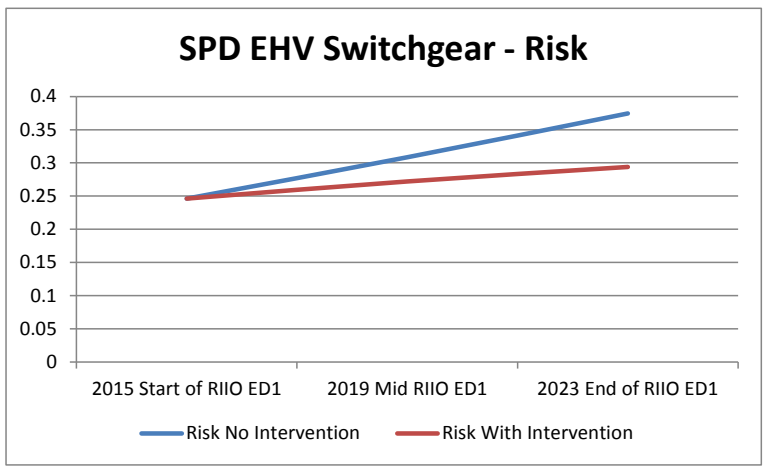
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	**0**
CI2	50614	17207	29983	21622	35473	**154899**
CI3	3527	1186	1910	1355	2438	**10416**
CI4	166	47	71	79	115	**478**
Total HI	**54307**	**18440**	**31964**	**23056**	**38026**	165793

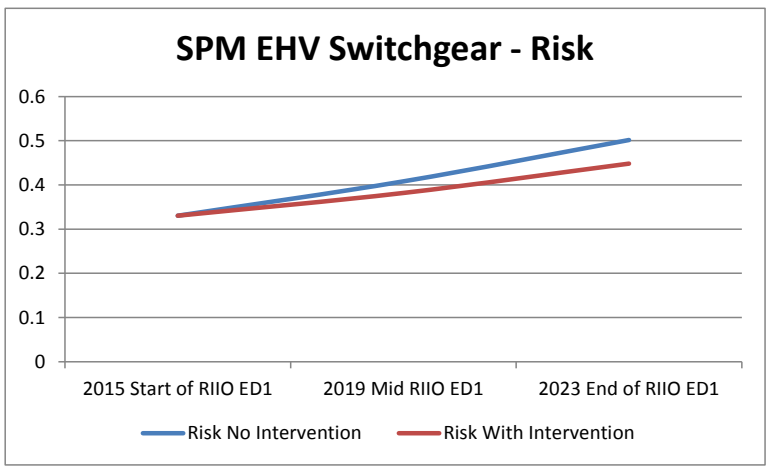
Interventions

We have three investment programmes that will impact on the health & criticality of HV Wood Pole assets.

- *HV wood pole rebuild – Targeted at a circuit level and addressing both condition and weather resilience issues. Results in the removal of HI5 assets and the addition of HI1 assets will result in a range of HI movements and the addition of HI1 poles. Not all poles are expected to be HI5 as modernisation will be targeted at circuits.*
- *HV Pole replacement – Based on pole condition results in the removal of HI5 assets and the addition of HI1 assets*
- *ESQCR Low Ground Clearance - Replacement of wood poles or conductor where existing poles do not meet HSE requirements for the distance between conductors and the ground and/or other structures and obstacles. Will result in the removal of HI5 poles and the addition of HI1 poles*

6.6. EHV Switchgear





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	134	106	48	48	149	485
CI2	78	30	21	17	126	272
CI3	54	59	31	23	65	232
CI4	17	12	3	7	47	86
Total HI	283	207	103	95	387	1075

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	188	238	161	259	562	1408
CI2	12	41	53	41	55	202
CI3	3	19	19	12	13	66
CI4	21	111	93	65	200	490
Total HI	224	409	326	377	830	2166

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	68	0	0	-4	-64	0
CI2	36	-2	-4	0	-30	0
CI3	15	-6	-1	-1	-7	0
CI4	0	0	0	0	0	0
Total HI	119	-8	-5	-5	-101	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	204	-2	-1	-20	-127	54
CI2	16	0	0	-3	-9	4
CI3	11	0	0	-1	-7	3
CI4	20	0	0	0	-15	5
Total HI	251	-2	-1	-24	-158	66

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	202	106	48	44	85	485
CI2	114	28	17	17	96	272
CI3	69	53	30	22	58	232
CI4	17	12	3	7	47	86
Total HI	402	199	98	90	286	1075

SPM 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	392	236	160	239	435	1462
CI2	28	41	53	38	46	206
CI3	14	19	19	11	6	69
CI4	41	111	93	65	185	495
Total HI	475	407	325	353	672	2232

