Transgrid

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STPIS Service Component Probability Distribution Fitting

2023-28 Revenue Proposal

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1. Introduction

This attachment outlines the approach we have taken to determine the performance targets, caps and floor for the Service Component (SC) of STPIS which will apply to our 2023-28 regulatory period. This supports the information presented in Chapter 14 of our revenue proposal.

We have followed the requirements set out by the AER in STPIS version 5 to calculate these parameters. The date ranges we have used for historical performance data are as stipulated by the AER, being 2016-2020 for our initial proposal. We will revise this to 2017-2021 for our revised revenue proposal.

This appendix is structured as follows:

- chapter 2 sets out our approach to calculating the parameters
- chapter 3 details the calculations and probability distribution fitting undertaken to determine the targets, caps and floor values.

2. Approach

We have used the *@Risk* product, a risk analysis and simulation add-in tool for Microsoft Excel, to determine the types of probability distribution that best fit the reliability data.

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:

- Average circuit outage rates are fitted with continuous probability distributions bounded at a lower limit of zero.
- Loss of supply events are fitted with discrete probability distributions.
- Average outage duration are fitted using continuous probability distributions bounded at a lower limit of zero.
- Proper operation of equipment parameters are fitted with discrete probability distributions.

Two 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 non-discrete distributions, the Kolmogorov-Smirnov (K-S) fit statistic was used, based on the following rationale:

- Discrete data:
  - For discrete probability distributions, tests relied on are the chi-square, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC).
  - For the chi-square approximation to be valid the expected frequency in each interval bin should be at least 5. As this is not possible with only 5 values in the dataset (one value for each year 2016 to 2020), some uncertainty in the fitted distribution will occur.
  - 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. As such, AIC provides a means 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.
  - 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.
- Continuous data:
  - For non-discrete distributions, tests relied on are the chi-square and the Kolmogorov-Smirnov (K-S).
  - The chi-square test, as discussed above, will have some uncertainty in the fitted distribution for small sample sizes.
  - The K-S fit statistic focuses on the differences between the middle of the fitted distribution and the input data.

3. STPIS Service Component Values

This section contains our proposed STPIS Service Component values based on the historical data range specified by the AER from 2016 to 2020. These will be adjusted using values from 2017 to 2021 in our revised revenue proposal.

3.1. Summary

Our proposed service component parameter values are summarised in Table 1.

Table 1 – Summary of service component parameters

Service component (+/- 1.25% MAR)	Cap (5th percentile)	Target	Floor (95th percentile)	Distribution	Weighting (% MAR)
Unplanned outage circuit event rate (+/- 0.75% MAR)					
Lines event rate – fault	11.30%	15.12%	19.96%	Pearson5	0.2
Transformer event rate – fault	6.15%	11.70%	18.72%	Dagum	0.2
Reactive plant event rate – fault	5.28%	11.92%	18.46%	Dagum	0.1
Lines event rate – forced	6.71%	10.69%	15.44%	Erlang	0.1
Transformer event rate – forced	3.12%	12.57%	23.84%	Rayleigh	0.1
Reactive plant event rate – forced	7.52%	12.85%	22.15%	Dagum	0.05
Loss of supply events frequency (+/-0.3% MAR)					
Loss of supply events > 0.05 (x) system minutes	0	2	4	Poisson	0.15
Loss of supply events > 0.15 (y) system minutes	0	1	2	Poisson	0.15
Average outage duration (+/- 0.2% MAR)					
Average outage duration	33.12	75.60	159.81	Dagum	0.2
Proper operation of equipment (+/- 0% MAR)					
Failure of protection system	9	15	21	Poisson	0
Material failure of supervisory control and data acquisition (SCADA) system	0	1	3	Geometric	0
Incorrect operational isolation of primary or secondary equipment	2	5	9	Poisson	0

3.2. Unplanned circuit event outage rate

Lines event rate – fault

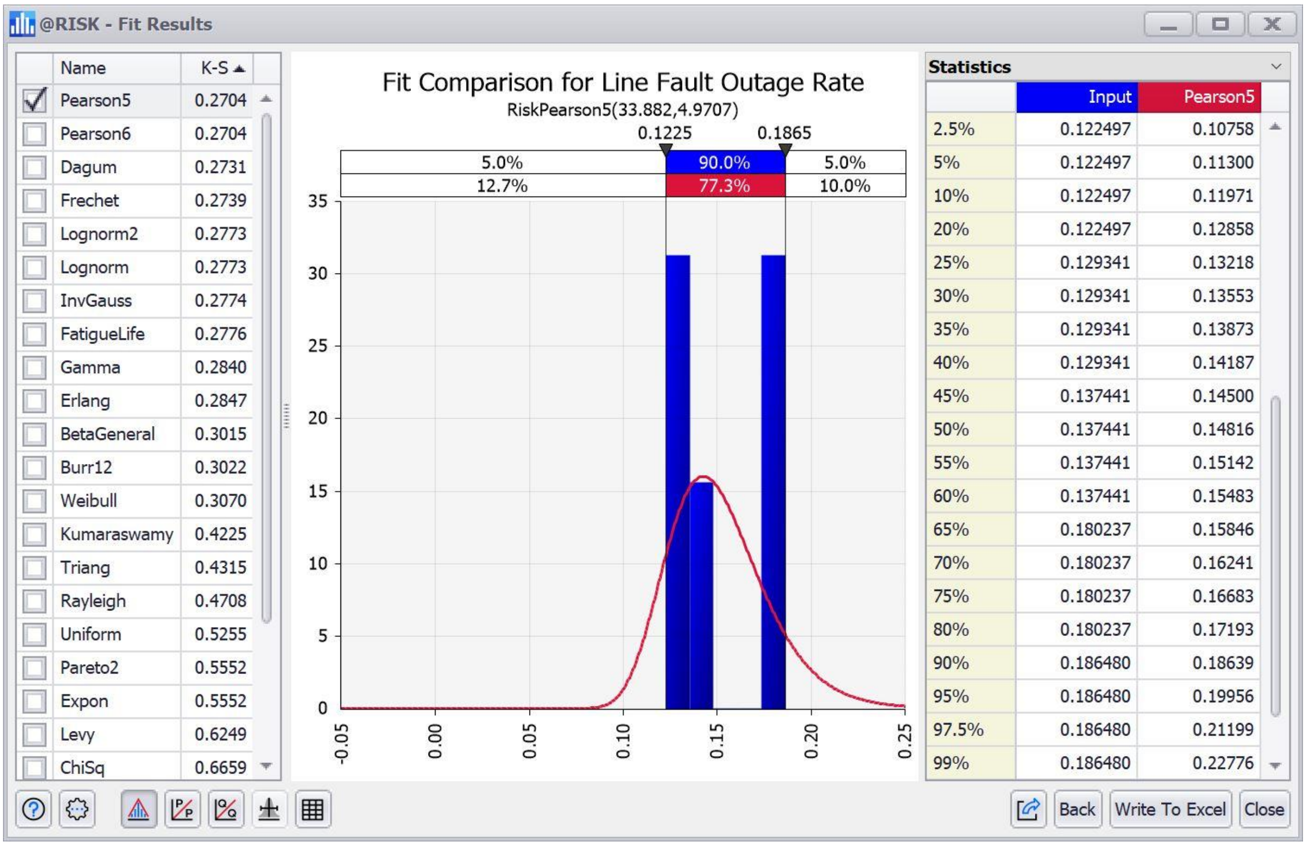
The five year performance data and average are shown in Table 2.

