2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

APPENDIX 15.02

WSP | Parsons Brinckerhoff
Powerlink's Statistical Methodology for STPIS Service Component - Verification Report

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POWERLINK'S STATISTICAL METHODOLOGY FOR STPIS SERVICE COMPONENT

VERIFICATION REPORT

JANUARY2016

POWERLINK'S STATISTICAL METHODOLOGY FOR STPIS SERVICE COMPONENT

VERIFICATION REPORT

Powerlink

Final Report

Project no: 2265057A
Date: January 2016

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QUALITY MANAGEMENT

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VERIFICATION STATEMENT

Powerlink engaged WSP | Parsons Brinckerhoff to undertake a verification of Powerlink's Statistical Methodology for Service Target Performance Incentive Scheme (STPIS) Service Component. This report details WSP | Parsons Brinckerhoff's verification of Powerlink's methodology/approach and subsequent outcomes for the targets, floors and caps of the STPIS Service Component based on Powerlink's STPIS historical reliability data.

This verification relates to the Service Component of the STPIS only (including sub-parameters):

- Parameter 1 – Unplanned outage circuit event rate
  - Line outage – fault
  - Transformer outage – fault
  - Reactive plant – fault
  - Line outage – forced
  - Transformer outage – forced
  - Reactive plant – forced
- Parameter 2 – Loss of supply event frequency
  - No. events > 0.05 system minutes
  - No. events > 0.40 system minutes
- Parameter 3 – Average outage duration

WSP | Parsons Brinckerhoff undertook a desktop review of Powerlink's methodology document and approach. The verification focused on the requirements of Section 3.2 of the STPIS and the set of objectives provided by the AER in SP AusNet's Draft Decision[1].

WSP | Parsons Brinckerhoff found Powerlink's methodology and approach to be sound and consistent with the requirements. We found the outputs to be logical, applied to historical data and we didn't recommend any alternatives to the approach.

We verified the actual statistical outputs from Powerlink's statistical modelling and confirm the dataset meets the STPIS requirements.

[1] AER Draft decision SP AusNet 2014-15 to 2016-17 STPIS, p184, 185

1 PURPOSE OF REPORT

The purpose of this report is to provide verification of Powerlink's Statistical Methodology for Service Target Performance Incentive Scheme (STPIS) Service Component. This report details WSP | Parsons Brinckerhoff's verification of Powerlink's methodology/approach and subsequent outcomes for the targets, floors and caps of the STPIS Service Component based on Powerlink's STPIS historical reliability data.

2 BACKGROUND

2.1 STATEMENT ABOUT WSP PARSONS BRINCKERHOFF

WSP and Parsons Brinckerhoff have combined and are now one of the world's leading engineering professional services consulting firms, with more than 31,000 employees world-wide. We have assisted many network services businesses in Australia to develop their service incentive scheme parameters and attributes.

WSP | Parsons Brinckerhoff's verifier is very familiar with, and has a proven track record in, regulatory processes associated with the submission and review of STPIS proposals, gained through working directly with the AER to review proposals and working with businesses in the preparation of proposals. The critical analysis included in this verification report has been undertaken by an acknowledged industry specialist in incentive schemes and modelling of curves of best fit to historic data for the purpose of determining collars/caps.

Our work processes are quality assured through accreditation to AS/NZS ISO 9001:2008.

2.2 POWERLINK'S STATISTICAL METHODOLOGY FOR STPIS SERVICE COMPONENT

Powerlink is required to propose values for the performance targets, caps and floors for the Service Component by Section 3.2 of Version 5 Service Target Performance Incentive Scheme (STPIS)[2].

2.3 VERIFICATION PROCESS

Our process involved:

- reviewing Powerlink's methodology document and approach
- reviewing the actual statistical outputs from Powerlink's statistical modelling
- recommending considering alternatives/enhancements to the modelling approach
- providing a report detailing the soundness of Powerlink's methodology.