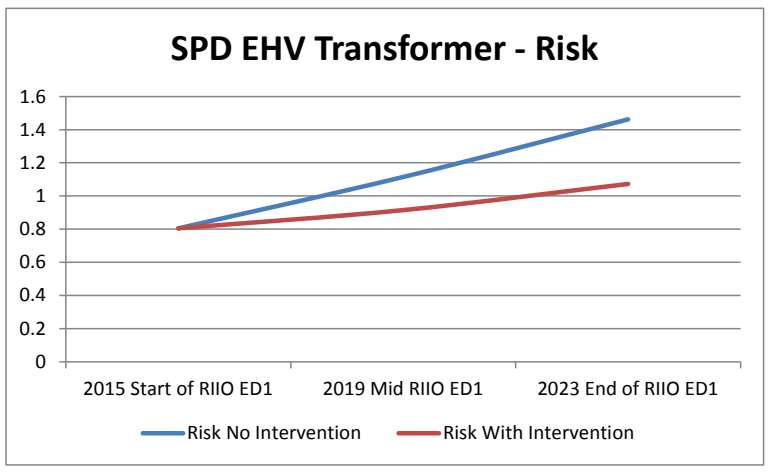
Interventions

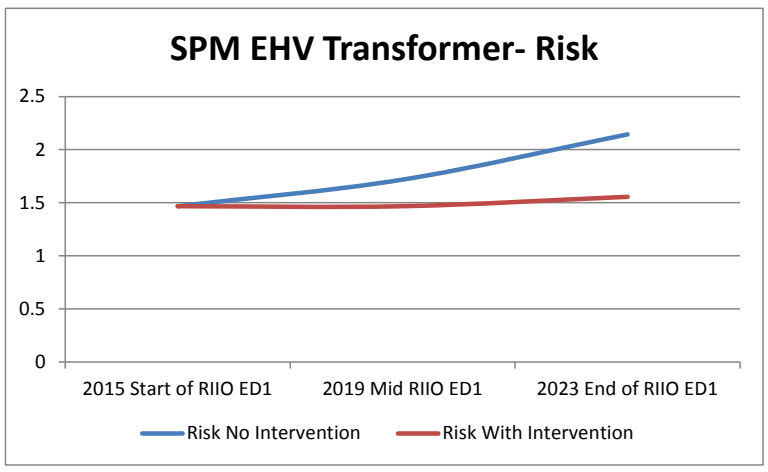
We have two investment programmes that will impact on the health & criticality of EHV Switchgear assets.

- *EHV Circuit Breaker replacement – The replacement of EHV Circuit Breakers based on condition. Results in the removal of HI5 assets and the addition of HI1 assets*

- *EHV RMU replacement - The replacement of EHV RMUs based on condition. Typically results in the removal of 1 HI5 asset and the addition of 3x HI1 assets. This is because there is no commercially viable modern equivalent of the EHV RMU and so 3x EHV CBs are installed instead.*

6.7. EHV Transfomers





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	34	57	56	70	61	**278**
CI2	44	54	63	73	67	**301**
CI3	11	17	35	40	31	**134**
CI4	1	12	13	8	9	**43**
Total HI	**90**	**140**	**167**	**191**	**168**	756

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	45	73	72	42	98	**330**
CI2	41	82	83	35	75	**316**
CI3	24	45	46	12	39	**166**
CI4	0	0	0	0	0	**0**
Total HI	**110**	**200**	**201**	**89**	**212**	812

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	26	31	0	-31	-26	**0**
CI2	25	32	0	-32	-25	**0**
CI3	6	18	0	-18	-6	**0**
CI4	4	4	0	-4	-4	**0**
Total HI	**61**	**85**	**0**	**-85**	**-61**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	45	23	0	-23	-45	**0**
CI2	29	19	0	-19	-29	**0**
CI3	15	6	0	-6	-15	**0**
CI4	0	0	0	0	0	**0**
Total HI	**89**	**48**	**0**	**-48**	**-89**	0

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	60	88	56	39	35	**278**
CI2	69	86	63	41	42	**301**
CI3	17	35	35	22	25	**134**
CI4	5	16	13	4	5	**43**
Total HI	**151**	**225**	**167**	**106**	**107**	756

SPM 2023 with Intervention

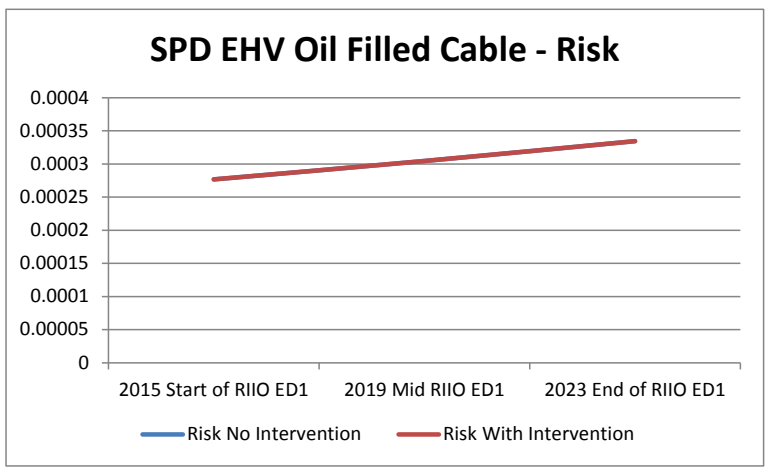
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	90	96	72	19	53	**330**
CI2	70	101	83	16	46	**316**
CI3	39	51	46	6	24	**166**
CI4	0	0	0	0	0	**0**
Total HI	**199**	**248**	**201**	**41**	**123**	812

