2023-27
POWERLINK QUEENSLAND REVENUE PROPOSAL

Appendix 15.03 – PUBLIC

WSP
Statistical Methodology for STPIS SC Validation Report

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POWERLINK QUEENSLAND

STATISTICAL VALIDATION OF STPIS SERVICE COMPONENT

JANUARY 2021

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Statistical validation of STPIS Service Component

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REV	DATE	DETAILS
A	26 November 2020	Draft Report
B	9 December 2020	Final Report
C	9 December 2020	Correction of cross-reference and typographical errors
D	15 January 2021	Appendix A included: addendum detailing the review of the 2016-2020 data analysis
E	19 January 2021	Summary Table A.2 added; corrected typographical errors
F	20 January 2021	Final Report - minor amendments to Appendix A

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EXECUTIVE SUMMARY

REQUIREMENTS OF POWERLINK

WSP was engaged by Powerlink Queensland (Powerlink) to undertake a review of Powerlink's proposed targets, caps and floors for the service component of the service target performance incentive scheme (STPIS), based on historical performance data from the most recent five years of available data (2015-2019) for each of the parameters. The standard calculation methodology was applied for all parameters other than the 'large' loss of supply event frequency > 0.40 system minutes, for which Powerlink has proposed an alternative calculation methodology.

SERVICE COMPONENTS CONSIDERED

The parameters and sub-parameters of the service component of Powerlink's STPIS included in this review are:

- Unplanned outage circuit event rate:
  - lines event rate - fault
  - transformer event rate - fault
  - reactive plant event rate - fault
  - lines event rate - forced outage
  - transformer event rate - forced
  - reactive plant event rate - forced
- Loss of supply event frequency:
  - 'small' loss of supply event frequency > 0.05 system minutes
  - 'large' loss of supply event frequency > 0.40 system minutes
- Average outage duration

APPROACH

For all sub-component parameters of the service component, WSP identified the probability distribution providing the best fit to each parameter's historical performance data using the most recent five years of data available (2015-2019). WSP used the @RISK analysis and simulation tool for Microsoft Excel to select the probability distributions with the best fit according to standard fit tests appropriate to the types of data and distributions being modelled.

WSP applied the Australian Energy Regulator's principles when identifying each parameter's best-fit probability distribution: distributions should reflect inherent skewness of the historical data; distributions should not imply that impossible values are reasonably likely; and, that discrete distributions should be used to represent discrete data.

STANDARD APPROACH TAKEN

In the standard approach for continuous distributions (all unplanned outage circuit event rates and the average outage duration), the target value was calculated as the mean of the best-fit probability distribution identified for the parameter, with the cap and floor values being calculated as the 5th and 95th percentile values of the same distributions.

In the standard approach taken for discrete distributions ('small' loss of supply event frequency > 0.05 system minutes), the mean, and 5th and 95th percentiles were rounded to the nearest integer.

ALTERNATIVE APPROACH TAKEN

For the 'large' loss of supply event frequency > 0.40 system minutes parameter, Powerlink proposes an alternative approach owing to the fact that the standard approach results in a target and cap both equal to zero.

In the alternative approach, Powerlink has applied the same analysis methodology to identify the best-fit probability distribution, with the exception that they have proposed that the target value be rounded to the nearest non-zero integer of the mean of the distribution.

If the target were to be set at zero, Powerlink would never receive the benefit of an incentive payment under the STPIS for this parameter. This would result in an asymmetric profile with maximum incentive of 0% of MAR and maximum penalty of 0.15% of MAR.

WSP has assessed the proposed alternative calculation methodology against the requirements of STPIS clause 3.2(i) and NER clause 6A.7.4(b) and finds it to be consistent with the requirements.

RECOMMENDATIONS

The recommended STPIS parameter values are shown in Table ES.1 based on:

— Targets set at the average of five-year performance for parameters with continuous distributions

— Caps and floors set at 5% and 95% POE for all parameters and bounded at zero where appropriate

— Target, cap and floor rounded to nearest integer for loss of supply event frequency > 0.05 system minutes

— Target for loss of supply event frequency > 0.40 system minutes rounded to the nearest non-zero integer with cap and floor rounded to the nearest integer

Weightings as set out in STPIS Table 3-1 are also shown in the table.

Table ES.1 Recommended parameter values

PARAMETER	FLOOR	TARGET	CAP	WEIGHTING MAR %
Lines event rate – fault	23.85%	18.92%	14.85%	0.20
Transformer event rate – fault	25.09%	18.07%	10.44%	0.20
Reactive plant event rate - fault	29.16%	25.60%	22.34%	0.10
Lines event rate – forced	21.00%	16.83%	11.85%	0.10
Transformer event rate – forced	19.07%	14.10%	9.78%	0.10
Reactive plant event rate - forced	22.80%	21.18%	18.92%	0.05
Loss of supply event frequency (events > 0.05 system minutes)	7	2	0	0.15
Loss of supply event frequency (events > 0.40 system minutes)	2	1	0	0.15
Average outage duration	147.17 min	69.00 min	7.91 min	0.20

1 INTRODUCTION

1.1 OVERVIEW

WSP was engaged by Powerlink to undertake a review of Powerlink's proposed targets, caps and floors for the service component of the service target performance incentive scheme (STPIS)[1]. The assessment is based on performance data from the most recent five years of available data (2015-2019) at the time of this assessment. The standard calculation methodology was applied for all parameters other than the 'large' loss of supply event frequency parameter, for which Powerlink has proposed an alternative calculation methodology.

The parameters and sub-parameters of the service component of Powerlink's STPIS included in this review are:

- Unplanned outage circuit event rate:
  - lines event rate - fault
  - transformer event rate - fault
  - reactive plant event rate - fault
  - lines event rate - forced outage
  - transformer event rate - forced
  - reactive plant event rate - forced
- Loss of supply event frequency:
  - 'small' loss of supply event frequency > 0.05 system minutes
  - 'large' loss of supply event frequency > 0.40 system minutes
- Average outage duration

We note that the proper operation of equipment parameter was excluded from the scope of this review as it has an incentive weighting of zero and hence has no financial impact.

1.2 ALTERNATIVE METHODOLOGY

Powerlink applied an alternative methodology for the calculation of target value for the 'large' loss of supply event frequency parameter. This parameter is defined as the number of outage events with duration of greater than 0.40 system minutes.

This parameter is non-continuous as it must have an integer value. The standard approach requires rounding the average performance for the most recent five years to the nearest integer; however, this results in a target of zero and therefore an asymmetric incentive/penalty profile. To address this issue, Powerlink modified the methodology to round the average to the nearest non-zero integer, resulting in a minimum possible target of one event.

WSP's assessment of this alterative methodology is presented in section 3.

[1] Service Target Performance Incentive Scheme Version 5 (corrected), 30 September 2015

1.3 APPROACH

WSP calculated a curve of best fit using the reliability performance data for each of the parameters from the most recent five years (2015-2019). The @RISK product, a risk analysis and simulation add-in tool for Microsoft Excel, was used to determine the types of probability distribution that best fit the reliability data.

The target value was calculated as the average of the performance across the most recent five years. For discrete items, other than the 'large' loss of supply event frequency parameter, the value was rounded to the nearest integer; for the 'large' loss of supply event frequency parameter an alternative approach was applied. For all items, 5th and 95th percentile values were calculated from the best fit probability distribution as the basis for the proposed caps and floors.

The Australian Energy Regulator's principles for selecting a distribution to calculate caps and floors were considered:

- The chosen distribution should reflect any inherent skewness of the performance data.
- The distribution should not imply that impossible values are reasonably likely. For example, the distribution for an unplanned outage circuit event rate sub-parameter should not imply that values below zero per cent are reasonably likely.
- Discrete distributions should be used to represent discrete data. For example, a discrete distribution such as the Poisson distribution should be used when calculating caps and floors for loss of supply sub-parameters. Continuous distributions should not be used.

Recognising the need to present the best fit distribution curve based on the nature of the reliability data, the following distribution parameters were chosen for this exercise:

- Unplanned outage circuit event rates are represented by continuous probability distributions bounded at a lower limit of zero.
- Loss of supply event frequencies are represented by discrete probability distributions.
- Average outage duration data are represented by continuous probability distributions bounded at a lower limit of zero.

To align with the methodology applied by the AER and remain consistent across all distribution types, the caps and floors were calculated using the 5th and 95th percentiles.

Three key fit statistics were used to measure how well the probability distribution functions fit the input data. For discrete probability distributions, the Akaike Information Criterion (AIC) was used. For continuous distributions, the Kolmogorov-Smirnov (K-S) and the Anderson-Darling (A-D) fit statistics were used, based on the following rationale:

The chi-square, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) tests were assessed for suitability for use on the discrete probability distributions:

- For the chi-square approximation to be valid the expected frequency in each interval bin should be at least five. As this is not possible with only five values in the dataset (one value for each year 2015 to 2019), some uncertainty in the fitted distribution will occur. Therefore, the chi-square approximation is not used for model selection.
- BIC is closely related to the AIC, with a greater penalty for the number of parameters in the model. It is only valid for sample sizes much larger than the number of parameters in the model and is therefore likely to be inaccurate for small sample sizes. Therefore, BIC is not used for model selection.
- AIC is a measure of the relative quality of a statistical model for a given set of data. AIC deals with the trade-off between the goodness of fit of the model and the complexity of the model. It is founded on information entropy: it offers a relative estimate of the information lost when a given model is used to represent the process that generates the data. AIC is considered to provide a more appropriate methodology for determining the curve of best fit to small datasets than the chi-square or BIC. As such, AIC provides a means for model selection.

The chi-square, the Kolmogorov-Smirnov (K-S), the Anderson-Darling (A-D), and the AIC and BIC tests were assessed for suitability for use on the continuous probability distributions:

— The chi-square test, as discussed above, will have some uncertainty in the fitted distribution for small sample sizes and is not used for model selection.

— The BIC test, as discussed above, is a valid test but is only valid for small sample sizes and is not used for model selection.

— The AIC test, as discussed above, is a valid test and is preferred over the BIC for small sample sizes.

— The K-S fit statistic focuses on the differences between the middle of the fitted distribution and the input data. The A-D fit statistic focuses on the difference between the tails of fitted distribution and input data. Historically the AER has applied the K-S fit statistic in its regulatory determinations to calculate the caps and floors, stating that it considers the K-S fit statistic to be preferred due to its simplicity, especially when there is no evidence to suggest the A-D fit statistic is more appropriate in this case. Further, with only 5 data points being available, it considers placing more weight at the tail end by using the A-D statistical fit to be unsound[2].

— Given the simplicity of the K-S fit statistic, we have used this in preference to the A-D or AIC tests.

Because a probability distribution is being fitted to a dataset of only five values for each parameter, the fit statistics are typically low in value and the curve of best fit is sensitive to small changes in any of the five values. We have examined the curve of second best fit to see if similar values occur at the 5th and 95th percentile, as these values are used to set the cap and floor values.

Where the curve of best fit and the curve of second best fit do not align, they are further examined to test for any large variations in the calculated values that might indicate that the curve of best fit should not have been used. Where parameters suggest that the curve of best fit should not be used, a number of other parameters may be examined:

— the underlying data - a distribution may be chosen that best reflects the shape and spread of the underlying data,

— other fit statistics – the results of other fit statistics may indicate the use of another curve.

— longer run data to assist in improving the fit statistic.

Figure 1.1 shows where the information about the fit statistic and distribution is located on the charts that are produced by @RISK.

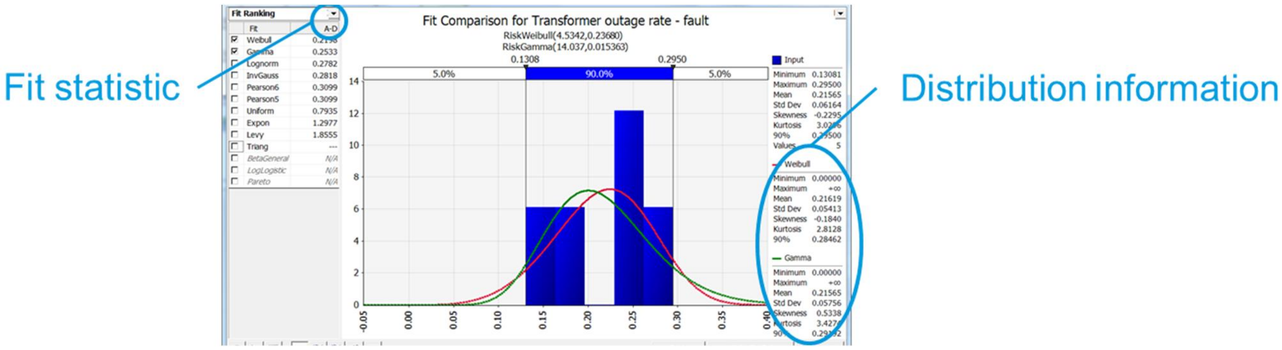

Figure 1.1 @Risk information locations

2 AER, *Final – Service Target Performance Incentive Scheme*, October 2015, cl. 3.2(e).

1.4 PARAMETER DATA

Table 1.1 shows the most recent five complete years' data used to calculate the parameter values.

Table 1.1 Reliability Data 2015-2019

PARAMETER	UNIT	2015	2016	2017	2018	2019
Unplanned outage circuit event rate:						
— Lines event rate – fault	%	18.52	16.22	18.64	24.58	16.67
— Transformers event rate – fault	%	17.92	13.37	21.05	24.56	13.45
— Reactive plant event rate – fault	%	22.30	25.74	27.94	27.41	24.63
— Lines event rate - forced	%	17.17	13.85	20.68	13.80	18.67
— Transformers event rate - forced	%	15.03	14.53	18.71	10.53	11.70
— Reactive plant event rate - forced	%	20.14	21.32	22.79	20.00	21.64
Loss of supply event frequency:						
— >0.05 system minutes	No.	2	1	6	2	0
— >0.40 system minutes	No.	1	0	0	1	0
Average event duration	min	236.23	30.06	27.45	36.24	15.00

2 STANDARD CALCULATION METHODOLOGY

This section contains an explanation of the fitting for each parameter, followed by a summary of the distribution fittings.

2.1 UNPLANNED OUTAGE CIRCUIT EVENT RATES

Unplanned outage circuit event rates represent measures of availability for components of transmission circuits. It is expressed as a percentage of the year the circuit was unavailable. The optimal performance limit is 0%, which represents total availability for the component for the year; as such a lower limit of zero is set for fitting curves to the data.

2.1.1 LINES EVENT RATE – FAULT

The data for lines event rate – fault performance is best fitted with a Pearson5 distribution according to the K-S and A-D fit statistics (Figure 2.1). The curve of second best fit is a Pearson6 and then a LogNormal distribution. Powerlink's analysis also found the Pearson5 distribution to be the best fit.