[2] AER electricity transmission STPIS version 5 (corrected) - 1 October 2015

This verification relates to the Service Component of the STPIS only (including sub-parameters):

- Parameter 1 – Unplanned outage circuit event rate
  - Line outage – fault
  - Transformer outage – fault
  - Reactive plant – fault
  - Line outage – forced
  - Transformer outage – forced
  - Reactive plant – forced
- Parameter 2 – Loss of supply event frequency
  - No. events > 0.05 system minutes
  - No. events > 0.40 system minutes
- Parameter 3 – Average outage duration

The verification focused on the requirements of Section 3.2 of the STPIS and the set of objectives provided by the AER in SP AusNet's Draft Decision[3].

WSP | Parsons Brinckerhoff verified Powerlink's statistical methodology for STPIS Service Components for alignment with Section 3.2 of the STPIS, specifically:

- (d) Data used to calculate proposed values must be accurate and reliable
- (e) The proposed floors and caps must be calculated by reference to the proposed performance targets and using a sound methodology.
- (f) Subject to clause 3.2(g) to 3.2(k) below, proposed performance targets must be equal to the TNSP's average performance history over the most recent five years. The data used to calculate the performance target must be consistently recorded based on the parameter definitions that apply to the TNSP under this service component of the scheme.
- (j) Proposed performance targets may be subject to adjustment to allow for:
  - (1) statistical outliers
  - (2) the expected effects on the TNSP's performance from any increases or decreases in the volume of capital works planned during the regulatory control period (compared with the volume of capital works undertaken during the period used to calculate the performance target)
  - (3) the expected material effects on the TNSP's performance from any changes to the age and ratings of the assets comprising the TNSP's transmission system during the TNSP's next regulatory control period (compared to the age and ratings of the TNSP's assets comprising the TNSP's transmission system during the period used to calculate performance targets)
  - (4) material changes to an applicable regulatory obligation.
- (k) 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] AER Draft decision SP AusNet 2014-15 to 2016-17 STPIS, p184, 185

The AER's objectives, as set out in SP AusNet's Draft Decision[4], require that each distribution must:

- reflect the inherent skewness of the data,
- be bound by the logical limits of the parameter type,
- be discrete when fitting discrete data,
- be continuous when fitting continuous data,
- distributions with fewer parameters are preferred to distributions with more, and
- be a good fit for the performance data.

WSP | Parsons Brinckerhoff considers that for a distribution to be a good fit for the performance data it must reflect the inherent skewness in the data, and therefore has grouped these two requirements.

WSP | Parsons Brinckerhoff considers that in practically setting up the available distributions, the selection of discrete or continuous distributions and any boundaries must be determined, and therefore has grouped these three requirements. As such, WSP | Parsons Brinckerhoff's verification of each set of parameters aligns with the AER's objectives, set out as follows:

- reflect the inherent skewness of the data and be a good fit for performance data
- be bound by the logical limits of the parameter type, be discrete when fitting discrete data, be continuous when fitting continuous data,
- distributions with fewer parameters are preferred to distributions with more.

Powerlink has used goodness of fit tests to determine the curve of best fit to the reliability data. WSP | Parsons Brinckerhoff's verification assesses whether the test relied on was appropriate for the data, 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 2011 to 2015), 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.

[4] AER Draft decision SP AusNet 2014-15 to 2016-17 STPIS, p184, 185

→ Continuous data:

- For non-discrete distributions, tests relied on are the chi-square, the Kolmogorov-Smirnov (K-S), the Anderson-Darling (A-D), and the AIC and BIC.
- 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. The A-D fit statistic focuses on the difference between the tails of fitted distribution and input data. Hence, where the input data is concentrated around the middle of a distribution curve the K-S fit statistic is preferred and where the data is near the tails the A-D fit statistic is preferred. The results from both were compared in each case. Where the input data was both in the middle and the tails of a distribution, the result from the A-D fit statistic was favoured, because the best fit of the data and the distribution curve at the tails improves the calculation of the scheme measures (caps and collars at one or two standard deviations).
- The AIC test, as discussed above, is a valid test and is preferred over the BIC for small sample sizes.
- Given that the A-D test focusses on the goodness of fit in the tails of the distribution, the A-D test is preferred when the performance data has data in the tails as this is the part of the distribution of most interest in setting collars. Otherwise the K-S or AIC tests are appropriate.

