Powerlink QUEENSLAND

Powerlink's Comments on ACCC's Draft Decision on Queensland Transmission Network Revenue Cap 2002-2006/07

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1 Executive Summary

Powerlink has reviewed the *Draft Decision* and has identified 4 areas which require further consideration by the ACCC:

- **Weighted average cost of capital (WACC)**, which does not meet the ACCC's own principle of national consistency, and is internally inconsistent. A nationally consistent WACC would be 3.42% above the 10 year bond rate, as for TransGrid. Based on the 10 year rate at 29 August of 5.49%, the resultant WACC of 8.91% would be nationally consistent. Thus, reasonableness test #1 is a test of national consistency.

  Reasonableness test #2 involves examining the financial ratios and resultant credit ratings. The draft determination delivers financial ratios which correspond to a credit rating of BBB (below investment grade). For Powerlink to retain at least an investment grade "A" rating, a minimum WACC of 8.92% is necessary, and this would not decrease if the risk free rate decreased further. This is attributable to the fact that in the real world, the cost of equity does not move with the same volatility as spot interest rates, contrary to the assumptions in the WACC calculation. Thus, in the present environment of lower, quite volatile bond rates in recent weeks, the real cost of equity remains fundamentally unchanged.

  The WACC needs to be the higher number from these 2 reasonableness tests (at this date, 8.92%).

  This WACC is only marginally higher than the draft WACC of 8.83%, and would therefore still deliver real reductions in transmission prices for the Queensland grid, excluding QNI. In short, the price for national consistency and equitable outcomes is negligible compared with the long term public benefit.

- **Opening asset values**, where Powerlink still believes that the ACCC has discretion and also believes that the ACCC has misinterpreted some of the conclusions from PB consultants. We also believe that the ACCC has not adequately addressed the longer term regulatory issue of valuation of the various components of easement value.

- **Operating costs**, where Powerlink has accepted the ACCC's invitation to quantify the identified risk-related exposures, and

- **Service standards**, where Powerlink, with advice from a consultant statistician, has identified statistical flaws in some of the targets.

2 Cost of Capital

2.1 Introduction

Given the capital intensive nature of electricity networks, the return on capital component of regulated revenue accounts for a significant portion of the annual aggregate revenue.

The ACCC has assessed a post-tax nominal WACC of 7.00% as being the appropriate return on capital for the purpose of setting the transmission revenue cap for Powerlink for the five and a half year period ending 30 June 2007.

Powerlink believes that this WACC is unreasonably low, and Powerlink's submission addresses the WACC from 3 perspectives:

a) a "top down" comparative analysis which shows that the outcome is inconsistent and unfair

b) a "top down" analysis of the resultant financial ratios and ratings which shows that the outcome will result in the degradation of Powerlink's credit rating and the actual costs of funds to Powerlink being higher than that calculated by the ACCC

c) a "bottom up" analysis of the individual components which identifies the elements which contribute to the above unsatisfactory outcomes

2.1.1 Reasonableness Test #1 – National Consistency

In its recent draft determination on the Tasmanian derogations, the ACCC outlined the need for nationally consistent regulation of the transmission entities in the NEM:

> *"The Commission considers that installing a national transmission regulator has public benefits associated with **ensuring consistent regulatory decisions** across the NEM transmission networks."* [1]

Powerlink believes that the ACCC's own principle of national consistency should be applied to the determination of Powerlink's revenues.

[1] ACCC (2001), Tasmanian Derogations and Vesting Contract, July 2001, page 71

A dissection of the variances between the WACC in the ACCC's draft for Powerlink (8.83%) and the final determination for TransGrid (10.23%) shows that of the total difference of 1.40%:

- 0.81% is attributable to the lower interest rate environment between TransGrid's final determination and Powerlink's draft decision (ie. the 10 year bond rates at the 2 different times)
- 0.29% is attributable to the ACCC's use of the 5 year bond rate for Powerlink vs the 10 year bond rate for TransGrid
- 0.30% is attributable to the ACCC assigning a higher risk profile to the TransGrid business than to Powerlink.

The 2nd and 3rd of these elements highlight the fundamental inconsistency in the ACCC's approach to Powerlink.