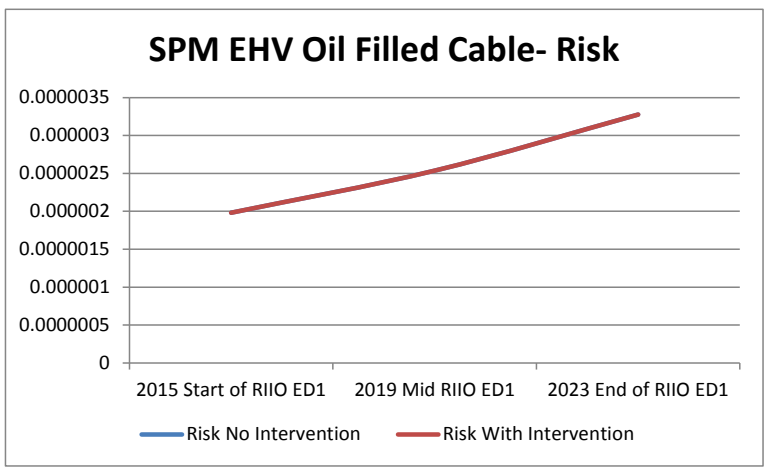
Interventions

We have two investment programmes that will impact on the health & criticality of EHV Transformer assets.

- *EHV Transformer replacement – The replacement of EHV Transformers based on condition. Results in the removal of HI5 assets and the addition of HI1 assets*
- *EHV Transformer refurbishment - The refurbishment of EHV transformers. Typically results in the movement of an HI4 asset to an HI2 asset*

6.8. EHV Oil Filled Cable





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0.2	1.2	2.6	3.4	0.4	**7.8**
CI2	0.3	2.4	2.7	4.6	3.4	**13.5**
CI3	0.3	1.9	2.3	2.3	0.9	**7.7**
Total HI	**0.8**	**5.5**	**7.6**	**10.3**	**4.7**	28.9

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0.0	0.0	0.0	0.0	0.0	**0.0**
CI2	0.0	0.2	0.0	0.0	0.2	**0.5**
CI3	0.0	0.0	0.0	0.0	0.0	**0.0**
Total HI	**0.0**	**0.2**	**0.0**	**0.0**	**0.2**	0.5

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	**0**
CI2	0	0	0	0	0	**0**
CI3	0	0	0	0	0	**0**
Total HI	**0**	**0**	**0**	**0**	**0**	0

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	**0**
CI2	0	0	0	0	0	**0**
CI3	0	0	0	0	0	**0**
Total HI	**0**	**0**	**0**	**0**	**0**	0

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0.2	1.2	2.6	3.4	0.4	**7.8**
CI2	0.3	2.4	2.7	4.6	3.4	**13.5**
CI3	0.3	1.9	2.3	2.3	0.9	**7.7**
Total HI	**0.8**	**5.5**	**7.6**	**10.3**	**4.7**	28.9

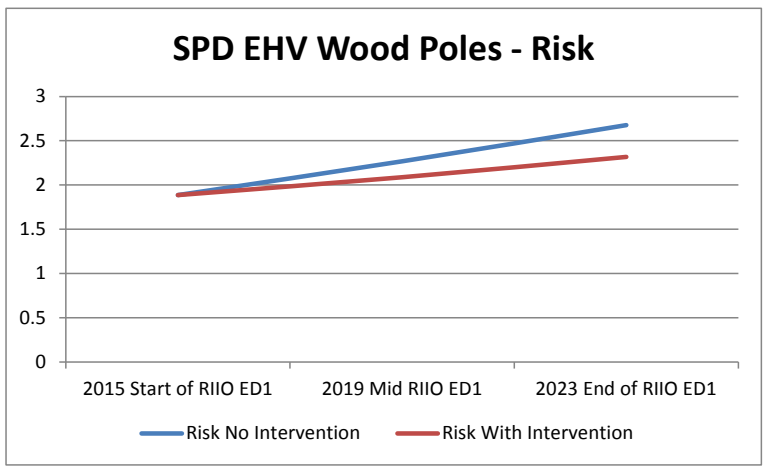
SPM 2023 with Intervention

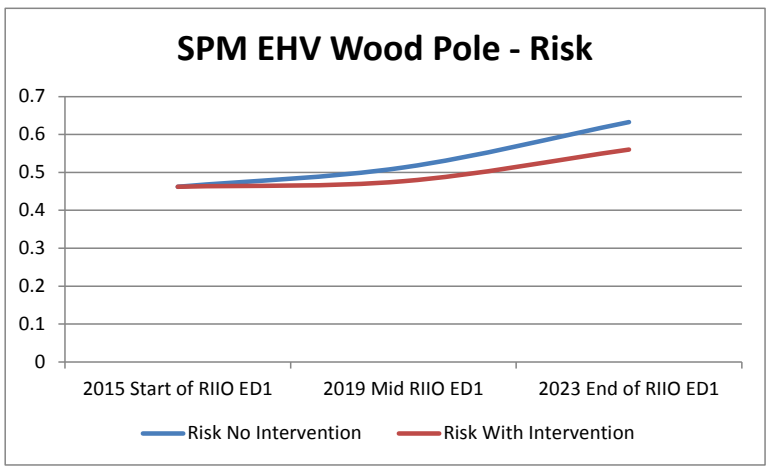
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0.0	0.0	0.0	0.0	0.0	**0.0**
CI2	0.0	0.2	0.0	0.0	0.2	**0.5**
CI3	0.0	0.0	0.0	0.0	0.0	**0.0**
Total HI	**0.0**	**0.2**	**0.0**	**0.0**	**0.2**	0.5

Interventions

We have no specified plans to invest in EHV Oil filled cable however based on condition there is a possibility that we would target EHV oil filled circuits under our EHV cable modernisation programme.