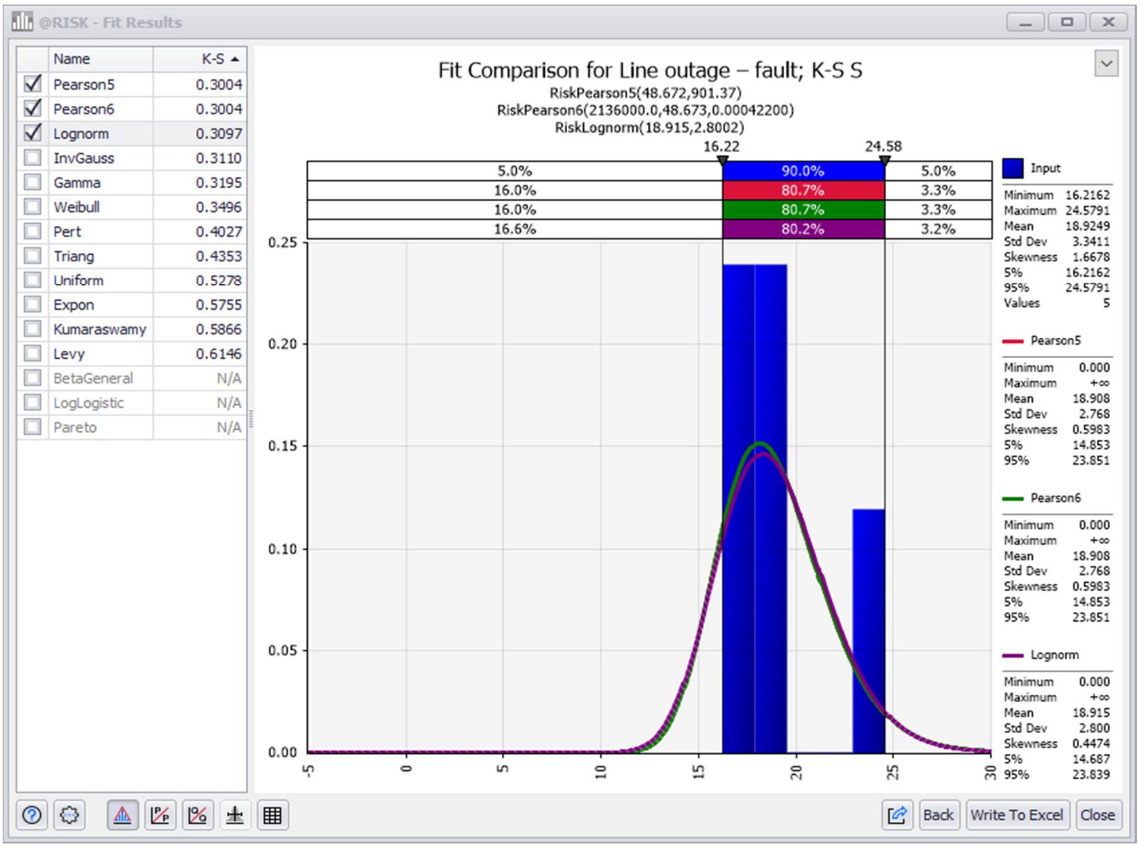

Figure 2.1 Lines event rate – fault, comparison using K-S

Table 2.1 Lines event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Pearson5	0.598	14.853	23.851
Pearson6	0.598	14.853	23.851
LogNormal	0.447	14.687	23.839

Table 2.2 shows that the differences between the Pearson5 distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions are not material as there is approximately 1% or less difference in the 5th and 95th percentiles. WSP considers that the selection of the Pearson5 distribution and resulting values are appropriate for this parameter.

Table 2.2 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	PEARSON5	PEARSON6	LOGNORM
5th percentile	0%	0%	-1%
95th percentile	0%	0%	0%

2.1.2 TRANSFORMER EVENT RATE – FAULT

The data for transformer event rate – fault performance is best fitted with a Weibull distribution according to the K-S and A-D fit statistics (Figure 2.2). The curve of second best fit is a Pert and then a Gamma distribution. The Gamma distribution has a skew in the opposite direction to the other two distributions. Powerlink's analysis also found the Weibull distribution to be the best fit.

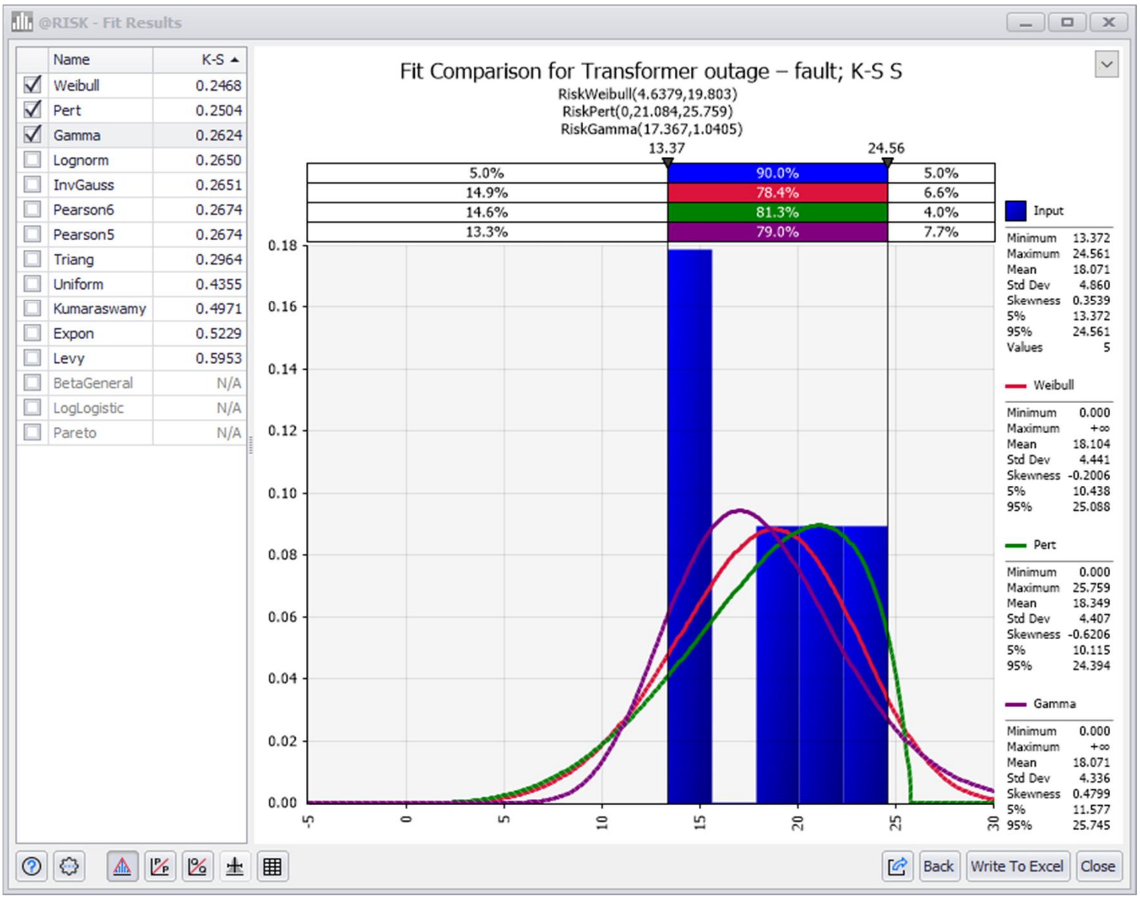

Figure 2.2 Transformer even rate – fault, comparison using K-S

Table 2.3 Transformer event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Weibull	-0.201	10.438	25.088
Pert	-0.621	10.115	24.394
Gamma	0.480	11.577	25.745

Table 2.4 shows that there are differences between the Weibull distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions. The second best fit Pert distribution results in a 3% lower cap and floor. WSP considers that the selection of the Weibull distribution and resulting values are appropriate for this parameter.

Table 2.4 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	WEIBULL	PERT	GAMMA
5th percentile	0%	-3%	11%
95th percentile	0%	-3%	3%

2.1.3 REACTIVE PLANT EVENT RATE – FAULT

The data for reactive plant event rate – fault performance is best fitted with a LogNormal distribution according to the K-S fit statistic (Figure 2.3). The curve of second best fit is a InvGauss, and then a Gamma distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the LogNormal distribution to be the best fit.

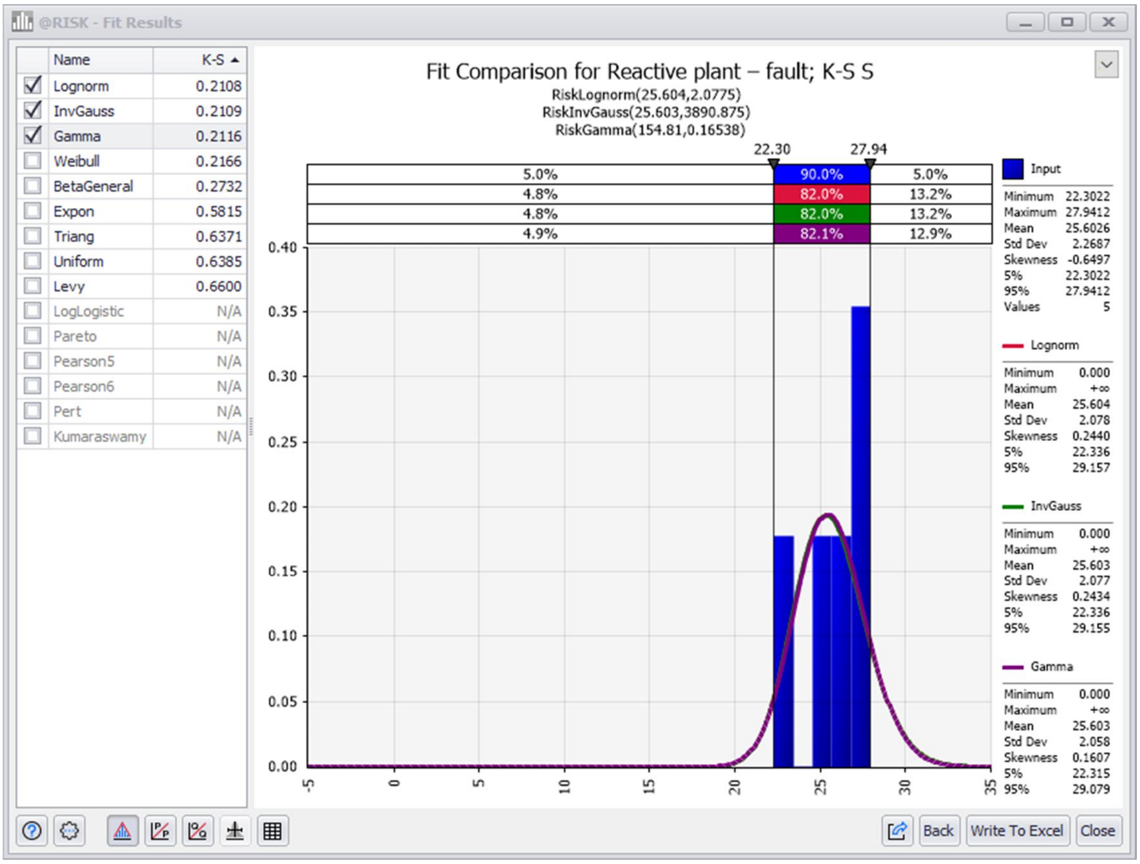

Figure 2.3 Reactive plant event rate – fault, comparison using K-S

Table 2.5 Reactive plant event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
LogNormal	0.244	22.336	29.157
InvGauss	0.243	22.336	29.155
Gamma	0.161	22.315	29.079

Table 2.6 shows that there is no difference between the LogNormal distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions. WSP considers that the selection of the LogNormal distribution and resulting values are appropriate for this parameter.

Table 2.6 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	LOGNORMAL	INVGAUSS	GAMMA
5th percentile	0%	0%	0%
95th percentile	0%	0%	0%

2.1.4 LINES EVENT RATE – FORCED

The data for lines event rate – fault performance is best fitted with a Weibull distribution according to the K-S and A-D fit statistics (Figure 2.4). The curve of second best fit is a Gamma and then a InvGauss distribution. The best fit Weibull distribution has a skewness that is opposite to the Gamma and InvGauss distributions and fits better to the underlying data. Powerlink's analysis also found the Weibull distribution to be the best fit.

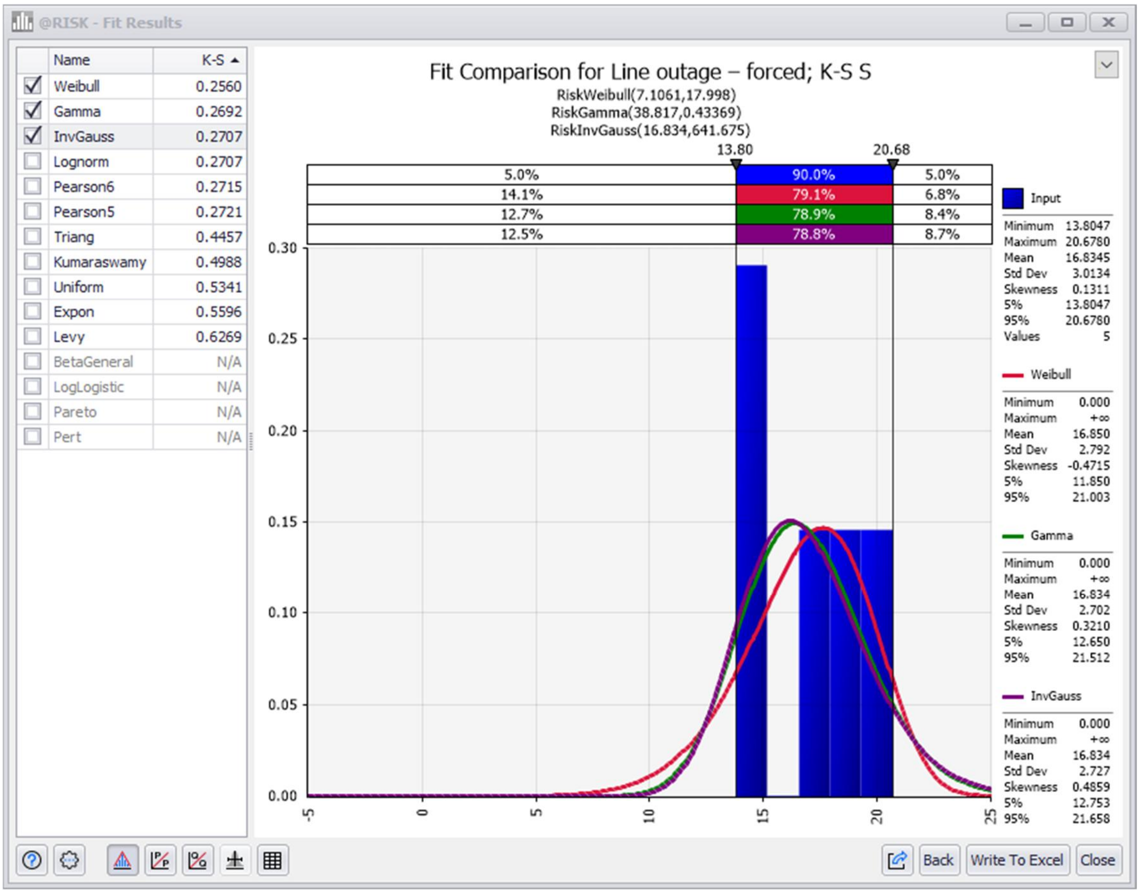

Figure 2.4 Lines event rate – forced, comparison using K-S

Table 2.7 Lines event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Weibull	-0.472	11.850	21.003
Gamma	0.321	12.650	21.512
InvGauss	0.486	12.753	21.658

Table 2.8 shows that there is a difference between the Weibull distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions. While the difference is material for the 5th percentile, considering the results of the two fit tests and alignment to the underlying data, WSP considers that the selection of the Weibull distribution and resulting values are appropriate for this parameter.