In its original submission, Powerlink presented arguments as to why its business had a higher risk profile than other businesses, and whilst the ACCC, in its draft determination, tabled arguments for alternative ways of addressing some of the increased risks, at no stage did it present any evidence to support a conclusion that Powerlink is a lower risk business than TransGrid. In short, there is no basis for the 3rd variance element.

In relation to the use of the 5 year bond rate rather than the 10 year rate, this is clearly inconsistent with TransGrid. Powerlink believes that if the ACCC is going to make fundamental changes such as this, it should only do so on a nationally consistent basis (as it did for the move to a post tax basis, which applies equally to all transmission entities). Thus, **any such material changes post TransGrid should not be implemented until after all transmission entities have received their initial determinations.**

This would support, rather than undermine, the ACCC's own view that national consistency is important.

In that context, Powerlink does not consider the Snowy determination to be relevant - the transmission assets are negligible, and transmission is only an incidental business to that entity.

We note that whilst the ACCC's draft determination also stated it desirable to be consistent with the QCA's approach in relation to the risk free rate, the outcome was inconsistent, since the QCA used the 10 year rate.

One reasonableness test which the ACCC should apply is to deliver on its own national consistency principle. This would mean the elimination of the 2nd and 3rd variances above - such an outcome for Powerlink would be nationally consistent. That is, the reasonableness test for national consistency requires that the WACC should be at least 3.42% above the 10 year bond rate as for TransGrid.

2.1.2 Reasonableness Test #2 – Financial Ratios and Credit Rating

There are some key financial ratios, primarily related to interest cover, which the recognised ratings agencies use to establish a credit rating for a business. In the market, these ratings are key determinants of the cost of funds (especially debt) to the rated business.

An analysis of the calculated ratings for Powerlink, based on the ACCC's draft determination, shows that:

- the draft determination delivers a degradation to Powerlink's ratings (down to BBB, which is below investment grade). This means that Powerlink's actual costs of funds will be higher than those assumed by the ACCC in its WACC determination.

- the draft determination delivers ratings to Powerlink which are 1 to 1.5 rating levels below TransGrid , yet both businesses are remarkably similar. Both have very similar asset values (around $2.2 billion) and both have very similar levels of debt - yet the ACCC's final determination for TransGrid delivered credit ratings which for most years were AA. The only explanation for this variance is the low WACC assigned to Powerlink.

The ratios and comparisons show that the WACC outcome for Powerlink fails this reasonableness test. For reasonable outcomes to be attained on this test, the minimum WACC (at August 29) needs to be 8.92 %, to deliver an investment grade "A" rating. This is higher (at August 29) than the outcome for reasonableness test #1 because, contrary to the assumptions in the WACC calculation, the real world cost of equity does not track the short term and quite volatile movements in interest rates.

2.1.3 Analysis of WACC Parameters

Powerlink also submits a detailed analysis of the elements which are used to compute the WACC to identify the elements which should be modified to deliver the consistent, equitable and reasonable outcomes which are highlighted above.

This analysis is presented in sections 2.2 to 2.5.

It must be emphasised that even when these individual elements are adjusted, the ACCC should still conduct the above 2 reasonableness tests – and this may indicate the need for further adjustment in one or more individual elements of WACC.

2.2 Risk Free Rate

The estimation of a risk-free rate is required for the derivation of a return on equity under CAPM. The Code notes that the risk-free rate is normally taken to be the yield to maturity on long term (ten year) Commonwealth bonds.

The ACCC has based its risk free rate of return on the observed yield on the five and a half year government bond rate. The ACCC has justified its approach on the basis that:

- the maturity of the benchmark risk free asset should correspond with the length of the revenue reset period;
- if a ten year government bond is used, Powerlink would be compensated for inflation risk beyond the five and half year period for which its revenue is set; and
- the practice of selecting a risk free rate that matches the duration of the regulatory determination has precedent in recent regulatory determinations, in particular, the recent decision by the QCA on electricity distribution in Queensland.

2.2.1 Revenue Reset Period

Powerlink contends that the most appropriate benchmark for measuring the risk free rate of return is the ten year government bond. We believe the argument that the risk free rate should match the term between revenue re-sets does not correctly interpret the CAPM. The role of the risk free rate of return in the CAPM is to provide investors with a way of leveraging up or down their investment in risky assets. This concept is a central component of Capital Market Theory, upon which the CAPM is based.