Once the probability distribution function of best fit was verified for each parameter the standard deviation or $5^{th}/95^{th}$ percentile values of the probability distribution functions were examined.

Because a probability distribution is being fitted to a dataset of five values only 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. The curve of second best fit can be examined to test for any large variations in the calculated values that might indicate that the curve of best fit should not have be used.

WSP | Parsons Brinckerhoff undertook a desktop review of Powerlink's methodology document and approach, refer Table 2.1.

Table 2.1 Items reviewed

ITEM	DATE	FILE
Summary of Powerlink's Methodology and Approach	Dec 2015	201512 Summary of Powerlink's Methodology and Approach - Setting STPIS V.pdf
Powerlink - Setting STPIS Values	8 Jan 2016	Powerlink - Setting STPIS Values.docx
Powerlink STPIS Service Component Data	7 Jan 2016	Powerlink RR18-22 - Reset RIN STPIS Data as of 7 Jan 2016.xlsx
Powerlink STPIS Service Component Data and Values	8 Jan 2016	Powerlink STPIS Service Component Data and Values.xlsx
Powerlink STPIS Service Component Data and Values - @Risk data	8 Jan 2016	20160112 Powerlink RR18-22 - Reset RIN STPIS Data with @RISK data.xlsx

3 REVIEW OF POWERLINK'S STATISTICAL METHODOLOGY FOR STPIS SERVICE COMPONENT

This section includes WSP | Parsons Brinckerhoff's independent assessment of the STPIS proposed by Powerlink.

WSP | Parsons Brinckerhoff verified Powerlink's statistical methodology for STPIS Service Components for alignment with Section 3.2 of the STPIS, as outlined in Table 3.1

Table 3.1 Alignment with Section 3.2 STPIS

CLAUSE	ASSESSMENT	CONCLUSION
(d) Data used to calculate proposed values must be accurate and reliable	Powerlink's historical data is subject to audit and is outside of our scope. We have assumed that the data when audited is accurate and reliable.	The use of audited data will meet the requirements of clause 3.2(d).
(e) The proposed floors and caps must be calculated by reference to the proposed performance targets and using a sound methodology.	Powerlink has fitted distributions to the data, refer to sections 3.1, 3.2and 3.3, utilising @Risk. They have then calculated the caps and floors as the 5th and 95th percentiles of the chosen distributions.	Powerlink's methodology aligns with clause 3.2 (e).
(f) Subject to clause 3.2(g) to 3.2(k) below, proposed performance targets must be equal to the TNSP's average performance history over the most recent five years. The data used to calculate the performance target must be consistently recorded based on the parameter definitions that apply to the TNSP under this service component of the scheme.	Powerlink has used the performance history of the previous 5 years. Powerlink's historical data is subject to audit and is outside of our scope. We have assumed that the data is recorded consistently with the definitions.	The use of audited data will meet the requirements of clause 3.2(f).
(j) Proposed performance targets may be subject to adjustment to allow for: (1) statistical outliers (2) the expected effects on the TNSP's performance from any increases or decreases in the volume of capital works planned during the regulatory control period (compared with the volume of capital works undertaken during the period used to calculate the performance target) (3) the expected material effects on the TNSP's performance from any changes to the age and ratings of the assets	Powerlink has advised that it has not made any adjustments to the data.	Powerlink's data aligns with clause 3.2 (j).