Table 2.8 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	WEIBULL	GAMMA	INVGAUSS
5th percentile	0%	7%	8%
95th percentile	0%	2%	3%

2.1.5 TRANSFORMER EVENT RATE – FORCED

The data for transformer event rate – forced performance is best fitted with a Gamma distribution according to the K-S fit statistic (Figure 2.5). The curve of second best fit is a InvGauss and then a LogNormal distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the Gamma distribution to be the best fit.

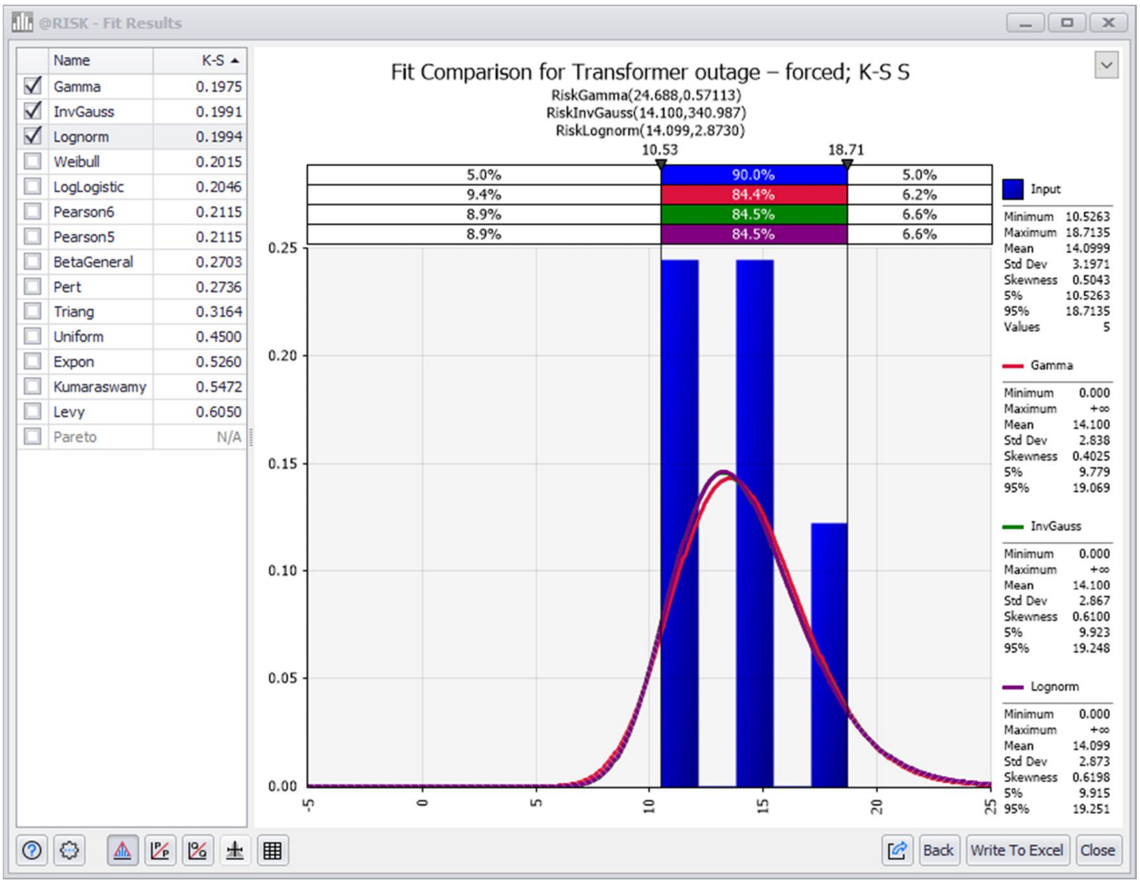

Figure 2.5 Transformer event rate – forced, comparison using K-S

Table 2.9 Transformer event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Gamma	0.403	9.779	19.069
InvGauss	0.610	9.923	19.248
Lognorm	0.620	9.915	19.251

Table 2.10 shows that there is no material difference between the Gamma distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions.

Table 2.10 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	GAMMA	INVGAUSS	LOGNORMAL
5th percentile	0%	1%	1%
95th percentile	0%	1%	1%

WSP considers that the selection of the Gamma distribution and resulting values are appropriate for this parameter.

2.1.6 REACTIVE PLANT EVENT RATE – FORCED

The data for reactive plant event rate – forced performance is best fitted with a Weibull distribution according to the K-S fit statistic (Figure 2.6). The curve of second best fit is a Gamma and then a LogNormal distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the Weibull distribution to be the best fit.

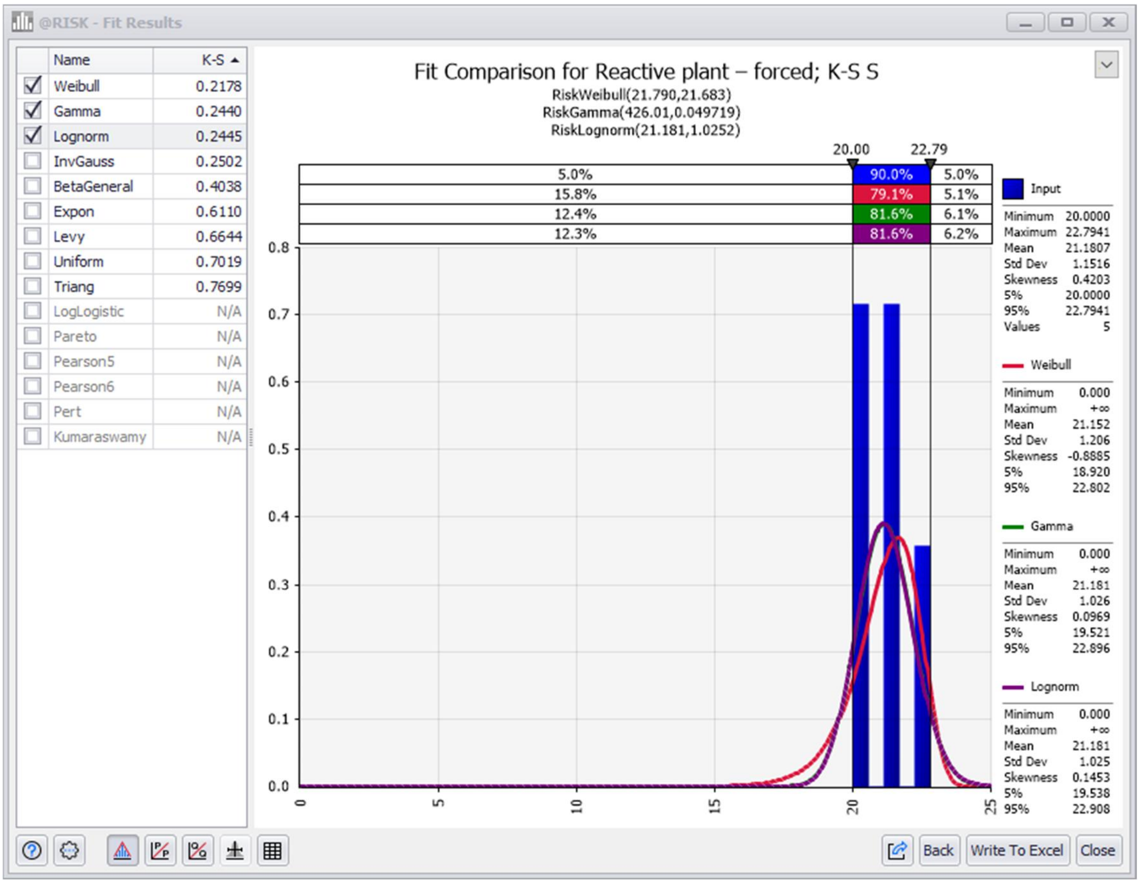

Figure 2.6 Reactive plant event rate – forced, comparison using K-S

Table 2.11 Reactive plant event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Weibull	-0.889	18.920	22.802
Gamma	0.097	19.521	22.896
Lognorm	0.145	19.538	22.908

Table 2.12 shows that there is a small difference to the 5th percentile value between the Weibull distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions, but no difference with the 95th percentile.

Table 2.12 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	WEIBULL	GAMMA	LOGNORMAL
5th percentile	0%	3%	3%
95th percentile	0%	0%	0%

The K-S fit statistic identified the Weibull distribution as the best fit by a larger margin than the difference between the Weibull and the other two distributions under the A-D fit statistic. Therefore, WSP considers that the selection of the Weibull distribution and resulting values are appropriate for this parameter.

2.2 LOSS OF SUPPLY EVENT FREQUENCIES

Loss of supply events represent discrete occurrences of failure. An event is recorded when the system minutes incurred during an outage exceed the threshold of each parameter and hence can only be integer values. In order to best fit the loss of supply events data, discrete distribution curves are used with equal interval binning.

2.2.1 LOSS OF SUPPLY EVENT FREQUENCY > 0.05 SYSTEM MINUTES

The data for loss of supply event frequency > 0.05 system minutes performance is best fitted with a Geometric distribution according to the AIC fit statistic (Figure 2.7). The curve of second best fit is a Poisson distribution and then a NegBin distribution. All three distributions have very similar shape and percentile characteristics. Since the parameter can only have a minimum value of zero, the 5th percentile is set to zero as the lowest possible value. Powerlink's analysis also found the Geometric distribution to be the best fit.

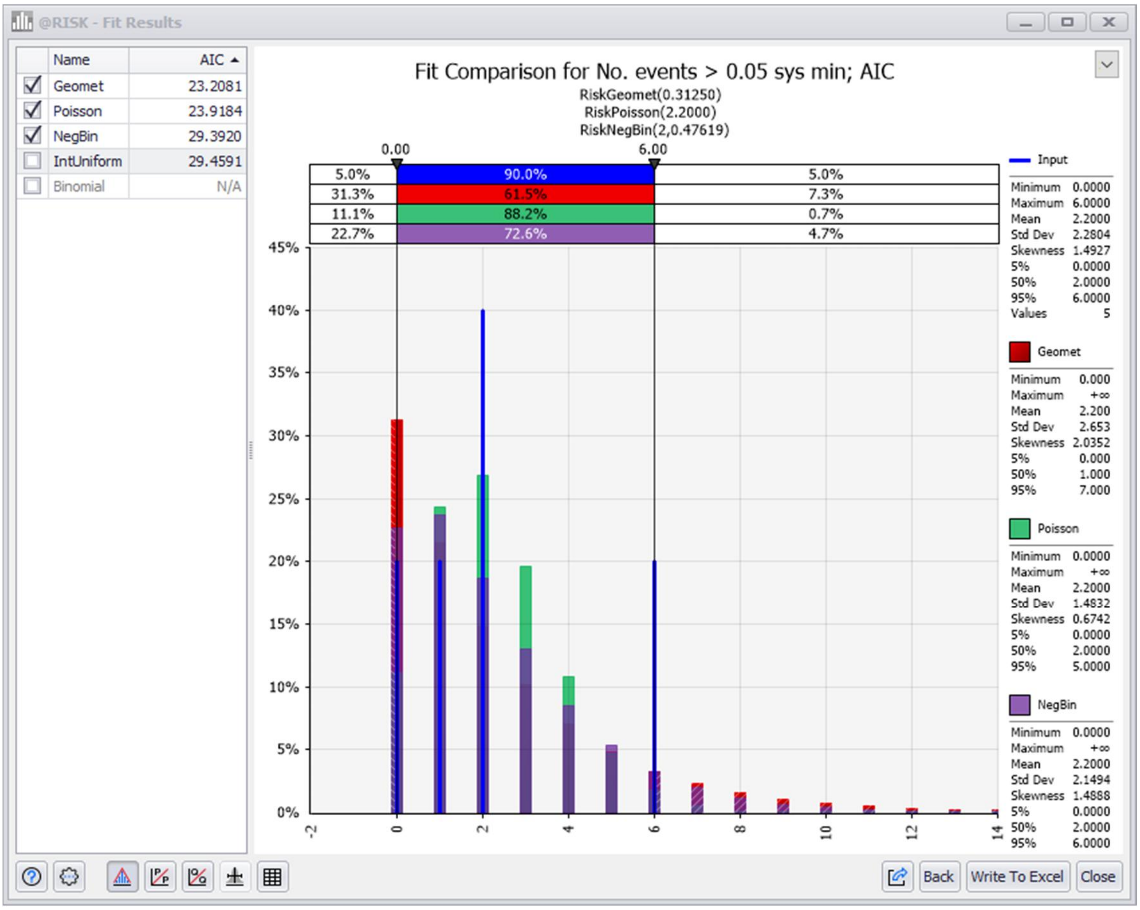

Figure 2.7 Loss of supply events > 0.05 system minutes, comparison using AIC

Table 2.13 Loss of supply events > 0.05 system minutes performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Geometric	2.035	0	7
Poisson	0.674	0	5
NegBin	1.489	0	6

Table 2.14 shows that there is no difference in the 5th percentile value between the Geometric distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions, but a significant difference with the 95th percentile. The percentage difference is exacerbated by this being a discrete distribution so the values must be integers and even a small change at a low value results in a large percentage difference.

Table 2.14 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	GEOMETRIC	POISSON	NEGBIN
5th percentile	0%	0%	0%
95th percentile	0%	-30%	-14%

The AIC fit statistic identified the Geometric distribution as the best fit and review of the underlying data shows that it more closely aligns with the data than the other distributions. Therefore, WSP considers that the selection of the Geometric distribution and resulting values are appropriate for this parameter.

2.2.2 LOSS OF SUPPLY EVENTS > 0.40 SYSTEM MINUTES

Powerlink has proposed an alternative methodology for this parameter. WSP assesses the methodology against the requirements of the NER and STPIS in section 3.

2.3 AVERAGE OUTAGE DURATION

The average outage duration is a measure of the response time to outages. The optimal performance limit is close to zero, which represents an immediate response; as such a lower limit of zero is set for fitting curves to the data.

The data for 2015 of 236.23 minutes is a significant outlier compared with the data for 2016-2019. However, we understand that the AER has not previously removed outlier data from the data sets being analysed. We also note that reducing the data set to just four data points is problematic as the analysis software returns an error statement "insufficient data" in such cases.

We note that the final assessment will be made using 2016-2020 five-year data once that data for 2020 becomes available, at which time, we expect that the outlier will no longer exist in the data set.

The data for average outage duration performance is best fitted with a LogLogistic distribution according to the K-S fit statistic (Figure 2.8). The distribution of second best fit is a Pearson5 and then a LogNormal distribution. Powerlink's analysis also found the LogLogistic distribution to be the best fit.