Professor Stephen Gray[2], in a paper supporting the joint submission by Texas Utilities and Eastern Energy to the ACCC in relation to the Victorian gas access arrangements, notes the following:

> *"Davis (Section 7.3) argues that a shorter term risk-free rate should be used such that the term to maturity should match the term between pricing reviews. He argues that this is because the company does not bear interest rate risk beyond this period. In a CAPM framework, however, the role of the riskless rate is to provide investors with a way of leveraging (up or down) their investment in risky assets. Since the risky assets under consideration here have a long duration, the appropriate riskless rate is one with a comparable long duration. The role of the risk free rate in the CAPM is not to capture interest rate risk."*

2.2.2 Inflation Risk

The ACCC's argument on inflation risk is a relatively new area of research that is emerging and regulatory opinion on whether it exists remains divided. The ORG is unconvinced of the existence of inflation risk and its materiality.

Powerlink's financial advisor, KPMG, has advised that based on available research, if inflation risk exists, there are likely to be offsetting effects on the revenue of the regulated business. KPMG considers that for regulated businesses, whose revenue streams are set under a CPI-X framework, the existence of an inflation risk means that revenue received as compensation for the cost of borrowing will systematically fall short of their actual cost of borrowing. This is the case because the CPI element in the CPI-X price escalator represents "*outturn*" inflation, whereas the actual cost of borrowing incurred by the regulated business will reflect nominal interest rates, which compensate lenders for the real cost of funds plus "*expected*" inflation.

[2] Professor S. Gray, Dept. of Commerce, University of Queensland, *Discussion Paper on the Report of the Office of the Regulator-General, Victoria, Weighted Average Cost of Capital for Revenue Determination: Gas Distribution*, 16 June 1998. This paper was attached to a submission by Texas Utilities Australia Pty Ltd and Eastern Energy Limited, *Submission to the Australian Competition and Consumer Commission regarding Draft Decision of May 1998 on Access Arrangements for the Victorian Principal and Western Transmission Systems.*

In short, the regulated business faces an exposure to inflation risk because its revenues will vary with actual inflation, whereas its debt costs will vary with (higher than actual) expected inflation. Accordingly, if inflation risk is assumed to exist and a shorter term risk free rate is applied, revenues determined under the CPI-X framework should also be increased to compensate the regulated business for the inflation risk borne in debt costs.

2.2.3 Precedents

The ACCC has stated that selecting a risk free rate that matches the duration of the regulatory determination has precedent in other regulatory determinations. However, Powerlink does not consider that there is a clear precedent for adopting the five year government bond as the risk free rate by Regulators in Australia. We note that the ACCC also stated that selecting a five and a half year bond rate maintains consistency with the QCA's decision on electricity distribution, however, this reference has been made in error. The QCA's final decision of electricity distribution clearly specifies that:

> *"The Authority has adopted the use of the ten year Commonwealth bond as the proxy for calculating the risk-free rate."* [3]

In its draft decision on Queensland gas distribution, the QCA produced an extensive list of regulatory decisions in support of its use of the ten year Government bond rate. These are set out in Table 2.1 below.

[3] QCA, Final Determination, Regulation of Electricity Distribution, May 2001, page 81.

