ACIL ALLEN

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Report to ElectraNet

Statistical estimation of the STPIS service component

Fitting probability distributions to reliability data

About ACIL Allen

ACIL Allen is a leading independent economics, policy and strategy advisory firm, dedicated to helping clients solve complex issues.

Our purpose is to help clients make informed decisions about complex economic and public policy issues.

Our vision is to be Australia's most trusted economics, policy and strategy advisory firm. We are committed and passionate about providing rigorous independent advice that contributes to a better world.

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Executive summary

ACIL Allen was engaged by ElectraNet to propose performance targets, caps and floors for the service component of the service target performance incentive scheme (STPIS).

Historical performance data of the past five calendar years (2016-2020) was used to calculate performance targets, caps and floors for the following parameters and sub-parameters of the STPIS:

1. Unplanned outage circuit event rates:
   1.1. transmission line outage event rates – fault
   1.2. transformer outage event rates – fault
   1.3. reactive plant outage event rates – fault
   1.4. transmission line outage event rates -forced
   1.5. transformer outage event rates – forced
   1.6. reactive plant outage event rates – forced.
2. Loss of supply event frequency:
   2.1. loss of supply event frequency > 0.05 system minutes
   2.2. loss of supply event frequency > 0.2 system minutes.
3. The average outage duration in minutes.
4. Proper operation of equipment:
   4.1. failure of protection system
   4.2. material failure of the Supervisory Control and Data Acquisition (SCADA) system
   4.3. incorrect operational isolation of primary and secondary equipment.

Approach

In line with AER STPIS requirements[1], the proposed performance targets have been calculated by averaging the actual performance values of the most recent five years, in this case the performance values between 2016 and 2020.

The performance caps and floors for all parameters of the service component were calculated by fitting candidate probability distributions to the performance values of each parameter over the past five years. Based on the distribution of best fit the 5th and 95th percentiles for each individual parameter have been determined and proposed to be adopted as the floor and cap respectively. To determine the distribution with the best fit the Akaike Information Criterion (AIC) statistic was used to determine the appropriate probability distribution for the discrete parameters and the

[1] Service target performance incentive scheme version 5, AER, October 2015.

Kolmogorov-Smirnov (K-S) and the Anderson-Darling (A-D) statistics were used for continuous parameters.

ACIL Allen used the Excel add-in @Risk to fit the candidate probability distributions to historical data. @Risk produces charts of the fitted distribution as well as statistical summaries.

Recommendations

The recommended performance values listed in Table ES 1 are based on:

— Target values set at the average of 5 years historical performance values.

— Cap and Floor values set at the 5th and 95th percentiles of the best fit distributions as determined by a standard fit test.

— The values of Loss of supply events, as well as proper operation of equipment have been rounded to nearest integer.

— Weightings for all parameters can be found in the last column of the Table ES 1 and are taken from AER's version 5 of the STPIS[2].

Table ES 1 Recommended parameter values

Parameter	Floor	Target	Cap	Weighting (% of MAR)
Transmission line outage rate - fault	34.10%	16.21%	6.84%	0.20%
Transformer outage rate - fault	36.58%	22.58%	9.46%	0.20%
Reactive plant outage rate - fault	59.05%	25.63%	9.63%	0.10%
Transmission line outage rate - forced	19.74%	8.73%	1.35%	0.10%
Transformer outage rate - forced	8.68%	6.26%	3.65%	0.10%
Reactive plant outage rate - forced	22.87%	13.36%	4.90%	0.05%
Loss of supply event frequency >0.05 minutes	7	3	1	0.15%
Loss of supply event frequency >0.2 minutes	4	2	0	0.15%
Average outage duration	462	242	86	0.20%
Failure of protection system	18	11	3	0.00%
Material failure of SCADA	2	1	0	0.00%
Incorrect operational isolation of primary and secondary equipment	13	8	4	0.00%

Source: ACIL Allen analysis

[2] Service target performance incentive scheme version 5, AER, October 2015.

Introduction 1

ACIL Allen was engaged by ElectraNet to propose performance targets, caps and floors for the service component of the service target performance incentive scheme (STPIS).

Historical performance data of the past five years (2016-2020) was used to calculate performance targets, caps and floors for the following 12 parameters:

- Unplanned outage circuit event rates
  - Transmission line outage event rates -fault
  - Transformer outage event rates – fault
  - Reactive plant outage event rates – fault
  - Transmission line outage event rates -forced
  - Transformer outage event rates – forced
  - Reactive plant outage event rates – forced
- Loss of supply event frequency
  - Loss of supply event frequency > 0.05 system minutes
  - Loss of supply event frequency > 0.2 system minutes
- The average outage duration in minutes was included.
- Proper operation of equipment
  - Failure of protection system
  - Material failure of SCADA
  - Incorrect operational isolation of primary and secondary equipment.

1.1 Methodology

In accordance with AER STPIS requirements[3], the proposed performance targets have been calculated by averaging the performance values over the past five years, in this case the performance values between 2016 and 2020 calendar years.

In line with AER requirements, performance caps and floors for the service component were calculated by fitting probability distributions to the performance values over the past five years. Based on the distribution of best fit, the 5th and 95th percentiles for each individual parameter are determined. These percentiles represent the proposed performance cap and floor for the different parameters.

The best fit distributions were determined based on the following test statistics:

- The Kolmogorov-Smirnov (K-S) test statistic was the preferred test statistic for parameters with continuous distributions, and is consistent with the AER's historical approach. The K-S

[3] Section 3 of Service target performance incentive scheme version 5, AER, October 2015.

statistic was used to determine the appropriate probability distribution for fitting historical performance values over the past 5 years. . The K-S statistic is based on the maximum difference between the sample distribution and the test distribution and is more sensitive near the centre of the distribution. Given the limited data available for the distribution fitting it is appropriate to focus on the centre of the distribution.

— The Anderson-Darling (A-D) statistic was used as a secondary test statistic for parameters with continuous distributions when the K-S statistic did not give conclusive results or the distribution of best fit under the K-S statistic did not fit the observed data visually. The weakness of the K-S statistic is that it does not detect tail discrepancies very well, while the A-D statistic places more emphases on tail values.

— For discrete parameters we have used the Akaike Information Criterion (AIC) statistic, which is a measure of the relative quality of a statistical model for a given set of data. By measuring the relative loss of information, AIC deals with the trade-off between the goodness of fit of the model and the simplicity of the model.

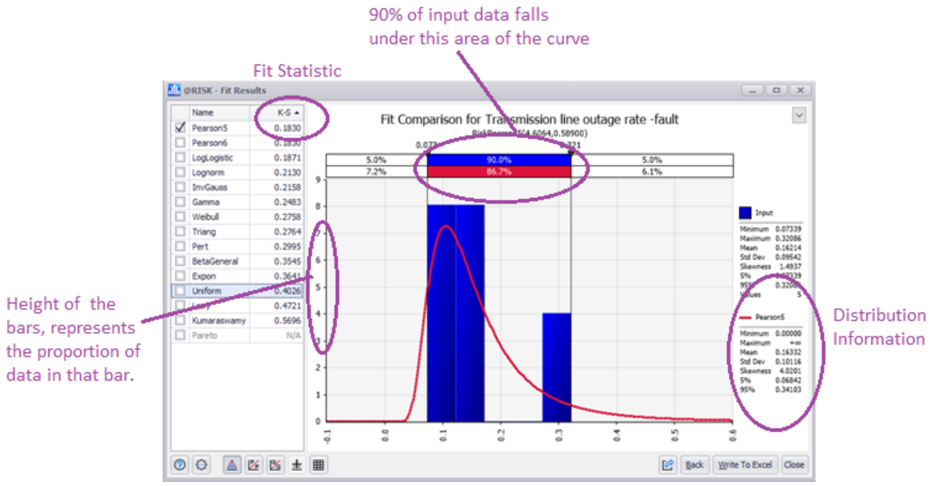
— The Chi-square statistic is not suitable to use as a test statistic in this instance, as it tends to perform poorly when applied to small data sets. The Bayesian Information Criterion (BIC), another much used test statistic, was also considered unsuitable for this dataset, since the BIC is mostly used for the comparison of multilevel models and is known to perform poorly for small samples.

1.2 Software

To fit probability distributions to the historical performance data, ACIL Allen has used the Excel add-in tool @RISK. @Risk is a risk analysis and simulation software tool which can be used to select the distribution of best fit based on different test statistics. The software produces charts of the fitted distribution as well as statistical summaries, which have been included for each individual parameter. An example of the @risk output is shown in Figure 1.1.