6.9. EHV Poles





SPD 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	2270	2133	3530	774	2139	**10846**
CI2	3436	3772	6737	2719	3071	**19735**
CI3	1731	1184	1974	494	2237	**7620**
CI4	10	0	95	117	39	**261**
Total HI	**7447**	**7089**	**12336**	**4104**	**7486**	38462

SPM 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	496	719	1388	606	975	**4184**
CI2	1117	2440	4650	1622	2957	**12786**
CI3	891	716	1228	358	558	**3751**
CI4	6	2	28	38	27	**101**
Total HI	**2510**	**3877**	**7294**	**2624**	**4517**	20822

SPD Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	1309	-459	-437	-269	-145	**-1**
CI2	2787	-810	-831	-940	-207	**-1**
CI3	820	-253	-244	-171	-152	**0**
CI4	55	0	-12	-40	-3	**0**
Total HI	**4971**	**-1522**	**-1524**	**-1420**	**-507**	-2

SPM Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	676	-189	-194	-220	-73	**0**
CI2	2100	-641	-650	-588	-222	**-1**
CI3	532	-188	-172	-130	-42	**0**
CI4	21	-1	-4	-14	-2	**0**
Total HI	**3329**	**-1019**	**-1020**	**-952**	**-339**	-1

SPD 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	3579	1674	3093	505	1994	**10845**
CI2	6223	2962	5906	1779	2864	**19734**
CI3	2551	931	1730	323	2085	**7620**
CI4	65	0	83	77	36	**261**
Total HI	**12418**	**5567**	**10812**	**2684**	**6979**	38460

SPM 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	1172	530	1194	386	902	**4184**
CI2	3217	1799	4000	1034	2735	**12785**
CI3	1423	528	1056	228	516	**3751**
CI4	27	1	24	24	25	**101**
Total HI	**5839**	**2858**	**6274**	**1672**	**4178**	20821

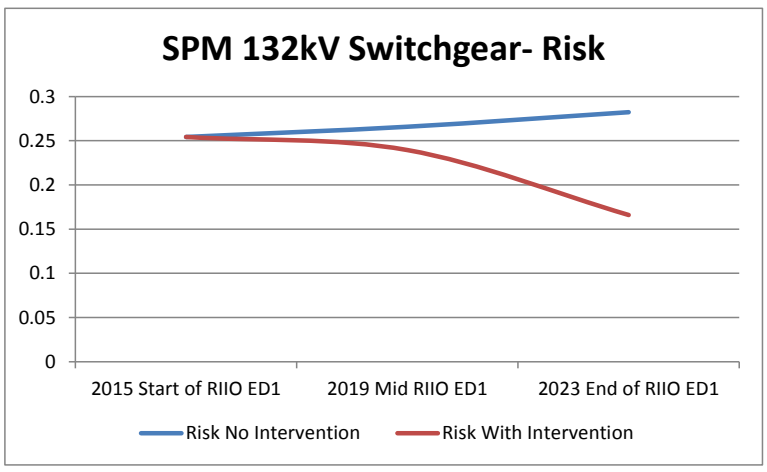
Interventions

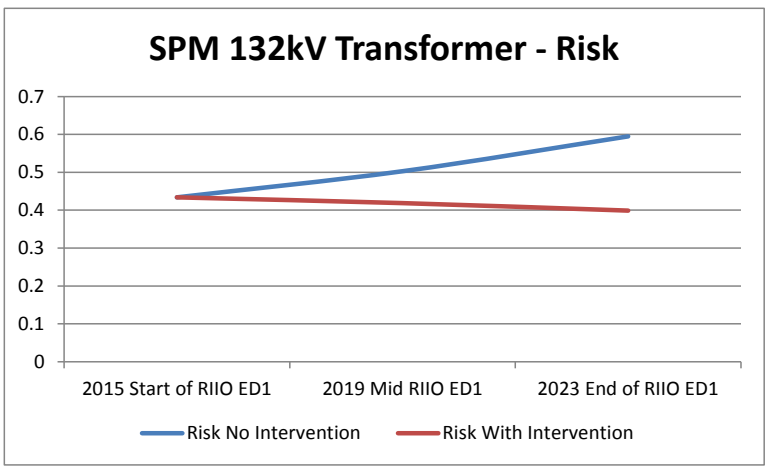
We have two investment programmes that will impact on the health & criticality of EHV Wood Pole assets.