Table 2.1. Risk free rate parameters adopted in regulatory decisions

Entity/Author	Industry	Benchmark bond	Estimation factor
ACCC (1998)	Gas transmission	10 year Commonwealth	12 month range
ACCC (2000b)	Gas transmission	10 year Commonwealth	40 day moving average
ACCC (2000c)	Gas transmission	5 year Commonwealth	40 day moving average
OffGAR (2000b)	Gas transmission	10 year Commonwealth	20 day average
OffGAR (2000c)	Gas transmission	10 year Commonwealth	20 day average
ORG (1998b)	Gas distribution	10 year Commonwealth	2 month average
IPART (1999b)	Gas distribution	10 year Commonwealth	20 day average
IPART (1999f)	Gas distribution	10 year Commonwealth	20 day average
IPART (2000)	Gas distribution	10 year Commonwealth	20 day average
OffGAR (2000a)	Gas distribution	10 year Commonwealth	20 day average
SAIPAR (2000)	Gas distribution	10 year Commonwealth	Na
ACCC (1999)	Electricity transmission	5 year Commonwealth	40 day moving average
ACCC (2000a)	Electricity transmission	10 year Commonwealth	40 day moving average
QCA (2000a)	Electricity distribution	10 year Commonwealth	On the day rate
IPART (1999c)	Electricity distribution	10 year Commonwealth	20 day average
IPART (1999e)	Electricity distribution	10 year Commonwealth	20 day average
ORG (2000)	Electricity distribution	10 year inflation indexed	20 day average
OTTER (1999)	Electricity distribution	10 year Commonwealth	12 month rolling average

Source: QCA, Proposed Access Arrangements for Gas Distribution Networks: Allgas Energy Limited and Envestra Limited, Draft Decision, March 2001, page 176

It is evident from the decisions quoted in the table above that the ACCC is the only regulator in Australia that has elected to base its risk free rate of return on a government bond of a maturity under 10 years, and even then it has only done so on two occasions. Only one of these is in electricity transmission, and for an entity with minuscule transmission assets and for whom transmission is a very small part of its revenue. For the only determination involving a mainstream electricity transmission business (TransGrid), the ACCC used the 10 year bond.

In making its final decision on the Victorian gas distribution businesses, the ORG abandoned the proposal to adopt a risk free rate of return based on the five year government bond in support of using the ten year government bond. In particular, the ORG referenced arguments presented by CSFB as a rationale for its decision:

> *"In other relevant jurisdictions, there is recognition that amortisation of relevant assets must be over their full economic life which implies that investors must have an expectation that they will be compensated for making long term investments before they commit to the investment. Therefore, even though regulators may review investment returns at regular intervals, it would be a mistake to believe investors' planning horizons only extend to the next review. Models of expected returns and any regulation of those returns must reflect and take account of the investors' planning horizons. The reapplication of the prevailing long term rate every five years is sufficient to achieve this, as the owners of the project make their investment decision based on the life of the project, using the appropriate discount rate determined with reference to the prevailing yield curve."*[4]

In the recent regulatory decision for the NSW and ACT revenue caps, the ACCC states that:

> *"Like IPART, the Commission has used ten year bonds to determine the risk free rate for the purposes of this final decision. Doing so maintains consistency with the NSW regulator and also accords with the broad indication contained in the NEC."*[5]

2.2.4 Conclusion

Powerlink does not believe the ACCC's decision to adopt a five and half year government bond rate as the basis for the risk free rate is justified or consistent. It is clear that the use of the ten year government bond is consistent with the precedent set by other regulators around Australia, including the ACCC, and in particular with both the ACCC's determination for TransGrid and the recent QCA determination for Queensland distribution networks.

Powerlink believes that the ten year government bond should be the proxy for calculating the risk free rate

2.3 Market Risk Premium

Within the CAPM framework that has been applied for setting returns, the risk free rate of return serves as a benchmark for two other parameters: the market risk premium ("MRP") and the debt margin. Available historical estimates of the

[4] ORG (1998), Weighted Average Cost of Capital for Revenue Determination: Gas Distribution, Staff Paper Number 1, 28 May.
[5] ACCC (2000), NSW and ACT Transmission Network Revenue Caps 1999/00 – 2003/04, page 17

MRP have conventionally been estimated as a premium over a risk free rate of return defined as the 10 year government bond rate.

Accordingly, if a risk free rate of return based on a five year government bond is adopted, without any corresponding adjustment to the MRP and debt margin for the difference between the yields on the five versus ten year bonds, the term structure of the investment would be distorted. Given the typically normal (upward sloping) yield curve, this practice will under-estimate the expected return on equity. Justifying the use of this approach on the basis that differences between short and long term rates are likely to be small is not valid. As the value of the regulatory asset base to which the return is applied is substantial, even small changes in the rate of return have a material impact on revenues.