Figure 1.1 shows how information is displayed in @Risk. For continuous data, @risk creates a probability density function, whereby the total area of all bars equals one. The blue bar at the top of Figure 1.1 shows the 90th percentile of the input data. In the left pane the test statistics are displayed (in this case, the K-S statistic) of the ranked best fit distributions. On the right pane of Figure 1.1 a statistical summary is provided of the selected distribution (in this case, the Pearson5 distribution). Here the min, max, mean, skewness and 5th and 95th percentiles are displayed.

Figure 1.1 @Risk chart information for continuous data



Source: ACIL Allen analysis

1.3 Parameter data

Table 1.1 shows the data that was used to calculate the performance targets, caps and floors.

Table 1.1 Reliability data 2016-2020

Parameter	2016	2017	2018	2019	2020
Transmission line outage rate - fault	32.09%	7.34%	15.18%	10.53%	15.94%
Transformer outage rate - fault	35.29%	13.43%	26.87%	23.88%	13.43%
Reactive plant outage rate - fault	51.35%	18.92%	15.79%	31.58%	10.53%
Transmission line outage rate - forced	8.02%	8.26%	8.93%	17.54%	0.89%
Transformer outage rate - forced	3.68%	6.72%	8.21%	7.46%	5.22%
Reactive plant outage rate - forced	18.92%	18.92%	7.89%	5.26%	15.79%
Loss of supply event frequency >0.05 minutes	5	4	3	4	1
Loss of supply event frequency >0.2 minutes	2	1	2	3	0
Average outage duration	251	97	463	192	205
Failure of protection system	17	9	18	6	3
Material failure of SCADA	2	0	2	0	0
Incorrect operational isolation of primary and secondary equipment	10	7	13	6	4

Source: Historical performance values provided by ElectraNet

Results of distribution fitting 2

This chapter starts with the results of fitted distributions for the six components of the unplanned outage circuit event rate, followed by the loss of supply event frequency, average outage duration, and the three components of the proper operation of equipment.

2.1 Unplanned outage circuit event rate

The ‘unplanned outage circuit event rate’ measures the availability of transmission circuit components and is expressed as a percentage of the year the circuit was unavailable. The optimal performance limit is 0 per cent, which represents total availability of the component for the year. Since the performance limit is 0 per cent, all fitted distributions have a lower bound of zero. Given these variables are continuous, the results presented are the best fitted continuous distributions, including charts showing the probability density functions for these fitted distributions.

2.1.1 Transmission line outage rate – fault performance

The data for the transmission line outage rate fault performance is best fitted with a Pearson5 distribution according to both the K-S and the A-D statistic.

The curve of second-best fit is the Pearson6 distribution, which gives the same values for the 5th and 95th percentiles. The third curve of best fit is a Loglogistic distribution, but this distribution shows more skewness and places more weight on apparent outlier in the data. That said, the fitted Loglogistic distribution results in 5th and 95th percentiles that are within one percentage point of the Pearson5 and 6 fitted distributions.

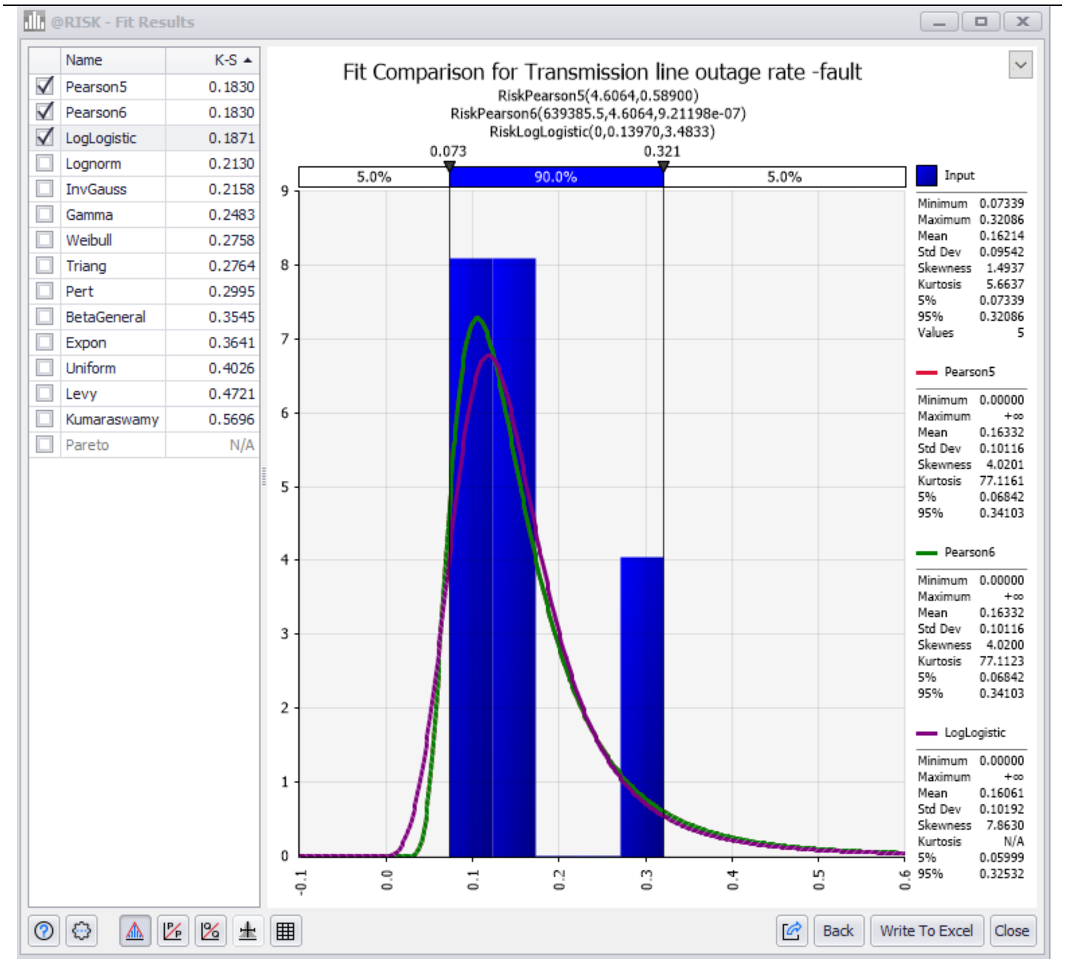
Table 2.1 shows that the 5^{th} and 95^{th} percentiles for the Pearson5 distribution are 7 per cent and 34 per cent respectively.

Table 2.1 Transmission line outage rate- fault performance: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Pearson5	4.020	7%	34%
Pearson6	4.020	7%	34%
Loglogistic	7.863	6%	33%

Source: ACIL Allen analysis

Figure 2.1 Transmission line outage rate (fault) – Distribution fit using K-S



Source: ACIL Allen analysis

2.1.2 Transformer outage rate– fault performance

Data for the Transformer outage rate - fault performance, is best fit with a Triangular distribution according to the K-S statistic. The distribution of second-best fit is the Weibull distribution, and the distribution of third best fit is the Pert distribution. Table 2.2 shows that the Triangular and the Pert distribution both have negative skewness, which is not supported by the underlying data.