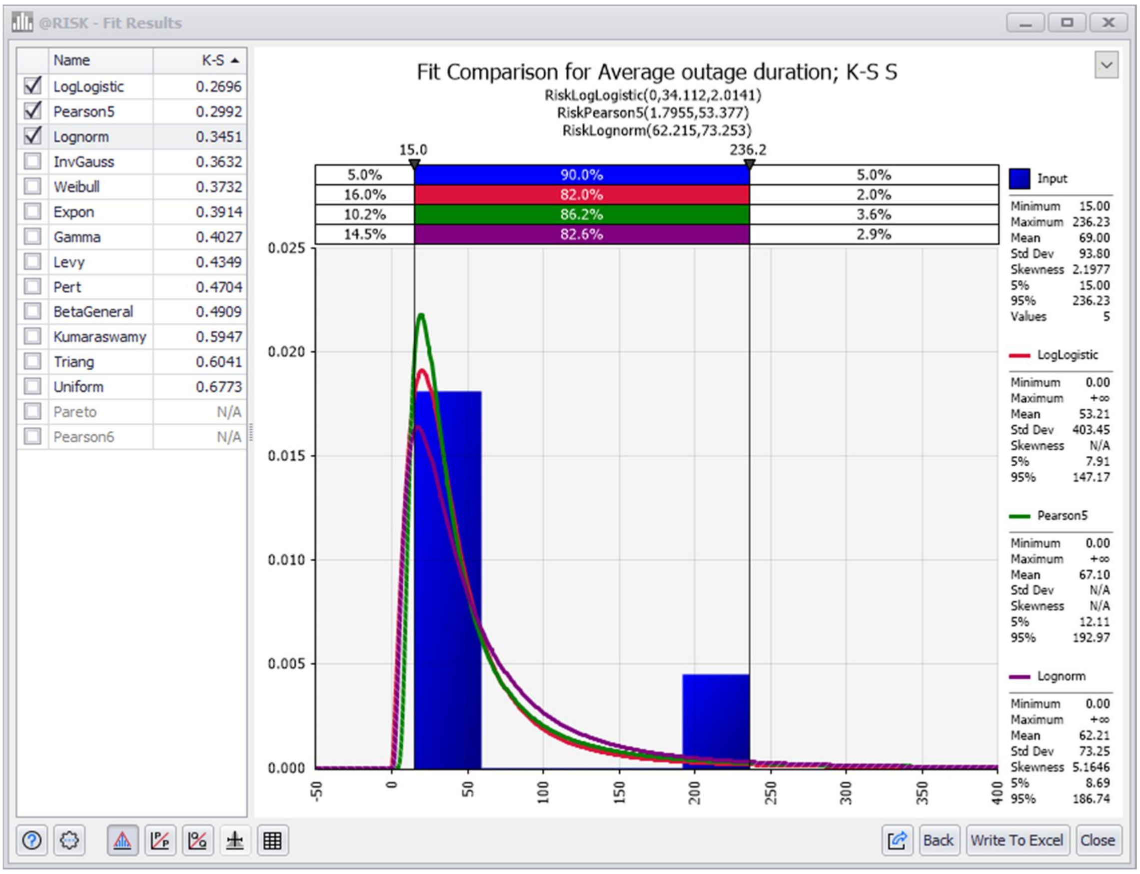

Figure 2.8 Average outage duration, comparison using K-S

Table 2.15 Average outage duration performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
LogLogistic	N/A	7.910	147.170
Pearson5	N/A	12.110	192.970
Lognorm	5.165	8.690	186.740

Table 2.16 shows that there is a material difference to the 5th and 95th percentile value between the LogLogistic distribution proposed by Powerlink, and found independently by WSP to have the best fit, and the alternative distributions. This is a result of the small data sets used for calculating these statistics and the inclusion of an outlier as the data for 2015.

Table 2.16 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	LOGLOGISTIC	PEARSON5	LOGNORMAL
5th percentile	0%	53%	10%
95th percentile	0%	31%	27%

Since the K-S test shows the LogLogistic curve to have the best fit, and the distribution shape aligns to the underlying data, WSP considers that the selection of the LogLogistic distribution and resulting values are appropriate for this parameter.

2.4 SUMMARY OF FINDINGS

Table 2.17 summarises the probability distribution functions that have been chosen to best fit the parameter data. In WSP's view this approach is robust, and does not seem to be sensitive to the choice of distribution function because the results were either close to the next best fit distributions or confirmed through close analysis of the underlying data. The approach is also consistent with the Australian Energy Regulator's previous regulatory decisions to use a curve of best fit approach.

Table 2.17 Summary of best fit distributions

PARAMETER	BEST FIT DISTRIBUTION	TARGET	5% POE	95% POE
Lines event rate – fault	Pearson5	18.92%	14.85%	23.85%
Transformer event rate – fault	Weibull	18.07%	10.44%	25.09%
Reactive plant event rate - fault	LogNormal	25.60%	22.34%	29.16%
Lines event rate – forced	Weibull	16.83%	11.85%	21.00%
Transformer event rate – forced	Gamma	14.10%	9.78%	19.07%
Reactive plant event rate - forced	Weibull	21.18%	18.92%	22.80%
Loss of supply event frequency > 0.05 system minutes	Geometric	2	0	7
Average outage duration	LogLogistic	69.00 min	7.91 min	147.17 min

3 ALTERNATIVE CALCULATION METHODOLOGY

Powerlink has proposed an alternative calculation methodology for the 'large' loss of supply event frequency parameter. This parameter is defined as the number of loss of supply events with durations greater than 0.40 system minutes.

3.1 CONSISTENCY WITH THE NER AND STPIS

This section reviews the alternative calculation methodology proposed, the reasoning for needing an alternative methodology, compliance and consistency with the requirements of the NER and STPIS, and the resulting target, cap and floor values.

INTENT OF THE STPIS

The STPIS is intended to provide an incentive for TNSPs to improve their performance. NER Clause 6A.7.4(b)(1) requires the scheme to "provide incentives …" to "provide greater reliability of the transmission system …" and "improve and maintain the reliability …".

An incentive is, by definition[3], a mechanism which incites or stimulates action, in this case an improvement or maintenance of reliability. As the NER Objectives require maintenance of reliability performance, the STPIS provides a mechanism for TNSPs to fund reliability improvements.

As shown in Figure 3.1, a typical outcome of the STPIS is a symmetrical cap and floor around the target value. The symmetrical structure provides financial incentive to improve reliability, while the penalty provides disincentive to allow reliability to fall, or stated differently, it is an incentive to maintain reliability. Together the two parts of the scheme therefore meet the requirement of Clause 6A.7.4(b)(1).

Symmetrical incentives are consistent with the objectives for the STPIS, as they usually provide a cost-neutral position for natural variation around the average. Where performance improvement is more difficult (costly) to achieve than performance reduction, the incentive to improve is weakened and should result in the more economic investment decision.

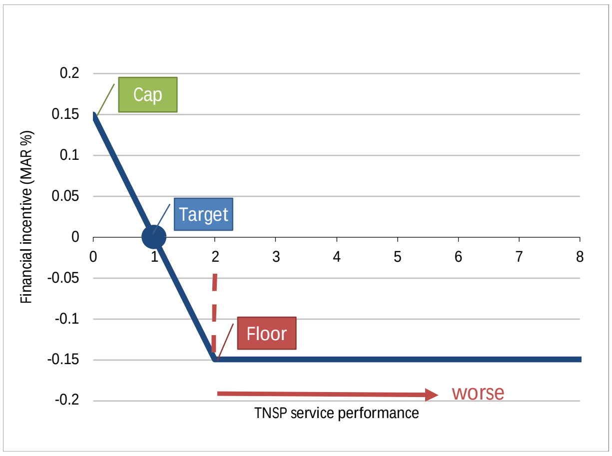

Figure 3.1 Indicative reward scheme structure

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3 https://www.macquariedictionary.com.au/features/word/search/?search_word_type=Dictionary&word=incentive

ASYMMETRIC PARAMETERS

WSP does not consider that setting the target and cap to zero for the ‘large’ loss of supply event frequency parameter is consistent with the requirements of the NER and STPIS as it does not provide incentive to improve reliability as set out by NER Clause 6A.7.4(b)(1), nor does it enable the scheme to provide a maximum revenue increment of 1.25% MAR as required by STPIS Clause 3.3(a).

Analysing Powerlink’s recent performance for the ‘large’ loss of supply event frequency parameter, and following the standard methodology, results in an asymmetric scheme. As this is a discrete parameter bound at zero as the lowest value, with both the target and cap are set at zero, there is no possibility of outperforming the target and hence there is no incentive to improve reliability, only an expectation of being penalised for failing to meet a target that has not previously been achieved consistently. This is shown in Figure 3.2 below.

As NER Clause 6A.7.4(b)(1) requires the scheme to provide incentive to improve and maintain reliability, this scenario only provides for an incentive to maintain reliability (disincentive to allow reduced reliability) and therefore may not be consistent with this requirement of the NER.

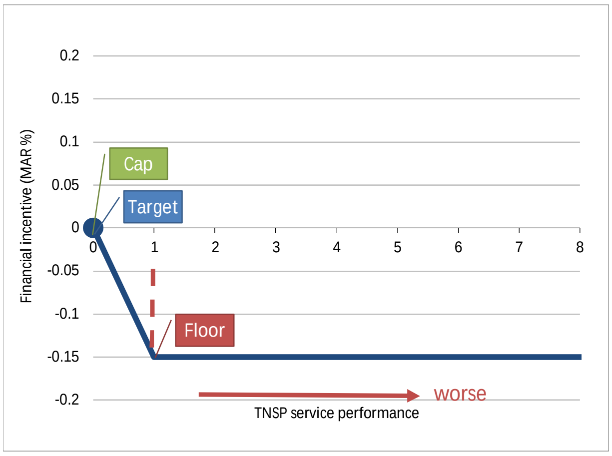

Figure 3.2 Powerlink’s asymmetric targets using the standard methodology

Further, setting both the cap and target to zero reduces the maximum revenue increment that Powerlink may earn against the parameters and values to below the value of 1.25% MAR that is specified by the STPIS:

— Clause 3.3(a) of the STPIS version 5 (Corrected) specifies that the maximum revenue increment or decrement a TNSP may earn against its parameters under the service component is 1.25% of MAR, and

— Clause 3.4(b) Table 3-1 of the STPIS sets the weighting for the large loss of supply parameter at 0.15% MAR.

If zero incentive applies to the large loss of supply parameter, the maximum revenue increment provided for by the STPIS under this scenario is 1.1% of MAR and the maximum revenue decrement is 1.25%. This may not comply with the requirements of the STPIS, hence the cap, floor and target are not considered appropriate.

UPDATING THE STPIS PARAMETER THRESHOLDS

WSP considers that setting a symmetric maximum revenue increment and decrement around a target value is most consistent with the requirements of the NER and the STPIS. With Powerlink’s improved performance resulting in the asymmetric values, the most appropriate action to ensure consistency with the NER and STPIS is to adjust the system minutes threshold for this parameter such that the historical performance would result in a symmetrical cap and floor around a central target using the standard calculation approach.

However, in an email to Powerlink[4], the AER clarified that the STPIS does not provide for changes to be made to the scheme (including resetting of STPIS parameter thresholds) via the transmission determination process. Changes can only occur under Clause 1.7(a) of the STPIS, but it requires a full consultation process as set out in the NER Clause 6A.20. The AER stated that given the required timeframes required for a full review and other processes currently underway, it is not appropriate at this time.

In light of this, WSP considers that the application of an alternative methodology, as allowed for by Clause 3.2(i) of the STPIS, is appropriate.

POWERLINK'S ALTERNATIVE CALCULATION METHODOLOGY

To address the issues noted above, Powerlink proposed an alternative methodology for the calculation of target value for the 'large' loss of supply event frequency parameter, as allowed by Clause 3.2(i) of the STPIS.

This parameter is non-continuous as it must have an integer value. The standard approach requires rounding the average performance for the most recent five years to the nearest integer; however, this results in both a target and cap set to zero and therefore an asymmetric incentive profile.

To address this issue, Powerlink modified the methodology to round the average to the nearest non-zero integer. This will result in a minimum possible target of one event. This alternative methodology will only affect the outcome in the situation where the average of the past performance is less than 0.5 events per year. In any other case, rounding to the nearest integer (the standard calculation) and rounding to the nearest non-zero integer will result in the same outcome.

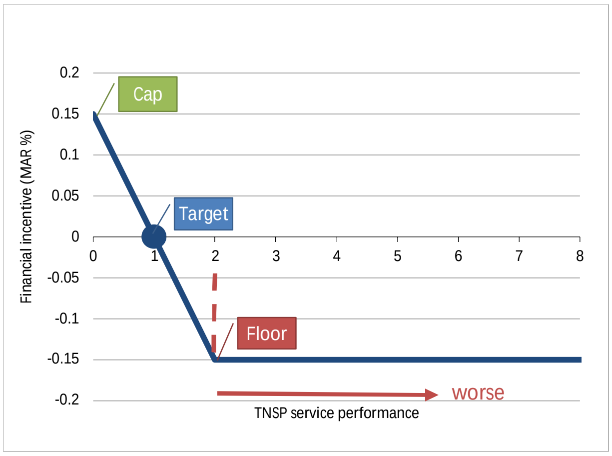

Figure 3.3 Outcome of Powerlink's alternative methodology

ASSESSMENT AGAINST STPIS REQUIREMENTS

The application of an alternative methodology is allowed for in STPIS Clause 3.2(i) as explained in Table 3.1 below.

Table 3.1 Alignment to STPIS Clause 3.2(i) requirements

STPIS CLAUSE	REQUIREMENT	FINDING
Clause 3.2(i)	Where the performance history information described in clause 3.2(f) is available, the AER may approve a performance target based on an alternative methodology proposed by the TNSP if it is satisfied that:	

[4] Chan, David "Subject: Powerlink request for review of STPIS". Message to Jenny Harris (Powerlink). 14 November 2019. By email.

STPIS CLAUSE	REQUIREMENT	FINDING
Clause 3.2(i)(1)	the methodology is reasonable	WSP considers that the methodology is reasonable as it targets the specific issue and will only affect the outcome in the situation where the average of the past performance is less than 0.5 events per year. In any other case, rounding to the nearest integer (the standard calculation) and rounding to the nearest non-zero integer will result in the same outcome.
Clause 3.2(i)(2)	the TNSP's performance as measured by the relevant parameter has been consistently very high over every calendar year of the previous five years	Powerlink's reliability performance has been consistently high during the past five calendar years, exceeding their target in three years and meeting the target in two. Hence this clause is satisfied.
Clause 3.2(i)(3)	it is unlikely that the TNSP will be able to improve its performance during the next regulatory control period (or any potential improvement would be marginal), or any further improvements are likely to compromise the TNSP's other regulatory obligations	It is unlikely that the TNSP would be able to improve its performance significantly, and cannot improve it beyond the target that would be set by the standard calculation methodology, hence the lack of incentive described in the sections above.
Clause 3.2(i)(4)	where applicable, the TNSP's proposed performance targets are not a lower threshold than the performance targets that applied to an identical parameter in the previous regulatory control period	The performance target in the current regulatory control period is 1 with a cap of zero and floor of 2. Hence, the proposed values are the same as for the current period and are not lower.
Clause 3.2(i)(5)	the proposed methodology is consistent with the objectives in clause 1.4 of the scheme.	The proposed methodology ensures: — there is a cost neutral position over the long term to allow for natural variation around the average, hence promoting prudent and efficient expenditure decisions and consistency with STPIS Clause 1.4(a)(1) and STPIS Clause 1.4(b)(3). — there is incentive to improve performance and therefore is consistent with STPIS Clause 1.4(a)(2). — provide a transparent calculation approach and therefore is consistent with STPIS Clause 1.4(b)(1) and (2).