- *EHV wood pole rebuild – Targeted at a circuit level and addressing both condition and weather resilience issues. Results in the removal of HI5 assets and the addition of HI1 assets will result in a range of HI movements and the addition of HI1 poles. Not all poles are expected to be HI5 as modernisation will be targeted at circuits.*

- *EHV Pole replacement – Based on pole condition results in the removal of HI5 assets and the addition of HI1 assets*

6.10. 132kV Switchgear and Transformers





Switchgear 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	17	25	8	3	28	81
CI2	27	23	0	0	23	73
CI3	13	11	3	2	30	59
CI4	1	0	0	0	4	5
Total HI	58	59	11	5	85	218

Transformer 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	6	9	14	6	21	56
CI2	7	13	15	7	19	61
CI3	3	2	2	2	6	15
CI4	1	2	1	4	3	11
Total HI	17	26	32	19	49	143

Switchgear Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	12	0	0	0	-12	0
CI2	23	0	0	0	-23	0
CI3	15	-2	0	0	-13	0
CI4	0	0	0	0	0	0
Total HI	50	-2	0	0	-48	0

Transformer Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	10	5	0	-6	-9	0
CI2	6	6	0	-6	-6	0
CI3	5	2	0	-2	-5	0
CI4	0	3	0	-3	0	0
Total HI	21	16	0	-17	-20	0

Switchgear 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	29	25	8	3	16	81
CI2	50	23	0	0	0	73
CI3	28	9	3	2	17	59
CI4	1	0	0	0	4	5
Total HI	108	57	11	5	37	218

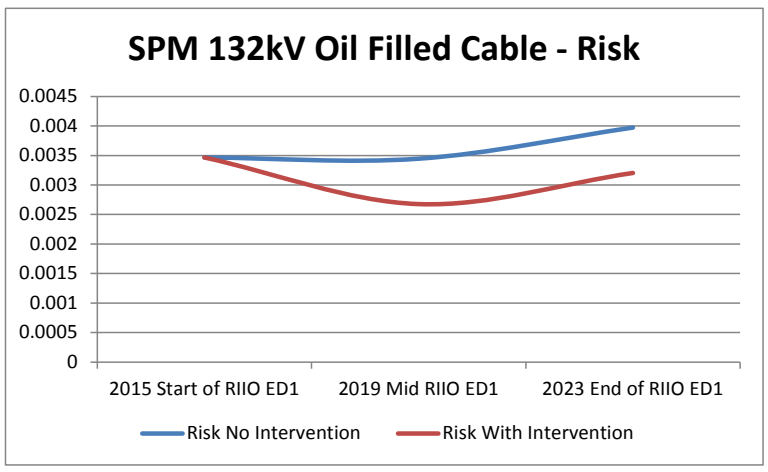
Transformer 2023 with Intervention

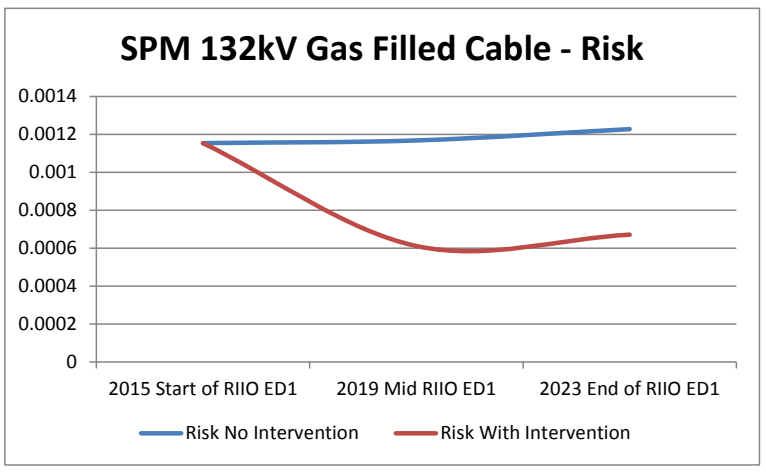
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	16	14	14	0	12	56
CI2	13	19	15	1	13	61
CI3	8	4	2	0	1	15
CI4	1	5	1	1	3	11
Total HI	38	42	32	2	29	143

Interventions

For 132kV Plant assets we have targeted the specific sites based on their condition and will carry out all works to bring the level of risk to an acceptable level. The results of these interventions have been incorporated into our HI & CI movements.

6.11. 132kV Gas and Oil Filled cable





132kV Gas Cable 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	-
CI2	1.38	6.24	4.00	1.33	8.23	21
CI3	0	0	0	0	0	-
CI4	0	0	0	0	0	-
Total HI	1	6	4	1	8	21

132kV Oil Cable 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	-
CI2	12.0	37.3	25.8	48.4	23.5	147
CI3	0.0	3.6	2.3	3.1	0.0	9
CI4	0.0	0.0	0.0	0.0	2.6	3
Total HI	12	41	28	52	26	159

132kV Gas Cable Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	0
CI2	0	0	0	0	-5	-5
CI3	0	0	0	0	0	0
CI4	0	0	0	0	0	0
Total HI	0	0	0	0	-5	-5

132kV Oil Cable Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	0
CI2	0	0	0	0	-8.28	-8.28
CI3	0	0	0	0	0.00	0.00
CI4	0	0	0	0	-2.62	-2.62
Total HI	0	0	0	0	-10.9	-10.9

132kV Gas Cable 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	0
CI2	1.38	6.24	4.00	1.33	3.23	16.18
CI3	0	0	0	0	0	0.00
CI4	0	0	0	0	0	0.00
Total HI	1.38	6.24	4.00	1.33	3.23	16.18