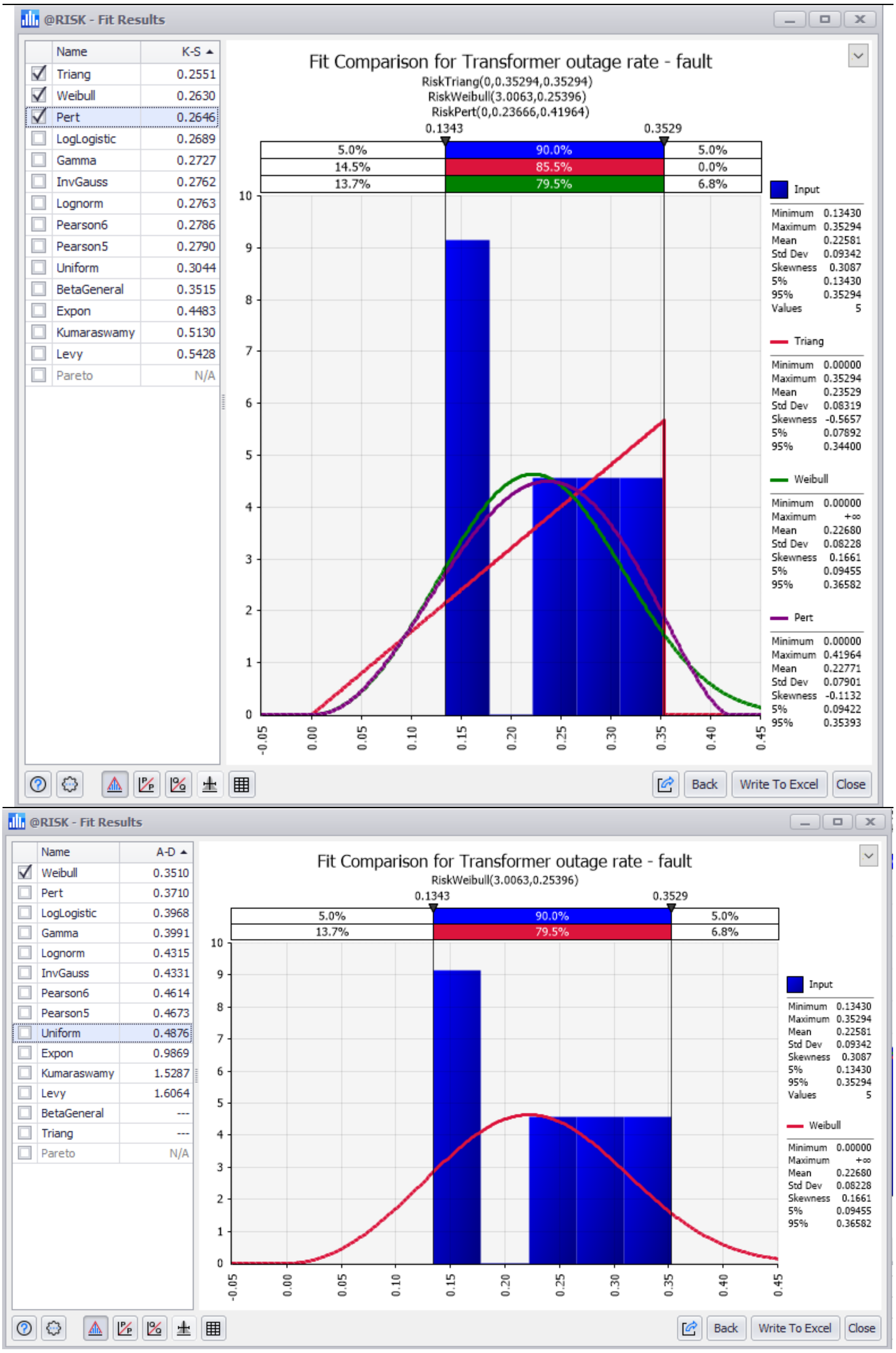
The A-D statistic places more focus on the tails and has therefore selected distributions for this data that are more left skewed, in line with the data. The A-D statistic selects the Weibull distribution as the distribution of best fit. Therefore, the Weibull distribution is selected as the distribution of best fit. Table 2.2 shows that the 5th and 95th percentile of the Weibull distribution is 9 per cent and 37 per cent respectively.

Table 2.2 Transformer outage rate- fault performance: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Triangular	-0.566	8%	34%
Weibull	0.166	9%	37%
Pert	-0.113	9%	35%

Source: ACIL Allen analysis

Figure 2.2 Transformer outage rate (fault) – Distribution fit using K-S and A-D



Source: ACIL Allen analysis

2.1.3 Reactive plant outage rate - fault performance

The data for the reactive plant outage rate – fault performance is best fitted with a Pearson5 distribution, according to the K-S statistic. The distribution of second-best fit is the Loglogistic distribution, followed by the Inverse Gaussian distribution. This ranking is also supported by the A-D statistic.

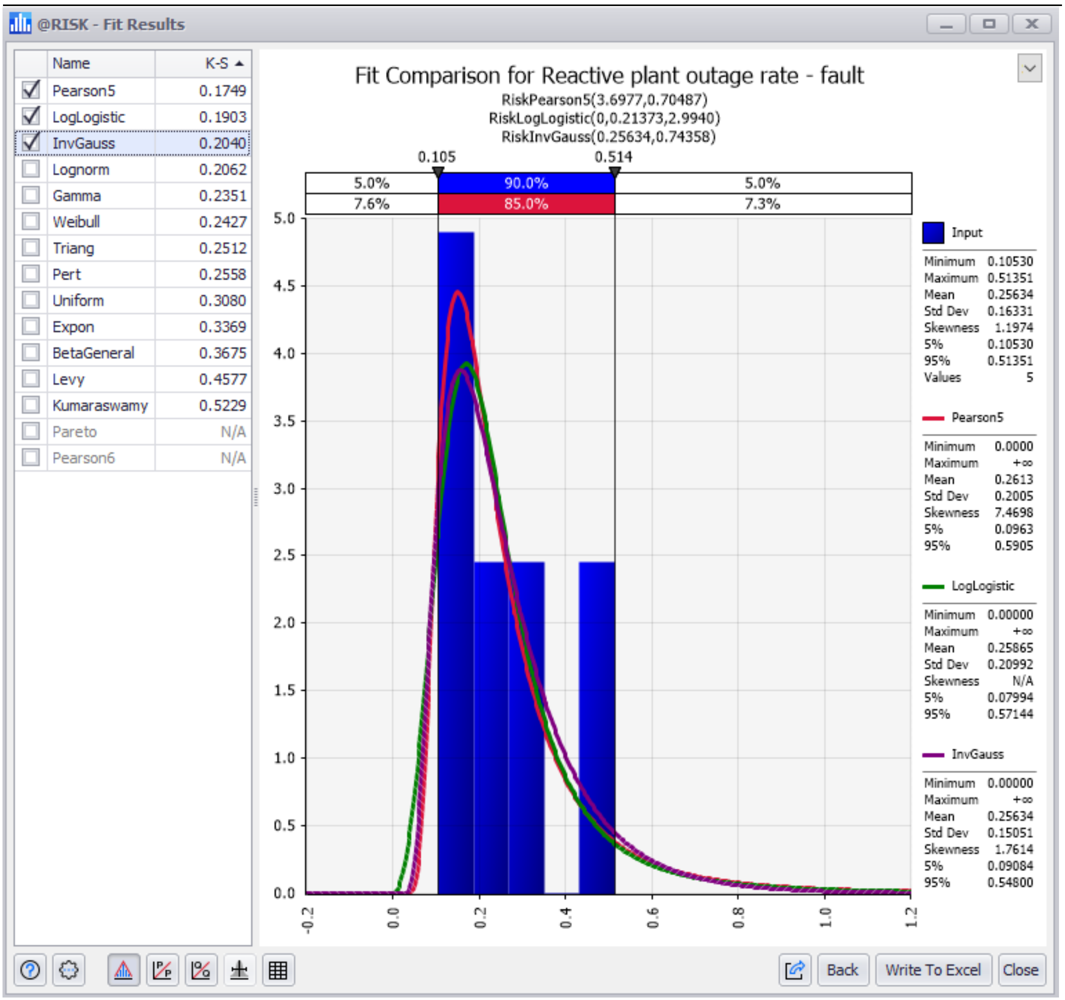
The distributions show strong positive skewness, as shown in Table 2.3 and this is supported by the underlying data. The 5th and 95th percentile parameters for the three distributions are very similar. For the preferred distribution, the Pearson5 distribution, the 5th and 95th percentile is 10 per cent and 59 per cent respectively.

Table 2.3 Reactive plant outage rate - fault performance: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Pearson5	7.470	10%	59%
LogLogistic	N/A	8%	57%
InvGauss	1.761	9%	55%

Source: ACIL Allen analysis

Figure 2.3 Reactive plant outage rate (fault) – Distribution fit using K-S



Source: ACIL Allen analysis

2.1.4 Transmission line outage rate– forced outage

Based on the K-S statistic the distributions of first- and second-best fit are the Loglogistic distribution and the Levy distribution respectively. However, Figure 2.4 shows that the curve of second best fit, the Levy distribution, has a 95th percentile of 827 per cent and therefore does not appropriately represent the input data. For the LogLogistic distribution, both the standard deviation and the skewness cannot be defined. This means this distribution places too much weight on outliers in the input data. The Weibull distribution seems to be the best fit to the input data and has a low degree of skewness which is supported by the input data.