Table 2 – Five year performance data lines outage rate - fault

	2016	2017	2018	2019	2020	Average
Lines event rate – fault	13.74%	12.93%	18.02%	12.25%	18.65%	15.12%

As shown in Figure 1, we have selected the Pearson5 distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 1 – Best fit distribution lines outage rate - fault



Our proposed values for lines fault event rate are shown in Table 3.

Table 3 – Proposed values lines outage rate - fault

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Lines event rate – fault	11.30%	15.12%	19.96%	Kolmogorov–Smirnov	Pearson5

Transformer event rate – fault

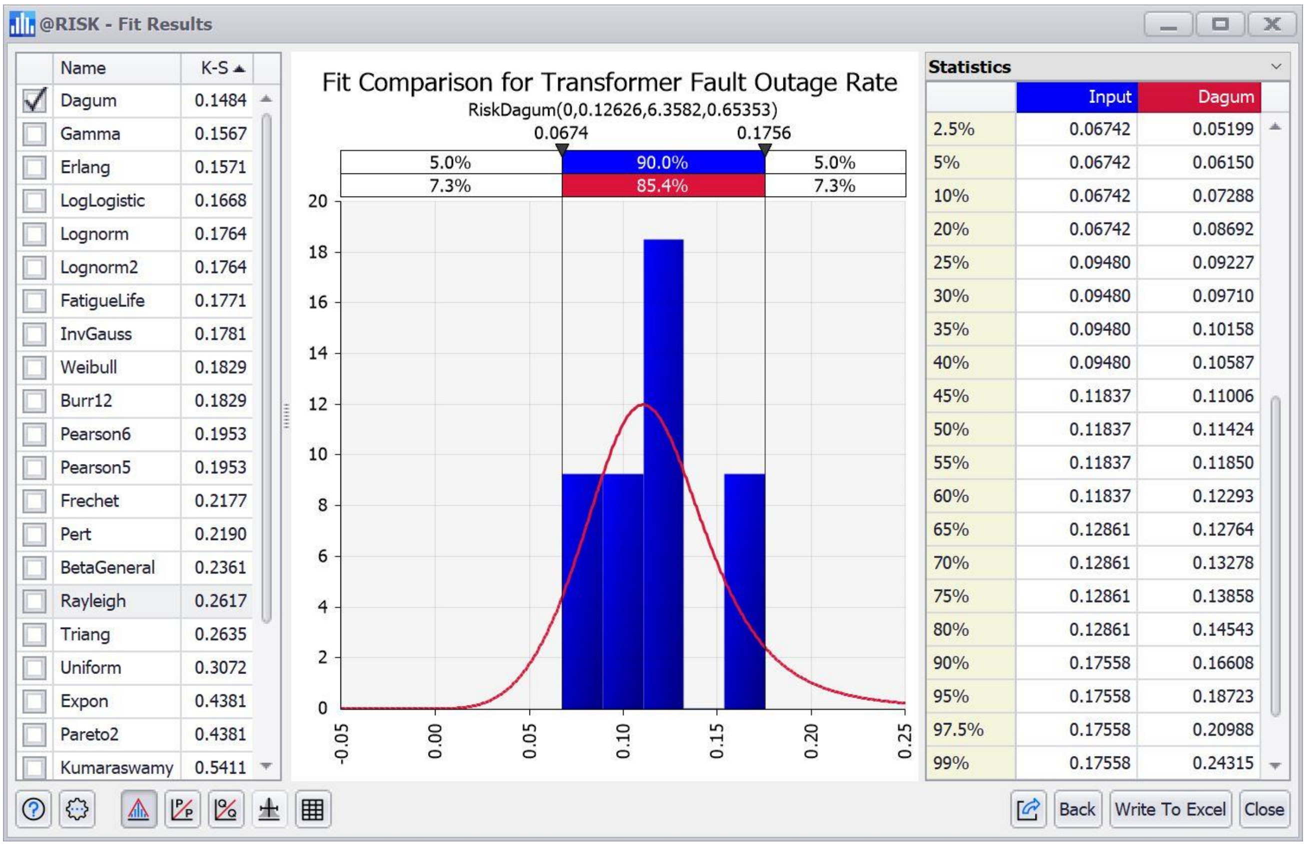
The five year performance data and average are shown in Table 4.

Table 4 – Five year performance data transformer outage rate - fault

	2016	2017	2018	2019	2020	Average
Transformer event rate – fault	17.56%	9.48%	12.86%	6.74%	11.84%	11.70%

As shown in Figure 2, we have selected the Dagum distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 2 – Best fit distribution transformer outage rate - fault



Our proposed values for transformers fault event rate are shown in Table 5.

Table 5 – Proposed values transformer outage rate - fault

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Transformer event rate – fault	6.15%	11.70%	18.72%	Kolmogorov–Smirnov	Dagum