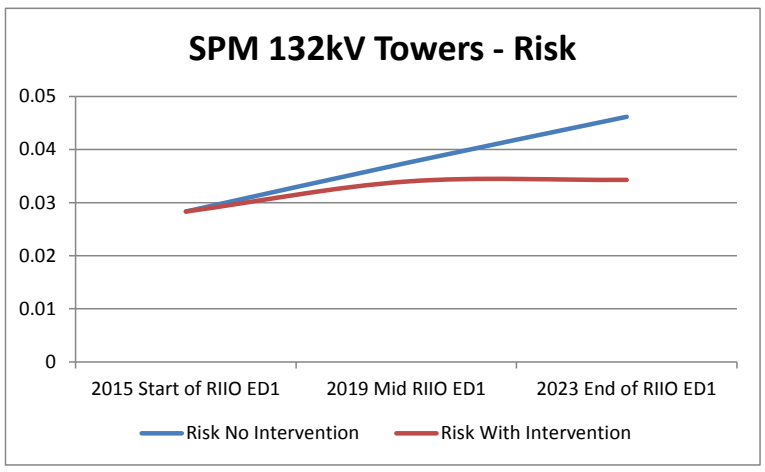
132kV Oil Cable 2023 with Intervention

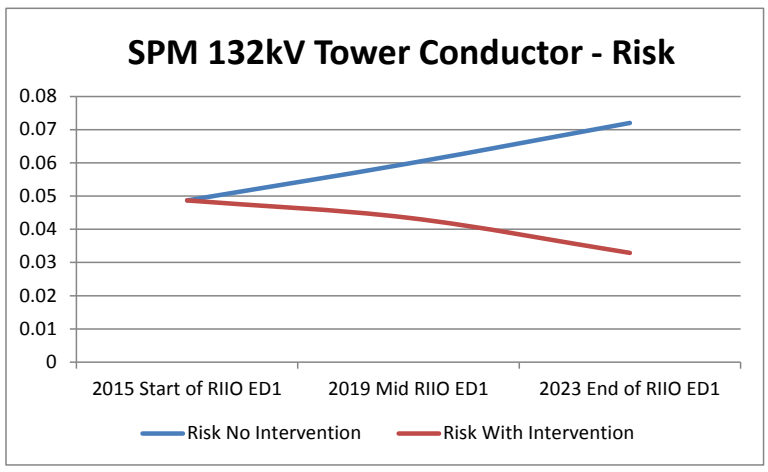
	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	0	0	0	0	0.00
CI2	12.00	37.28	25.82	48.40	15.22	138.72
CI3	0.00	3.60	2.32	3.12	0.00	9.04
CI4	0.0	0.0	0.0	0.0	0.0	0.00
Total HI	12.00	40.88	28.14	51.53	15.22	147.76

Interventions

For 132kV Cable assets we have targeted the specific circuits and will remove the existing oil or gas filled cable on these circuits. There is no corresponding addition as 132kV Non pressurised cable will be added to the network.

6.12. 132kV Towers and 132kV Tower Line Conductor





132kV Towers 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	15	4	11	32	127	**189**
CI2	158	4	115	533	1579	**2389**
CI3	11	0	21	75	33	**140**
CI4	0	0	0	0	0	**0**
Total HI	**184**	**8**	**147**	**640**	**1739**	2718

132kV Conductor 2023 No Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	3.0	0.0	2.1	6.7	13.5	**25**
CI2	72.0	46.3	271.8	94.2	501.5	**986**
CI3	12.0	4.4	27.3	9.5	45.9	**99**
CI4	0.0	0.0	0.0	0.0	0.0	**-**
Total HI	**87**	**51**	**301**	**110**	**561**	1,110

132kV Towers Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	0	40	-6	-20	-32	**-18**
CI2	0	565	-59	-329	-398	**-221**
CI3	0	61	-11	-46	-9	**-5**
CI4	0	0	0	0	0	**0**
Total HI	**0**	**666**	**-76**	**-395**	**-439**	-244

132kV Conductor Planned Interventions

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	9	0	0	0	-10	**-1**
CI2	328	0	0	0	-368	**-40**
CI3	30	0	0	0	-34	**-4**
CI4	0	0	0	0	0	**0**
Total HI	**367**	**0**	**0**	**0**	**-412**	-45

132kV Towers 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	15	44	5	12	95	**171**
CI2	158	569	56	204	1181	**2168**
CI3	11	61	10	29	24	**135**
CI4	0	0	0	0	0	**0**
Total HI	**184**	**674**	**71**	**245**	**1300**	2474

132kV Conductor 2023 with Intervention

	HI1	HI2	HI3	HI4	HI5	Total CI
CI1	12.0	0.0	2.1	6.7	3.5	**24.2**
CI2	400.0	46.3	271.8	94.2	133.5	**945.8**
CI3	42.0	4.4	27.3	9.5	11.9	**95.1**
CI4	0.0	0.0	0.0	0.0	0.0	**0.0**
Total HI	**454.0**	**50.7**	**301.2**	**110.4**	**148.9**	1065.1

Interventions

For 132kV OHL assets we have targeted specific circuits based on their condition and will carry out all works to bring the level of risk to an acceptable level. The results of these interventions have been incorporated into our HI & CI movements.