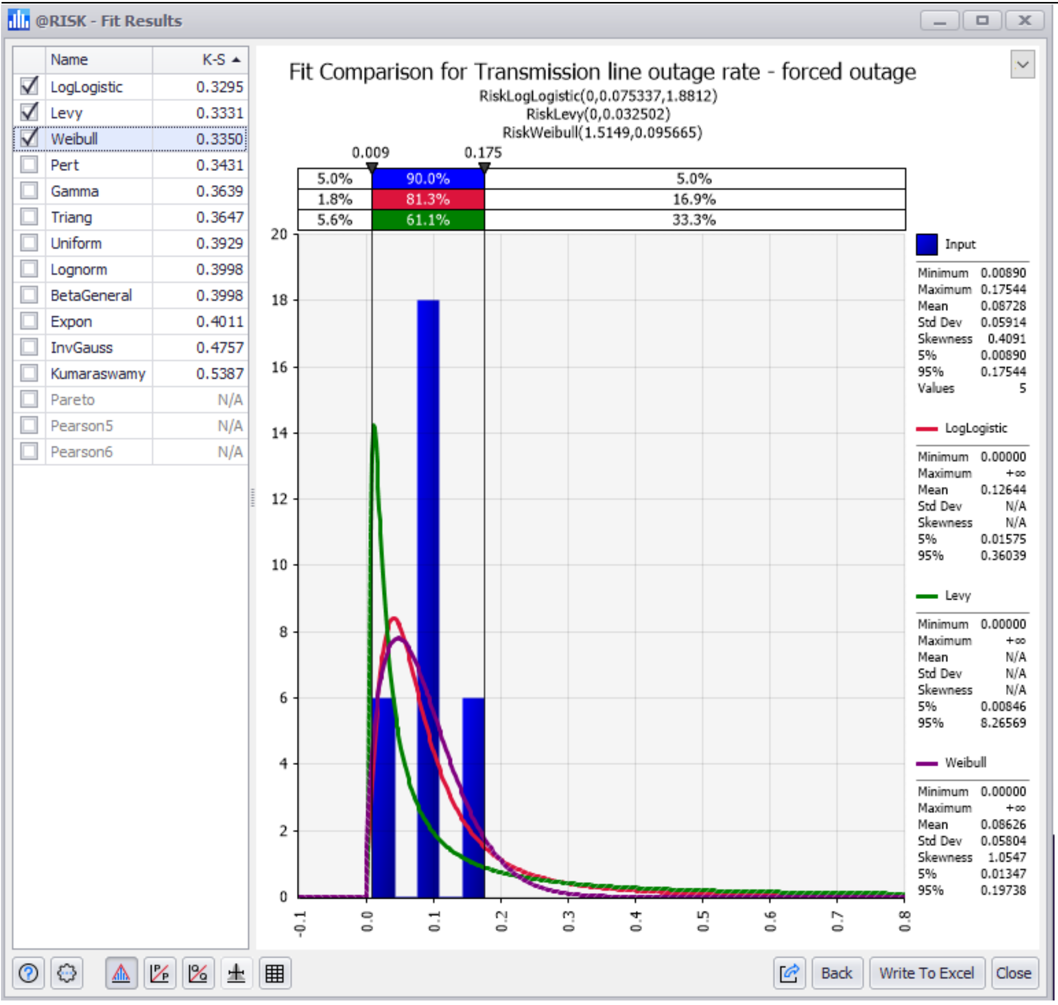
The Weibull distribution is therefore selected as the curve of best fit. The 5th and 95th percentile parameters for the Weibull distribution are 1 per cent and 20 per cent respectively.

Table 2.4 Transmission line outage rate – forced outage performance: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
LogLogistic	N/A	2%	36%
Levy	N/A	1%	827%
Weibull	1.055	1%	20%

Source: ACIL Allen analysis

Figure 2.4 Transmission line outage rate (forced) - Distribution fit using K-S



Source: ACIL Allen analysis

2.1.5 Transformer outage rate – forced outage

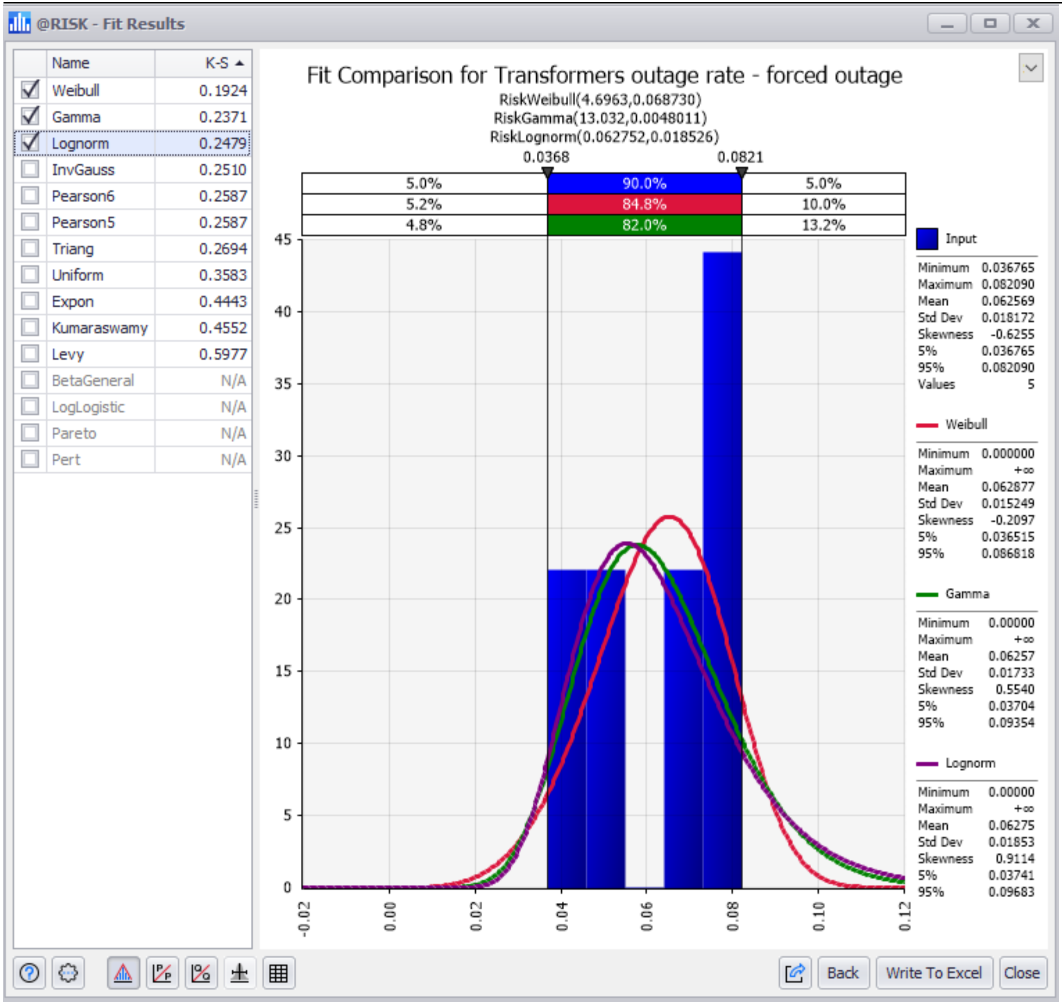
The distribution of best fit for the transformer outage rate – force outage performance, is the Weibull distribution. The next best fit is the Gamma distribution, followed by the Lognorm distribution. The Weibull distribution shows a negative skewness, which is consistent with the input data. The 5th percentile for the Weibull distribution is 4 per cent and the 95th percentile is 9 per cent. These results are also supported by the A-D statistic.