Reactive plant event rate – fault

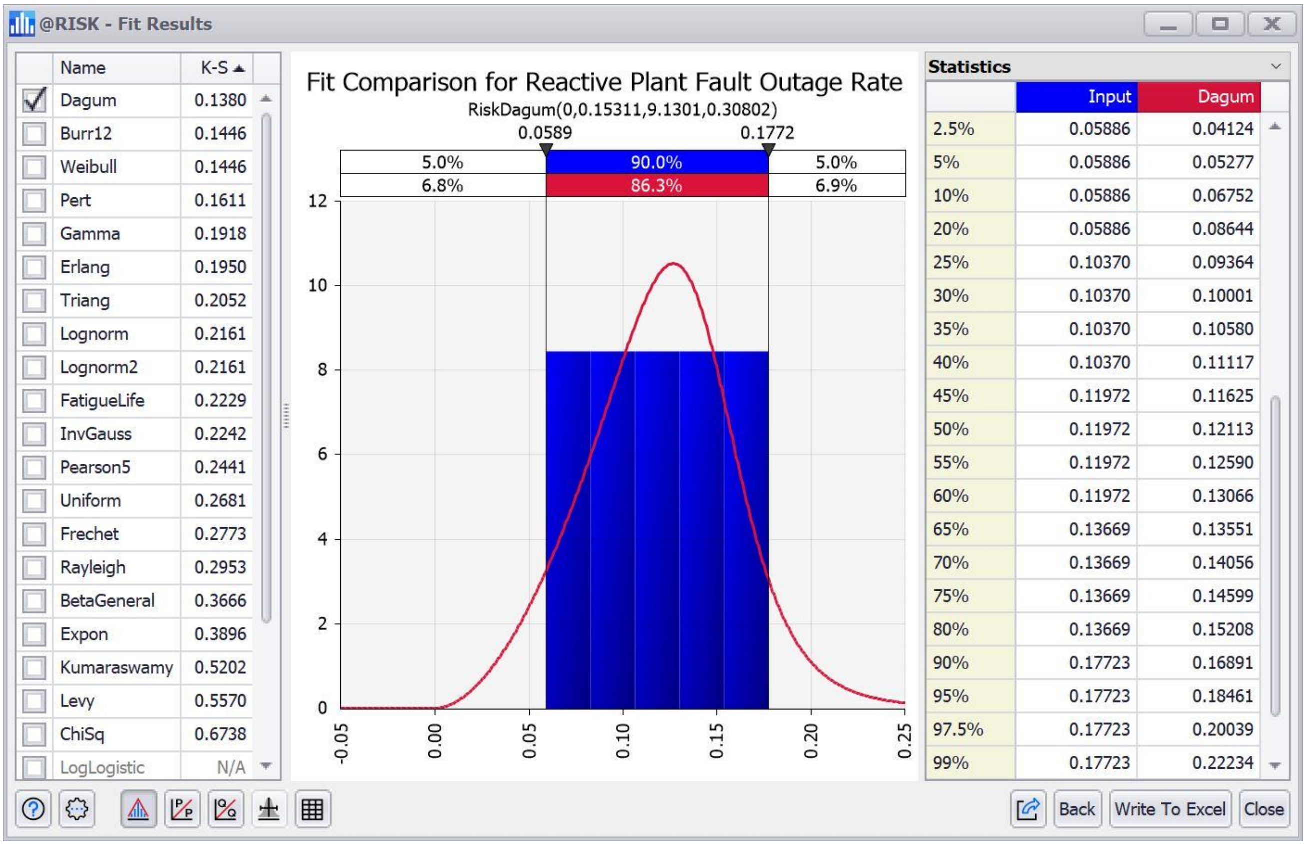
The five year performance data and average are shown in Table 6.

Table 6 – Five year performance data reactive plant outage rate - fault

	2016	2017	2018	2019	2020	Average
Reactive plant event rate – fault	5.89%	10.37%	17.72%	13.67%	11.97%	11.92%

As shown in Figure 3, we have selected the Dagum distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 3 – Best fit distribution reactive plant outage rate - fault



Our proposed values for reactive plant fault event rate are shown in Table 7.

Table 7 – Proposed values reactive plant outage rate - fault

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Reactive plant event rate – fault	5.28%	11.92%	18.46%	Kolmogorov–Smirnov	Dagum

Lines event rate – forced

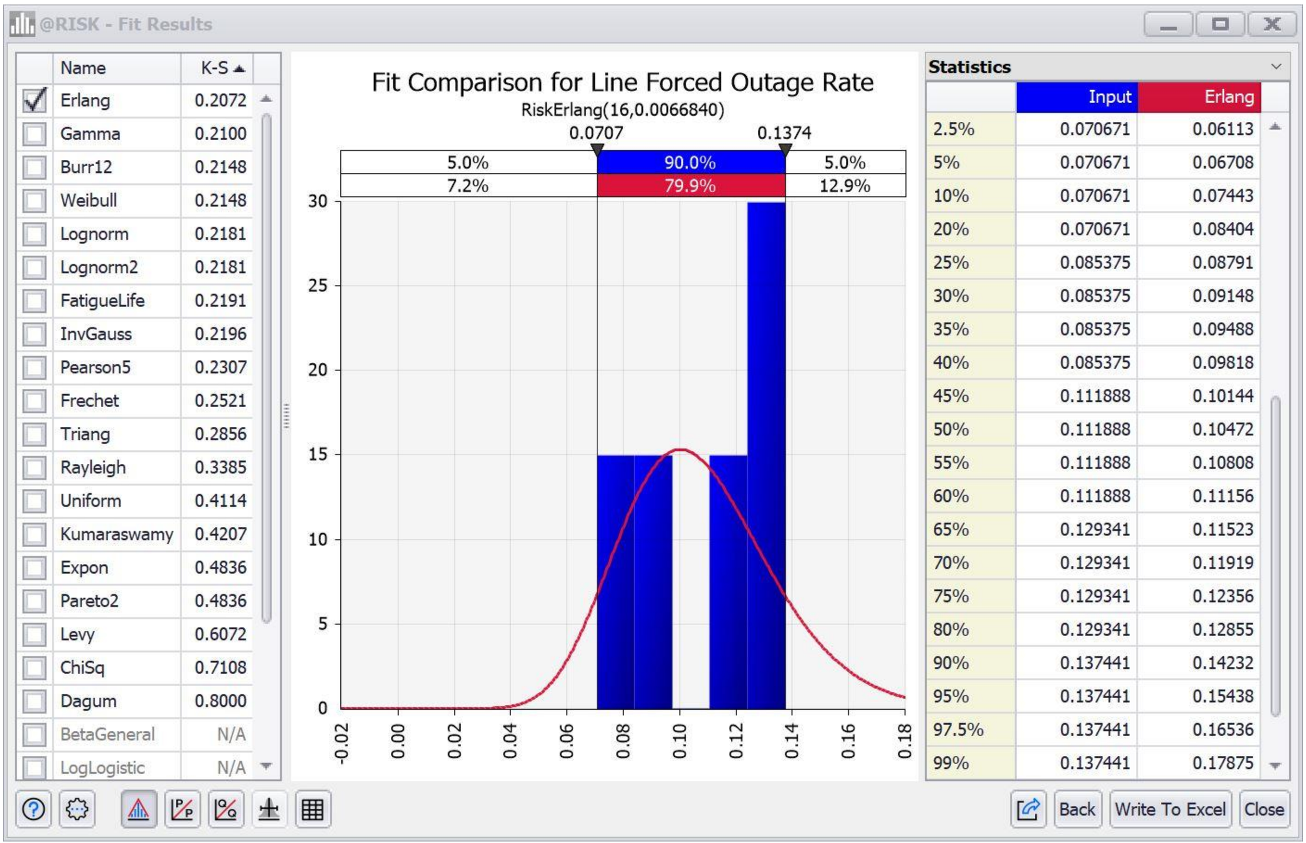
The five year performance data and average are shown in Table 8.

Table 8 – Five year performance data lines outage rate - forced

	2016	2017	2018	2019	2020	Average
Lines event rate – forced	13.74%	12.93%	8.54%	7.07%	11.19%	10.69%

As shown in Figure 4, we have selected the Erlang distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 4 – Best fit distribution lines outage rate - forced



Our proposed values for lines forced event rate are shown in Table 9.

