

SHE-T LSA T3 2026-2031 v1

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TRANSMISSION

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2. Factors Common to All Lead Assets

2.1. LSE Factor

LSE Factor is a combination of Location, Situation and Environmental factors. Situation and environmental tend to only include single variables such as if the asset indoors or outdoors and if the weather is poor or not. Location factors are often more complex taking multiple different variables and combining them first before moving to produce an LSE calculation. Each lead asset can calculate its LSE factor differently. The table below describes the processes and input variables to calculate LSE factor for each lead asset.

Table Error! No text of specified style in document.-1 Common LSE Factors

Asset Category	Location Factor 1	Location Factor 2	Location Factor 3	Location Factor 4	Overall LSE Factor		
<i>Circuit</i>	<u>Distance to Coast - DC_F - Miles</u>	<u>Altitude - A_F - Meters</u>	<u>Corrosion - C_F</u>		= (((Max [DC _F , A _F , E _F] – Minimum location factor) * Situation factor + Minimum Possible Location factor * Environment factor		
<i>Breakers</i>							
	Distance	Factor, F_D	Altitude	Factor, F_A			
			Corrosion Factor	Factor, F_C			
	<5	1.35	0-50	1		1	0.85
	5-10	1.2	50-100	1		2	1
	10-15	1.1	100-250	1.1		3	1.05
	15-20	1	250>	1.2	4	1.15	
	20-25	1			5	1.35	
	25>	1					

Asset Category	Location Factor 1	Location Factor 2	Location Factor 3	Location Factor 4	Overall LSE Factor																																				
Transformers & Reactors	<u>Distance to Coast - DC_F - Miles</u> <table border="1"> <thead> <tr> <th>Distance</th> <th>Factor, F_D</th> </tr> </thead> <tbody> <tr><td><5</td><td>1.35</td></tr> <tr><td>5-10</td><td>1.2</td></tr> <tr><td>10-15</td><td>1.1</td></tr> <tr><td>15-20</td><td>1</td></tr> <tr><td>20-25</td><td>1</td></tr> <tr><td>25></td><td>1</td></tr> </tbody> </table>	Distance	Factor, F _D	<5	1.35	5-10	1.2	10-15	1.1	15-20	1	20-25	1	25>	1	<u>Altitude - A_F - Meters</u> <table border="1"> <thead> <tr> <th>Altitude</th> <th>Factor, F_A</th> </tr> </thead> <tbody> <tr><td>0-50</td><td>1</td></tr> <tr><td>50-100</td><td>1</td></tr> <tr><td>100-250</td><td>1.1</td></tr> <tr><td>250></td><td>1.2</td></tr> </tbody> </table>	Altitude	Factor, F _A	0-50	1	50-100	1	100-250	1.1	250>	1.2	<u>Corrosion - C_F</u> <table border="1"> <thead> <tr> <th>Corrosion Factor</th> <th>Factor, F_C</th> </tr> </thead> <tbody> <tr><td>1</td><td>0.85</td></tr> <tr><td>2</td><td>1</td></tr> <tr><td>3</td><td>1.05</td></tr> <tr><td>4</td><td>1.15</td></tr> <tr><td>5</td><td>1.35</td></tr> </tbody> </table>	Corrosion Factor	Factor, F _C	1	0.85	2	1	3	1.05	4	1.15	5	1.35		= ((Max [DC _F , A _F , E _F] – Minimum location factor) * Situation factor + Minimum Possible Location factor * Environment factor
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Asset Category	Location Factor 1	Location Factor 2	Location Factor 3	Location Factor 4	Overall LSE Factor
<i>Overhead Line (Fittings)</i>	<u>Distance to Coast - DC_F - Miles</u>	<u>Altitude - A_F - Meters</u>	<u>Corrosion - C_F</u>	<u>Severe Weather Zone - S_F</u>	= ((Max [DC _F , A _F , E _F] – Minimum location factor) * Situation factor + Minimum Possible Location factor * Environment factor
	Distance Factor, F_D	Altitude Factor, F_A	Corrosion Factor Factor, F_C	Weather Factor Factor, F_w	
	<5 1.5	0-50 1	1 0.85	Normal 1	
	5-10 1.25	50-100 1	2 1	No 1	
	10-15 1.1	100-250 1.1	3 1.1	Poor 1.1	
	15-20 1	250> 1.25	4 1.25	Bad 1.33	
	20-25 1		5 1.5		
25> 1					

Asset Category	Location Factor 1	Location Factor 2	Location Factor 3	Location Factor 4	Overall LSE Factor				
Overhead Line (Towers - Foundations)	Soil Resistivity - S_{RS}		Soil pH Rating - S_P		Redox Potential - S_{RD}		Combined Test - F_T		<p>IF F_T and/or F_R are available values, then</p> <p>FLSE = Max (F_T, F_R)</p> <p>ELSE</p> <p>IF F_T and or F_R are not available values, then</p> <p>F_T and/or F_R = Default value and therefore</p> <p>FLSE = Max (F_T, F_R)</p> <p>WHERE F_R = SOIL RATING</p>
	Soil Resistivity	Rating, S_R	Soil pH	Rating, S_R	Potential mV	Rating, S_R	Combined Rating	Factor	
	<1000	12	<2	12	<0	6	<2	0.85	
	<5000	8	<4	9	<300	5	<4	0.95	
	<20000	4	<7	3	<500	3	<8	1	
	<80000	1	<9	0	<800	1	<12	1.2	
	80000>	0	<14	0	<1000	0	<50	1.35	

Asset Category	Location Factor 1	Location Factor 2	Location Factor 3	Location Factor 4	Overall LSE Factor				
Overhead Line (Towers - Steelwork)	Distance to Coast - DC_F - Miles		Altitude - A_F - Meters		Corrosion - C_F		Severe Weather Zone - S_F		= ((Max [DC _F , A _F , E _F] – Minimum location factor) * Situation factor + Minimum Possible Location factor * Environment factor
	Distance	Factor, F _D	Altitude	Factor, F _A	Corrosion Factor	Factor, F _C	Weather Factor	Factor, F _w	
	<5	1.5	0-50	1	1	0.85	Normal	1	
	5-10	1.25	50-100	1	2	1	No	1	
	10-15	1.1	100-250	1.1	3	1.1	Poor	1.1	
	15-20	1	250>	1.25	4	1.25	Bad	1.33	
	20-25	1			5	1.5			
25>	1								

2.2. Duty Factor

Duty factor is calculated for all lead assets and is required for calculation of each asset's initial end of life modifier value EoL₁. The duty factor is included in the calculation to give an indication of how much “work” that asset is doing. The more an asset is utilising it will tend to degrade faster than assets utilized less. Below is a table which breaks down the duty factor inputs and calculation for each lead asset types.

Table Error! No text of specified style in document.-2 Common Duty Factors

Asset Category	Duty Factor 1	Duty Factor 2	Duty Factor 3	Overall Duty Factor	
Circuit Breakers	Feeder Protection - P_R		Auto-Reclose - R_A		IF (D _H = OR (Very High, High)) F _D = D _H ELSE F _D = R _A * P _R
	Presence of Feeder Protection	Factor, Prot	Presence of Auto-Reclose	Factor R _A	
	No	1.0	No	1.0	
	Yes	1.2	Yes	1.2	
			High Duty - D_H		
			Duty Level	Factor D _H	
			Normal	1.0	
			High	1.15	
			Very High	1.35	