Table 2.5 Transformer outage rate – forced outage performance: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Weibull	-0.210	4%	9%
Gamma	0.554	4%	9%
Lognorm	0.911	4%	10%

Source: ACIL Allen analysis

Figure 2.5 Transformers outage rate (forced) - Distribution fit using K-S



Source: ACIL Allen analysis

2.1.6 Reactive plant outage rate– forced outage

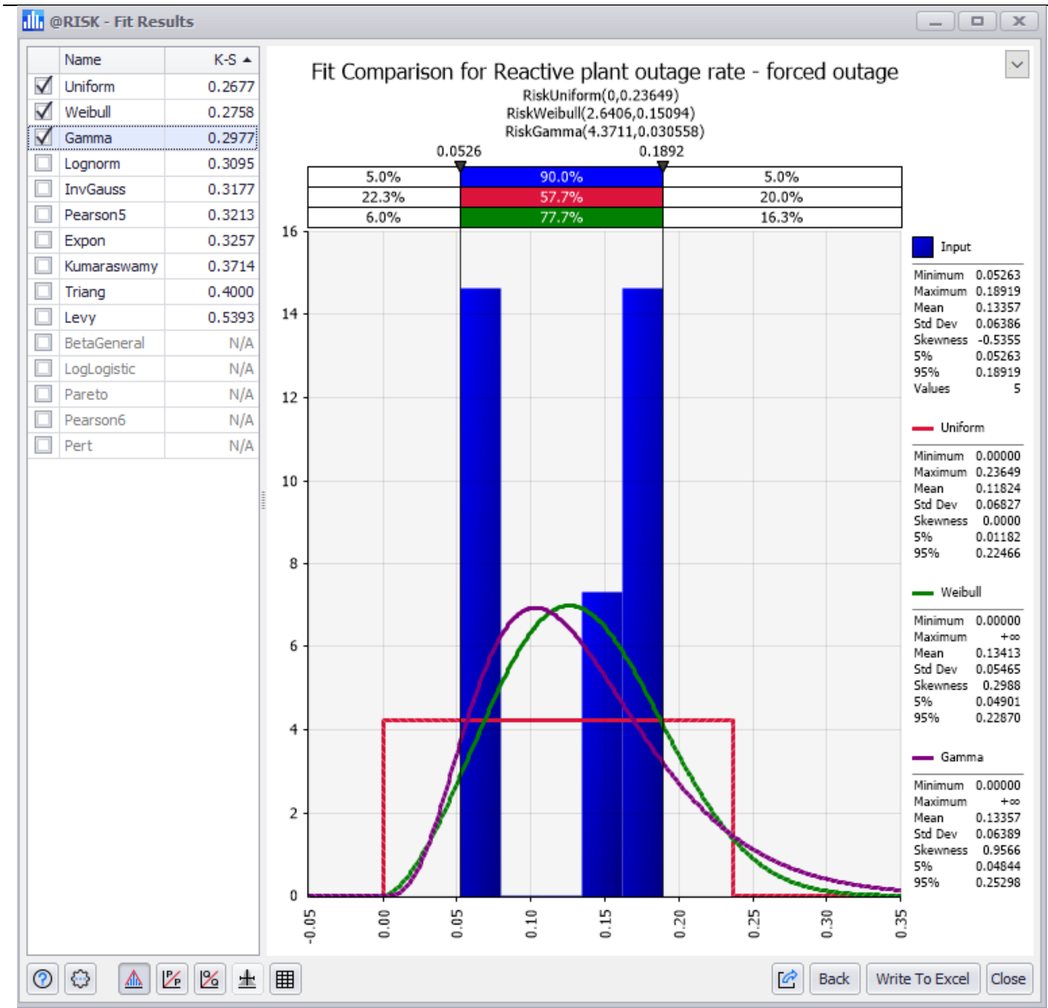
Data for the reactive plant outage rate – forced outage performance, is best fit with a Uniform distribution according to the K-S statistic. The curve of second-best fit is the Weibull distribution and the curve of third best fit is the Gamma distribution. The Uniform distribution assumes a symmetric distribution. However, the underlying data shows a skewness in shape. This is better reflected by the Weibull distribution, which we propose as the preferred distribution for the data. The 5th and 95th percentile of the Weibull distribution is 5 per cent and 23 per cent, respectively.

Table 2.6 Reactive plant outage rate – forced outage performance: Skewness and percentile parameters

Distribution	Skewness	Std dev	5th percentile	95th percentile
Uniform	0.000	0.068	1%	22%
Weibull	0.299	0.055	5%	23%
Gamma	0.957	0.064	5%	25%

Source: ACIL Allen analysis

Figure 2.6 Reactive plan outage rate (forced) - Distribution fit using K-S



Source: ACIL Allen analysis

2.2 Loss of supply event frequency

The loss of supply event parameter measures the frequency of the unplanned outages that result in a loss of supply. An event is recorded when it exceeds a predetermined threshold of 0.05 minutes or 0.2 minutes. Since the data is discrete, we have fitted discrete distributions with equal interval binning to the data.

2.2.1 Loss of supply event frequency > 0.05 system minutes

Based on the AIC statistic the distribution of best fit for the loss of supply event frequency (>0.05 minutes) is the Poisson distribution. The curves of second and third best fit are the Uniform and the Gamma distribution respectively. In terms of shape, the underlying data supports the choice of the Poisson distribution as distribution of best fit. The standard deviation of the Poisson distribution is 1.84 compared to the standard deviation of the Uniform distribution of 1.4. This shows that the Poisson distribution incorporates more data variation, which is supported by the underlying data. The Geometric distribution shows a strong positive skewness, which is not supported by the underlying data. The 5th and 95th percentile parameters for the Poisson distribution are 1 and 7, respectively.

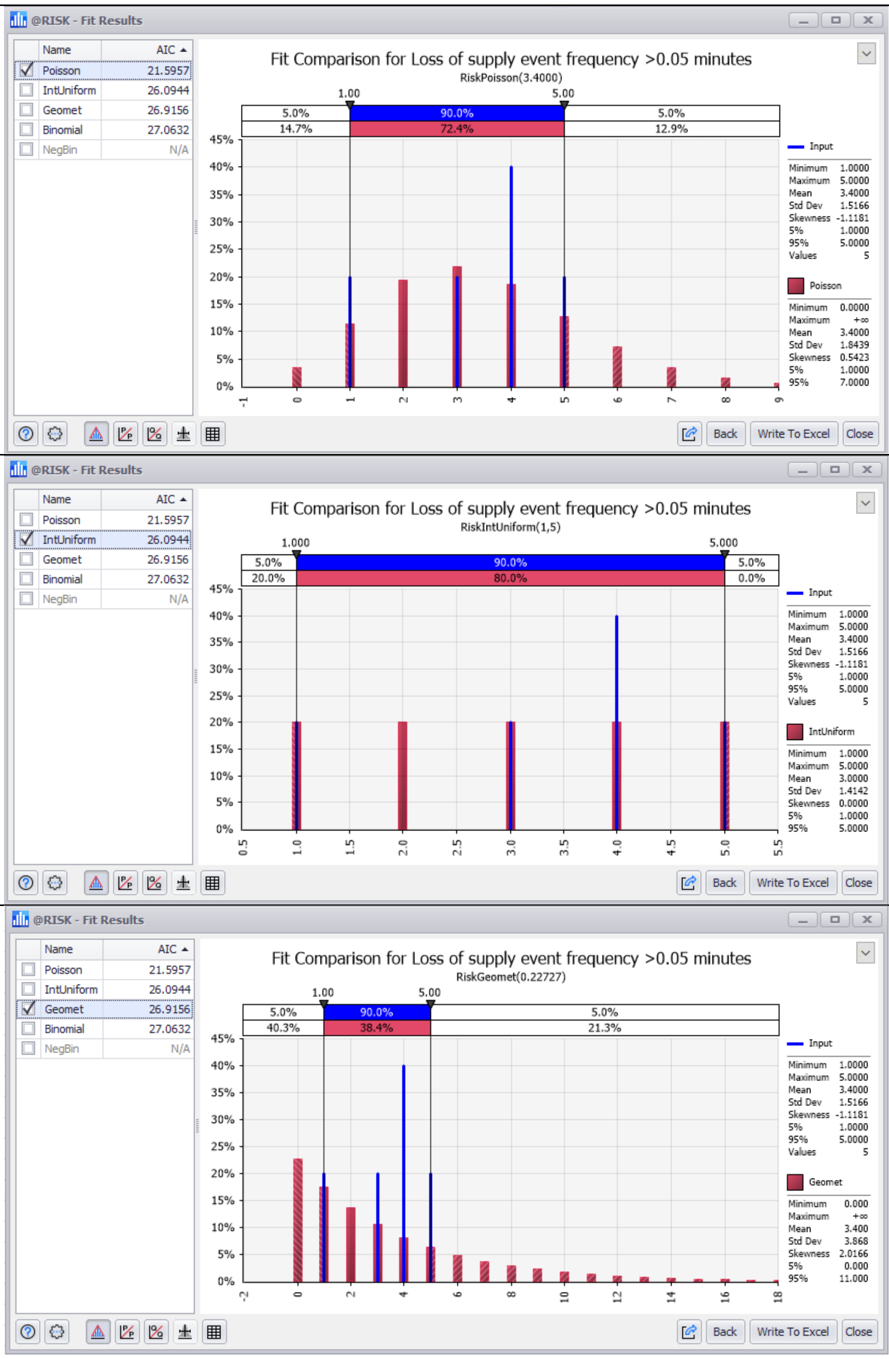
Table 2.7 Loss of supply event frequency (>0.05 minutes): Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Poisson	0.542	1	7
Uniform	0.000	1	5
Geometric	2.017	0	11

Source: ACIL Allen analysis

Distribution	Skewness	5th percentile	95th percentile

Figure 2.7 Loss of supply event frequency >0.05 minutes – Distribution fit using AIC



Source: ACIL Allen analysis

2.2.2 Loss of supply event frequency > 0.2 system minutes

Data for the loss of supply event frequency (>0.2 minutes) is also best fit with the Poisson distribution, based on the AIC statistic. The curve of second-best fit is the Geometric distribution and the curve of third best fit is the Uniform distribution. Table 2.8 shows that the 5th and 95th percentiles of the Poisson distribution are 0 and 4 respectively.