Table 9 – Proposed values lines outage rate - forced

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Lines event rate – forced	6.71%	10.69%	15.44%	Kolmogorov–Smirnov	Erlang

Transformer event rate – forced

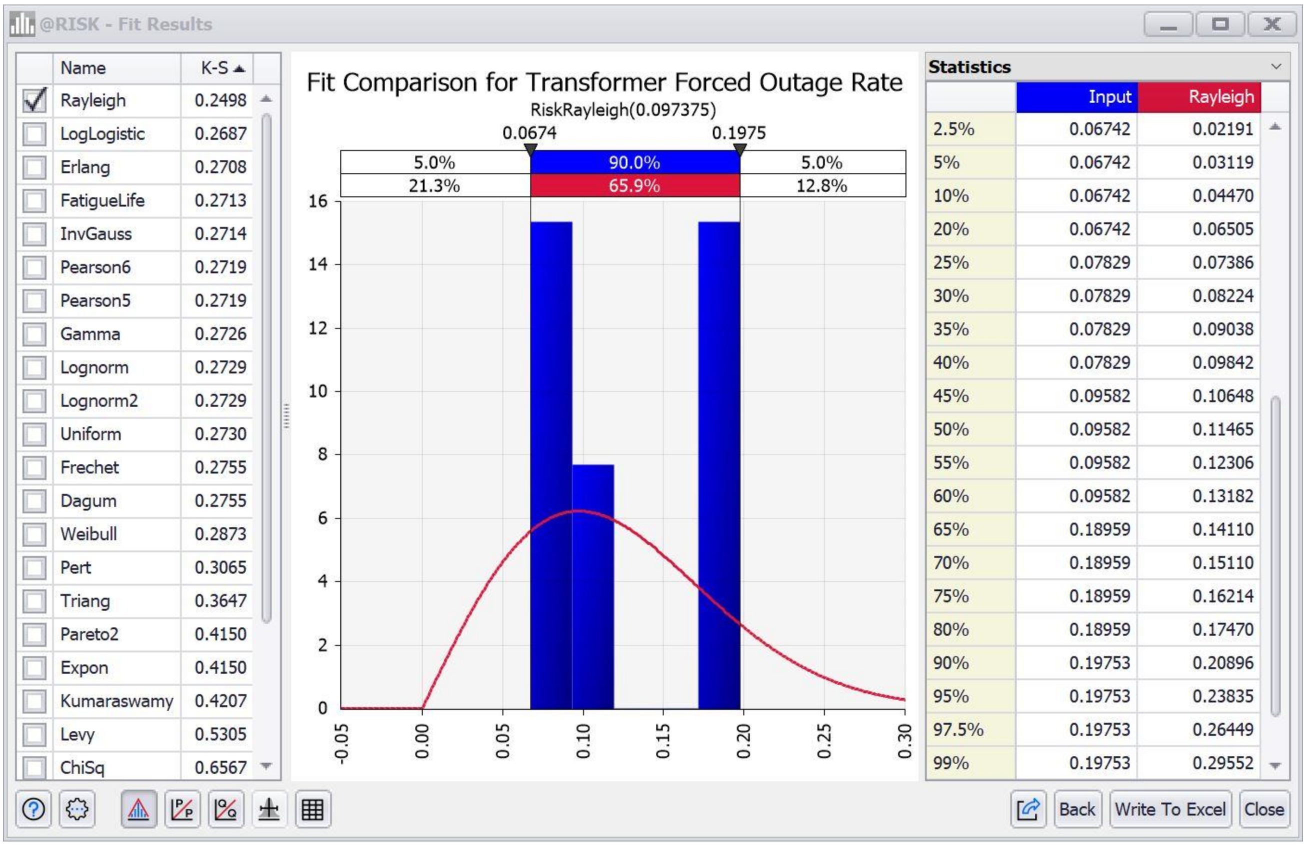
The five year performance data and average are shown in Table 10.

Table 10 – Five year performance data transformer outage rate - forced

	2016	2017	2018	2019	2020	Average
Transformer event rate – forced	19.75%	18.96%	7.83%	6.74%	9.58%	12.57%

As shown in Figure 5, we have selected the Rayleigh distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 5 – Best fit distribution transformer outage rate - forced



Our proposed values for transformer forced event rate are shown in Table 11.

Table 11 – Proposed values transformer outage rate - forced

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Transformer event rate – forced	3.12%	12.57%	23.84%	Kolmogorov–Smirnov	Rayleigh

Reactive plant event rate – forced

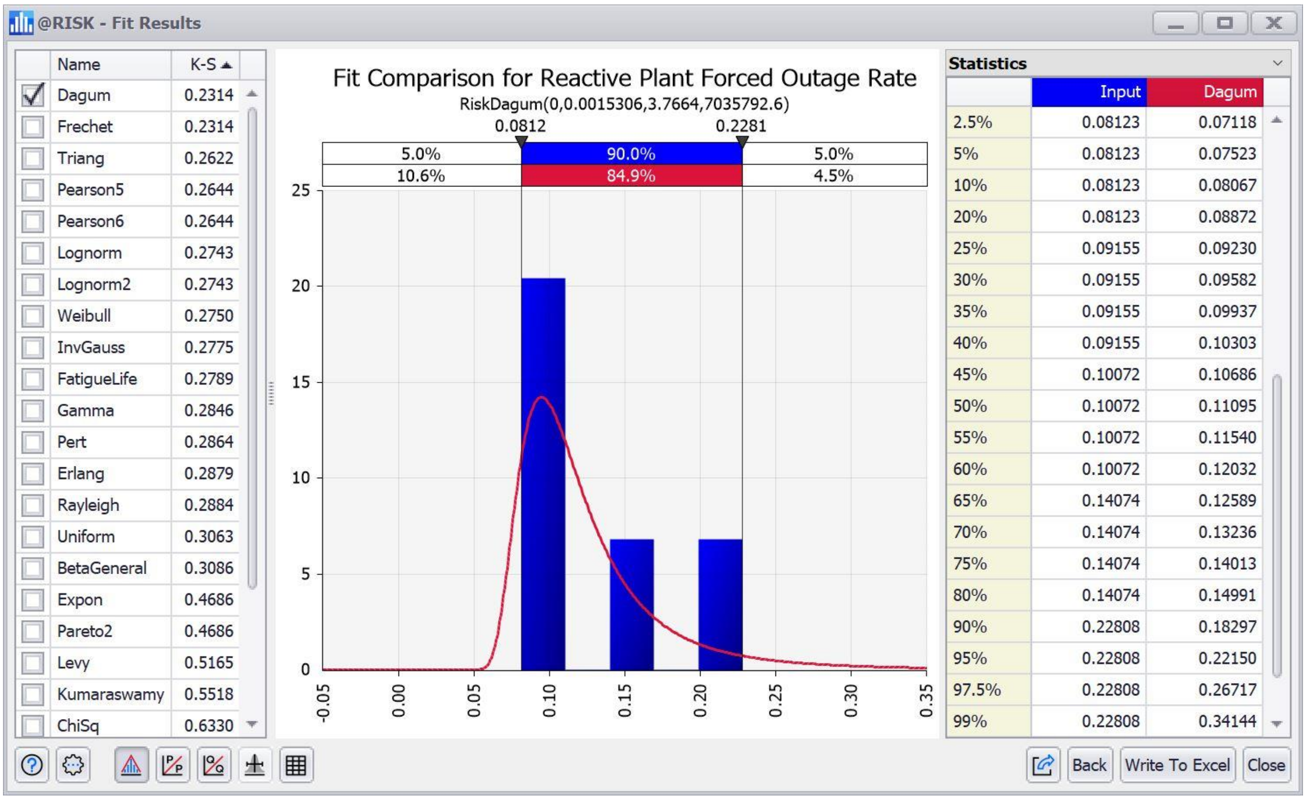
The five year performance data and average are shown in Table 12.