ASSESSMENT AGAINST NER REQUIREMENTS

To test if Powerlink's proposed alternative methodology is consistent with the NER, WSP assessed the methodology against the requirements of Clause 6A.7.4(b). The clause, requirements and findings are set out in Table 3.2 below.

Table 3.2 Alignment to NER Clause 6A.7.4(b) requirements

NER CLAUSE	**REQUIREMENT**	**FINDING**
Clause 6A.7.4(b)(1)	provide incentives for each TNSP to: i. provide greater reliability of the transmission system that is owned, controlled or operated by it at all times when transmission network users place greatest value on the reliability of the transmission system; and ii. improve and maintain the reliability of those elements of the transmission system that are most important to determining spot prices;	Having a maximum revenue increment set to zero does not incentivise improved performance. An incentive is a mechanism to reward improved performance is required by the scheme as the disincentive through the maximum revenue decrement only incentivises maintaining reliability. Both aspects of the STPIS are needed in order to be consistent with these requirements.
Clause 6A.7.4(b)(2)	result in a potential adjustment to the revenue that the TNSP may earn, from the provision of prescribed transmission services, in each regulatory year in respect of which the STPIS applies	This is achieved with the standard and alternative methodology.
Clause 6A.7.4(b)(3)	ensure that the maximum revenue increment or decrement as a result of the operation of the STPIS will fall within a range that is between 1 and 5 per cent of the maximum allowed revenue for the relevant regulatory year	With the target and cap of the 'large' outage event frequency parameter set to zero, the maximum revenue increment that can be achieved through the STPIS is 1.1%. While this does comply with the requirement of Clause 6A.7.4(b)(3), being between 1% and 5%, it does not comply with the STPIS version 5 Clause 3.3(a) that specifies a maximum revenue increment and decrement of 1.25%. Hence, application of Powerlink's alternative methodology, which is allowed under STPIS Clause 3.2(i), provides an outcome that is more consistent with Clause 6A.7.4(b)(3).

NER CLAUSE	REQUIREMENT	FINDING
Clause 6A.7.4(b)(4)	take into account the regulatory obligations or requirements with which TNSPs must comply	TNSPs are required to invest efficiently and prudently to meet the NER Objectives and are required to maintain reliability. A STPIS without an incentive to encourage investment, and instead only a penalty for not meeting reliability targets, may result in additional expenditure in excess of what is efficient and prudent in order to avoid the penalty. Without the scheme, this additional expenditure would be funded through the regulatory asset base, hence increasing the cost of electricity to customers. Inclusion of the increment ensure that over the long term there is a cost neutral position for natural variation around the average, removing the incentive to over invest in network reliability. Exclusion of the increment component could potentially have an adverse impact on meeting other regulatory obligations.
Clause 6A.7.4(b)(5)	take into account any other incentives provided for in the Rules that TNSPs have to minimise capital or operating expenditure	As above.
Clause 6A.7.4(b)(6)	take into account the age and ratings of the assets comprising the relevant transmission system	A material change in age or ratings would be required to have a material impact on the STPIS parameters and is not considered to be likely during a five-year period. There is no difference between the two methodologies with respect to this clause.

3.2 VALIDATION OF THE PARAMETERS

The data for loss of supply event frequency > 0.40 system minutes is best fitted with a Poisson distribution according to the AIC fit statistic (Figure 2.7). The curve of second best fit is a Geometric and then a Binomial distribution. All three distributions have very similar shape and percentile characteristics. Since the parameter can only have a minimum value of zero, the 5^{th} percentile is set to zero as the lowest possible value.

The AIC fit statistic identified the Poisson distribution as the best fit and review of the underlying data shows that it more closely aligns with the data than the other distributions. Therefore, WSP considers that the selection of the Poisson distribution and resulting 5th and 95th percentile values are appropriate for this parameter, noting the target has been set using the alternative calculation methodology.

Table 3.3 Loss of supply event frequency > 0.40 system minutes performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Poisson	1.581	0.000	2.000
Geomet	2.405	0.000	2.000
Binomial	0.408	0.000	1.000

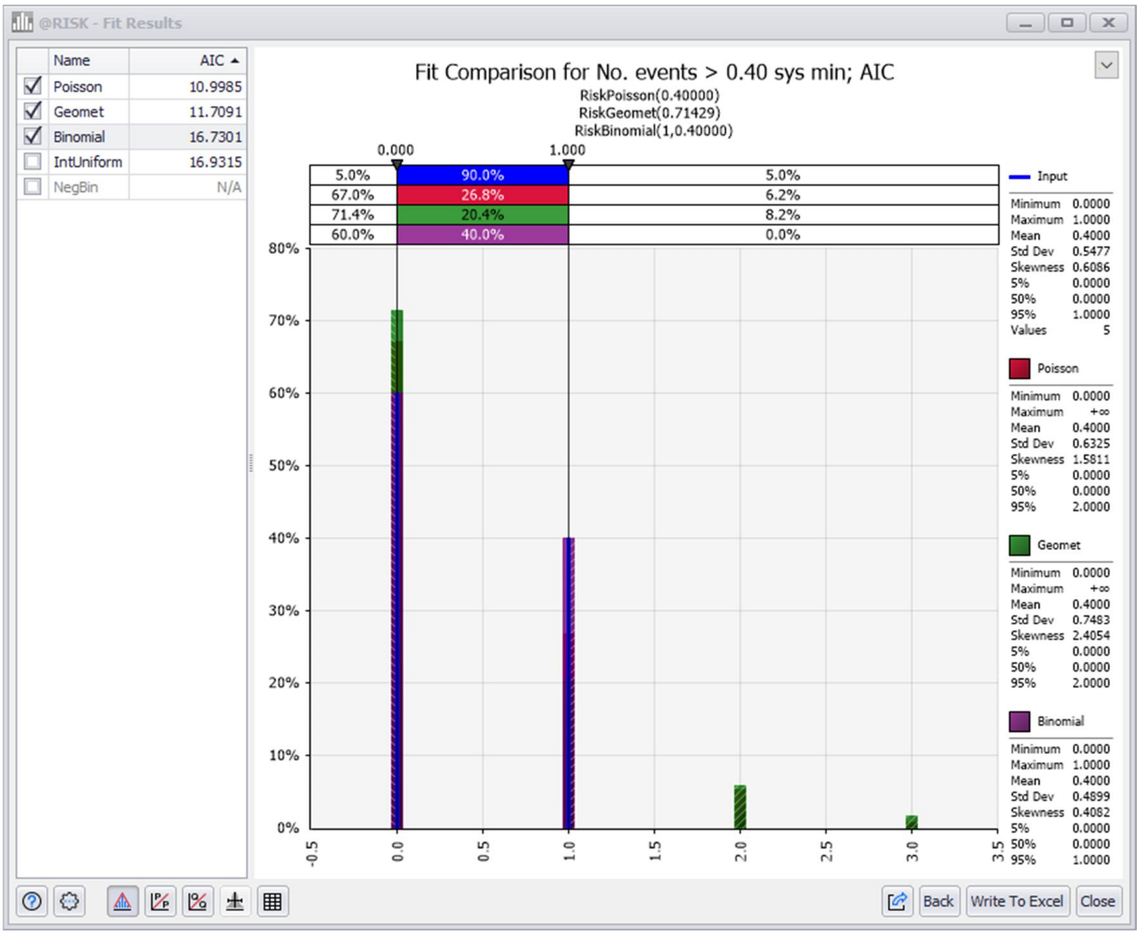

Figure 3.4 Loss of supply event frequency > 0.40 system minutes, comparison using AIC

3.3 SUMMARY OF FINDINGS

Table 3.4 summarises the probability distribution function that has been chosen to best fit the parameter data and determine the 5th and 95th percentiles for the cap and floor values, respectively. The approach is also consistent with the Australian Energy Regulator's previous regulatory decisions to use a curve of best fit approach.

The target has been set based on the alternative calculation methodology described above.

Table 3.4 Summary of best fit distributions

PARAMETER	BEST FIT DISTRIBUTION	TARGET	5% POE	95% POE
Loss of supply event frequency > 0.4 system minutes	Poisson	1	0	2

4 VALUES FOR PARAMETERS

4.1 STPIS REQUIREMENTS FOR PARAMETER VALUES

STPIS Clause 3.2 sets out the requirements for parameter values. For each parameter, the TNSP must propose values for:

— a performance target

— a floor

— a cap

Specific requirements are:

— A performance target may take the form of a deadband (3.2(c)).

— The proposed floors and caps must be calculated by reference to the proposed performance targets and using a sound methodology (3.2(e)).

— Proposed performance targets must be equal to average performance over the most recent five years (3.2(f)).

— Proposed performance targets may be subject to adjustment to allow for statistical outliers, volume of capital works, changes in the age and ratings of the assets and changes in regulatory obligations (3.2(j)).

Additionally, a proposed cap and floor value may result in symmetric or asymmetric incentives. WSP's views on these requirements are summarised in Table 4.1.

Table 4.1 Recommendations on scheme requirements for parameter values

REQUIREMENT	DISCUSSIONS	RECOMMENDATION
Deadbands	Deadbands are used to remove the impact of small variations in performance around the average performance. Because performance in a five-year period is most often four "good" years with a single year of lower performance, deadbands most often have the effect of removing a net positive value.	Not applicable
Most recent five-year period	Calendar years 2015-2019 were the most recent five years of complete data at the time of performing this assessment. However, when this report is submitted to the AER, the 2020 calendar year will have been completed, and hence the 2016-2020 data will then be the most recent five years.	2015 to 2019 data is acceptable at this time. The assessment should be updated using 2016-2020 data prior to final submission to the AER.

REQUIREMENT	DISCUSSIONS	RECOMMENDATION
Methodology	Statistical analysis should be used where possible to meet the requirement to use a sound methodology. The proposed caps and floor values should preferably be based on an analysis of the same five years of data on which targets are based, to ensure they are calculated by reference to the proposed performance targets. If a curve of best fit cannot be found using statistical analysis, then a larger data set could be used to establish the preferred distribution but it must then be applied to the five years of data only. As described in this report, Powerlink has proposed an alternative calculation methodology for the target value of the 'large' loss of supply event frequency parameter. WSP's assessment of this methodology has found that it, and the resulting values, are consistent with the requirements of the NER and STPIS.	Adopt the approach as set out in this report.
Adjustments	Statistical outliers – these must be in the underlying reliability data rather than one of the five years of performance. WSP has not undertaken any audit of this data. Removal of outliers can have a small but material impact on a single year's performance, but little effect on the five-year average. As outliers are typically related to poor performance, removing them has the impact of making targets harder to achieve, noting that similar outliers should they occur in future performance are not removed. Volume of capital works – applies only where the parameter includes planned outages. As all the service component parameters exclude planned outages, no adjustment applies. Change in age/ratings – would require a material change, not usually evident in aggregated reliability performance.	No adjustments
Asymmetric incentives	Symmetric incentives are consistent with the objectives for the scheme, as they usually provide a cost neutral position for natural variation around the average. Where better performance is more difficult (costly) to achieve than a decline, the incentive to improve is weakened. This may be inconsistent with NER clause 6A.7.4(b)(ii), which requires that the scheme should "provide incentives …to: (i) provide greater reliability of the transmission system … at all times when Transmission Network Users place greatest value on the reliability of the transmission system; and (ii) improve and maintain the reliability of those elements of the transmission system that are most important to determining spot prices;" The counter-argument is that improvements should only be made when it is economic to do so.	Symmetric incentives should be adopted unless this results in an incentive that is inconsistent with scheme objectives.

4.2 CAPS AND FLOORS

The following factors are considered when setting caps and floor values:

— The expected range of performance should be within the cap and floor values, 5^{th} and 95^{th} percentile, meaning that the probability of performance being outside of the cap/floor is approximately 1 in 10 years.

— Performance should be bounded at zero where the curve of best fit has been bounded at zero.

— The 'Small' loss of supply event frequency parameter should be rounded to the nearest integer before applying a standard deviation, in accordance with the AER's recent determinations.

— The 'large' loss of supply event frequency parameter should be rounded to the nearest non-zero integer before applying a standard deviation.

Table 4.2 compares the caps and floors set at 5^{th} and 95^{th} percentile with the maximum and minimum performance in the 2012 to 2016 period. It demonstrates that caps and floors are best set at 5^{th} and 95^{th} percentile.

Table 4.2 Caps and floors comparisons with 2015 to 2019 data

PARAMETER	TARGET	FLOOR	CAP	MAX	MIN	COMMENT	RECOMMENDATION
Lines outage rate - fault	18.92%	23.85%	14.85%	24.58%	16.22%	Max. outage rate is slightly above the floor but not excessively	Use the calculated target, cap and floor
Transformer outage rate - fault	18.07%	25.09%	10.44%	24.56%	13.37%		Use the calculated target, cap and floor
Reactive plant outage rate - fault	25.60%	29.16%	22.34%	27.94%	22.30%	Min. outage rate is very slightly below the cap	Use the calculated target, cap and floor
Lines outage rate - forced outage	16.83%	21.00%	11.85%	20.68%	13.80%		Use the calculated target, cap and floor
Transformer outage rate - forced outage	14.10%	19.07%	9.78%	18.71%	10.53%		Use the calculated target, cap and floor
Reactive plant outage rate - forced outage	21.18%	22.80%	18.92%	22.79%	20.00%		Use the calculated target, cap and floor
Loss of supply event frequency (Events > 0.05 system minutes)	2	7	0	6	0		Use the calculated target, cap and floor
Loss of supply event frequency (Events > 0.40 system minutes)	1	2	0	1	0	Alternative methodology proposed	Use the calculated target, cap and floor

PARAMETER	TARGET	FLOOR	CAP	MAX	MIN	COMMENT	RECOMMENDATION
Average outage duration (minutes)	69.00	147.17	7.91	236.23	15.00	Max. average outage duration from 2015 of 236.23 is significantly greater than the calculated floor value and is clearly an outlier in the data set. It is likely that the target, floor and cap values will calculate differently when the calculation is repeated using 2016-2020 data	Use the calculated target, cap and floor subject to reassessment using the 2016-2020 data

4.3 RECOMMENDED PARAMETER VALUES

The recommended parameter values are shown in Table 4.3. These are based on:

— Targets set at the average of five-year performance

— Caps and floors set at 5% and 95% POE for all parameters and bounded at zero where appropriate

— Target, cap and floor rounded to nearest integer for loss of supply event frequency > 0.05 system minutes)

— Target for loss of supply event frequency > 0.40 system minutes rounded to the nearest non-zero integer before applying a standard deviation; cap and floor rounded to the nearest integer

Weightings as set out in STPIS Table 3-1 are also shown in the table.