Table 2.8 Loss of supply event frequency (>0.2 minutes): Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Poisson	0.791	0	4
Geometric	2.059	0	6
Uniform	0.000	0	3

Source: ACIL Allen analysis

Figure 2.8 Loss of supply event frequency >0.2 minutes – Distribution fit using AIC

Source: ACIL Allen analysis

2.3 Average outage duration

The average outage duration parameter measures the average duration of unplanned outages that cause a loss of supply. Since the performance limit for this parameter is zero, the fitted distributions have a lower bound set to zero. Continuous distributions have been fitted to the historical data of this parameter.

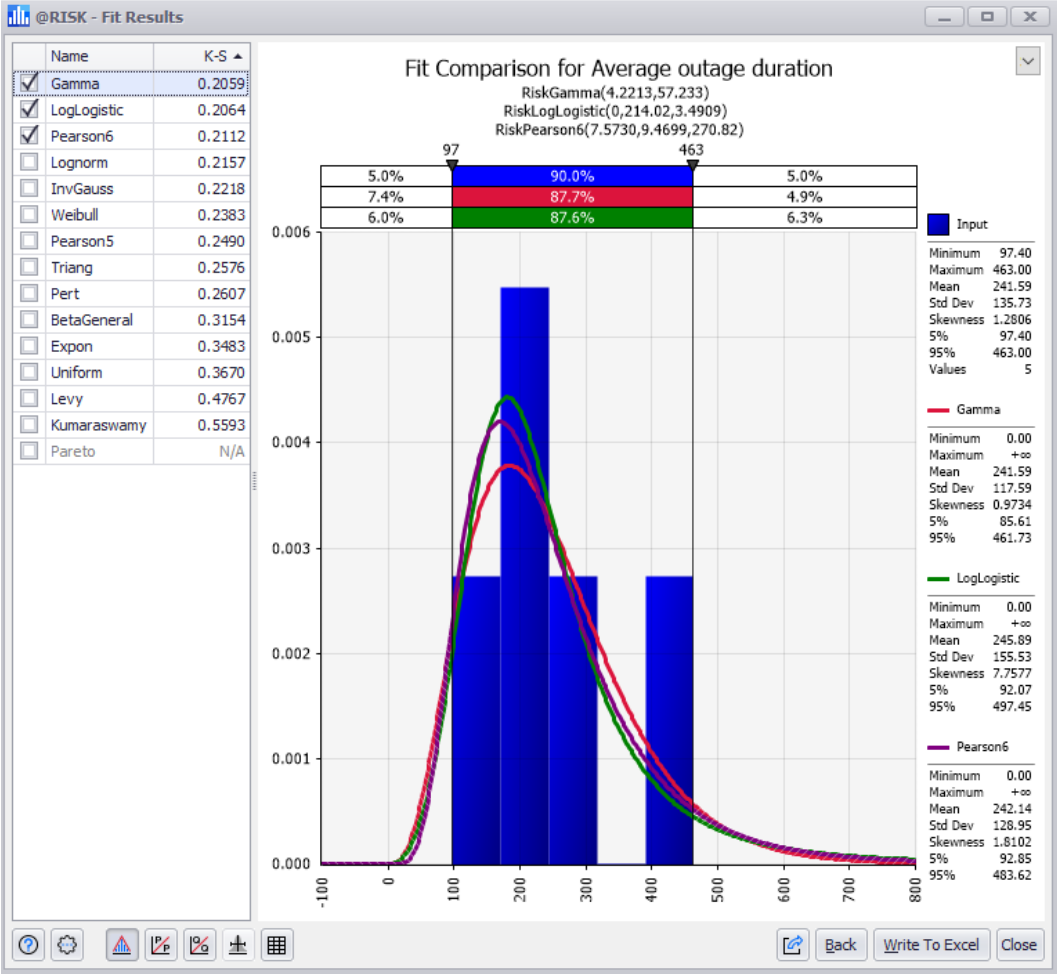
The historical data for the average outage duration during 2018 is higher than the values in other years (84% higher than the next highest value). However, ACIL Allen has not been made aware that this is the result of an outlier. Based on the AIC statistic, the distribution of best fit of the average outage duration is the Gamma distribution. The curve of second-best fit was LogLogistic distribution and the curve of third best fit was the Pearson6 distribution. The 5th and 95th percentiles of all three distributions are within similar range. The 5th percentile of the Gamma distribution is 86 and the 95th percentile was 462.

Table 2.9 Average outage duration: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Gamma	0.973	86	462
LogLogistic	7.758	92	497
Pearson6	1.810	93	484

Source: ACIL Allen analysis

Figure 2.9 Average outage duration – Distribution fit using K-S



Source: ACIL Allen analysis

2.4 Proper operation of equipment

This section presents best fit distributions for the proper operation of equipment parameter. This parameter counts the number of times a protection or control system fails in a year, as well as the occurrences of incorrect operational isolation of equipment during maintenance. The proper operation of equipment events is a discrete parameter. We have therefore fitted discrete distributions with equal interval binning to the sub-parameters.

2.4.1 Failure of protection system

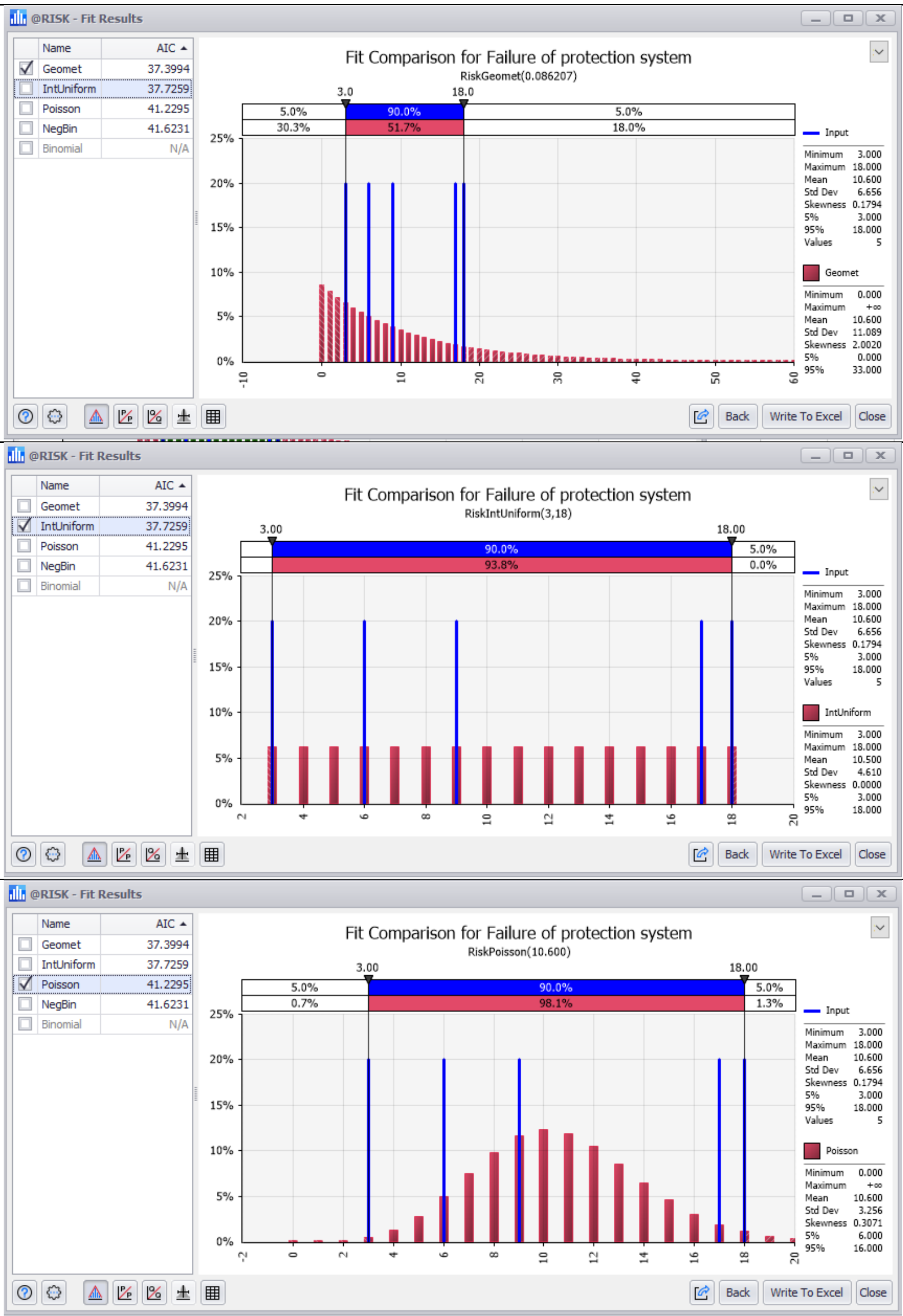
Based on the AIC statistic the distribution of best fit for the failure of protection system data is the Geometric distribution. The Uniform distribution is the distribution of second best fit and the Poisson distribution is the distribution of third best fit. The Geometric distribution has a positive skewness of 2, which is not supported by the underlying data. The AIC test statistic of the Uniform distribution and the Geometric distribution are very close. The Uniform distribution is however a better fit given the range and spread of the data. The Uniform distribution is therefore selected as curve of best fit. The 5^{th} and 95^{th} percentile of the Uniform distribution is 3 and 18 respectively.