CLAUSE	ASSESSMENT	CONCLUSION
comprising the TNSP's transmission system during the TNSP's next regulatory control period (compared to the age and ratings of the TNSP's assets comprising the TNSP's transmission system during the period used to calculate performance targets) (4) material changes to an applicable regulatory obligation.		
(k) 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.	Supply event frequency parameters have been provided as whole numbers. No deadbands are applied.	Powerlink's data aligns with clause 3.2 (k).

WSP | Parsons Brinckerhoff's verification of each set of parameters aligns with the AER's objectives, as set out in SP AusNet's Draft Decision[5]. The findings of our verification of each set of parameters are set out in sections 3.1, 3.2 and 3.3.

3.1 PARAMETER 1 – UNPLANNED OUTAGE CIRCUIT EVENT RATE

WSP | Parsons Brinckerhoff assessed the following sub-parameters:

- Line outage – fault
- Transformer outage – fault
- Reactive plant – fault
- Line outage – forced
- Transformer outage – forced
- Reactive plant – forced

Table 3.2 Alignment with AER's objectives, as set out in SP AusNet's Draft Decision

OBJECTIVE	ASSESSMENT	CONCLUSION
→ reflect the inherent skewness of the data and be a good fit for performance data	Powerlink has selected distributions that provide the best available fit for the performance data, refer Table B1 in Appendix B.	Powerlink's Unplanned outage circuit event rate aligns with the AER's objective

5 AER Draft decision SP AusNet 2014-15 to 2016-17 STPIS, p184, 185

OBJECTIVE	ASSESSMENT	CONCLUSION
→ be bound by the logical limits of the parameter type, be discrete when fitting discrete data, be continuous when fitting continuous data,	Unplanned outage circuit event rates are fitted with continuous probability distributions bounded at a lower limit of zero, refer to The @Risk software allows different setups for data that will result in different tests and profiles being available. The set up accounts for the type of data (continuous or discrete), boundaries on the data (fixed at a bound or unsure) and the distributions that are considered in the testing. Powerlink has utilised the settings outlined in Table B2, which WSP | Parsons Brinckerhoff has found appropriate. Table B2 in Appendix B. Unplanned outage circuit event rates represent measures of availability for components of transmission circuits. The optimal performance limit is 0%, which represents total availability for the component for the year.	Powerlink's Unplanned outage circuit event rate aligns with the AER's objective
→ distributions with fewer parameters are preferred to distributions with more, and	N/A	N/A

3.2 PARAMETER 2 – LOSS OF SUPPLY EVENT FREQUENCY

WSP | Parsons Brinckerhoff assessed the following sub-parameters:

- No. events > 0.05 system minutes
- No. events > 0.40 system minutes

Table 3.3 Alignment with AER's objectives, as set out in SP AusNet's Draft Decision

OBJECTIVE	ASSESSMENT	CONCLUSION
→ reflect the inherent skewness of the data and be a good fit for performance data	Powerlink has selected distributions that provide the best available fit for the performance data, refer Table B1 in Appendix B.	Powerlink's Loss of supply event frequency aligns with the AER's objective
→ be bound by the logical limits of the parameter type, be discrete when fitting discrete data, be continuous when fitting continuous data,	Loss of supply event frequency are fitted with discrete probability distributions, refer to The @Risk software allows different setups for data that will result in different tests and profiles being available. The set up accounts for the type of data (continuous or discrete), boundaries on the data (fixed at a bound or unsure) and the distributions that are considered in the testing. Powerlink has utilised the settings outlined in Table B2, which WSP | Parsons Brinckerhoff has found appropriate. Table B2 in Appendix B. Losses of supply events represent discrete occurrences of failure. The optimal performance limit is 0 events, which represents no loss of supply. In order to best fit the loss of supply events data, discrete distribution curves are used with equal interval binning.	Powerlink's Loss of supply event frequency aligns with the AER's objective
→ distributions with fewer parameters are preferred to distributions with more, and	Powerlink has selected the final distribution based on the preference of fewer parameters.	Powerlink's Loss of supply event frequency aligns with the AER's objective