Table 12 – Five year performance data reactive plant outage rate - forced

	2016	2017	2018	2019	2020	Average
Reactive plant event rate – forced	22.81%	14.07%	8.12%	10.07%	9.15%	12.85%

As shown in Figure 6, we have selected the Dagum distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 6 – Best fit distribution reactive plant outage rate - forced



Our proposed values for reactive plant forced event rate are shown in Table 13.

Table 13 – Proposed values reactive plant outage rate - forced

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Reactive plant event rate – forced	7.52%	12.85%	22.15%	Kolmogorov–Smirnov	Dagum

3.3. Loss of supply event frequency

Loss of supply events > 0.05 (x) system minutes

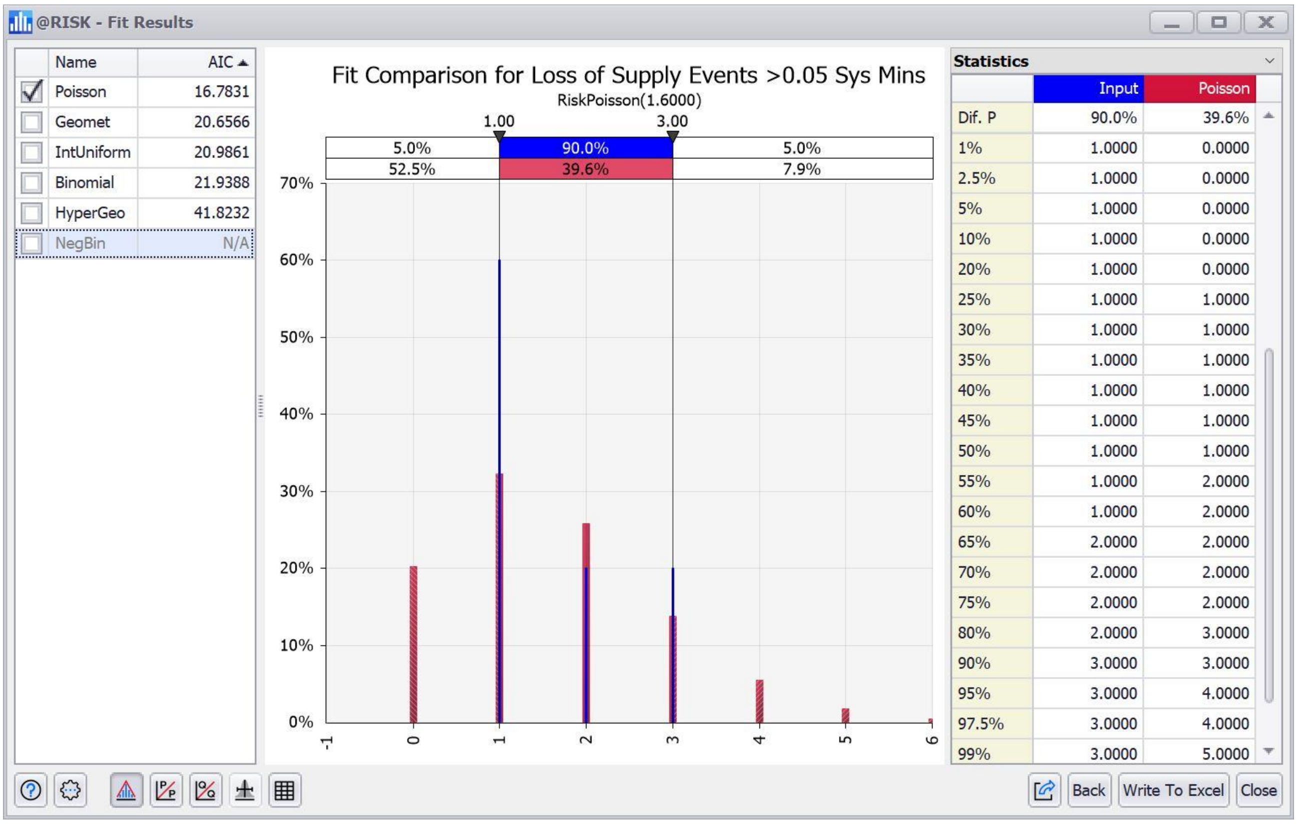
The five year performance data and average are shown in Table 14.

Table 14 – Five year performance data loss of supply events > 0.05 (x) system minutes

	2016	2017	2018	2019	2020	Average
Loss of supply events > 0.05 (x) system minutes	2	1	1	3	1	2

As shown in Figure 7, we have selected the Poisson distribution as the best fit distribution for this parameter, as it scores the best on the Akaike Information Criterion test.

Figure 7 – Best fit distribution loss of supply events > 0.05 (x) system minutes



Our proposed values for Loss of supply events > 0.05 (x) system minutes are shown in Table 15.

Table 15 – Proposed values loss of supply events > 0.05 (x) system minutes

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Loss of supply events > 0.05 (x) system minutes	0	2	4	Akaike Information Criterion	Poisson

Loss of supply events > 0.15 (y) system minutes

Using a Y threshold of 0.25 system minutes with a Poisson distribution, the initial values are listed in Table 16 for the loss of supply events > 0.25 (y) system minutes.

Table 16 – Initial values loss of supply events > 0.25 (y) system minutes

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Loss of supply events > 0.25 (y) system minutes	0	0	1	Akaike Information Criterion	Poisson

Our strong performance for the loss of supply events >0.25 (y) system minutes has resulted in the target and cap based on best probability distribution fit of Poisson to be zero.

Setting both the target and cap to zero would result in the asymmetric operation of this performance measure. This means that it would be impossible to attain a positive incentive outcome for this measure, while clause 6A.7.4 (b)(1)(i) of the National Electricity Rules (NER) requires STPIS to '*provide incentives for each Transmission Network Service Provider to… provide greater reliability*'.

Based on analysis, TransGrid proposes the Y threshold changes from 0.25 system minutes to 0.15 system minutes. This new Y threshold results in a performance target of one.