Table 2.10 Failure of protection system – Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Geometric	2.002	0	33
Uniform	0.000	3	18
Poisson	2.017	6	16

Source: ACIL Allen analysis

Figure 2.10 Failure of protection system – Distribution of fit using AIC



Source: ACIL Allen analysis

2.4.2 Material failure of SCADA

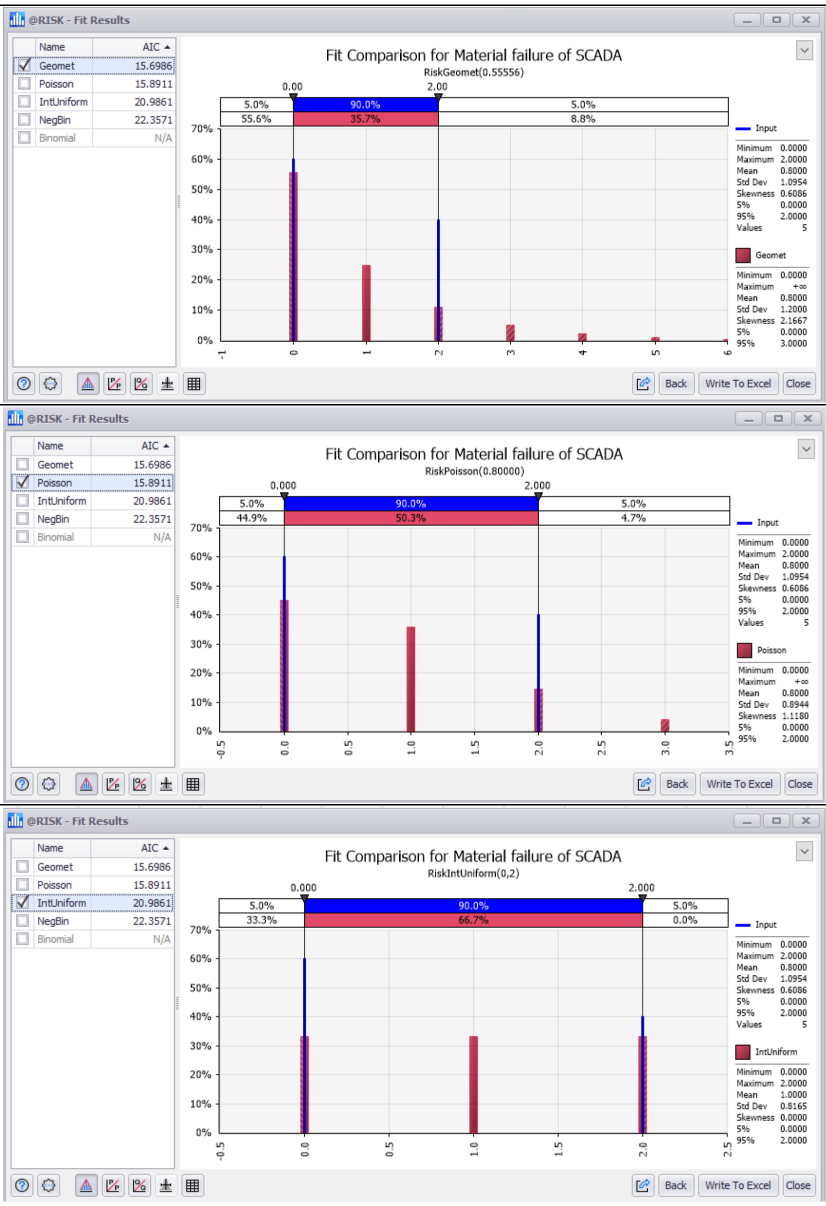
Data for the material failure of SCADA is best fit with a Geometric distribution based on the AIC statistic. The second-best fit is the Poisson distribution and the third best fit is the Uniform distribution. The Geometric distribution has a strong positive skewness of 2.17, which is not supported by the data. Reviewing the underlying data suggests the Poisson distribution is a better fit. Regardless, the Poisson and Uniform distribution have the same 5th and 95th percentile, namely 0 and 2 respectively.

Table 2.11 Material Failure of SCADA: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Geometric	2.167	0	3
Poisson	1.118	0	2
Uniform	0.000	0	2