Table 4.3 Parameter values

PARAMETER	FLOOR	TARGET	CAP	WEIGHTING MAR %
Lines event rate – fault	23.85%	18.92%	14.85%	0.20
Transformer event rate – fault	25.09%	18.07%	10.44%	0.20
Reactive plant event rate - fault	29.16%	25.60%	22.34%	0.10
Lines event rate – forced	21.00%	16.83%	11.85%	0.10
Transformer event rate – forced	19.07%	14.10%	9.78%	0.10
Reactive plant event rate - forced	22.80%	21.18%	18.92%	0.05
Loss of supply event frequency (events > 0.05 system minutes)	7	2	0	0.15
Loss of supply event frequency (events > 0.40 system minutes)	2	1	0	0.15
Average outage duration	147.17	69.00	7.91	0.20

5 LIMITATIONS

This Report is provided by WSP Australia Pty Limited (*WSP*) for Powerlink Queensland (*Client*) in response to specific instructions from the Client and in accordance with WSP's proposal dated 18 September 2020 and agreement with the Client dated 27 November 2020 (*Agreement*).

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APPENDIX A

ADDENDUM – REVIEW OF AMENDED PARAMETERS BASED ON 2016-2020 HISTORICAL DATA

A1 PARAMETER DATA

In January 2021, the reliability data for 2020 was released, and the analysis was repeated based on the data shown in Table A.1 to produce Powerlink's alternative proposed STPIS parameters.

Table A.1 Reliability Data for Set 2 2016-2020

PARAMETER	UNIT	2016	2017	2018	2019	2020
Unplanned outage circuit event rate:						
— Lines event rate – fault	%	16.22	18.64	24.58	16.67	9.06
— Transformers event rate – fault	%	13.37	21.05	24.56	13.45	11.63
— Reactive plant event rate – fault	%	25.74	27.94	27.41	24.63	22.56
— Lines event rate - forced	%	13.85	20.68	13.80	18.67	18.12
— Transformers event rate - forced	%	14.53	18.71	10.53	11.70	18.60
— Reactive plant event rate - forced	%	21.32	22.79	20.00	21.64	20.30
Loss of supply event frequency:						
— >0.05 system minutes	No.	1	6	2	0	0
— >0.40 system minutes	No.	0	0	1	0	0
Average event duration	min	30.06	27.45	36.24	15.00	57.41

Powerlink and WSP repeated the probability distribution curve fitting process for the alternative input data and we report on our recommended values for Powerlink's alternative proposed STPIS parameters in the following sections.

A2 SUMMARY OF RESULTS

Our recommended values for Powerlink's alternative proposed STPIS parameters (Set 2) are shown in Table A.2, with our recommended values for Powerlink's compliant dataset (Set 1) shown in parentheses. These are based on the same approach as was adopted for the compliant dataset, as follows:

- Targets set at the average of 2016-2020 five-year performance
- Caps and floors set at 5% and 95% POE for all parameters and bounded at zero where appropriate
- Target, cap and floor rounded to nearest integer for loss of supply event frequency > 0.05 system minutes)
- Target for loss of supply event frequency > 0.40 system minutes rounded to the nearest non-zero integer; cap and floor selected as the nearest integers below and above target

Table A.2 Set 2 parameter values (Set 1 values in parentheses)

PARAMETER	FLOOR	TARGET	CAP	COMMENT
Lines event rate – fault	24.44% (23.85%)	17.03% (18.92%)	8.40% (14.85%)	The event rate in 2020 was lower than in 2015, so the changed period of the data set resulted in a decrease to the target and cap values.
Transformer event rate – fault	23.94% (25.09%)	16.81% (18.07%)	5.49% (10.44%)	The event rate in 2020 was lower than in 2015, so the changed period of the data set resulted in a decrease to the target and cap values.
Reactive plant event rate - fault	29.05% (29.16%)	25.65% (25.60%)	22.53% (22.34%)	Not a material (<1%) difference
Lines event rate – forced	21.13% (21.00%)	17.02% (16.83%)	12.15% (11.85%)	Not a material (<1%) difference
Transformer event rate – forced	22.35% (19.07%)	14.82% (14.10%)	9.37% (9.78%)	The event rate in 2020 was higher than in 2015, so the changed period of the data set resulted in an increase to the target and floor values.
Reactive plant event rate - forced	22.79% (22.80%)	21.21% (21.18%)	19.00% (18.92%)	Not a material (<1%) difference
Loss of supply event frequency (events > 0.05 system minutes)	6 (7)	2 (2)	0 (0)	Two events in 2015 were removed from the data set and 2020 did not have any events. This reduced the floor value.
Loss of supply event frequency (events > 0.40 system minutes)	2 (2)	1 (1)	0 (0)	No change. Data set reduced to one item; curve-fitting not possible
Average outage duration	59.00 min (147.17 min)	33.23 min (69.00 min)	14.06 min (7.91 min)	2015 data item was a significant outlier in the 2015-19 data set which was excluded from the 2016-20 data set. Its exclusion resulted in a significant reduction of target and floor values and an increase of the cap value.

A3 UNPLANNED OUTAGE CIRCUIT EVENT RATES

A3.1 LINES EVENT RATE – FAULT

The data for lines event rate – fault performance is best fitted with a Pert distribution according to the K-S fit statistic (Figure A.1). The curve of second best fit is a Weibull and then a Triangular distribution. Powerlink's analysis found the Weibull distribution to be the best fit.

WSP understands that the discrepancy may arise from WSP and Powerlink using different versions of @RISK (WSP uses ver. 8.0, whilst Powerlink uses ver. 7.5.2), and that whilst ver. 8.0 includes the Pert distribution in the suite of distributions selected by @RISK for analysis, ver. 7.5.2 does not.

Whilst the K-S fit statistics for the two distributions are very close – 0.2222 (Pert) vs. 0.2268 (Weibull) – and the differences between the two distributions' 5th and 95th percentiles are quite small (less than 5 per cent), they are not non-material. Therefore, WSP recommends that Powerlink selects the Pert distribution and the resulting values as being most appropriate for this parameter.

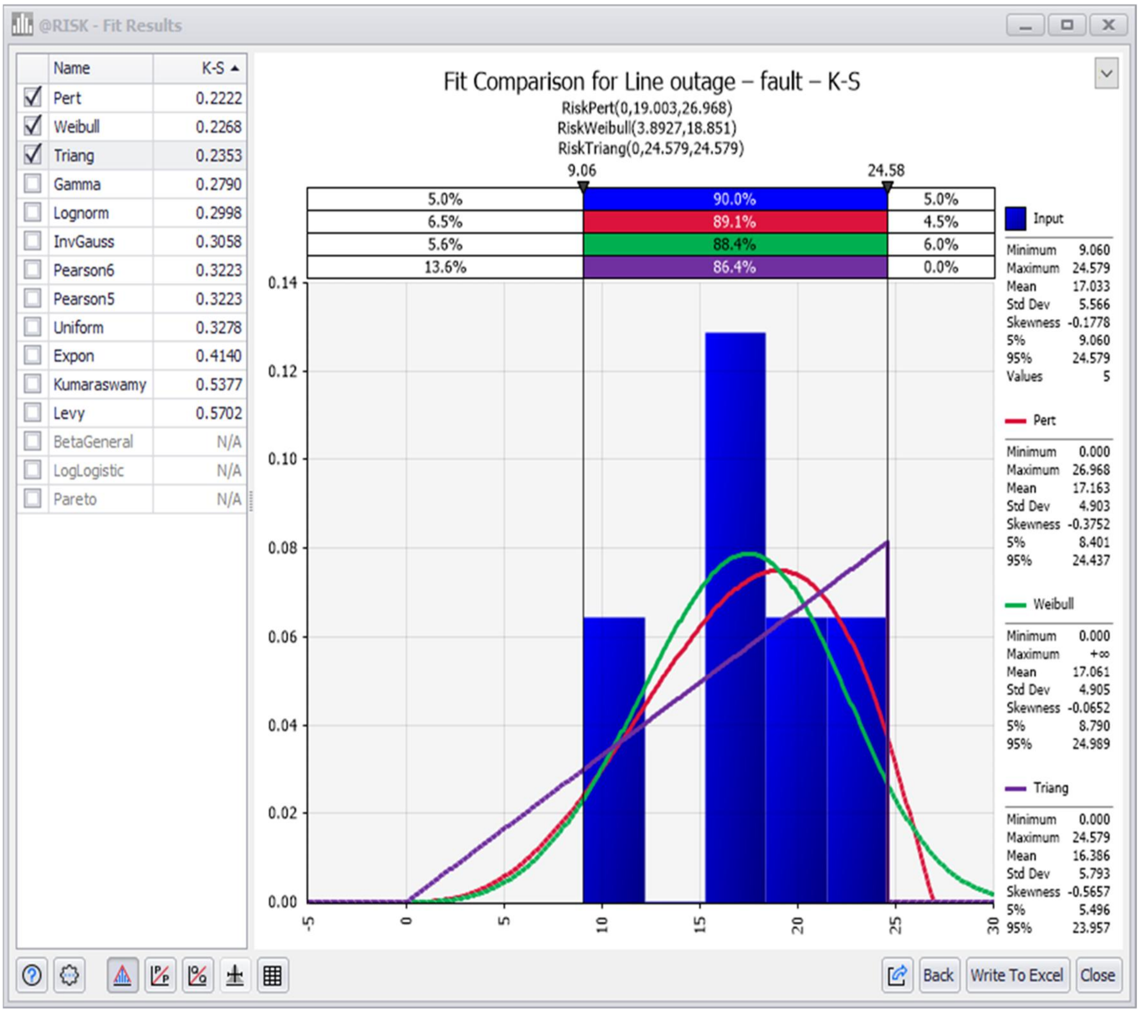

Figure A.1 Lines event rate – fault, comparison using K-S

Table A.3 Lines event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Pert	-0.375	8.401	24.437
Weibull	-0.065	8.790	24.989
Triangular	-0.566	5.496	23.957

Table A.4 Percentage difference between Powerlink's proposed (Weibull) values and other distributions

PERCENTILE	PERT	WEIBULL	TRIANGULAR
5^{th} percentile	-4.4%	0.0%	-37.5%
95^{th} percentile	-2.2%	0.0%	-4.1%

A3.2 TRANSFORMER EVENT RATE – FAULT

The data for transformer event rate – fault performance is best fitted with a Triangular distribution according to the K-S fit statistic (Figure A.2). The curve of second best fit is a LogLogistic and then a Pearson5 distribution. Powerlink's analysis also found the Triangular distribution to be the best fit.

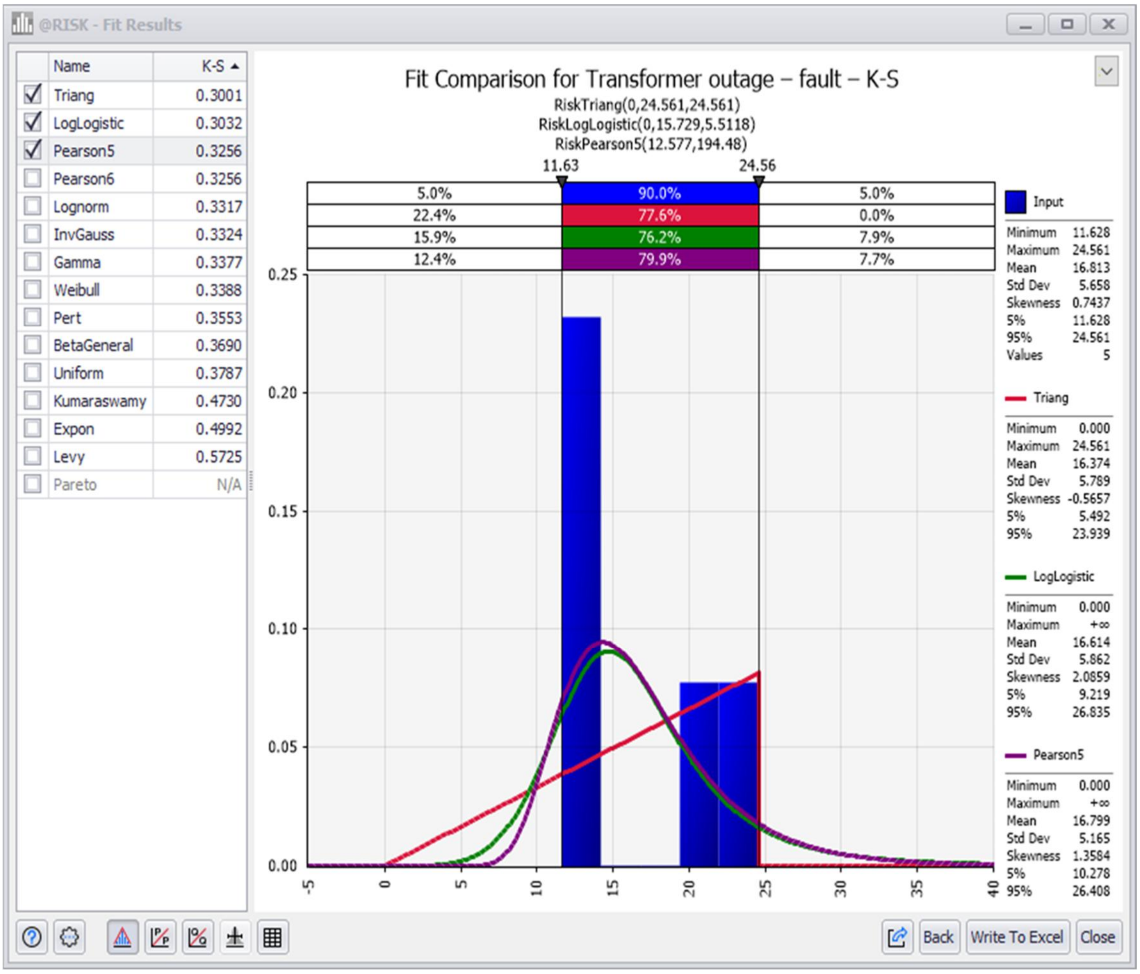

Figure A.2 Transformer event rate – fault, comparison using K S

Table A.5 Transformer event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Triangular	-0.566	5.492	23.939
LogLogistic	2.086	9.219	26.835
Pearson5	1.358	10.278	26.408

Table A.6 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	TRIANGULAR	LOGLOGISTIC	PEARSON5
5th percentile	0.0%	67.9%	87.1%
95th percentile	0.0%	12.1%	10.3%

WSP considers that the selection of the Triangular distribution and resulting values are appropriate for this parameter.

A3.3 REACTIVE PLANT EVENT RATE – FAULT

The data for reactive plant event rate – fault performance is best fitted with a LogNormal distribution according to the K-S fit statistic (Figure A.3). The curve of second best fit is a InvGauss, and then a Gamma distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the LogNormal distribution to be the best fit.