Asset Category	Duty Factor 1	Duty Factor 2	Duty Factor 3	Overall Duty Factor																														
Transformers & Reactors	<p>Maximum Operating Temperature - T_{Max}</p> <table border="1"> <thead> <tr> <th>Maximum Operating Temperature</th> <th>Factor, T_{max}</th> </tr> </thead> <tbody> <tr><td>0 - 80</td><td>0.75</td></tr> <tr><td>80 - 95</td><td>1.0</td></tr> <tr><td>95 - 105</td><td>1.25</td></tr> <tr><td>105 - 150</td><td>1.5</td></tr> </tbody> </table>	Maximum Operating Temperature	Factor, T _{max}	0 - 80	0.75	80 - 95	1.0	95 - 105	1.25	105 - 150	1.5	<p>Maximum Demand - D_{Max}</p> <table border="1"> <thead> <tr> <th>Max Demand/Rating</th> <th>Factor D_{max}</th> </tr> </thead> <tbody> <tr><td>0.0 – 0.7</td><td>0.75</td></tr> <tr><td>0.7 – 0.9</td><td>0.9</td></tr> <tr><td>0.9 – 1.0</td><td>1.0</td></tr> <tr><td>1.0 – 1.15</td><td>1.25</td></tr> <tr><td>1.15 – 2.0</td><td>1.5</td></tr> </tbody> </table>	Max Demand/Rating	Factor D _{max}	0.0 – 0.7	0.75	0.7 – 0.9	0.9	0.9 – 1.0	1.0	1.0 – 1.15	1.25	1.15 – 2.0	1.5	<p>Through Faults - T_F</p> <table border="1"> <thead> <tr> <th>Severity /Frequency of Through Faults</th> <th>Through Faults Duty Factor (T_F)</th> </tr> </thead> <tbody> <tr><td>Normal</td><td>1</td></tr> <tr><td>High</td><td>1</td></tr> <tr><td>Very High</td><td>1</td></tr> </tbody> </table>	Severity /Frequency of Through Faults	Through Faults Duty Factor (T _F)	Normal	1	High	1	Very High	1	<p>IF (D_{MAX} & T_{MAX} Factor are blank)</p> <p>F_{DY} = Default Demand/Temperature Factor x T_F</p> <p>ELSE</p> <p>F_{DY} = Max (D_{MAX}, T_{MAX}) x T_F</p> <p>WHERE: Default Demand/Temperature Factor = 1.0</p>
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Maximum Demand/Rating	Factor, D _{max}																																	
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40 - 60	1																																	
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No	1																																	
Yes	1																																	
Cables (fluid filled)	<p>Maximum Demand - D_{Max}</p> <table border="1"> <thead> <tr> <th>Maximum Demand/Rating</th> <th>Factor, D_{max}</th> </tr> </thead> <tbody> <tr><td>0 - 40</td><td>1</td></tr> <tr><td>40 - 60</td><td>1</td></tr> <tr><td>60 - 75</td><td>1</td></tr> <tr><td>75 - 85</td><td>1.05</td></tr> <tr><td>85 - 100</td><td>1.1</td></tr> <tr><td>100 +</td><td>1.5</td></tr> </tbody> </table>	Maximum Demand/Rating	Factor, D _{max}	0 - 40	1	40 - 60	1	60 - 75	1	75 - 85	1.05	85 - 100	1.1	100 +	1.5	<p>Duty Exception Report - D_E*</p> <table border="1"> <thead> <tr> <th>Duty Exception Factor</th> <th>R_E Factor</th> </tr> </thead> <tbody> <tr><td>No</td><td>1</td></tr> <tr><td>Yes</td><td>1</td></tr> </tbody> </table>	Duty Exception Factor	R _E Factor	No	1	Yes	1		Overall Duty Factor = Maximum demand Factor * Duty Exception Report Factor										
Maximum Demand/Rating	Factor, D _{max}																																	
0 - 40	1																																	
40 - 60	1																																	
60 - 75	1																																	
75 - 85	1.05																																	
85 - 100	1.1																																	
100 +	1.5																																	
Duty Exception Factor	R _E Factor																																	
No	1																																	
Yes	1																																	
Overhead Line (Conductor)	<p>Default 1</p>			Default Factor = Overall Duty Factor																														

<i>Asset Category</i>	<i>Duty Factor 1</i>	<i>Duty Factor 2</i>	<i>Duty Factor 3</i>	<i>Overall Duty Factor</i>						
<i>Overhead Line (Fittings)</i>	<p><u>High Damper Replacement Rate</u></p> <table border="1"> <tr> <td>High Damper Replacement Rate</td> <td>Factor, D_{max}</td> </tr> <tr> <td>No</td> <td>1</td> </tr> <tr> <td>Yes</td> <td>1.2</td> </tr> </table>	High Damper Replacement Rate	Factor, D_{max}	No	1	Yes	1.2			High Damper Rate = Overall Duty Factor
High Damper Replacement Rate	Factor, D_{max}									
No	1									
Yes	1.2									
<i>Overhead Line (Towers - Foundations)</i>	<p><u>Default</u></p> <p>1</p>			Default Factor = Overall Duty Factor						
<i>Overhead Line (Towers - Steelwork)</i>	<p><u>Default</u></p> <p>1</p>			Default Factor = Overall Duty Factor						

3. Circuit breaker Factors and EoL Calculations

The following sections of this document provide an overview of the Circuit Breaker model design.

For each stage in the EoL Value derivation, the overview will identify and name all the component parts of each derivation and provide a high-level explanation of what the component parts represent.

3.1. Oil Condition

SHE Transmission has no Bulk-Oil Circuit Breakers and no Air Blast Circuit Breakers; therefore, this information is not relevant for SHE Transmission assets.

3.2. After Fault Maintenance

For assets, which have after fault maintenance (AFM), scores, (i.e. assets whose arc extinguishing medium is either vacuum or SF₆), the AFM Score module considers the rate of change of each assets AFM score to estimate an “extrapolated life”. This estimation is used to determine an AFM factor which is used within the “FV₁” derivation.

Table Error! No text of specified style in document.-3 Extrapolated Life Calibration Table

> Extrapolated life Minimum	<= Extrapolated life Maximum	AFM Score Factor
-1	5	1.5
5	20	1.25
20	50	1.1
50	100	1
100	1,000,000.00	1

In the current implementation, AFM is included in the model but is not utilised in the overall calculations. It uses a default score of 1 to neutralise the effects it has on the calculation. In the future, we MAY/MAYNOT include AFM data to produce a more effective FV₁ calculation.

3.3. SF6 Condition

SF₆ condition results (e.g. moisture, purity, dew point etc) use a series of defined multipliers to derive separate gas condition scores. The sum of the gas condition scores is then used to determine an overall SF₆ condition factor (SF_{6COND}) (See Table **Error! No text of specified style in document.-4**) used in the creation of modifying factor “FV₁”, and an optional minimum EoL Modifier can be set where poor gas condition is detected, which is set aside for later in the process.

Table Error! No text of specified style in document.-4 SF₆ Condition Calibration Table

Max SF ₆ Condition	SF ₆ Condition Factor, SF _{6COND}
-1 to 50	1.0
51 to 200	1.0
201 to 500	1.05
500 to 1000	1.1
1000+	1.2

Table 3-3 Defined Condition Period

Defined Condition Period (Years)
5

3.4. SF₆ Leakage

The leakage history is used to create two different factors as per Table **Error! No text of specified style in document.-54**:

- SF_{6NO}, determined by the number of times an asset has been topped up with SF₆,
- SF_{6LOST} a second factor which considers the percentage of gas replaced relative to the design weight.
- Only leaks that have occurred within a “Defined Leak Period” are considered

Table Error! No text of specified style in document.-5 SF₆ Leakage History Calibration Tables

Number of SF ₆ Leaks	SF ₆ Volume Factor, SF _{6NO}	Weighted Lost SF ₆	SF ₆ Condition Factor, SF _{6LOST}
0	1.0	0 to 0.1	1.0
1	1.1	0.1 to 0.2	1.05
2-3	1.25	0.2 to 0.5	1.1
3+	1.5	0.5 to 0.8	1.25
		0.8 +	1.4

Defined Leak Period (years)
5

4. Transformer and Reactor Factors and EoL Calculation

4.1. Oil Condition

Established techniques such as oil analysis provide an effective means of identifying and quantifying degradation of the insulation system (oil and paper) within transformers. Oil results can also be used to identify incipient faults. The oil condition factors (See Table **Error! No text of specified style in document.-6** Oil Condition Calibration Tables) considers the latest oil condition tests, (moisture, acidity, breakdown strength and tan delta) each of which is used to create a test score (See Table **Error! No text of specified style in document.-8** Overall Oil Condition Calibration table) by combination with a Multiplier (See Table **Error! No text of specified style in document.-7** Oil Condition Multipliers Calibration Table).

Table Error! No text of specified style in document.-6 Oil Condition Calibration Tables

Relative Humidity (%)	Moisture Score	Breakdown Voltage (kV)	Breakdown Strength Score
0 - 15	0	0 - 30	10
15 - 30	2	30 - 40	4
30 - 50	4	40 - 50	2
50 - 65	8	50 - 10000	0
65 - 500	10		

Tan Delta @90°C	Tan Delta Score	Acidity – mg KOH/g	Acidity Score
0 – 0.02	0	0 – 0.03	0
0.02 – 0.06	2	0.03 – 0.075	2
0.06 – 0.12	4	0.075 - 0.15	4
0.12 – 0.2	8	0.15 - 0.25	8
0.2 - 1	10	0.25 - 2	10

Each of these scores is given a multiplier which accounts for the significance of the result:

Table Error! No text of specified style in document.-7 Oil Condition Multipliers Calibration Table

Test	Multiplier
Relative Humidity	80
Breakdown Voltage (kV)	80
Tan Delta @90°C	80
Acidity – mg KOH/g	125

The summation of the individual oil condition test scores is then used to determine an overall oil condition factor.