3.3 PARAMETER 3 – AVERAGE OUTAGE DURATION

WSP | Parsons Brinckerhoff assessed the following sub-parameters:

→ Average outage duration

Table 3.4 Alignment with AER's objectives, as set out in SP AusNet's Draft Decision

OBJECTIVE	ASSESSMENT	CONCLUSION
→ reflect the inherent skewness of the data and be a good fit for performance data	Powerlink has selected distributions that provide the best available fit for the performance data, refer Table B1 in Appendix B.	Powerlink's Average outage duration aligns with the AER's objective
→ be bound by the logical limits of the parameter type, be discrete when fitting discrete data, be continuous when fitting continuous data,	Average outage duration data are fitted using continuous probability distributions bounded at a lower limit of zero, refer to The @Risk software allows different setups for data that will result in different tests and profiles being available. The set up accounts for the type of data (continuous or discrete), boundaries on the data (fixed at a bound or unsure) and the distributions that are considered in the testing. Powerlink has utilised the settings outlined in Table B2, which WSP | Parsons Brinckerhoff has found appropriate. Table B2 in Appendix B. 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.	Powerlink's Average outage duration aligns with the AER's objective
→ distributions with fewer parameters are preferred to distributions with more, and	N/A	N/A

4 CONCLUSION

WSP | Parsons Brinckerhoff undertook a desktop review of Powerlink's methodology document and approach. The verification focused on the requirements of Section 3.2 of the STPIS and the set of objectives provided by the AER in SP AusNet's Draft Decision[6].

WSP | Parsons Brinckerhoff reviewed Powerlink's methodology and approach and found it to be sound and consistent with the requirements. We found the outputs to be logical, applied to historical data and we didn't recommend any alternatives to the approach.

We verified the actual statistical outputs from Powerlink's statistical modelling and confirm the dataset meets the STPIS requirements.

Table A1 Verification of distribution

PARAMETER	SUB-PARAMETER	POWERLINK'S DISTRIBUTION OF BEST FIT	WSP | PARSONS BRINCKERHOFF'S DISTRIBUTION OF BEST FIT
Unplanned Outage Circuit Event Rate	Line outage – fault	Pearson5	Pearson5
	Transformer outage – fault	LogNormal	LogNormal
	Reactive plant – fault	LogLogistic	LogLogistic
	Line outage – forced	Weibull	Weibull
	Transformer outage – forced	Weibull	Weibull
	Reactive plant – forced	LogLogistic	LogLogistic
Loss of Supply Event Frequency	No. events > 0.05 sys min	Poisson	Poisson
	No. events > 0.40 sys min	Poisson	Poisson
Average Outage Duration (mins)	Average outage duration	Exponential	Exponential

6 AER Draft decision SP AusNet 2014-15 to 2016-17 STPIS, p184, 185

Appendix A

PERFORMANCE DATA

Table A1 Performance data

PARAMETER	SUB-PARAMETER	PERFORMANCE ACTUALS					DISTRIBUTION OF BEST FIT	DISTRIBUTION PERCENTILES	
		2011	2012	2013	2014	2015		5%	95%
Unplanned Outage Circuit Event Rate	Line outage – fault	26.32%	23.36%	16.64%	19.59%	18.52%	Pearson5	15.859%	27.171%
	Transformer outage – fault	20.96%	17.86%	18.40%	19.41%	17.92%	LogNormal	17.092%	20.841%
	Reactive plant – fault	35.07%	39.13%	23.66%	29.08%	22.30%	LogLogistic	19.488%	43.417%
	Line outage – forced	17.29%	23.36%	21.84%	22.30%	17.17%	Weibull	15.898%	24.085%
	Transformer outage – forced	22.75%	17.26%	21.96%	18.82%	15.03%	Weibull	13.956%	23.489%
	Reactive plant – forced	18.66%	21.74%	28.67%	31.91%	20.14%	LogLogistic	15.953%	34.247%
Loss of Supply Event Frequency	No. events > 0.05 sys min	7	2	1	5	2	Poisson	1	7
	No. events > 0.40 sys min	2	0	0	2	1	Poisson	0	3
Average Outage Duration (mins)	Average outage duration	86.77	26.09	5.62	115.97	236.23	Exponential	4.83	282.00