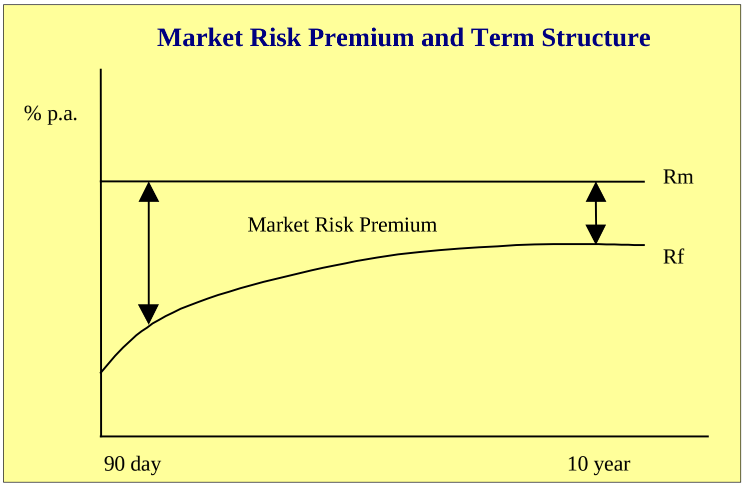
2.3.1 Need for Consistency

The need for consistency in the approach has been described by Professor Neville Hathaway[6] as follows, in relation to the MRP:

> *"No one that I am aware of has ever discovered a term structure of equity so why the argument is mounted to use a short maturity interest rate completely escapes me…*
>
> *"Because there is no term structure of equity, one needs only to be consistent: measure risk premia relative to the maturity of the rate and then add the (expected) risk premium to that (expected) yield to get the (expected) return on equity. For example, we could measure market risk premia relative to the 90 day rate and then add that risk premium to the expected 90 day rate in order to estimate expected returns on equity. Typically we measure risk premia relative to the ten year rate so we add that risk premium to the ten year bond rate. Anything else will clearly introduce an error. For example, because the yield curve is typically normal (upward sloping) the ten year measure of the market risk premium added to the expected 90 day rate will under-estimate the expected return on equity.*
>
> *The following diagram of this concept should make it clear that consistency between measures and use is critical. As long as one is consistent, it does not matter, in theory, which rate is used as the basis for the risk free rate. In practice, the short rates are more volatile than the long rates so they lead to less reliable*

[6] Neville Hathaway, *Comments on the WACC determination for Victorian gas distribution by the Victorian ORG and the ACCC*, 16 June 1998

estimates of MRP. (There is also the problem of determining expected 90 day rates which compounds the difficulty of using the shorter rates.)"



Advice was sought from Macquarie Risk Advisory Services Limited as part of the ORG and ACCC's review of the Victorian gas access arrangements in 1998, regarding the potential use of a five year government bond as the risk free rate. Macquarie recommended the use of a five year rate, however they noted it was necessary to make an adjustment to the MRP which has been estimated with reference to 10 year bond rates. They concluded that an adjustment up of 0.2% to 0.3% was needed to achieve an appropriate MRP for a five year rate.

In the recent determination for the Queensland distribution networks, in which the use of the ten year Commonwealth bond was adopted, the QCA stated:

> *"At the pragmatic level, adoption of a five year bond rate as a matter of principle would effectively require an adjustment to the market risk premium on the basis that it has traditionally been calculated against the ten year bond rate. Given the broad consistency of the margin between the five year and ten year bond rates over time, the most practical approach would be to adopt the ten year bond rate and use the standard calculation of market risk premium."* [7]

2.3.2 ACCC Approach

The ACCC has elected to apply the 5 year government bond yield, but has neglected to make a compensating adjustment in the MRP (and to the debt

[7] QCA, Final Determination, Regulation of Electricity Distribution, May 2001, page 80.

margin). By dismissing this adjustment, the ACCC is in effect allowing an MRP of 5.7% - 5.8% in setting regulatory returns rather than the 6% that is frequently quoted. As a result, rates of return determined by the ACCC under this approach suffer from an internal inconsistency, which results in under-estimated returns.

2.3.3 Conclusion

Powerlink considers that a fundamental issue has been ignored in setting the market risk premium – that there must be consistency between the choice of the risk-free rate and the assumed market risk premium ("MRP").