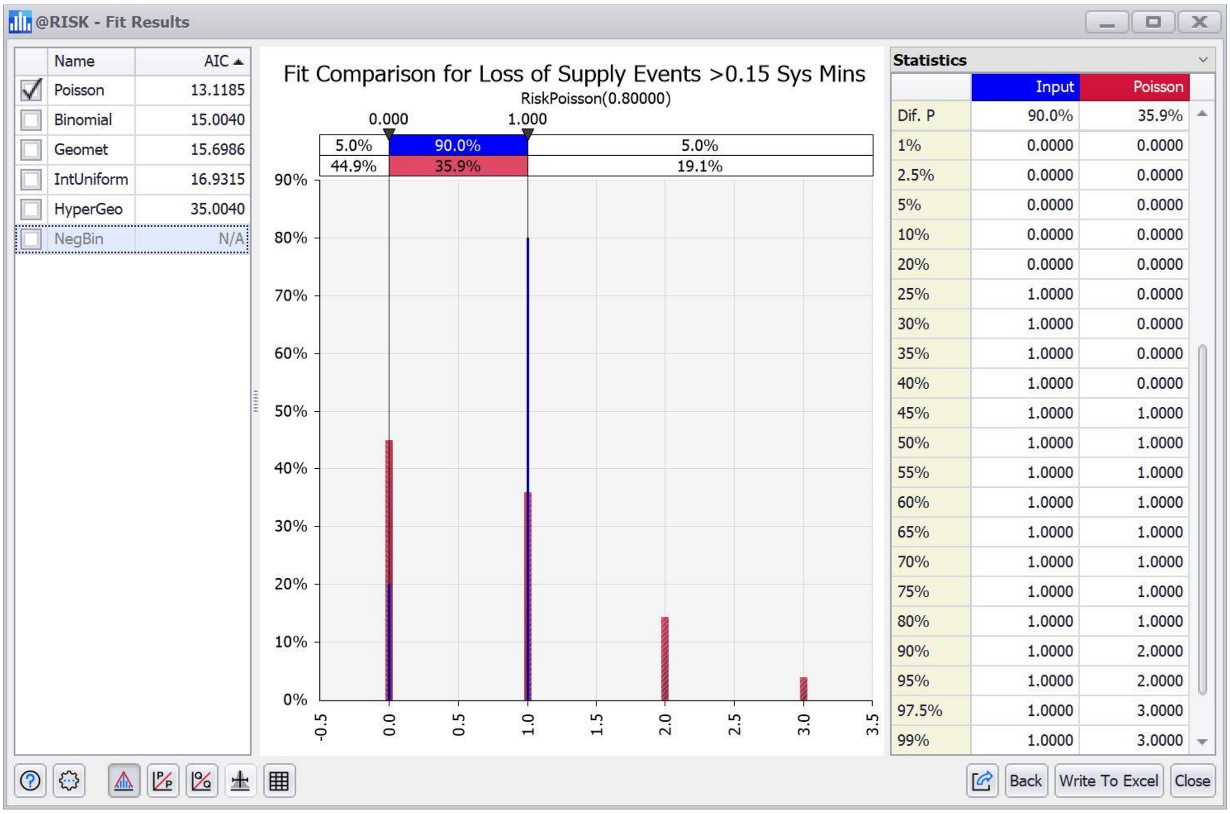
The five year performance data and average based on the new threshold are listed in Table 17.

Table 17 – Five year performance data loss of supply events > 0.15 (y) system minutes

	2016	2017	2018	2019	2020	Average
Loss of supply events > 0.15 (y) system minutes	1	0	1	1	1	1

As shown in Figure 8, we have selected the Poisson distribution as the best fit distribution for this parameter, as it scores the best on the Akaike Information Criterion test.

Figure 8 – Best fit distribution loss of supply events > 0.15 (y) system minutes



Our proposed values for loss of supply events > 0.15 (y) system minutes are shown in Table 18.

Table 18 – Proposed values loss of supply events > 0.15 (y) system minutes

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Loss of supply events > 0.15 (y) system minutes	0	1	2	Akaike Information Criterion	Poisson

3.4. Average outage duration

Average outage duration

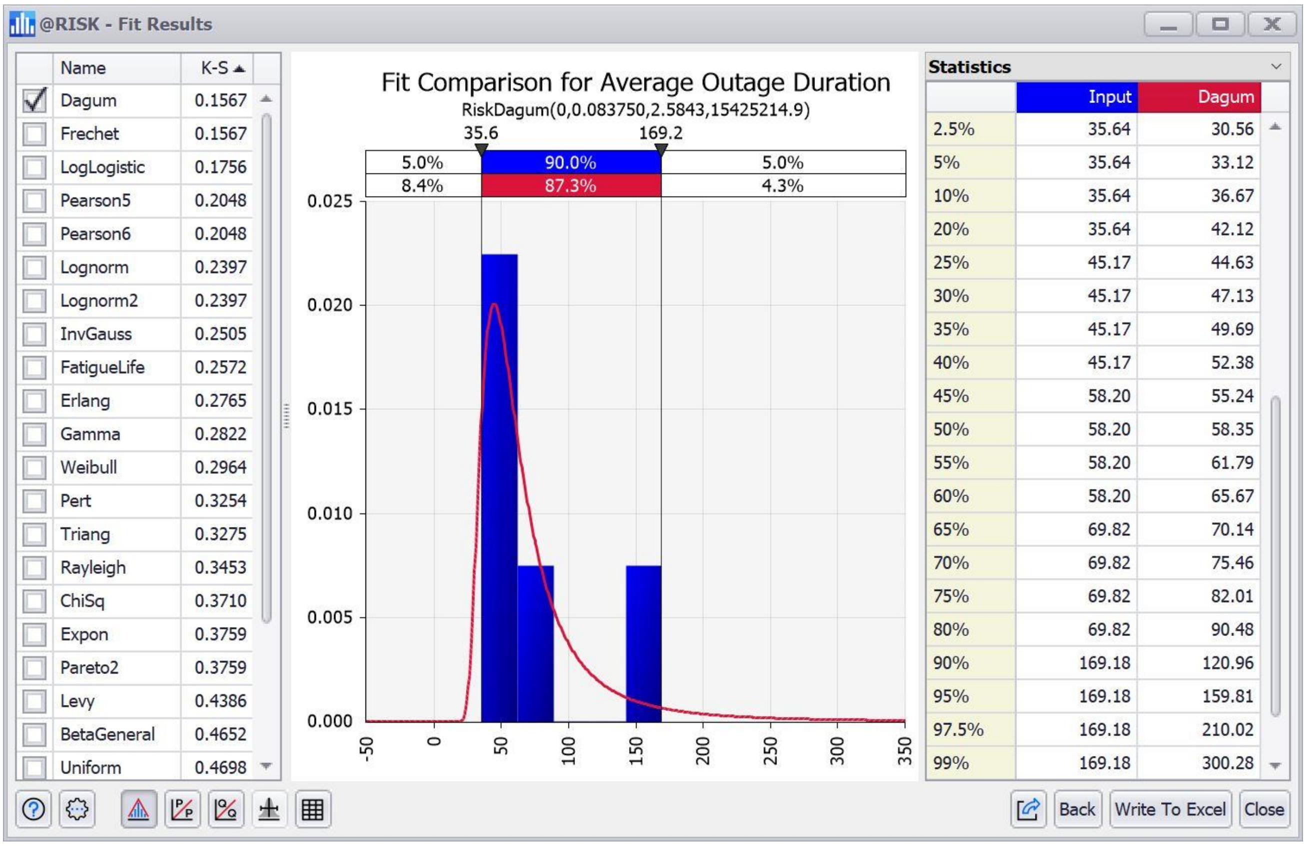
The five year performance data and average are shown in Table 19.