Table Error! No text of specified style in document.-8 Overall Oil Condition Calibration table

Oil Condition Score	Factor, F _{OIL}
0 – 200	1.0
200 – 500	1.0
500 – 950	1.05
950 – 1500	1.1
1500+	1.2

Where the oil test is not considered to be valid it is excluded, and the next available set of results are used. Oil condition is not included if the latest sample is beyond the cut-off date which in the case of SHE-T is within the last 7 years.

The EoL₂ module combines the overall condition factor, defect history factor, family reliability factor, overall test result factor, overall OR factor and the overall oil condition score to determine modifying factor 'FV₁'. This is then multiplied by EoL₁ to determine EoL₂. This is further Explained in the Technical Guidance Note and Network Asset Risk Annex.

4.2. Derivation of Tx EoLDGA

The parameters used to derive EoLDGA are listed in the tables below:

Table Error! No text of specified style in document.-9 DGA Factors

Hydrogen (H ₂) (ppm)	Score	Acetylene (C ₂ H ₂) (ppm)	Score	Ethylene (C ₂ H ₄) Methane (CH ₄) & Ethane (C ₂ H ₆) (Each)(ppm)	Score
0 – 20	0	0 – 1	0	0 – 10	0
20 - 40	2	1 – 5	2	10 – 20	2
40 – 100	4	5 – 20	4	20 – 50	4
100 – 200	10	20 – 100	8	50 – 150	10
200+	16	100+	10	150+	16

A specific multiplier is then applied to each score:

Table Error! No text of specified style in document.-10 DGA Multipliers and Parameters

Gas	Multiplier
H ₂	50
C ₂ H ₂	120
C ₂ H ₄	30
CH ₄	30
C ₂ H ₆	30

Setting Item	Value
DGA Divider	220
DGA HI Max	10
DGA HI Min	0.5
DGA History Threshold	4

>DGA% Change Minimum	<= DGA % Change	DGA Change Description	DGA Factor
-1000	95	Negative	0.9
95	105	Neutral	1
105	125	Small	1.05
125	200	Significant	1.15
200	1000	Large	1.2

4.3. Derivation of Tx EoLffa

The parameters used to derive EoL_{DGA} are listed in the tables below:

Table Error! No text of specified style in document.-6 FFA Factors

Factor	Value
FFA HI Maximum	10
FFA Multiplier	0.02125
FFA Power Value	0.7056
DP Multiplier	-121
DP Addition	1294

5. Cable Factors and EoL calculation

5.1. Leak History

The leak history information for a circuit is used to determine a leak history factor and an associated minimum EoL for each circuit. The leak history is derived from information on the volume of top-ups over a ten-year period.

Leak History Factor

Table Error! No text of specified style in document.-11 Leak History Calibration Table

> Sum of weighted top up volumes/ $\sqrt{\text{Length}}$	\leq Sum of weighted top up volumes/ $\sqrt{\text{Length}}$	Leak History Factor
-1	2	1.0
2	5	1.1
5	10	1.2
10	25	1.3
25	50	1.4
50	5,000	1.5

Leak History Minimum EoL

Table Error! No text of specified style in document.-12 Leak History Min EoL Calibration Table

> Sum of weighted top up volumes	\leq Sum of weighted top up volumes	Initial Leak History Minimum EoL
0	5	0.5
5	10	0.5
10	15	0.5
15	20	6.5
20	25	8
25	1,000	8

5.2. Fault rate

The fault rate information for a circuit will be used to determine a Fault rate factor and derive a minimum EoL, as shown below.

Fault Rate Factor

Table Error! No text of specified style in document.-13 Fault Rate Calibration Table

Fault rate (Faults/per year/100km)	Fault Rate Factor
-1 - 1	1.0
1 - 2	1.1
2 - 4	1.2
4 - 6	1.3
6 - 50	1.5

Fault Rate Minimum EoL

Table Error! No text of specified style in document.-14 Fault Rate Minimum Calibration Table

Fault rate min	Fault Rate Factor
-1 - 1	0.5
1 - 2	0.5
2 - 4	0.5
4 - 6	5.5
6 - 50	8.0

6. Overhead lines factors

6.1. Conductors

6.1.1. Conductor Age

The age is based on when the conductor was last replaced.

6.1.1.1. CONDUCTOR AVERAGE LIFE

An average life will be assigned to conductors based on the conductor type and the cross-sectional area. These values will be assigned via a calibration table, as described below.

Table Error! No text of specified style in document.-15 Conductor Average Life Data Capture

<i>Conductor Type</i>	<i>Conductor Size</i>	<i>Average Life (years)</i>
ACSR	-	50
Araucaria AAAC	-	60
Lynx ACSR	-	50
Tiger ACSR	-	40
ZEBRA ACSR	-	60
Tiger ACSR	125	40
Wolf ACSR	150	50
-	175	50
ACSR	175	50
BEAR	175	50
Bear ACSR	175	50
Lynx	175	50
Lynx ACSR	175	50
Porc	175	50
Wolf ACSR	175	50
Zebra ACSR	175	60
Lynx ACSR	177	-
Lynx ACSR	178	-
Lynx ACSR	179	-
Bear ACSR	250	50
ACSR	300	50
Goat ACSR	300	50
Upas AAAC	300	50
Zebra ACSR	400	60
Cmpctl	520	50
LAMFIL TAAAC	625	50
Araucaris AAAC	700	50
AAAC	821	50

Table Error! No text of specified style in document.-16 Default Age and constants

Setting Item	Value
Default Average Age	50
Maximum HI1	5.5
HI at End of Expected Life	5.5

6.1.2. Visual Condition

The visual condition record will determine a factor per condition point as per below:

Table Error! No text of specified style in document.-17 Conductor Scoring and MinHI Tables

Score	Termination Condition Factor	Conductor Damage Condition Factor	Jumper Condition Factor	Condition at Clamp Condition Factor	Condition Override Factor
1	1	1	1	1	1
2	1	1.1	1	1	1
3	1	1.25	1.05	1.1	1.1
4	1	1.5	1.1	1.25	1.25

Score	Termination Condition MinHI	Conductor Damage Condition MinHI	Jumper Condition MinHI	Condition at Clamp Condition MinHI	Condition Override MinHI
1	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5
3	0.5	5	4	0.5	5
4	0.5	8	5	8	8

6.1.3. Defect History

The number of defects experienced on the span over the previous 5 years (including those that have been repaired are identified. Each defect will then be assigned a severity rating (using a scale of 1 to 4, where 4 is the most severe) via a calibration table.

Table Error! No text of specified style in document.-18 Defect Calibration table

Defect Description	Defect Severity Rating
Minor	1
Significant	2

Major	4
--------------	----------

These values are summed together to produce a severity score which is compared to a severity look up table which in turn produces a Defect factor.

Table Error! No text of specified style in document.-19 Defect Factor Value Calibration Table

Overall defect score minimum	Overall Defect minimum	Defect Factor	Defect MinHI
0	5	1	0.5
5	10	1.05	0.5
10	25	1.1	0.5
25	35	1.25	0.5
35	50	1.5	0.5

Override Defect History	Defect History Factor	Defect History MinHI
Normal	1	0.5
Poor	1.25	0.5
Bad	1.5	0.5

6.1.4. Infra-Red Testing

Helicopter inspections of the Overhead Lines are used to identify hot joints on conductors. This information will be used to derive an infra-red test factor and a minimum EoL value via calibration tables as shown below.

Where tests have been undertaken, the results (either pass, or fail) for each test type are used to derive individual test factors (and if desired minimum EoL indices) and are then combined to produce an overall test factor. The overall test factor is included in the formation of modifying factor FV₁, while any defined minimum EoL indices are set aside for use later in the process.

Table Error! No text of specified style in document.-20 Infra-Red Test Factor and Minimum EoL Calculation

Infra-Red Results	Infra-Red Test Factor
Pass	1.0
Fail	1.35

Infra-Red Results	Infra-Red Test Minimum EoL
Pass	0.5
Fail	6.5

6.1.5. Corrosion Survey testing results

Conductor sampling determines the extent of corrosion a sample of the overhead conductor, which is considered to provide a representative indication of the EoL of the circuit. The results can be used to derive an EoL Modifier independently of any other information on condition or age.

The test results are used to derive a Conductor Sampling EoL Modifier via a calibration table of the form shown below. The tests results are conducted on a span or number of spans and then applied to the whole circuit.