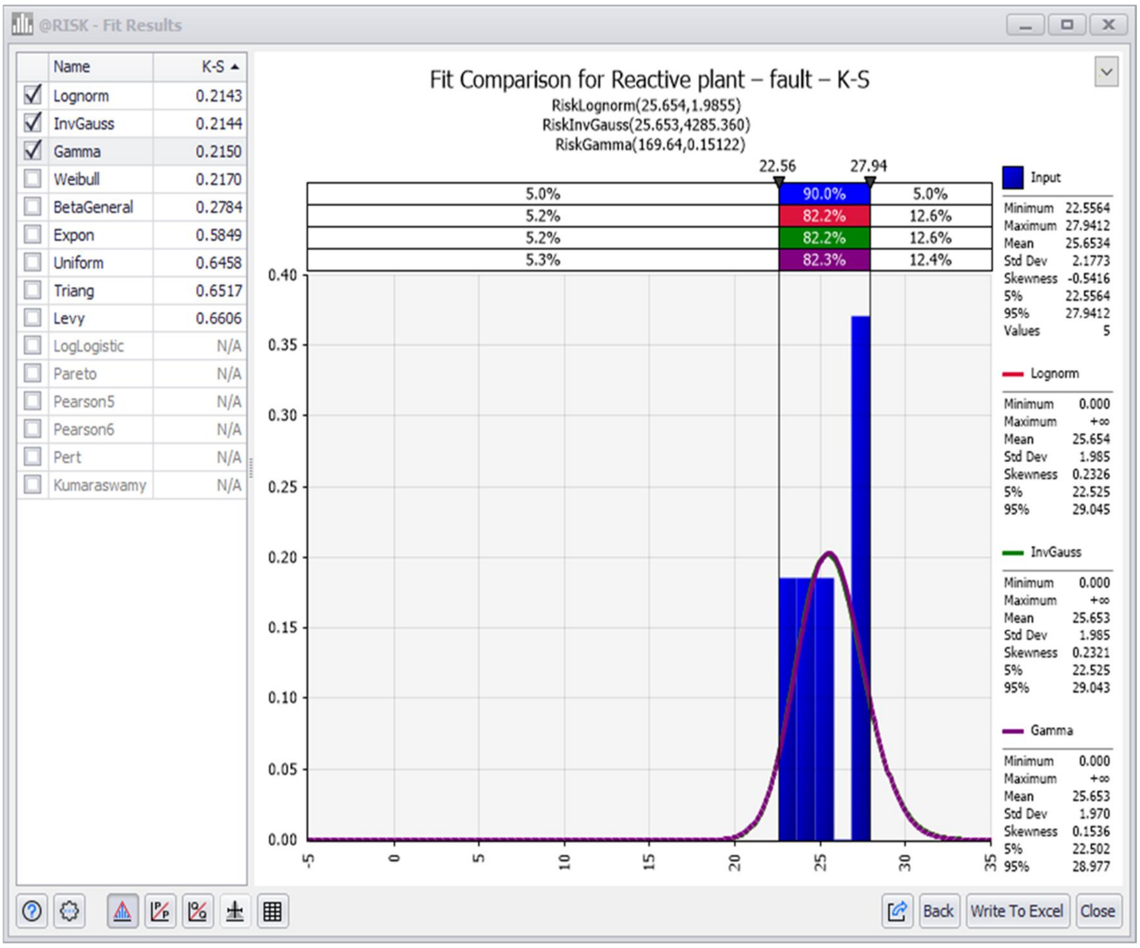

Figure A.3 Reactive plant event rate – fault, comparison using K-S

Table A.7 Reactive plant event rate – fault performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Lognorm	0.233	22.525	29.045
InvGauss	0.232	22.525	29.043
Gamma	0.154	22.502	28.977

Table A.8 Reactive plant event rate – fault performance: Standard deviations for best fit distributions

PERCENTILE	LOGNORM	INVGAUSS	GAMMA
5th percentile	0.0%	0.0%	-0.1%
95th percentile	0.0%	0.0%	-0.2%

WSP considers that the selection of the LogNorm distribution and resulting values are appropriate for this parameter.

A3.4 LINES EVENT RATE – FORCED

The data for lines event rate – fault performance is best fitted with a Weibull distribution according to the K-S fit statistic (Figure A.4). The curve of second best fit is a Gamma and then an InvGauss distribution. The best fit Weibull distribution has a skewness that is opposite to the Gamma and InvGauss distributions and fits better to the underlying data. Powerlink's analysis also found the Weibull distribution to be the best fit.

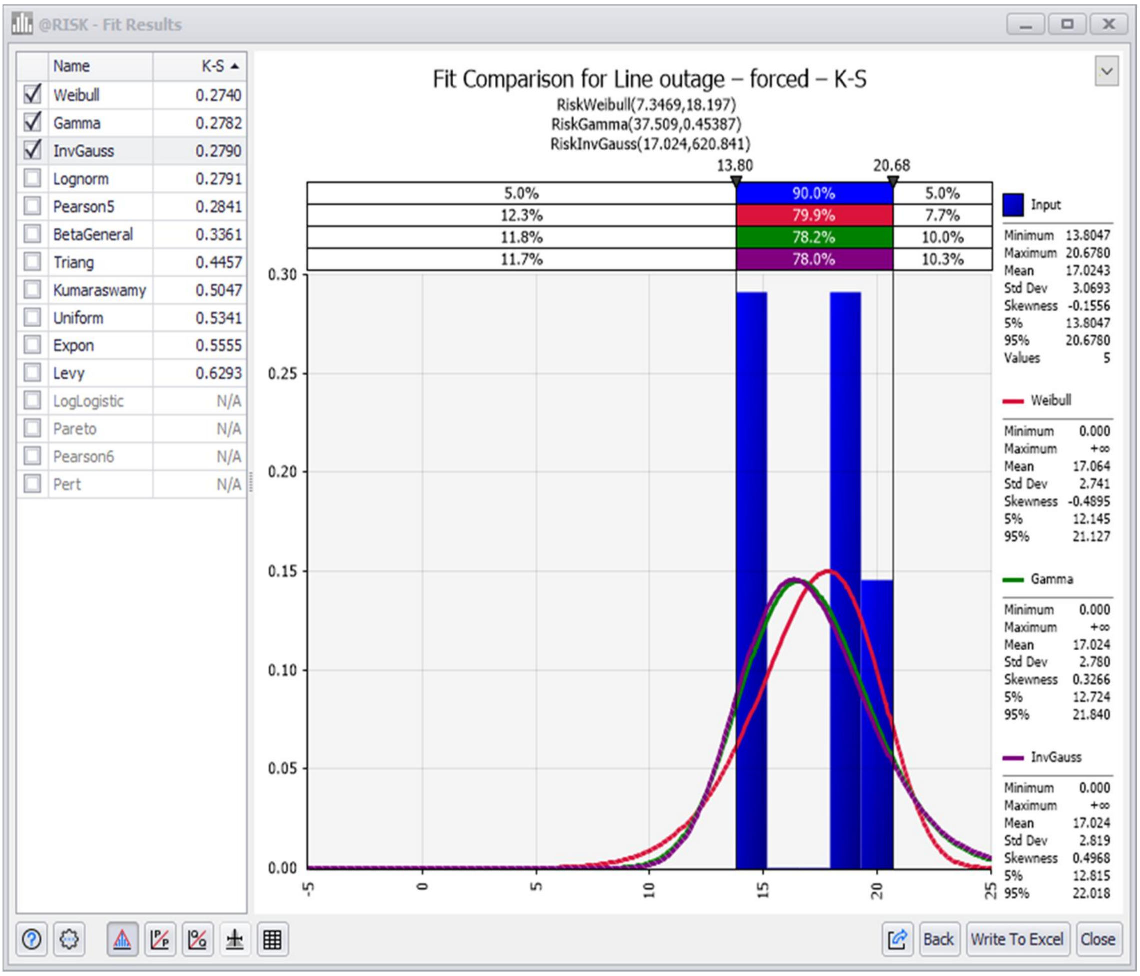

Figure A.4 Lines event rate – forced, comparison using K-S

Table A.9 Lines event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Weibull	-0.490	12.145	21.127
Gamma	0.327	12.724	21.840
InvGauss	0.497	12.815	22.018

Table A.10 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	WEIBULL	GAMMA	INVGAUSS
5th percentile	0.0%	4.8%	5.5%
95th percentile	0.0%	3.4%	4.2%

WSP considers that the selection of the Weibull distribution and resulting values are appropriate for this parameter.

A3.5 TRANSFORMER EVENT RATE – FORCED

The data for transformer event rate – forced performance is best fitted with a LogLog distribution according to the K-S fit statistic (Figure A.5). The curve of second best fit is a Pearson5 and then a LogNormal distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the LogLog distribution to be the best fit.

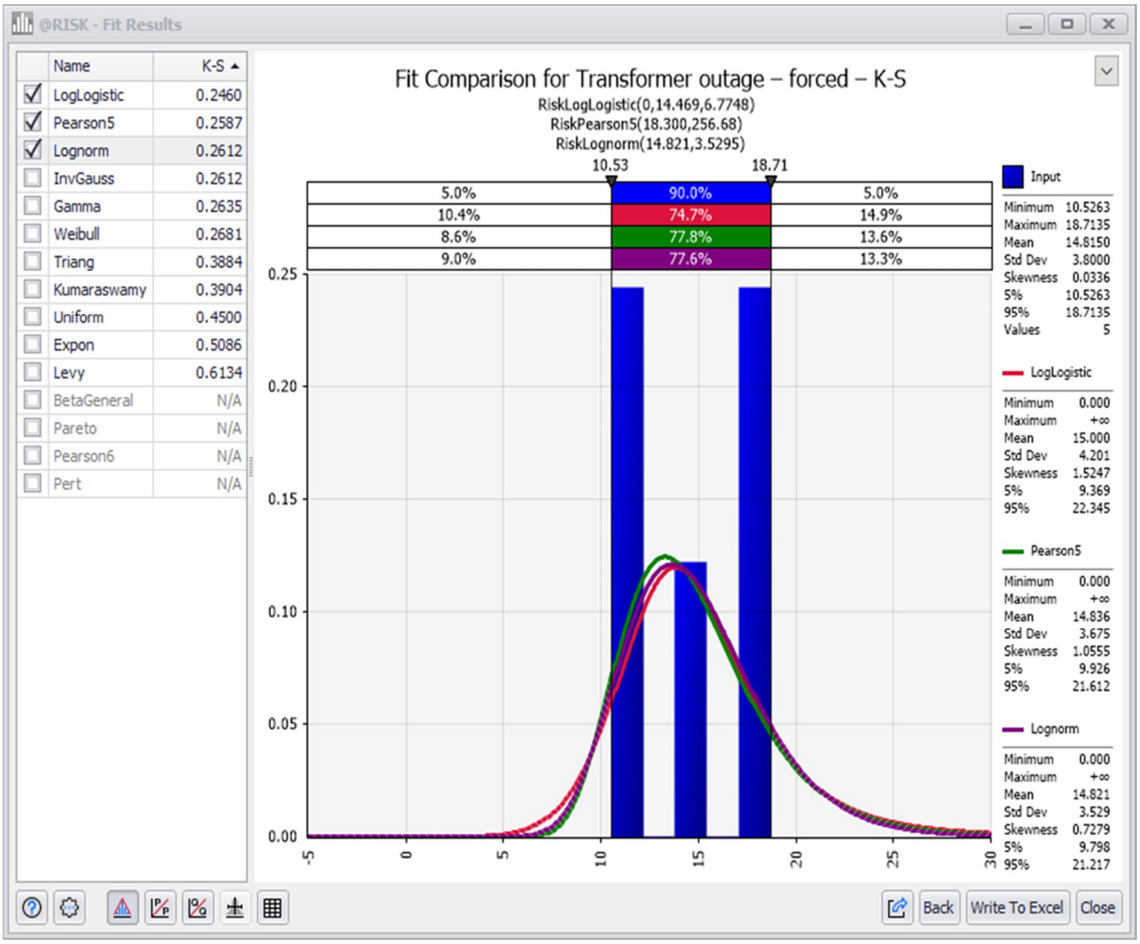

Figure A.5 Transformer event rate – forced, comparison using K-S

Table A.11 Transformer event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
LogLogistic	1.525	9.369	22.345
Pearson5	1.056	9.926	21.612
Lognorm	0.728	9.798	21.217

Table A.12 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	LOGLOGISTIC	PEARSON5	LOGNORM
5th percentile	0.0%	5.9%	4.6%
95th percentile	0.0%	-3.3%	-5.0%

WSP considers that the selection of the LogLog distribution and resulting values are appropriate for this parameter.

A3.6 REACTIVE PLANT EVENT RATE – FORCED

The data for reactive plant event rate – forced performance is best fitted with a Weibull distribution according to the K-S fit statistic (Figure A.6). The curve of second best fit is a Gamma and then a LogNormal distribution. All three distributions have very similar shape and percentile characteristics. Powerlink's analysis also found the Weibull distribution to be the best fit.

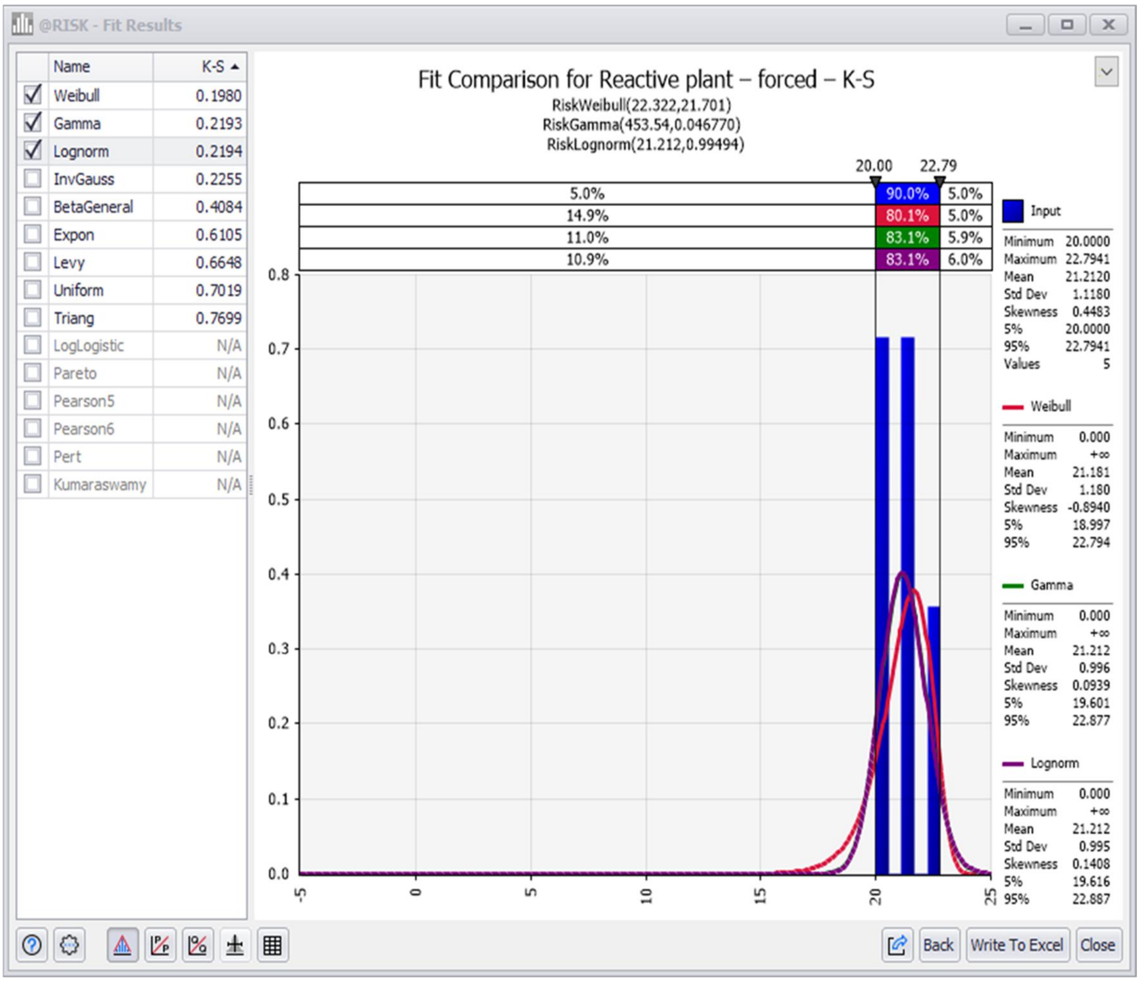

Figure A.6 Reactive plant event rate – forced, comparison using K-S

Table A.13 Reactive plant event rate – forced performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Weibull	-0.894	18.997	22.794
Gamma	0.939	19.601	22.877
Lognormal	0.141	19.616	22.887

Table A.14 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	WEIBULL	GAMMA	LOGNORMAL
5th percentile	0.0%	3.2%	3.3%
95th percentile	0.0%	0.4%	0.4%

WSP considers that the selection of the Weibull distribution and resulting values are appropriate for this parameter.