Source: ACIL Allen analysis

Figure 2.11 Material failure of SCADA -Distribution fit using AIC



Source: ACIL Allen analysis

2.4.3 Incorrect operational isolation of primary or secondary equipment

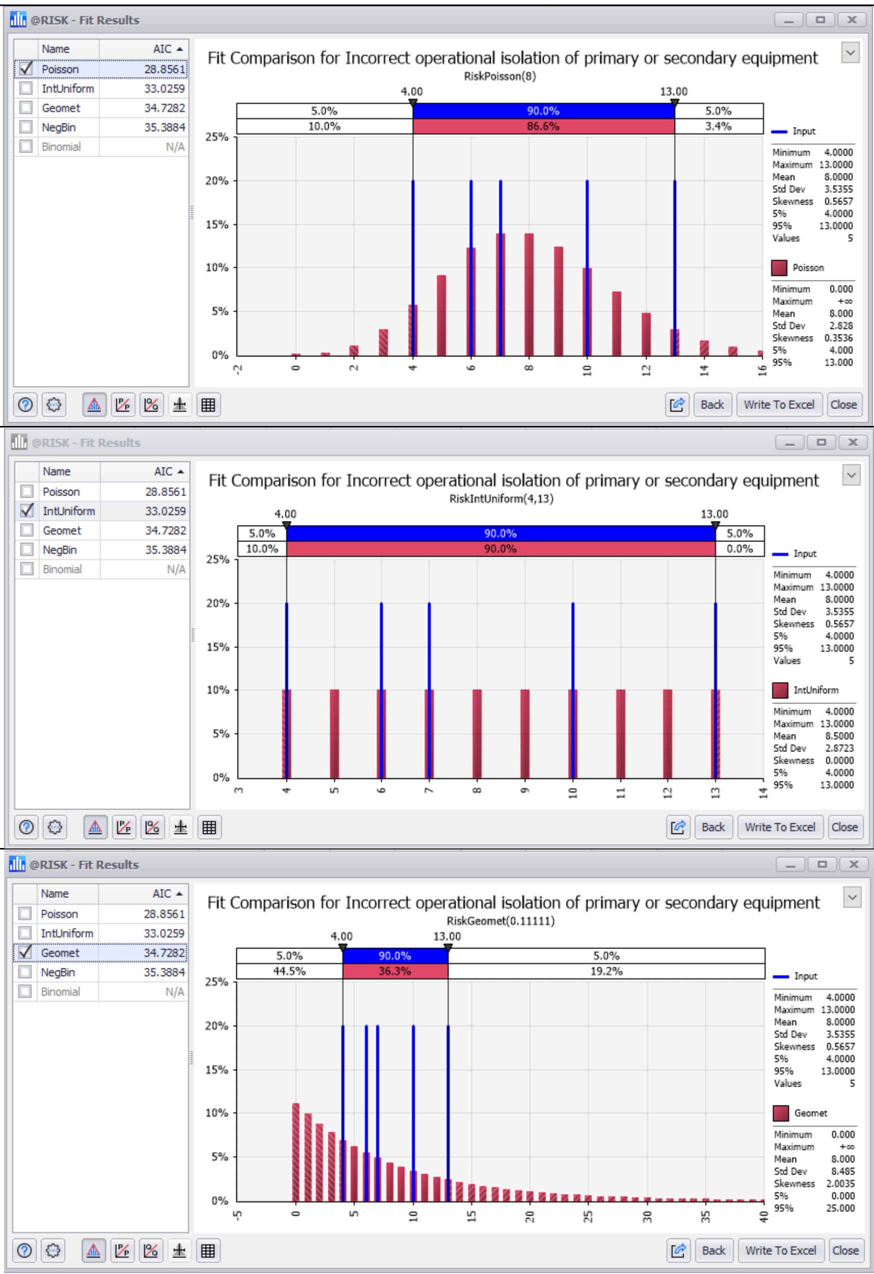
Based on the AIC statistic the distribution of best fit for the incorrect operation isolation of primary or secondary equipment parameter is the Poisson distribution. The distribution of second-best and third-best fit is the Uniform and Geometric distribution respectively. The first two distributions have the same 5th and 95th percentiles, so the choice of either first- or second-best fit will not change the results of the percentile parameters. The 5th and 95th percentile of the Poisson distribution is 4 and 13 respectively.

Table 2.12 Incorrect operational isolation of primary or secondary equipment: Skewness and percentile parameters

Distribution	Skewness	5th percentile	95th percentile
Poisson	0.354	4	13
Uniform	0.000	4	13
Geometric	2.004	0	25

Source: ACIL Allen analysis

Figure 2.12 Incorrect operational isolation of primary or secondary equipment



Source: ACIL Allen analysis

2.5 Summary of findings

Table 2.13 summarises the probability distribution functions that have been chosen to best fit the different parameter datasets. The choice for the distribution functions is supported by relevant test statistics and aligns with the approach the AER takes in choosing the best fit distribution.

Where there was uncertainty about the curve of best fit a second test statistic was used to confirm the results of the first test statistic. We are therefore comfortable with the results of our analysis.

Table 2.13 Summary of best fit distributions

Parameter	Best fit distribution	5% POE	95% POE
Transmission line outage rate - fault	Pearson5	6.84%	34.10%
Transformer outage rate - fault	Weibull	9.46%	36.58%
Reactive plant outage rate - fault	Pearson5	9.63%	59.05%
Transmission line outage rate - forced	Weibull	1.35%	19.74%
Transformer outage rate - forced	Weibull	3.65%	8.68%
Reactive plant outage rate - forced	Weibull	4.90%	22.87%
Loss of supply event frequency >0.05 minutes	Poisson	1	7
Loss of supply event frequency >0.2 minutes	Poisson	0	4
Average outage duration (minutes)	Gamma	86	462
Failure of protection system	Uniform	3	18
Material failure of SCADA	Poisson	0	2
Incorrect operational isolation of primary and secondary equipment	Poisson	4	13

Source: ACIL Allen analysis

Values for parameters 3

This chapter discusses the calculated parameter values in more detail by discussing how they meet the requirements set by the AER and comparing them with minimum and maximum values.

3.1 Parameter requirements

The parameter requirements for the service component of the STPIS are set out in section 3.2 of the AER's Service Target Performance Incentive Scheme. It is stated that the TNSP must propose values for:

— performance target

— a floor

— a cap

Some specific requirements in section 3.2 of the STPIS are:

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

— the proposed *performance target*s must be equal to the *TNSP*'s average performance history over the most recent five years (3.2 f)

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

— Unless a performance deadband is applied, performance targets, floors and caps for loss of supply event frequency parameters must be rounded to the nearest integer number. (3.2 k)

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

ACIL Allen's views on these requirements are summarised in Table 3.1 on the next page.

Table 3.1 Comments on scheme requirements for the parameter values

Requirement	Discussions	Conclusion
Performance Deadbands	When a deadband is applied the performance target is set over a range of values, within which a TNSP neither receives a financial penalty nor financial reward in the regulatory year. This can be used to remove the impact of small variations in performance around the average performance. However, deadbands most often have the effect of removing a net positive value.	Not applicable.
Most recent 5-year period	Parameter values for the years 2016 to 2020 were available and used.	Requirement satisfied.

Requirement	Discussions	Conclusion
Methodology	A sound methodology for the calculation of caps and floors is required. The same five years of historical performance data should be used as input to the analysis to make sure the parameter values are based on consistent data.	Requirement satisfied.
Adjustments	Statistical outliers: The 5 years of performance targets that have been supplied are annual average values. ACIL Allen has not been made aware of any outliers. Volume of capital works: This applies only when planned outages are included. The service component excludes this category. Changes in age or ratings: ACIL Allen has not been made aware of any material changes .	No adjustments required. Requirement satisfied.

Source: ACIL Allen analysis

3.2 Evaluating caps and floors

Table 3.2 compares the estimated 5th and 95th percentiles from the chosen fitted distribution, with the fitted minimum and maximum performance values for each of the parameters. The 5th and 95th percentiles generally cover a wider range than the minimum and maximum values and are therefore more suitable to be used as performance cap and floor values.

Table 3.2 Caps and floors comparison with 2016-2020 data

Parameter	Target	Floor	Cap	Min	Max
Transmission line outage rate - fault	16.21%	34.10%	6.84%	32.09%	7.34%
Transformer outage rate - fault	22.58%	36.58%	9.46%	35.29%	13.43%
Reactive plant outage rate - fault	25.63%	59.05%	9.63%	51.35%	10.53%
Transmission line outage rate - forced	8.73%	19.74%	1.35%	17.54%	0.89%
Transformer outage rate - forced	6.26%	8.68%	3.65%	8.21%	3.68%
Reactive plant outage rate - forced	13.36%	22.87%	4.90%	18.92%	5.26%
Loss of supply event frequency >0.05 minutes	3	7	1	5	1
Loss of supply event frequency >0.2 minutes	2	4	0	3	0
Average outage duration	242	462	86	463	97
Failure of protection system	11	18	3	18	3
Material failure of SCADA	1	2	0	2	0
Incorrect operational isolation of primary and secondary equipment	8	13	4	13	4

Source: ACIL Allen analysis

3.3 Recommended parameter values

In Table 3.3 the recommended performance values are listed:

1. Target values are set at the average of 5 years historical performance values.
2. Cap and Floor values are set at the 5th and 95th percentiles of the best fit distributions as determined by a standard fit test.
3. The values of Loss of supply events, as well as proper operation of equipment have been rounded to nearest integer.

Weightings for all parameters can be found in the last column of the table.

Table 3.3 Recommended parameter values

Parameter	Floor	Target	Cap	Weighting (% of MAR)
Transmission line outage rate - fault	34.10%	16.21%	6.84%	0.20%
Transformer outage rate - fault	36.58%	22.58%	9.46%	0.20%
Reactive plant outage rate - fault	59.05%	25.63%	9.63%	0.10%
Transmission line outage rate - forced	19.74%	8.73%	1.35%	0.10%
Transformer outage rate - forced	8.68%	6.26%	3.65%	0.10%
Reactive plant outage rate - forced	22.87%	13.36%	4.90%	0.05%
Loss of supply event frequency >0.05 minutes	7	3	1	0.15%
Loss of supply event frequency >0.2 minutes	4	2	0	0.15%
Average outage duration	462	242	86	0.20%
Failure of protection system	18	11	3	0.00%
Material failure of SCADA	2	1	0	0.00%
Incorrect operational isolation of primary and secondary equipment	13	8	4	0.00%

Source: ACIL Allen analysis

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