Once an End of Life value has been assigned, it is then used to calculate an overall End of Life for the span by adjusting the Aging rate Reduction factor used in the EoLy0 calculation.

Table Error! No text of specified style in document.-21 Cormon testing Score Conversion table

Cormon EoL Maximum	Aging Rate Reduction Factor
<2	1
>2	1.5

Table Error! No text of specified style in document.-22 Conductor Sampling Score Conversion Table

Conductor Sampling EoL Maximum	Aging Rate Reduction Factor
<2	1
>2	1.5

6.2. Fittings

To attach, insulate and join conductor spans various fittings and insulators are used. Over the course of the lifetime of these assets an EoL indicator needs to be calculated (on a per circuit and a per tower basis) as summarised in the schematic diagram below.

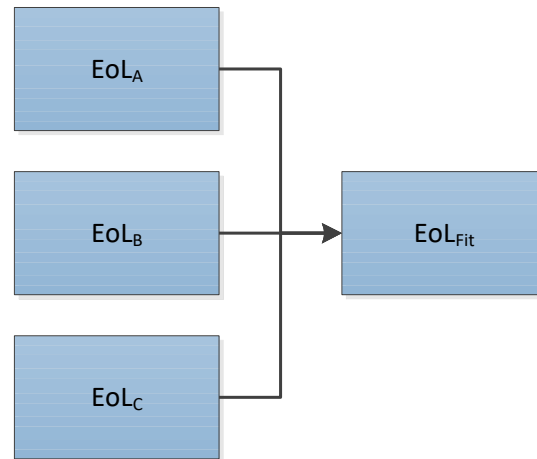


Figure Error! No text of specified style in document.-1 Final EoL Indicator for Fittings

EoL_a is the highest of the condition scores divided by a calibration value, whilst EoL_b is the sum of the three highest condition scores divided by a second calibration value.

6.2.1. EoL_c – Asset Expected Life

Table Error! No text of specified style in document.-23 EoL_c Calibration Defaults

EoL _c Term	Calibration value
Max HI c	5.5
Min Hi	0.5
Default Average Life	35
HI at End of Expected Life	5.5

EoL_c is based on the Initial indicator calculation where LSE factor is multiplied with the average life of that asset class to produce expected life values.

6.2.2. Asset Average Life

An average life will be assigned to the fittings based on the type of insulators (i.e. glass, polymeric or porcelain), whether they are tension/suspension fittings and the operating voltage, and its operating voltage as highlighted below.

Table Error! No text of specified style in document.-9 Fitting Material and Average Life Look-Up Table

Fitting Type	Voltage	Average Life (years)
Glass - Suspension	132	35
Porcelain - Suspension	132	35
Polymeric – Suspension	132	35
Glass – Tension	132	35
Porcelain – Tension	132	35
Polymeric – Tension	132	35
Glass - Suspension	275	35
Porcelain - Suspension	275	35
Polymeric – Suspension	275	35
Porcelain - Tension	275	35
Glass - Suspension	400	35
Porcelain - Suspension	400	35
Polymeric – Suspension	400	35
Glass – Tension	400	35
Porcelain – Tension	400	35
Polymeric – Tension	400	35

6.2.3. Condition Scoring

Table Error! No text of specified style in document.-10 Fittings Condition Point Weighting table

Component Score								
Component Condition Point	UBolts/attach ments	Shackles & Links	Suspension Clamps	Tension Clamps	Conductors at Clamps	Jumpers	Dampers	Insulators Electrical
1	0	0	0	0	0	0	0	0
2	8	8	8	8	0	0	8	8
3	22	22	22	22	0	0	22	22
4	40	40	40	40	0	0	40	40
5	40	40	40	40	0	0	40	40
Component Condition Point	Insulators Mechanical	Flashover Marks	Arcing Horns	Downlead Insulators (top)	Downlead Insulators (Bottom)	Cable Sealing Ends		
1	0	0*	0	0	0	0		
2	8	16*	8	8	8	8		
3	22	-	22	22	22	22		
4	40	-	40	40	40	40		
5	40	-	40	40	40	40		

*Flashover marks are only present or not present (Y/N), as such these are not graded like the other data points

Table Error! No text of specified style in document.-24 Condition Divider Calibration

Condition Score Summation	Calibrated Divider
EoL _A	4
EoL _B	15
No of Max Scores Required	4

6.3. Towers

6.3.1. Steelwork Eol Value

6.3.1.1. DERIVATION OF STEELWORK EOLC

Table Error! No text of specified style in document.-252 Steelwork Constants Calibration

Setting Item	Value
Max EoLc	5.5
Minimum HI	0.5
Default Average Age	80
HI at End of Expected Life	5.5

6.3.1.2. DERIVATION OF STEELWORK EOL_A AND EOL_B

Table Error! No text of specified style in document.-263 Steelwork Condition Point Weighting table

Component Condition Point	Component Score					
	Tower Legs	Step Bolt	Bracings	Cross-arms	Peak	Paint
1	0	0	0	0	0	0
2	8	8	8	8	8	8
3	22	22	22	22	22	22
4	40	40	40	40	40	40
5	40	40	40	40	40	40

Table Error! No text of specified style in document.-274 Condition Divider Calibration

Condition Score Summation	Calibrated Divider
EoL _A	4
EoL _B	15
No. of Max Scores Required	4

6.3.1.3. DERIVATION OF STEELWORK EOL_{Y0}

Table Error! No text of specified style in document.-285 Steelwork Max and Min HIs

Setting Item	Value
MinHI for Very Good Condition	1.5
MaxHI for No Condition Data	4
MinHI	0.5
Max Y0 EoL	10

>HIY0 Minimum	<=HIY0 Maximum	HIY0 Weighting
0	2.5	1
2.5	5.5	2
5.5	15	3

6.3.2. Foundation EoL Value

6.3.2.1. FOUNDATION OF THE INITIAL EOL INDICATOR

Table Error! No text of specified style in document.-16 Soil Resistivity Rating

>Soil Resistivity Minimum	<= Soil Resistivity Maximum	Soil Resistivity Rating
-1	1000	12
1000	5000	8
5000	20000	4
20000	80000	1
80000	100000	0

Table Error! No text of specified style in document.-297 Soil Chemistry Rating

>Soil Chemistry (pH) Minimum	<= Soil Chemistry (pH) Maximum	Soil Chemistry Rating
-1	2	12
2	4	9
4	7	3
7	9	0
9	14	0

Table Error! No text of specified style in document.-308 Redox Potential Rating

>Redox Potential (mV) Minimum	<= Redox Potential (mV) Maximum	Redox Potential Rating
-500	2	6
0	300	5
300	500	3
500	800	1
800	1000	0

Table Error! No text of specified style in document.-319 Combined Soil Test Factor

>Combined Soil Test Rating Minimum	<= Combined Soil Test Rating Maximum	Combined Soil Test Factor
0	2	0.85
2	4	0.95
4	8	1
8	12	1.2
12	50	1.35

Table Error! No text of specified style in document.-20 Overall Soil Rating Factor

Overall Soil Rating	Overall Soil Rating Factor
1	0.85
2	1

3	1.2
4	1.35

Table Error! No text of specified style in document.-32 Constants and Defaults

Setting Item	Value
Location Factor Default	1

Setting Item	Value
HI at End of Expected Life	5.5
Maximum HI1	5.5
Default Average Age	80

6.3.2.2. FOUNDATION OF THE INTERMEDIATE EOL INDICATOR

The results from polarisation resistance tests provide an indication of the probability of future corrosion of the tower foundation taking place, while TDR/TECO measurements can detect cracks and abnormalities in the foundation concrete. The results from either test are converted into factors via calibration lookup tables before combination into an overall modifying factor value used to adjust foundation EoL₁ to create an interim foundation EoL in the year the tests were carried out.