Table 19 – Five year performance data average outage duration

	2016	2017	2018	2019	2020	Average
Average outage duration	169.18	35.64	58.20	69.82	45.17	75.60

As shown in Figure 9, we have selected the Dagum distribution as the best fit distribution for this parameter, as it scores the best on the Kolmogorov-Smirnov test.

Figure 9 – Best fit distribution average outage duration



Our proposed values for average outage duration are shown in Table 20.

Table 20 – Proposed values average outage duration

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Average outage duration	33.12	75.60	159.81	Kolmogorov–Smirnov	Dagum

3.5. Proper operation of equipment

Failure of protection system

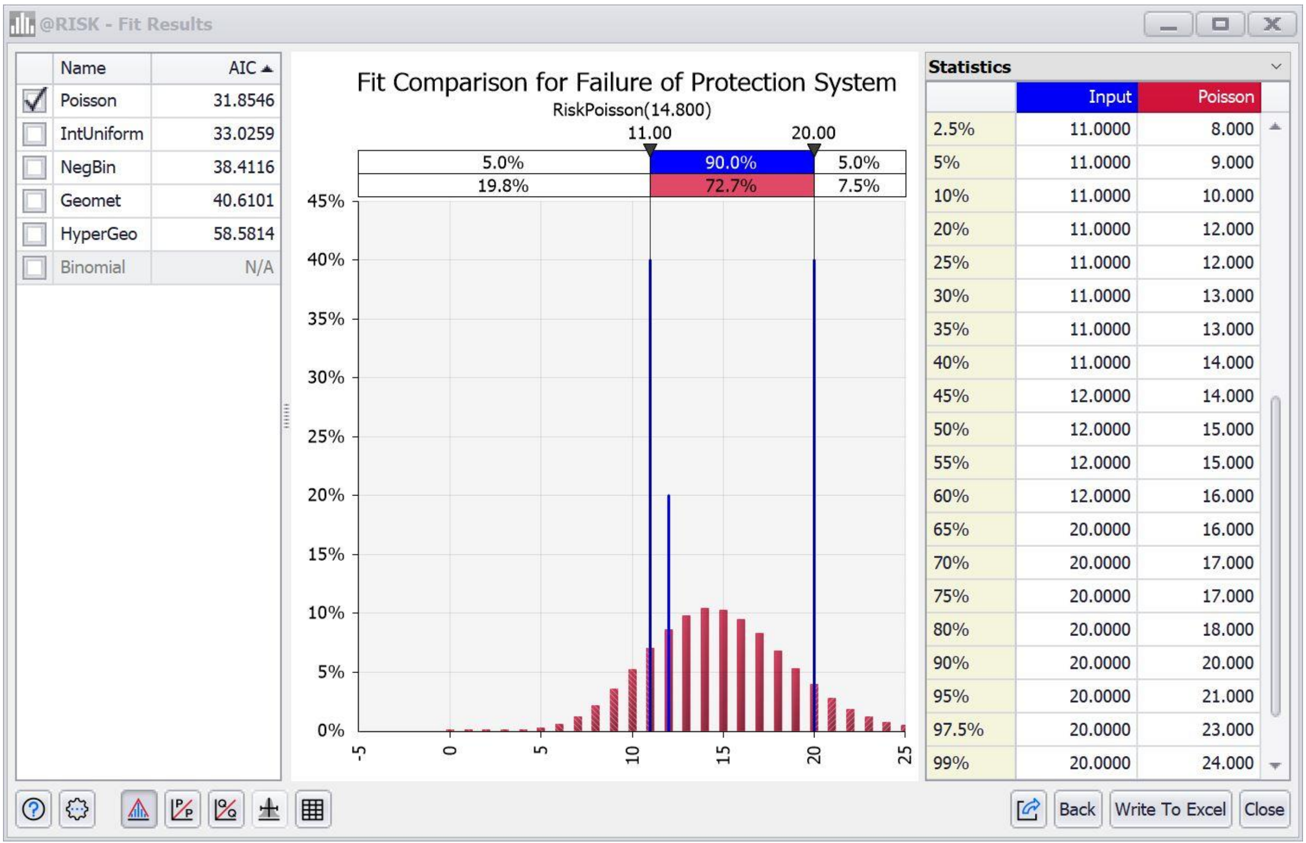
The five year performance data and average are shown in Table 21.

Table 21 – Five year performance data failure of protection system

	2016	2017	2018	2019	2020	Average
Failure of protection system	20	11	20	12	11	15

As shown in Figure 10, we have selected the Poisson distribution as the best fit distribution for this parameter, as it scores the best on the Akaike Information Criterion test.

Figure 10 – Best fit distribution failure of protection system



Our proposed values for failure of protection system are shown in Table 22.

Table 22 – Proposed values failure of protection system

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Failure of protection system	9	15	21	Akaike Information Criterion	Poisson