Powerlink's preference is for the use of a ten year government bond rate as the basis for the risk free rate. However, if a five year rate is employed it is imperative that the appropriate adjustment be made to the MRP and debt margin to ensure the consistency between the risk free rate and the market risk premium is maintained. However, the overriding requirements for the WACC to meet the minimum levels outlined in Section 2.1 must take priority when determining the value for the MRP.

Whilst Powerlink believes that the 10 year bond should be used for national consistency, internal consistency requires that if the five year bond is used, then the market risk premium needs to be increased to at least 6.3%

2.4 Cost of Debt

As mentioned above, the risk free rate of return serves as a benchmark for two other parameters: the market risk premium ("MRP") and the debt margin. In previous regulatory decisions debt margins that have been quoted have been measured as margins against the ten year government bond rate. Therefore, if the risk free rate of return is based on a five year government bond yield, it is necessary to make a compensatory adjustment to the debt margin for the difference between the yields on the five versus ten year government bond.

The ACCC has proposed a debt margin of 1.2% (midpoint of the ACCC range) over the risk free rate, based the following considerations:

- a benchmark industry wide cost of debt is in the region of 80 to 160 basis points above the nominal risk free rate of return; and

- the fact that the ACCC has applied this margin over a five and a half year Commonwealth Government bond rate instead of a margin of 100 basis points (that was used in the ACCC's decisions on TransGrid and Snowy Mountains Hydro Electric Authority) over the ten year government bond rate.

2.4.1 Precedents

We consider that the ACCC's approach to estimating an appropriate debt margin for Powerlink fails to properly take into consideration the evidence on such margins that are indicated by financial markets. In the ORG's decision in relation to the Victorian electricity distributors, a debt margin of 150 basis points was set and the various submissions to the regulator pointed to a debt margin in the range of 140 to 177 basis points. This information is reproduced in Table 2.2 below.

Table 2.2 Views in submissions to ORG

Participant	Assumptions adopted	Estimated margin over risk free rate
AGL	Appeared to be based on ratings higher than BBB/BBB+ and terms not longer than 5-8 years	1.4%
CitiPower	Lower end of band for BBB+, term of around 5 years	1.48%
TXU	BBB, term unstated	1.4%
Powercor	BBB and term of ten years	1.77%
JP Morgan (for Powercor)	BBB, 5 year term	1.53%
United Energy	Unstated	1.4%
View of anonymous market participant in the United Energy submission	Unstated	1.4%
UBS Warburg	Unstated	1.4%
	BBB, 10 year term	1.68%

Source: Table 1.10, ORG, Electricity Distribution Price Determination 2001-2005, Volume 1, Statement of Purpose and Reasons (page 298)

The final decision of the QCA adopted a debt margin of 165 basis points over the 10 year government bond rate, based on the margin attracted by BBB rated debt. The QCA stated that:

"BBB rated debt currently attracts yields up to 200 basis points above the redemption yield on 10 year Commonwealth Government Bonds…….. The

Authority's own analysis suggests that, if the prescribed distribution activities were considered in isolation from the DNSPs' total business activities, and if the gearing levels used were those associated with the proposed industry average debt to total capital ratio of 60 percent (as discussed below), then the effective credit rating would be in the range of A- to BBB. Under current capital market conditions, debt rated in this range typically display margins in the range of 125 to 210 basis points. Debt rated at BBB+ attracts a margin of approximately 165 basis points."[8]

We consider that the evidence presented by Westpac referred to in the ORG's decision should be taken into account in setting the appropriate debt margin for Powerlink. The ORG's decision to apply a debt margin of 150 basis points and the recent QCA determination to adopt a debt margin of 165 basis points represents precedents that should be noted by the ACCC in its determination for Powerlink.

2.4.2 Five year bond rate

In the Draft Statement of Principles for the Regulation of Transmission Revenues (DRP), one of the underlying reasons for the ACCC adopting a debt margin expressed over the five year government bond rate is the view that regulated businesses would seek to align the maturity of their debt portfolios with the length of the revenue re-set period in order to minimise their interest rate risk.