Table Error! No text of specified style in document.-22 Constants and Defaults

Setting Item	TDR/TECO Factor
Ecorr Default	0
Kcorr Deault	2
TDR/TECO Factor Default	1
TDR/TECO Min HI Default	0.5

Table Error! No text of specified style in document.-23 Ecorr Rating

>Ecorr Value (mVs) Minimum	<=Ecorr Value (mVs) Maximum	ECCorr Rating
-10000	-850	1
-850	-250	0
-250	0	0

Table Error! No text of specified style in document.-24 Kcorr Rating

>Kcorr Value (mA) Minimum	<=Kcorr Value (mA) Maximum	KCorr Rating
-5	50	1
50	150	2
150	300	3
300	1000	4

Table Error! No text of specified style in document.-25 Polarisation Resistance Factor & Min HI

Ecorr Rating	Kcorr Rating	Polarisation Resistance Factor
1	1	1
1	2	1
1	3	1
1	4	1
0	1	1
0	2	1
0	3	1.2
0	4	1.35

Ecorr Rating	Kcorr Rating	Polarisation Resistance Facot
1	1	0.5
1	2	0.5
1	3	0.5
1	4	0.5
0	1	0.5
0	2	0.5
0	3	0.5
0	4	0.5

Table Error! No text of specified style in document.-26 Test Results Factors Calibration Table

TDR/TECT Result	TDR/TECO Factor	E Corr Rating	I Corr Rating	Polarisation Resistance Factor
1	1	0	1	1
2	1	0	2	1
3	1.15	0	3	1.2
4	1.35	0	4	1.35
		1	Any	1

Table Error! No text of specified style in document.-2733 Constants and Defaults

Setting Item	Value
As New HI Default	0.5
Max Y0 HI	10
Repair HI (@ repair date)	0.5
Default Min HI	0.5
Default Max HI	10

Table Error! No text of specified style in document.-28 Excavation Condition Rating Min and Max HI

Excavation Foundation Condition Rating	Excavation Foundation Condition MinHI
1	0.5
2	0.5
3	6.5
4	8
5	8

Excavation Foundation Condition Rating	Excavation Foundation Condition MaxHI
1	3.5
2	5.5
3	8
4	10
5	10

Table Error! No text of specified style in document.-29 Unstable Condition Min HI

Foundation Unstable Rating	Foundation Unstable MinHI
No	0.5
Yes	8

6.3.2.3. FOUNDATION OF THE FINAL EOL INDICATOR

Table Error! No text of specified style in document.-30 Foundation Weighting

>HIY0 Minimum	<=HIY0 Maximum	HIY0 Weighting
0	5.5	1
5.5	7.5	1.5
7.5	15	3

7. Values of K

The values of k by asset class and failure mode are presented in the Table below. These values are calculated using historical failure data over the period 2009 to 2015 (i.e. over 7 years) where failures have been recorded. Where no failures have occurred over this time-period, it is necessary to estimate the “expected” failure rate as described in the NARA. Note that these factors are subject to change as a result of the “Calibration, Testing and Validation” Exercise.

Table Error! No text of specified style in document.-34 Calibration for Values of K per Failure Mode

Asset Class	Failure Mode			
	Defect	Minor	Significant	Major
Circuit Breakers	0.00359	0.00139	0.000455	0.0006601
Transformers	0.00576	0.000810	0.000326	0.000130
Reactors	0.00576	0.000810	0.000326	0.000130
Cables (Solid)	N/A	N/A	7.193e-10	9.114e-9 ¹
Cables (Fluid Filled)	2.183e-6	1.092e-6	3.191e-9	2.019e-9
Overhead Lines (Conductors)	N/A	7.898e-8	1.949e-8	4.163e-9
Overhead Lines (Fittings)	N/A	0.000396	0.000114	0.0000429
Overhead Lines (Towers)	0.000573	0.0000474	0.0000135	0.00000575

¹ The k-value is calculated based on a combination of failure rate and our asset base, so the age and condition of our solid cables indicates we are more likely to have a major failure than a significant failure.

8. System Consequence

Section 9 of the NARA outlines the manner in which the system consequence of asset failures is calculated. Three distinct consequence costs are calculated using separate methodologies, the cost of customer disconnection, a boundary transfer constraint cost and finally a reactive compensation unavailability cost. These are included in National Grid's risk model by separately calculating the three costs for each failure mode of every lead asset. The three costs for a specific failure mode are summed to give the monetised System Consequence of that failure mode for a specific lead asset. These costs are then fed into the model to be combined with the safety, environmental and financial costs of the failure mode.

8.1. CUSTOMER DISCONNECTION

Table 8-1 shows the values of M_z for commonly expected values of Z , calculated using Equation 57 in the System Consequence section of the NARA.

Z	M_z
1	1
2	1.5
3	2
4	2.5
5	3

Table 8-35: Values of M_z for $Z=1$ to $Z=5$

Table 8-2 outlines values used by SHE-T for the different probabilities of events leading to losses of circuits other than those lost by the original asset Failure being assessed.

Probability	Symbol	Definition of Value	Value Used
Coincident outage	P_o	Average planned unavailability across SHE-T ownership area	$0.047X_{\min}$
Damage to another circuit	P_d	TO historical experience of proportion of explosive/incendiary failures that result in the loss of a parallel circuit and engineering judgement of asset specific experts	For defect, minor and significant failure modes 0. For major failure mode, 0.01.
Maloperation of another circuit	P_m	TO statistics on number of protections maloperations against number of faults on the system	$0.01X_{\min}$
Coincident fault to another circuit	P_f	Average circuit unplanned unavailability	$0.017X_{\min}$
Overloading of remaining circuit(s)	P_l	See below	Circuit supplies 132 kV or below = 0.19 Circuit supplies 275 kV with $MW_D > 1200$ MW = 0.09

Otherwise = 0

Table 8-2

The probability of overloading remaining circuits after the loss of at least three circuits (including from the original lead asset failure mode) is dependent upon two things:

1. The capacity of the remaining circuits against the load they supply
2. The demand-time curve of the supplied load

Point 1 is primarily dictated by the SQSS and the rating of available and used asset types. The lower the voltage of the circuits the lower the capacity margin above the load supplied. This is because capacity become more expensive per MVA at lower voltages, so circuits are less likely to be designed with spare capacity. For this reason, three different values of P_i are defined in table 2 dependent upon the lowest voltage found on the circuits in question.

Derivation of 132 kV circuit value

The largest transformer units used to supply 132 kV in common deployment are 240 MVA. It is highly unusual for a demand group to have more transformers than required. Assuming a uniform spread of demand values across a population of demand groups with the same number of transformers the average spare capacity will be 120 MVA. For sites in the GB Transmission area with at least 3 transformers the average number of transformers will be 5. Given transformers are designed for N-2 during access period this means the average site has 720 MVA of post fault capacity. If our average spare capacity is 120 MVA then the access period peak of pour average is 600 MVA. Across the network the average ration of access period to peak demand is 0.9. Our average site therefore has a peak demand of 667 MVA.

In order for P_i to be relevant to a calculation it is assumed at least 3 circuits have been lost so in our average case the remaining capacity is 480 MVA. Therefore, if demand exceeds 72% of peak demand at the time of our asset failure then cascade tripping will occur. Looking at a year of demand data this is true for 19% or the year therefore a value of 0.19 is assigned to P_i for circuits that supply 132 kV.

Derivation of 275 kV circuit value

The nature of much of the 275 kV network is more similar to the 132 kV network than the 400 kV network. Flows are dominated by that which is necessary to supply local demand rather than bulk power transfer across the country as for 400 kV circuits. The rating of 275 kV circuits vary form 800 MVA in the case of cable circuits to 1600 MVA for highly rated overhead lines. Taking a mid-point gives us an indicative rating of 1200 MVA which is also around the rating of 400/275 interbus circuits. Therefore P_i will be zero if $MW_D < 1200$ MW. Demand groups supplied by 4 or 5 circuits in excess of 1500 MW are very rare given the security requirement for no demand loss for an N-D event even during the access period when outages occur. If 1500 MW is a reasonable maximum then customers will be lost when demand is in excess of $1200/1500 = 80\%$ of peak demand. This is true for 9% or the year therefore a value of 0.09 is assigned to P_i for circuits that supply 275 kV with $MW_D > 1200$ MW.

Derivation of 400 kV circuit value

400 kV circuits, especially those which connect customers with 4 or more circuits (the cases for which P_i is relevant) are rated to facilitate wider network flows and as such are more than adequate rated for local demand. Only very rarely is a 400 kV circuit rated below 2000 MVA so the risk of circuits being inadequately rated even with three other circuits lost is negligible. Therefore, for circuits entirely at 400 kV $P_i = 0$.

8.2. CUSTOMER DISCONNECTION - DURATION

Table 8-3 outlines values for the different durations of events leading to losses of circuits other than those lost by the original asset Failure being assessed.