Appendix B

VERIFICATION ANALYSIS

Table B1 Assessment of distribution fitting

PARAMETER	A-D	K-S	AIC	COMMENT	ASSESSMENT
Line outage – fault	Pearson5 and Pearson6 have same ranking	Pearson5	Pearson5		WSP Parsons Brinckerhoff verifies Powerlink's selection of Pearson5
Transformer outage – fault	LogNormal	LogNormal	InvGauss Lognormal	Data is around centre and tails. Prefer A-D test	WSP Parsons Brinckerhoff verifies Powerlink's selection of LogNormal
Reactive plant – fault	LogLogistic	LogLogistic	Rayleigh	Data is around centre and tails. Prefer A-D test	WSP Parsons Brinckerhoff verifies Powerlink's selection of LogLogistic
Line outage – forced	Weibull	BetaGeneral	Weibull	Data is around centre and tails. Prefer A-D test	WSP Parsons Brinckerhoff verifies Powerlink's selection of Weibull
Transformer outage – forced	Erlang	Weibull	Weibull	Data is around centre. Prefer K-S test.	WSP Parsons Brinckerhoff verifies Powerlink's selection of Weibull
Reactive plant – forced	LogLogistic	LogLogistic	Rayleigh	Data is around centre. Prefer K-S test.	WSP Parsons Brinckerhoff verifies Powerlink's selection of LogLogistic
LOS No. events > 0.05 sys min	N/A	N/A	Poisson	Powerlink have selected Poisson as it has fewer parameters. WSP | Parsons Brinckerhoff also prefers AIC test over other tests for discrete distributions	WSP Parsons Brinckerhoff verifies Powerlink's selection of Poisson

PARAMETER	A-D	K-S	AIC	COMMENT	ASSESSMENT
LOS No. events > 0.40 sys min	N/A	N/A	Poisson	Powerlink have selected Poisson as it has fewer parameters. WSP | Parsons Brinckerhoff also prefers AIC test over other tests for discrete distributions	WSP Parsons Brinckerhoff verifies Powerlink's selection of Poisson
AOD	Gamma	Pert Exponential	Exponential	Data is around most common value, hence K-S test is preferred. The K-S test ranks Pert highest with a 95th value of 250, followed by Exponential with 282. The large difference between the values indicates that the Pert may not be a valid distribution for this data. The PERT distribution is based on a minimum and maximum value and a "most likely" value. It mimics the normal distribution assuming that many real-world phenomena are normally distributed, without knowing the precise parameters of the related normal curve. Given that it focuses on the centre of the distribution (the most likely value), its higher ranking under the K-S test, which also focuses on goodness of fit in the centre of the distribution, is understandable. Focussing on the tails of the distribution, the A-D test ranks the Gamma as the best fit, with a 95th value of 287, close to the Exponential value of 282, supporting that the Exponential is preferred over the Pert. The AIC test ranks Exponential as the best fit.	WSP Parsons Brinckerhoff verifies Powerlink's selection of Exponential

The @Risk software allows different setups for data that will result in different tests and profiles being available. The set up accounts for the type of data (continuous or discrete), boundaries on the data (fixed at a bound or unsure) and the distributions that are considered in the testing. Powerlink has utilised the settings outlined in Table B2, which WSP | Parsons Brinckerhoff has found appropriate.

Table B2 Assessment of type of distribution and bounds

PARAMETER	TYPE	LOWER BOUND	UPPER BOUND	DISTRIBUTIONS CHECKED
Unplanned outage circuit event rate	Continuous	0	Unsure	All
Loss of supply event frequency	Discrete	-	-	All
Average outage duration	Continuous	0	Unsure	All