7. Roadmap for delivery & efficient expenditure

The IT solution in section 5 of this document provides a robust output for health & criticality however it requires reports to be manually run and refreshed in the database. Ultimately we believe that health & criticality reporting needs to be integrated into our corporate IT systems. To that end we are in the process of implementing a lasting solution which will be implemented prior to the commencement of RIIO ED1. Implementing such a system and integrating it with our corporate systems will be a significant commitment but will ensure that we have a reporting methodology capable of providing live updates on our Health Index & Criticality Index position and satisfying the reporting requirements for RIIO ED1.

8. Uncertainty & risk

8.1. Long term uncertainties and risks

Any long term modelling of asset condition and risk has an inherent level of uncertainty. Risk modelling is also highly dependent on the quality and availability of information used to derive the model outputs.

8.2. Mitigation of uncertainties & risks

We are in the process of implementing an asset health and criticality modelling tool that will be fully integrated with our corporate systems. The existing model has utilised corporate system information to derive Health Index and Criticality Index scores, this has been supplemented by additional information e.g. (Dissolved Gas Analysis reports).

Over the course of RIIO ED1, we plan to capture and record additional information within our corporate systems to improve our Health Index, Criticality Index and future Health Index modelling. We also plan to refine our deterioration modelling by including site specific factors for each asset e.g. Indoor assets will deteriorate slower than an equivalent outdoor asset.

9. Criticality model detailed parameters

The following section details the calculations and parameters which are used to quantify the financial consequence of asset failure within our criticality database.

9.1. Safety

The cost associated with safety is separated into three consequences; the cost of a minor injury, major injury and a fatality. These costs were sourced from HSE guidance and have been applied across the industry in determining asset criticality. The probability of each consequence is then multiplied by the costs and then summated to calculate a Generic Safety Risk for each asset category.

$$\begin{aligned}\text{Total Safety Cost} = {} & (\text{Prob of Fatality} \times \text{Cost of Fatality}) \\ & + (\text{Prob of Major Injury} \times \text{Cost of Major Injury}) \\ & + (\text{Prob of Minor Injury} \times \text{Cost of Minor Injury})\end{aligned}$$

The generic safety risk associated with each asset category is shown below:-

Asset Category	Generic Safety Risk (£)
LV Boards	£560
LV Link Boxes	£1,400
LV Network Pillars	£5,600
HV Primary Switchgear	£2,800
HV Distribution Switchgear	£2,800
HV Distribution Transformers	£1,400
EHV Switchgear	£2,800
EHV Transformers	£1,400
EHV Circuit Breakers	£2,800
132kV Transformers	£1,400
LV OHL Supports	£5,600
HV OHL Supports	£5,600
EHV OHL Supports	£5,600
132kV OHL Supports - Towers	£28,000
132kV OHL - Conductor & Fittings	£28,000
EHV UG Cable (Gas)	£2,800
EHV UG Cable (Oil)	£5,600
132kV UG Cable (Gas)	£2,800
132kV UG Cable (Oil)	£5,600

The generic safety scores are then adjusted based on the operating environment of the individual asset.

Proximity Customers (within 50m)		
low	high	Multiplier
0	4	**1**
5	14	**2**
15	49	**3**
50	99	**4**
100	>100	**5**

The current model is based on the proximity of connected customers within a selected radius of the asset. This was sourced via a spatial query on our ESRI system for each substation asset. We plan to incorporate additional factors to further refine the relative risk between assets but this is dependent on site specific safety assessments being carried out and captured in our corporate systems.

For wood pole assets the generic score was weighted based on specific on-site risk assessments that have been stored in our corporate systems.

Wood Pole Risk Multiplier	
Lower than Normal	0.7
Normal	1
Higher than Normal	1.3

9.2. System

System consequence is split into three areas; Customer Minutes Lost, Customers Interrupted, and Value of Lost Load. For every Customer Interrupted a penalty of £15.44 will be imposed during ED1. Similarly, for every Customer Minute Lost a £0.38 penalty is imposed. These values are based on SPEN's current CI/CML targets and may be subject to change over time.

Calculating the System consequence is complicated by the presence of midpoint protection and automation. These factors will reduce the number of customers that are affected by an assets failure however; incorporating these mechanisms was beyond the scope of our modelling.

Similarly, on the n-1 network the calculation process is complicated by the redundancy that is built into the network to allow an element of security of supply. An asset failure on the n-1 network may not necessarily result in customers off supply since there are varying degrees of redundancy on the network.

The methodologies to determine the approximate number of customers (CI) that would be affected by the failure an asset are shown below:

- *HVCI – A process currently used by SPEN to populate the list of disaggregated performance circuits given to Ofgem annually. Used for HV Primary and Secondary GM Switchgear and HV Transformers.*
- *LV Poles: Based on number of customers connected to its secondary transformer. If unknown based on the Zone average LV CI from NAFIRS.*
- *HV Poles: Very complex calculation (main & spur, re-closers, sectionalisers, …). Based on the number of customers connected to the HV circuit divided by total number of transformers in the HV circuit. If unknown based on the Zone average HV CI from NAFIRS.*
- *EHV Transformers: Based on Customers fed from Primary Substation and the Zone average %of EHV Faults causing Customers Interruption from NAFIRS.*
- *EHV Switchgear: Based on Customers and number of Primary Substations fed from Grid Substation and the Zone average % of EHV Faults causing Customers Interruption from NAFIRS.*
- *EHV Poles and Cables: Based on Customers fed from Primary substations connected to the circuit and the Zone average % of EHV Faults causing Customers Interruption from NAFIRS.*
- *132kV Transformers: Based on Customers fed from Grid Substation and the SPM average % of 132kV Faults causing Customers Interruption from NAFIRS.*
- *132kV Switchgear: Based on Customers and number of Grid Substations fed from SuperGrid Substation and the SPM average % of 132kV Faults causing Customers Interruption from NAFIRS.*
- *132kV OHL, Cable: Based on Customers and number of Grid connected to the circuit and the SPM average % of 132kV Faults causing Customers Interruption from NAFIRS.*

The length of time (CML) has been determined by the average restoration time in each operational zone. This is not intended to be an accurate restoration time but aims to account for urban vs. rural environments.

NAFIRS AVERAGE							
ZONE	LV_CML	HV_CML	EHV_CML	EHV CI Risk	LV_CI	HV_CI	EHV_CI
Glasgow & Clyde North	172	81	26	10%	22	440	1645
Lanarkshire	217	164	19	8%	20	286	3946
Edinburgh & Lothians	163	175	33	16%	19	348	2480
Borders	256	161	23	40%	11	152	809
Central & Fife	209	150	28	18%	17	372	4166
Dumfries & Stranraer	261	154	200	23%	8	134	1315
Ayrshire & Clyde South	213	114	128	15%	15	286	5748
Dee Valley	164	69	41	15%	8	213	2006
Merseyside	246	111	65	2%	10	341	2675
Mid Cheshire	173	86	38	16%	10	209	1338
Mid Wales	149	79	6	18%	7	148	2390
North Wales	184	82	29	19%	8	169	1978
Wirral	164	116	11	15%	9	145	7988
132kV_CML	26						
132kV_Risk	12%						

9.3. Environment

Environmental consequence has been determined by quantifying the financial impact caused by the leakage and clean-up of environmental contaminants. We have focused on insulating oil and SF^6 as they are the most common contaminants that employed within the industry.

They have been calculated as follows:-

$$\text{Oil Clean Up Cost (£)} = \text{Standard Cost/Litre} \times \text{Volume of Oil} \times \text{Environmental Multipliers}$$

$$\text{Standard Cost/Litre} = \ 0.88\ £/L$$

$$\text{Cost of SF6 (£)} = \text{SF6 Global Warming Potential x } \left(\frac{\text{Cost}}{\text{tonneCO2}}\right) \times \text{Mass SF6 Released}$$

$$\text{SF6 Global Warming Potential} = \ 23900$$

$$\left(\frac{\text{Cost}}{\text{tonneCO2}}\right) = \ 7.30£\ (\ 2016\ \text{value})$$

The multiplying factors which apply to the clean-up cost associated with oil only apply to the assets listed below:

• *HV GM Primary Switchgear*	• *EHV Transformer*
• *HV GM Secondary Switchgear*	• *132kV Circuit Breakers*
• *HV GM Transformer*	• *132kV Transformers*
• *EHV Switchgear (GM)*	

Using our ESRi system we have managed to quantify the distance to the nearest watercourse for all of our substation assets. This allows us to factor in the increased cost and exposure likely to result from oil leakage near major watercourses. The multiplying factors used are shown below:-

Distance from Watercourse (m)	River Multiplier	Coast Multiplier
x>200	1	1
100<x<200	1	1
50<x<100	1.2	1.2
25<x<50	5	2
x<25	10	3

9.4. Financial

The costs associated with asset repair and replacement is based on an average unit cost and an average cost of repair. The cost of any Post Fault Maintenance (PFM) also contributes towards the total cost. This is illustrated in the equation below which describes the Financial Consequence of Repair/Replacement.

$$\text{Total Cost} = (\text{Replacement Ratio} \times \text{Average Replacement Cost}) + (\text{Repair Ratio} \times \text{Average Repair Cost}) + \text{Average PFM Cost}$$

10. Glossary

C

Criticality Index **–** A measure of the consequence of failure of an asset on a 1-4 scale with criticality index 1 being significantly lower than the average within the same asset category and criticality index 4 being significantly higher than the average.

E

ESRi – Corporate register and mapping tool of SPEN's linear assets (overhead lines and cables). Also includes a customer connectivity model and can be used to carry out spatial queries between our assets and various raster layers (e.g. distance between substations and watercourses)

H

Health Index **–** A measure of the condition of an asset on a 1-5 scale with health index 1 being new and health index 5 being considered end of life

HSE – UK Health and Safety Executive (HSE)

I

IIS - Interruptions Incentive Scheme (IIS) a UK regulatory mechanism whereby DNOs can be rewarded or penalised based on the duration and frequency that customers are affected by the loss of electrical supply.

R

Reliability and Safety Working Group (RSWG) – A working group created as part of the RIIO ED1 licence development with the goal of developing a common criticality methodology across all of the UK DNOs. Ofgem and all of the UK DNOs were members of this group.

S

SAP – SPEN's corporate asset register. This system contains our asset register for nonlinear assets (e.g. substations, buildings, switchgear) and records all additions and disposals alongside detailed asset information.