Duration	Symbol	Definition of Value	Value Used
Duration of failure mode unavailability	D_{fm}	TO experience of failure durations	Defect failure mode: 0 Minor failure mode: 24 Significant failure mode: 240 Major failure mode: 480
Outage restoration time	D_o	TO statistics on planned unavailability of circuits	48
Circuit damage restoration time	D_d	TO historical experience of explosive/incendiary failures of failure mode	168
Protection mal-operation restoration time	D_m	TO statistics on protection maloperation	3
Unrelated fault restoration time	D_f	TO fault statistics	72
Circuit overload restoration time	D_l	TO historical experience of overload trips	3

Table 8-3

8.3. CUSTOMER DISCONNECTION – SIZE AND unit cost

The value of φ to be used is 0.01. This is because the expected reliability of a single circuit is on average around 100 times lower than that of a double circuit connection. The risk of disconnection of a customer choice connection (usually single circuit) is therefore given 1% of the weighting of a double circuit connection.

As described in the NARA document the cost per site per hour/event are based on historical data from disconnection events and are converted to pounds and today's money. The values to be used are shown in the tables below.

Vital Infrastructure Category	Symbol and Cost		
	Number of Sites	Cost per site per hour (£/hr)	Cost per site per disconnection event (£)
Transport Hubs	S_T	$V_T = 2,346,425.90$	-
Economic Key Point	S_E	$V_E = 1,816,587.80$	-
Particularly sensitive COMAH sites	S_C	-	$V_C = 21,407,982.57$

Table 8-4

Data Point Name	Value
Value of Lost Load (VOLL) £/MWh	£26,163.79/MWh
CSBP (annual average system buy price)	£183.92/MWh
CSMP (annual average system marginal price)	£181.73/MWh
TNUoS (total annual charge for all generators)	£842,000,000
CMVArh (Average cost of procuring MVAR from generation sources)	5.81
Total TEC of all Generation on the System	72443 MW
Winter Peak Demand	48,600 MW
Total Annual Transmission Demand	320,700,000 MWh
Total Energy Generated in a Year	240,564,175 MWh

Table 8-5

8.4. Boundary Transfer

The only variable to be TO define in this part of the methodology is P_{Y+1} , the proportion of time that another circuit on the boundary is unavailable in addition to a failure of the lead asset. Given the probability of another circuit being unavailable is dominated by the probability of planned unavailability then assuming the lead asset failure could occur at any time during the outage then the average time between failure and restoration on recommissioning will be half the planned unavailability of circuits which is equal to 0.18.

The annual boundary cost depletion for single and multiple circuits are shown in the table below.

Boundary Name	Annual Boundary Cost Depletion Single Circuit	Annual Boundary Cost Depletion Multiple Circuit
B0	£456,000,000	£458,000,000
B1	£456,000,000	£458,000,000
B1a	£456,000,000	£458,000,000
B2	£510,000,000	£672,000,000
B3b	£456,000,000	£465,000,000
B4	£510,000,000	£672,000,000

Table 8-6

8.5. Reactive compensation

R_f is defined as one for reactors and 0 for all other assets.

9. Safety Consequence

9.1. Injury and Probability of Injury

Individuals can sustain varying degrees of injury because of an asset failure. The TOs propose to categorise the severity of injury into the following types, the values below are the financial costs associated with a death or injury relating to any part of the system:

Table 9-36 Cost breakdown of different types of injuries

Type of Injury		Values (2003 Q3) [1]	Values (RPI to 2024)
FATALITY		£1,336,800	£2,669,968
INJURY			
<i>Permanently incapacitating injury</i>	Moderate to severe pain for 1-4 weeks. Thereafter some pain gradually reducing but may recur when taking part in some activities. Some permanent restrictions to leisure and possibly some work activities.	£2,072,000	£4,138,370
<i>Serious</i>	Slight to moderate pain for 2-7 days. Thereafter some pain/discomfort for several weeks. Some restrictions to work and/or leisure activities for several weeks/months. After 3-4 months return to normal health with no permanent disability.	£20,500	£40,944
<i>Slight</i>	Injury involving minor cuts and bruises with a quick and complete recovery.	£300	£599

The prices will be brought to 23/24 prices as per the Office of National Statistics RPI.

The prices are then multiplied by a Disproportion Factor which is currently set at **10**.

9.2. Exposure

Under the Electricity Safety Quality and Continuity Regulations 2002 (ESQCR), risk assessments must be carried out on substation sites and overhead lines to assess the risk of interference, vandalism or unauthorised access to the asset by the public.

The overall exposure value is built from an assigned matrix which adjusts the exposure based on the Staff activity level and the Type.

Table 9-37 - Exposure Table

	Low type	Medium Type	High Type
Low Activity	1	3.5	7.5
Medium Activity	7.5	12.5	20
High Activity	15	24.5	49

9.2.1. Activity rating

For staff activity; scores were provided as data points and then these were converted into an Activity “Low/Medium/High” setting for use in the exposure calibration table.

Table 9-3 Activity Score Calibration Table

Activity Risk Rating	
Low	1
Medium	2
High	3

9.2.2. Type Rating

For type risk, the data was inputted in as a low medium high value and this provided a type risk factor.

Type Risk Rating	
Low	0.8
Medium	1
High	1.2

Table 9-4 Type factor Calibration Table

This type risk factor was then combined with an arc interruption medium factor through multiplication.

Arc Interruption Medium Factor	
Air	1
Oil	1
SF6	1
Vacuum	1

Table 9-5 Arc Interruption Medium Factor

Overall type factor	
< 0.8	Low
0.8 – 1.19	Medium
1.19 >	High

Table 9-6 Arc Interruption Overall Type Factor

A final Type “Low/Medium/High” setting was established based on this product value.

10.Environmental Consequence

10.1. Environmental Impact type

Costs will be assigned to the different environmental impact types as per below:

Impact Type	Environmental Impact Measure
Oil	Average volume of oil lost per failure (litres)
SF ₆	Average volume of SF ₆ lost per failure (kg)
Fire	Average probability that failure results in a fire
Waste	Average quantity of waste per failure (t)

Table 10-1 Environmental Impact Types

Environmental Impact Costs:

- **Environmental cost per litre oil** = £50.48/litre
- **Environmental cost per kg of Gas lost;**

Gas Type	CO2 Equivalent (kg)	DESNZ 2031 high rate (£ per tonne CO2)	Cost per kg (£)
SF ₆	23500	426	10,011
C4 / G3	300	426	128
Clean Air	0	426	0

Table 10-2 Environmental Impact Values

- **Environmental cost of fire** = £7,210.56
- **Environmental cost per tonne waste** = £216.32/tonne

Fixed value	Source
Environmental cost per litre oil (£/litre)	The value used in the DNO CNAIM, page 81: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf and in Ofgem's RIIO-ED1 Cost Benefit Analysis template (used for the RIIO-ED1 submissions)
Traded carbon price (£/t)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/671194/Updated_short-term_traded_carbon_values_for_appraisal_purposes.pdf Table 1, central value estimated as at 2021
Conversion factor for cost of SF6 loss c/w cost of carbon (kg CO2e/kg)	https://www.gov.uk/guidance/calculate-the-carbon-dioxide-equivalent-quantity-of-an-f-gas

Environmental Cost of Fire	The value used in the DNO CNAIM, page 81: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf
Environmental Cost per Tonne Waste	The value used in the DNO CNAIM, page 81: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Table 10-3 Source Table for the Above Costs

10.2. Per asset Applied Environmental costs

10.2.1. Environmental Cost of Oil Leakage

CIRCUITBREAKERS				
Setting Item	132kV Circuit Breaker, Oil	132kV Circuit Breaker, Other Types	132kV Circuit Breaker, SF6, AIS	132kV Circuit Breaker, SF6, GIS
Average Volume of Oil Lost (litres) - Defect (Condition)	3068.5	0	0	0
Average Volume of Oil Lost (litres) - Minor (Condition)	4909.6	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	6137	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	12274	0	0	0
Setting Item	275kV Circuit Breaker, Oil	275kV Circuit Breaker, Other Types	275kV Circuit Breaker, SF6, AIS	275kV Circuit Breaker, SF6, GIS
Average Volume of Oil Lost (litres) - Defect (Condition)	9625	0	0	0
Average Volume of Oil Lost (litres) - Minor (Condition)	15400	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	19250	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	38500	0	0	0
Setting Item	400kV Circuit Breaker, Oil	400kV Circuit Breaker, Other Types	400kV Circuit Breaker, SF6, AIS	400kV Circuit Breaker, SF6, GIS
Average Volume of Oil Lost (litres) - Defect (Condition)	0	0	0	0
Average Volume of Oil Lost (litres) - Minor (Condition)	0	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	0	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	0	0	0	0