Material failure of Supervisory Control and Data Acquisition (SCADA) system

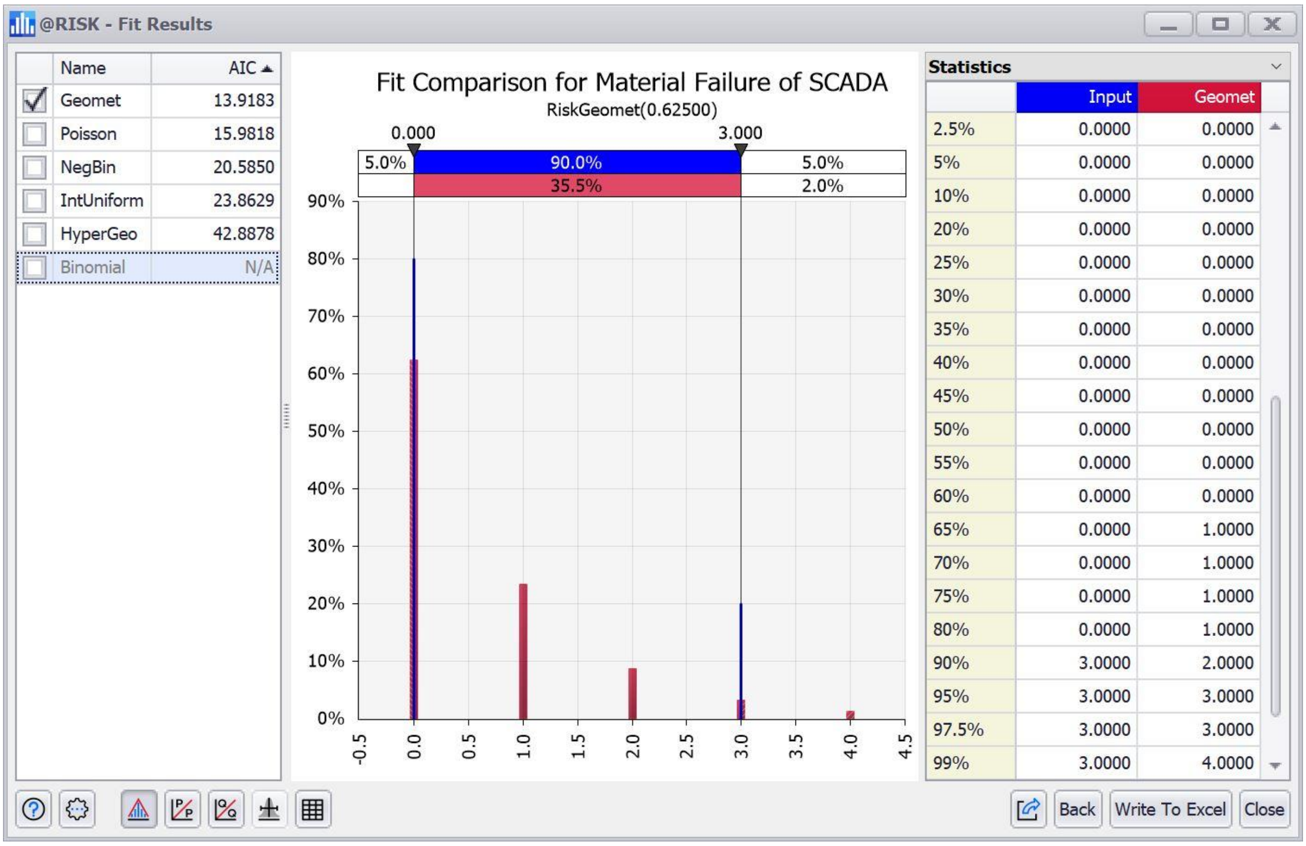
The five year performance data and average are shown in Table 23.

Table 23 – Five year performance data material failure of SCADA system

	2016	2017	2018	2019	2020	Average
Material failure of SCADA system	3	0	0	0	0	1

As shown in Figure 11, we have selected the Geometric distribution as the best fit distribution for this parameter, as it scores the best on the Akaike Information Criterion test.

Figure 11 – Best fit distribution material failure of SCADA system



Our proposed values for material failure of SCADA system are shown in Table 24.

Table 24 – Proposed values material failure of SCADA system

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Material failure of SCADA system	0	1	3	Akaike Information Criterion	Geometric

Incorrect operational isolation of primary or secondary equipment

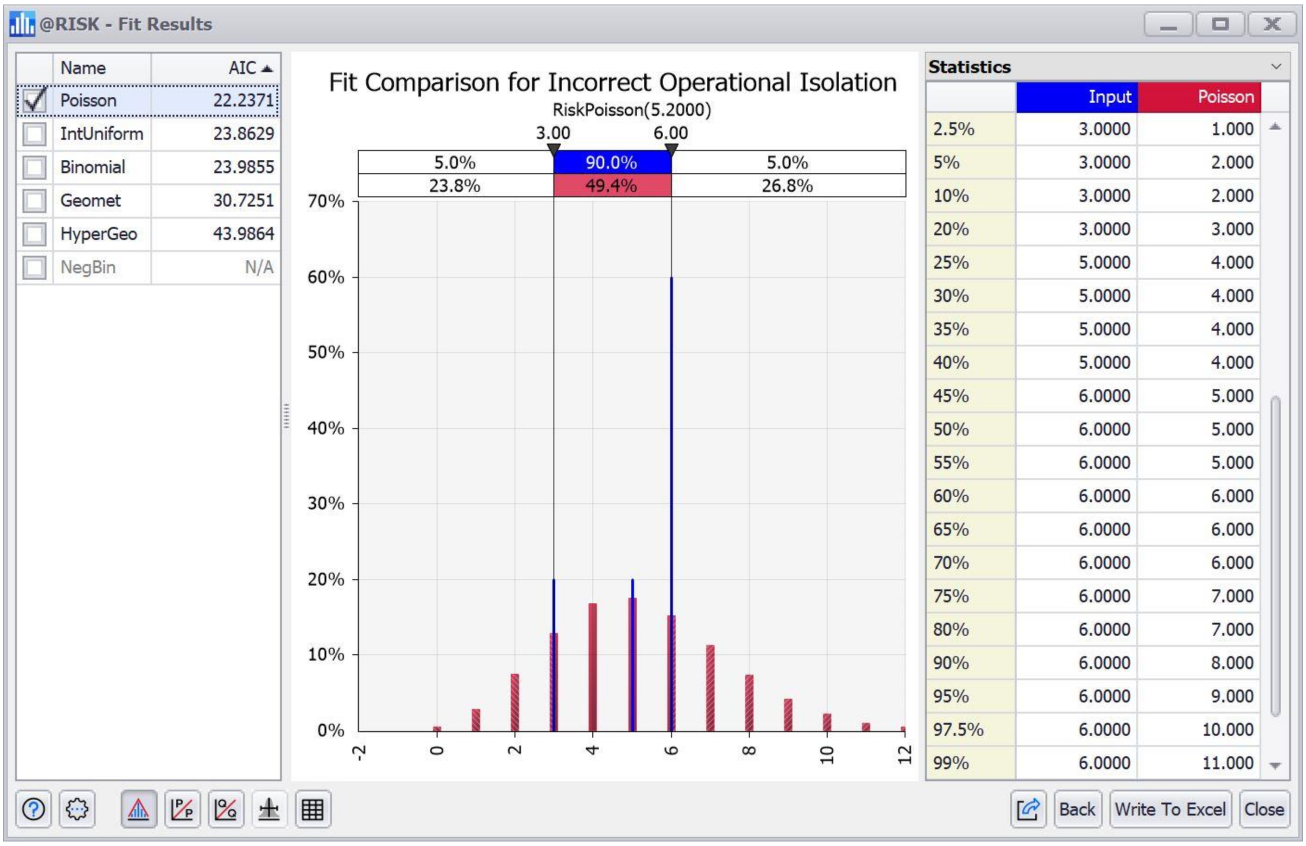
The five year performance data and average are shown in Table 25.

Table 25 – Five year performance data incorrect operational isolation of primary or secondary equipment

	2016	2017	2018	2019	2020	Average
Incorrect operational isolation of primary or secondary equipment	5	6	6	3	6	5

As shown in Figure 12, we have selected the Poisson distribution as the best fit distribution for this parameter, as it scores the best on the Akaike Information Criterion test.

Figure 12 – Best fit distribution incorrect operational isolation of primary or secondary equipment



Our proposed values for incorrect operational isolation of primary or secondary equipment are shown in Table 26.

Table 26 – Proposed values incorrect operational isolation of primary or secondary equipment

	Cap (5th percentile)	Target	Floor (95th percentile)	Model Selection Criteria	Distribution
Incorrect operational isolation of primary or secondary equipment	2	5	9	Akaike Information Criterion	Poisson