A4 LOSS OF SUPPLY EVENT FREQUENCIES

A4.1 LOSS OF SUPPLY EVENT FREQUENCY > 0.05 SYSTEM MINUTES

The data for loss of supply event frequency > 0.05 system minutes performance is best fitted with a Geometric distribution according to the AIC fit statistic (Figure A.7). The curve of second best fit is a Poisson distribution and then a NegBin distribution. All three distributions have similar shape and percentile characteristics. Since the parameter can only have a minimum value of zero, the 5th percentile is set to zero as the lowest possible value. Powerlink's analysis also found the Geometric distribution to be the best fit.

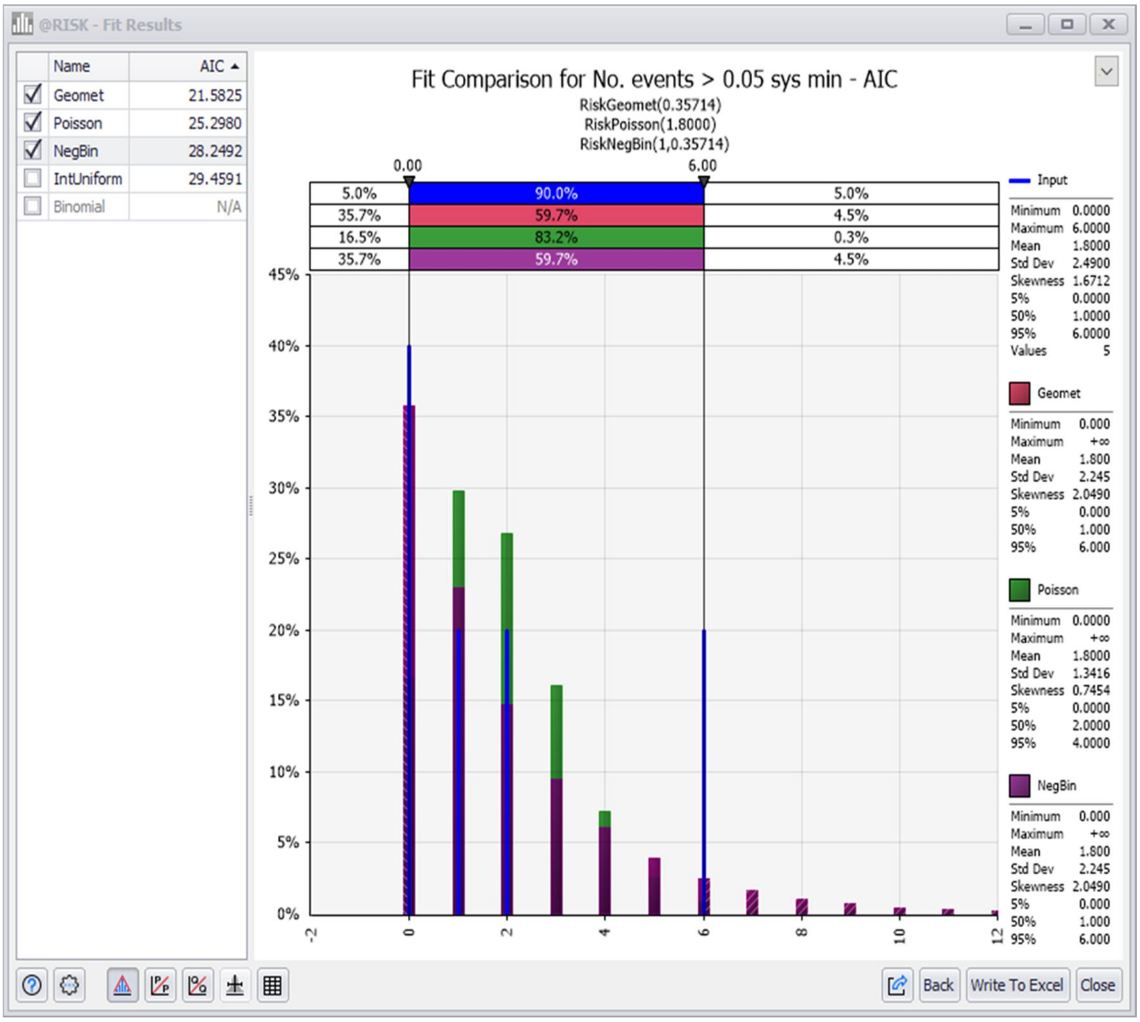

Figure A.7 Loss of supply events > 0.05 system minutes, comparison using AIC

Table 5.1 Loss of supply events > 0.05 system minutes performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Geometric	2.049	0	6
Poisson	0.745	0	4
NegBin	2.049	0	6

Table 5.2 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	GEOMETRIC	POISSON	NEGBIN
5^{th} percentile	0%	0%	0%
95^{th} percentile	0.0%	-33.3%	0.0%

WSP considers that the selection of the Geometric distribution and resulting values are appropriate for this parameter.

A4.2 LOSS OF SUPPLY EVENTS > 0.40 SYSTEM MINUTES

Powerlink has proposed the same alternative methodology and STPIS factors for this parameter in Set 2 as in Set 1 as described in section 3.

The data set for 2016-2020 includes only one loss of supply event > 0.4 system minutes, which occurred in 2018; there were no events recorded for 2016, 2017, 2019 and 2020. The average of this over the five-year period is 0.2 and by applying Powerlink's alternative methodology, the target is calculated to be 1.

As a result of only having one data point for the five-year period, it is not possible to identify a best fit probability distribution for this parameter. Hence, based on Clause 3.2(g), WSP recommends that the data for 2015-19 is used for determining the cap and floor values for this parameter as it is the most recent five-year period that enables the calculation of a distribution and is still representative of Powerlink's current network and its performance. Using this data and Powerlink's alternative methodology, the cap is calculated to be zero and the floor is calculated to be 2.

The application of the target, cap and floor values mentioned above is supported by the STPIS version 5 in Clause 3.2(i)(4) which states the alternative methodology provides targets that "…are not a lower threshold than the performance targets that applied to an identical parameter in the previous regulatory control period.". The proposed values are the same as applied for the 2016-20 control period and hence meet this requirement.

A5 AVERAGE OUTAGE DURATION

The average outage duration data for 2015 of 236.23 minutes was a significant outlier in the original data set from 2015-2019. As anticipated in our assessment of Set 1, the removal of this data item from the five-year data and the inclusion of the data for 2020 of 57.41 minutes has removed the anomaly that was this outlier.

PARAMETER	UNIT	2015	2016	2017	2018	2019	2020
Average event duration							
5-year data 2015-2019	min	236.23	30.06	27.45	36.24	15.00	
5-year data 2016-2020	min		30.06	27.45	36.24	15.00	57.41

The data for average outage duration performance is best fitted with a Gamma distribution according to the K-S fit statistic (Figure 2.8). The distribution of second best fit is a LogLogistic and then a Triangular distribution. Powerlink's analysis also found the Gamma distribution to be the best fit.

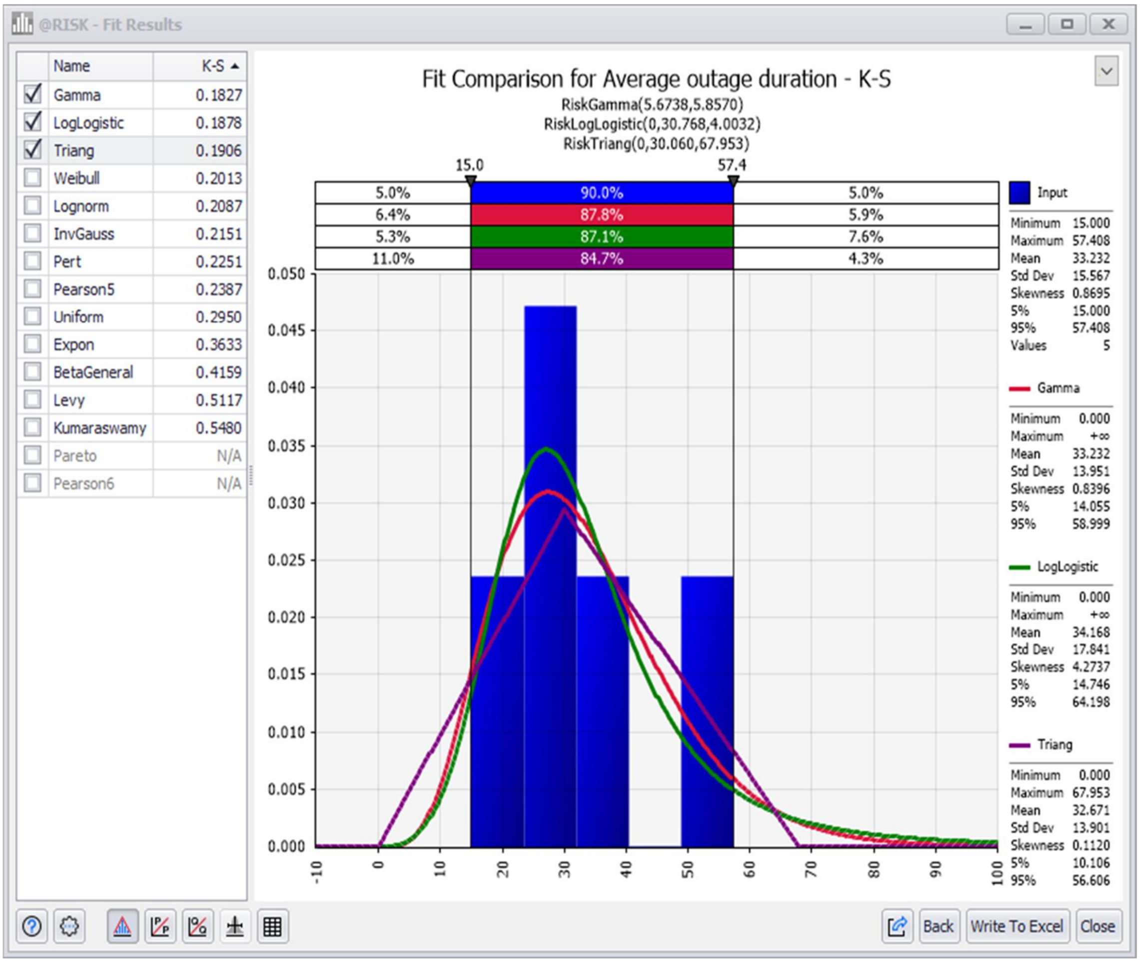

Figure A.8 Average outage duration, comparison using K-S

Table A.15 Average outage duration performance: Standard deviations for best fit distributions

DISTRIBUTION	SKEWNESS	5TH PERCENTILE	95TH PERCENTILE
Gamma	0.840	14.055	58.999
LogLogistic	4.274	14.746	64.198
Triangular	0.112	10.106	56.606

Table A.16 Percentage difference between Powerlink's proposed values and other distributions

PERCENTILE	GAMMA	LOGLOGISTIC	TRIANG
5th percentile	0.0%	4.9%	-28.1%
95th percentile	0.0%	8.8%	-4.1%

WSP considers that the selection of the Gamma distribution and resulting values are appropriate for this parameter.

A6 SUMMARY OF FINDINGS

Table A.17 summarises the probability distribution functions that have been chosen to best fit the parameter data. In WSP's view this approach is robust, and does not seem to be sensitive to the choice of distribution function because the results were either close to the next best fit distributions or confirmed through close analysis of the underlying data. The approach is also consistent with the Australian Energy Regulator's previous regulatory decisions to use a curve of best fit approach.

Table A.17 Summary of best fit distributions Set 2

PARAMETER	BEST FIT DISTRIBUTION	TARGET	5% POE	95% POE
Lines event rate – fault	Pert	17.03%	8.40%	24.44%
Transformer event rate – fault	Triangular	16.81%	5.49%	23.94%
Reactive plant event rate – fault	Lognorm	25.65%	22.53%	29.05%
Line event rate – forced	Weibull	17.02%	12.15%	21.13%
Transformer event rate – forced	LogLogistic	14.82%	9.37%	22.35%
Reactive plant event rate – forced	Weibull	21.21%	19.00%	22.79%
Loss of supply event frequency (events > 0.05 system minutes)	Geomet	2	0	6
Loss of supply event frequency (events > 0.40 system minutes)	Poisson[1]	1	0	2
Average outage duration	Gamma	33.23 min	14.06 min	59.00 min

Notes: 1 Best-fit distribution based on 2015-2019 five-year data as it is not possible to identify a distribution for just the single data point of 2016-2020 five-year data

Table A.18 shows the recommended Set 2 STPIS parameter values based on:

— Targets set at the average of five-year performance for parameters with continuous distributions

— Caps and floors set at 5% and 95% POE for all parameters and bounded at zero where appropriate

— Target, cap and floor rounded to nearest integer for loss of supply event frequency > 0.05 system minutes

— Target for loss of supply event frequency > 0.40 system minutes rounded to the nearest non-zero integer with cap and floor rounded to the nearest integer

Weightings as set out in STPIS Table 3-1 are also shown in the table.

Table A.18 Recommended Set 2 parameter values

PARAMETER	FLOOR	TARGET	CAP	WEIGHTING MAR %
Lines event rate – fault	24.44%	17.03%	8.40%	0.20
Transformer event rate – fault	23.94%	16.81%	5.49%	0.20
Reactive plant event rate - fault	29.05%	25.65%	22.53%	0.10
Lines event rate – forced	21.13%	17.02%	12.15%	0.10
Transformer event rate – forced	22.35%	14.82%	9.37%	0.10
Reactive plant event rate - forced	22.79%	21.21%	19.00%	0.05
Loss of supply event frequency (events > 0.05 system minutes)	6	2	0	0.15
Loss of supply event frequency (events > 0.40 system minutes)	2	1	0	0.15
Average outage duration	59.00 min	33.23 min	14.06 min	0.20

ABOUT US

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