TRANSFORMERS			
Setting Item	132kV Reactor	132kV Transformer	
Average Volume of Oil Lost (litres) - Defect (Condition)	432	471.9	
Average Volume of Oil Lost (litres) - Minor (Condition)	718	707.8	
Average Volume of Oil Lost (litres) - Significant (Condition)	2157.5	2359.3	
Average Volume of Oil Lost (litres) - Major (Condition)	21575	23593	
Setting Item	275kV Reactor	275kV Transformer	
Average Volume of Oil Lost (litres) - Defect (Condition)	432	1282.6	
Average Volume of Oil Lost (litres) - Minor (Condition)	718	1923.9	
Average Volume of Oil Lost (litres) - Significant (Condition)	2157.5	6412.9	
Average Volume of Oil Lost (litres) - Major (Condition)	21575	64129	
Setting Item	400kV Reactor	400kV Transformer	
Average Volume of Oil Lost (litres) - Defect (Condition)	432	1955	
Average Volume of Oil Lost (litres) - Minor (Condition)	718	2933	
Average Volume of Oil Lost (litres) - Significant (Condition)	2157.5	9775	
Average Volume of Oil Lost (litres) - Major (Condition)	21575	97752	

SOLID CABLES			
Setting Item	132kV Solid Cable	275kV Solid Cable	400kV Solid Cable
Average Volume of Oil Lost (litres) - Significant (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	0	0	0

FLUID CABLES			
Setting Item	132kV Fluid Cable	275kV Fluid Cable	400kV Fluid Cable
Average Volume of Oil Lost (litres) - Defect (Condition)	175.84	158.23	404.77
Average Volume of Oil Lost (litres) - Minor (Condition)	281.34	253.17	647.64
Average Volume of Oil Lost (litres) - Significant (Condition)	351.68	316.46	809.55
Average Volume of Oil Lost (litres) - Major (Condition)	703.36	632.92	1619.1

TOWER			
Setting Item	132kV Tower	275kV Tower	400kV Tower
Average Volume of Oil Lost (litres) - Defect (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Minor (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	0	0	0

Average Volume of Oil Lost (litres) - Major (Condition)	0	0	0
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CONDUCTOR			
Setting Item	132kV Conductor	275kV Conductor	400kV Conductor
Average Volume of Oil Lost (litres) - Minor (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	0	0	0

FITTINGS			
Setting Item	132kV Fittings	275kV Fittings	400kV Fittings
Average Volume of Oil Lost (litres) - Minor (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Significant (Condition)	0	0	0
Average Volume of Oil Lost (litres) - Major (Condition)	0	0	0

Table 10-4 Environmental Cost of Oil Leakage

10.2.2. Environmental Cost of SF6 Leakage

CIRCUITBREAKERS				
Setting Item	132kV Circuit Breaker, Oil	132kV Circuit Breaker, Other Types	132kV Circuit Breaker, SF6, AIS	132kV Circuit Breaker, SF6, GIS
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	1.91	1.91	21.75
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	3.06	3.06	34.8
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	3.83	3.83	43.5
Average Volume of SF6 Lost (kg) - Major (Condition)	0	23	23	87
Setting Item	275kV Circuit Breaker, Oil	275kV Circuit Breaker, Other Types	275kV Circuit Breaker, SF6, AIS	275kV Circuit Breaker, SF6, GIS
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	5.33	5.33	22.83
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	8.53	8.53	36.53
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	10.66	10.66	45.6

Setting Item	400kV Circuit Breaker, Oil	400kV Circuit Breaker, Other Types	400kV Circuit Breaker, SF6, AIS	400kV Circuit Breaker, SF6, GIS
Average Volume of SF6 Lost (kg) - Major (Condition)	0	64	64	274
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	21.6	21.6	64.58
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	34.6	34.6	103.33
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	43.33	43.33	129.16
Average Volume of SF6 Lost (kg) - Major (Condition)	0	260	260	775

TRANSFORMERS			
Setting Item	132kV Reactor	132kV Transformer	
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	
Setting Item	275kV Reactor	275kV Transformer	
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	
Setting Item	400kV Reactor	400kV Transformer	
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	

SOLID CABLES			
Setting Item	132kV Solid Cable	275kV Solid Cable	400kV Solid Cable
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	0

FLUID CABLES			
Setting Item	132kV Fluid Cable	275kV Fluid Cable	400kV Fluid Cable
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	0	0

Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	0

<u>TOWER</u>			
Setting Item	132kV Tower	275kV Tower	400kV Tower
Average Volume of SF6 Lost (kg) - Defect (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	0

<u>CONDUCTOR</u>			
Setting Item	132kV Conductor	275kV Conductor	400kV Conductor
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	0

<u>FITTINGS</u>			
Setting Item	132kV Fittings	275kV Fittings	400kV Fittings
Average Volume of SF6 Lost (kg) - Minor (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Significant (Condition)	0	0	0
Average Volume of SF6 Lost (kg) - Major (Condition)	0	0	0

Table 10-5 Environmental Cost of SF6 Leakage

10.2.3. Environmental Cost of Fire

<u>CIRCUITBREAKERS</u>				
Setting Item	132kV Circuit Breaker, Oil	132kV Circuit Breaker, Other Types	132kV Circuit Breaker, SF6, AIS	132kV Circuit Breaker, SF6, GIS
Average Likelihood of Fire - Defect (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1	0.1	0.1

Setting Item	275kV Circuit Breaker, Oil	275kV Circuit Breaker, Other Types	275kV Circuit Breaker, SF6, AIS	275kV Circuit Breaker, SF6, GIS
Average Likelihood of Fire - Defect (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1	0.1	0.1
Setting Item	400kV Circuit Breaker, Oil	400kV Circuit Breaker, Other Types	400kV Circuit Breaker, SF6, AIS	400kV Circuit Breaker, SF6, GIS
Average Likelihood of Fire - Defect (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1	0.1	0.1

<u>TRANSFORMERS</u>		
Setting Item	132kV Reactor	132kV Transformer
Average Likelihood of Fire - Defect (Condition)	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1
Setting Item	275kV Reactor	275kV Transformer
Average Likelihood of Fire - Defect (Condition)	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1
Setting Item	400kV Reactor	400kV Transformer
Average Likelihood of Fire - Defect (Condition)	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.05	0.05
Average Likelihood of Fire - Major (Condition)	0.1	0.1

<u>SOLID CABLES</u>			
Setting Item	132kV Solid Cable	275kV Solid Cable	400kV Solid Cable
Average Likelihood of Fire - Significant (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Major (Condition)	0.001	0.001	0.001

FLUID CABLES			
Setting Item	132kV Fluid Cable	275kV Fluid Cable	400kV Fluid Cable
Average Likelihood of Fire - Defect (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Major (Condition)	0.001	0.001	0.001

TOWER			
Setting Item	132kV Tower	275kV Tower	400kV Tower
Average Likelihood of Fire - Defect (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Minor (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Significant (Condition)	0.001	0.001	0.001
Average Likelihood of Fire - Major (Condition)	0.001	0.001	0.001

CONDUCTOR			
Setting Item	132kV Conductor	275kV Conductor	400kV Conductor
Average Likelihood of Fire - Minor (Condition)	0	0	0
Average Likelihood of Fire - Significant (Condition)	0	0	0
Average Likelihood of Fire - Major (Condition)	0.001	0.001	0.001

Table 10-6 Environmental Cost of Fire

10.2.4. Environmental Cost of Wastage

CIRCUITBREAKERS				
Setting Item	132kV Circuit Breaker, Oil	132kV Circuit Breaker, Other Types	132kV Circuit Breaker, SF6, AIS	132kV Circuit Breaker, SF6, GIS
Average Volume of Waste (tonnes) - Defect (Condition)	0.1	0.1	0.1	0.1
Average Volume of Waste (tonnes) - Minor (Condition)	0.4	0.4	0.4	0.3
Average Volume of Waste (tonnes) - Significant (Condition)	0.7	0.7	0.7	0.5
Average Volume of Waste (tonnes) - Major (Condition)	3.3	3.3	3.3	2.66
Setting Item	275kV Circuit Breaker, Oil	275kV Circuit Breaker, Other Types	275kV Circuit Breaker, SF6, AIS	275kV Circuit Breaker, SF6, GIS
Average Volume of Waste (tonnes) - Defect (Condition)	0.2	0.2	0.2	0.1

Average Volume of Waste (tonnes) - Minor (Condition)	0.7	0.7	0.7	0.5
Average Volume of Waste (tonnes) - Significant (Condition)	1.2	1.2	1.2	1
Average Volume of Waste (tonnes) - Major (Condition)	6	6	6	4.99
Setting Item	400kV Circuit Breaker, Oil	400kV Circuit Breaker, Other Types	400kV Circuit Breaker, SF6, AIS	400kV Circuit Breaker, SF6, GIS
Average Volume of Waste (tonnes) - Defect (Condition)	0.3	0.3	0.3	0.3
Average Volume of Waste (tonnes) - Minor (Condition)	1.2	1.2	1.2	1.2
Average Volume of Waste (tonnes) - Significant (Condition)	2.2	2.2	2.2	2.2
Average Volume of Waste (tonnes) - Major (Condition)	10.8	10.8	10.8	10.8

TRANSFORMERS			
Setting Item	132kV Reactor	132kV Transformer	
Average Volume of Waste (tonnes) - Defect (Condition)	0.3	0.3	
Average Volume of Waste (tonnes) - Minor (Condition)	2.8	3.5	
Average Volume of Waste (tonnes) - Significant (Condition)	11.2	14	
Average Volume of Waste (tonnes) - Major (Condition)	56.17	69.94	
Setting Item	275kV Reactor	275kV Transformer	
Average Volume of Waste (tonnes) - Defect (Condition)	0.3	0.7	
Average Volume of Waste (tonnes) - Minor (Condition)	2.8	7	
Average Volume of Waste (tonnes) - Significant (Condition)	11.2	28	
Average Volume of Waste (tonnes) - Major (Condition)	56.17	140.05	
Setting Item	400kV Reactor	400kV Transformer	
Average Volume of Waste (tonnes) - Defect (Condition)	0.65	1.336	
Average Volume of Waste (tonnes) - Minor (Condition)	6.5	13.361	
Average Volume of Waste (tonnes) - Significant (Condition)	26	53.445	
Average Volume of Waste (tonnes) - Major (Condition)	130	267.223	

SOLID CABLES			
Setting Item	132kV Solid Cable	275kV Solid Cable	400kV Solid Cable
Average Volume of Waste (tonnes) - Significant (Condition)	3.959	3.686	3.686
Average Volume of Waste (tonnes) - Major (Condition)	19.795	18.43	18.43

FLUID CABLES			
Setting Item	132kV Fluid Cable	275kV Fluid Cable	400kV Fluid Cable
Average Volume of Waste (tonnes) - Defect (Condition)	0.256	0.652	0.652
Average Volume of Waste (tonnes) - Minor (Condition)	1.295	3.26	3.26
Average Volume of Waste (tonnes) - Significant (Condition)	12.95	32.6	32.6
Average Volume of Waste (tonnes) - Major (Condition)	12.95	32.6	32.6

TOWER			
Setting Item	132kV Tower	275kV Tower	400kV Tower
Average Likelihood of Fire - Defect (Condition)	0	0	0
Average Likelihood of Fire - Minor (Condition)	0.3	1	3
Average Likelihood of Fire - Significant (Condition)	1.6	5	19.5
Average Likelihood of Fire - Major (Condition)	5	16	65

CONDUCTOR			
Setting Item	132kV Conductor	275kV Conductor	400kV Conductor
Average Volume of Waste (tonnes) - Minor (Condition)	0.03	0.1	0.1
Average Volume of Waste (tonnes) - Significant (Condition)	0.08	0.3	0.4
Average Volume of Waste (tonnes) - Major (Condition)	0.3	1	1.4

FITTINGS			
Setting Item	132kV Fittings	275kV Fittings	400kV Fittings
Average Volume of Waste (tonnes) - Minor (Condition)	0.01	0.03	0.04
Average Volume of Waste (tonnes) - Significant (Condition)	0.04	0.1	0.1
Average Volume of Waste (tonnes) - Major (Condition)	0.1	0.3	0.4

Table 10-7 Environmental Cost of Wastage

10.3. Proximity to Water Course Factor

Table 10-8 Water Course Factor Calibration Table

Asset Register Category (All Voltages)	Proximity to Water Course Factor			
	Not Close to Water Course (>120m) or No Oil	Moderately Close to Water Course (between 80m and 120m)	Close to Water Course (between 40m and 80m)	Very Close to Water Course (<40m)
Transformer	0.8	1	1.5	2.5
Circuit Breaker	0.8	1	1.5	2.5
Reactor	0.8	1	1.5	2.5
Cable	0.8	1	1.5	2.5

10.4. Asset Located within SSSI

This section is used to indicate whether an asset is located within a Site of Special Scientific Interest and will apply a multiplying factor accordingly. This is due to the recognition that any environmental impact within an SSSI is likely to have a more devastating effect.

Table 10-9 Site of Special Scientific Interest Calibration Table

Asset Located within SSSI	Multiplying Factor
Yes	1.5
No	1

The resulting Financial Cost of Failure value can then be modified for individual assets within a Lead Asset Category based on the application of a Location Factor to result in a Financial CoF that reflects the characteristics of an individual assets location.

Table 10-10 Location Factor of SSSI Calibration Table

Location Factor	Multiplying Factor
Standard (Default)	1
Non - Standard	1.5

10.5. Environmental Risk Table – Worked Example

Asset Category	Impact Type																				Exposure	Reference Environmental Consequence
	Average volume of oil lost per failure (litres)				Average volume of SF6 lost per failure (kg)				Average probability that failure results in a fire				Average quantity of waste per failure (t)				Probability of Failure Mode Effect					
	Defect	Minor	Significant	Major	Defect	Minor	Significant	Major	Defect	Minor	Significant	Major	Defect	Minor	Significant	Major	Defect	Minor	Significant	Major		
132kV Transformer	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1	£3,281
275kV Transformer	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1.5	£4,259
400kV Transformer	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1	£3,281
132kV Reactor	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1.5	£4,259
275kV Reactor	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1	£3,281
400kV Reactor	100	200	500	5000	0	0	0	0	0.0002	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1.5	£4,259
132kV Circuit Breaker	0	0	0	0	0	5	20	50	0	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1	£611
275kV Circuit Breaker	0	0	0	0	0	10	60	170	0	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1.5	£1,406
400kV Circuit Breaker	0	0	0	0	0	20	30	75	0	0.002	0.01	0.02	0.5	10	50	100	15%	3%	2%	1%	1	£827
132kV Tower	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1.5	£378
275kV Tower	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1	£302
400kV Tower	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1.5	£378
132kV Conductor	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1	£302
275kV Conductor	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1.5	£378
400kV Conductor	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1	£302
132kV Fittings	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1.5	£378
275kV Fittings	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1	£302
400kV Fittings	0	0	0	0	0	0	0	0	0	0	0.01	0.02	0	0	50	100	25%	10%	2%	1%	1.5	£378
132kV Cable	100	200	500	5000	0	0	0	0	0	0	0.01	0.02	0	0	50	100	0%	10%	7%	2%	1	£6,423
275kV Cable	100	200	500	5000	0	0	0	0	0	0	0.01	0.02	0	0	50	100	0%	10%	7%	2%	1.5	£8,378
400kV Cable	100	200	500	5000	0	0	0	0	0	0	0.01	0.02	0	0	50	100	0%	10%	7%	2%	1	£6,423

The worked example uses the “Environmental Impact Costs” stated in section 10.1 above.

11. Financial Consequence

11.1. Location Factor

The resulting Financial Cost of Failure value can then be modified for individual assets within a Lead Asset Category based on the application of a Location Factor to result in a Financial CoF that reflects the characteristics of an individual assets location.

Table Error! No text of specified style in document. 1-38 Location Factor for Financial Consequence Calibration Table

Location Factor	Multiplying Factor
Standard (Default)	1
Non - Standard	1.5

11.2. Per asset Financial Cost

Asset Category	Asset Cost (£)		
	132kV	275kV	400kV
Circuit Breakers	400,000	500,000	600,000
Transformers	2,000,000	6,000,000	8,000,000
Reactors	4,500,000	6,000,000	6,000,000
Solid Cable	1,000,000	2,000,000	3,000,000
Fluid Cable	1,000,000	2,000,000	3,000,000
Tower	60,000	100,000	150,000
Fittings	40,000	50,000	60,000
Conductor	100,000	300,000	400,000

Table Error! No text of specified style in document. 1-2 Financial replacement cost per asset class

11.3. Percentage of replacement

Asset Category	Percentage of Replacement (%)			
	Defect	Minor	Significant	Major
Circuit Breakers	5	15	40	100
Transformers	5	15	40	100
Reactors	5	15	40	100
Solid Cable	-	-	40	100
Fluid Cable	5	15	40	100
Tower	5	15	40	100
Fittings	-	15	40	100
Conductor	-	15	40	100

Table Error! No text of specified style in document. 1-3 Percentage of replacement per asset class

11.4. Example Financial Risk Calculation

Financial Risk = Sum (PoF of a Failure Mode X * Financial Consequence of a Failure X) * Location Factor.