KPMG believe that this argument is not warranted since, businesses with long-lived assets typically match the duration of their funding portfolios with the duration of their assets. However, even if the ACCC's argument was accepted, KPMG consider that a critical consequence of regulated businesses re-setting their debt portfolios simultaneously every five years would be to place enormous upward pressure on debt margins, due to demand for debt exceeding supply.

In the recent regulatory decision by the ORG in relation to the Victorian electricity distribution businesses consideration was given to the following:

"Westpac agreed that a long-term fixed rate financing benchmark is not an efficient benchmark. However, it argued that "the current capacity within the index-linked market is well short of meeting the funding requirements of the entire Victorian distribution businesses". It estimated current capacity at $600 million, plus a further $1 billion through the CPI swap market. It also argued that it would be

[8] QCA Regulation of Electricity Distribution Final Determination, page 85

unreasonable to assume that this capacity could be filled in a short time, without an adverse impact on credit spreads of the underlying real risk-free rate. It estimated these incremental costs to be in the order of 25 – 35 basis points;" [9]

The ORG also noted further evidence from a submission by United Energy on this issue:

"In a later submission, United presented further views (based upon advice from Westpac) about the cost of funding in index-linked terms. It stated that, if it wanted to finance in index-linked terms, and was the first to issue, it would cost it between 145 basis points or 170 basis points for 10 or 15 year terms (based on its current A- credit rating). However, if it was not the first to issue, the cost would be 175 basis points or 210 basis points for 10 or 15 year terms. In any case, United Energy could only access about $100 -$150 million of this source of funds. For the remainder, it would need to issue physical bonds and use CPI swaps. It estimated this cost to be 185 basis points or 230 basis points for 10 or 15 year terms. United Energy concluded that a debt margin of 200 basis points is warranted."

The ACCC's own assumptions imply a scenario where debt margins would necessarily increase to levels significantly above the industry norm of 80 to 160 basis points quoted by the ACCC, in order to balance out supply and demand of debt at the point of re-weighting every five years. On the basis on the above views, an appropriate debt margin for regulated businesses such as Powerlink would be in the range of 115 basis points to 215 basis points.

2.4.3 Conclusion

If the ACCC genuinely intends to give due consideration to evidence from the financial markets regarding debt margins existing at the time of each regulatory decision, as is foreshadowed in the DRP, we fail to see why the evidence provided by Westpac, and other regulatory determinations by the QCA and ORG, have not been appropriately factored into the ACCC's draft decision on Powerlink.

It should be noted that non-interest costs associated with refinancing debt need to be considered as legitimate operating costs. These costs were omitted from Powerlink's application. In view of the need to refinance debt (driven, amongst

[9] ORG Electricity Distribution Price Determination 2001-2005, Vol 1, page 287

other things, by the low risk free rate), an estimate of these costs has been included in the Opex section of this report.

Based on the above, we consider that the approximate all-in debt margin for Powerlink's transmission business, taking into account the impact of potential debt supply constraints, would be in the range of 115 basis points to 215 basis points. Powerlink believes the debt margin should be at least 190 basis points subject to the overriding requirement for the WACC to meet the minimum levels outlined in Section 2.1.

Powerlink believes the appropriate debt margin should in the top quartile of the range and at least 190 bp

2.5 Equity Beta

In its Draft Decision, the ACCC elected to exclude risks from its formulation of Equity Beta. The ACCC suggested that under the Capex model, such risks should be allowed for as explicit cashflow costs in the Opex.

In view of this position by ACCC, Powerlink has addressed specific risks as outlined below.

2.5.1 Asset Stranding Risks

In its application, Powerlink pointed out that transmission networks are subject to regulatory risks associated with asset optimisation, particularly as a result of asset stranding. In Queensland, risks of stranding will significantly increase due to the impacts of excessive generation capacity and introduction of a new gas transmission network. While the ACCC's regulatory principles seek to address this issue through its accelerated depreciation principles, such principles will only capture the effects of a portion of the stranding impacts envisaged in Queensland. These market risks could either be ameliorated either by allowing for an explicit additional depreciation allowance at each regulatory reset or by allowing an additional explicit equity risk premium.

In its Draft the ACCC addressed this particular concern by proposing that:

> *"Therefore, in light of the present uncertainty, at the regulatory reset, the Commission will conduct an assessment of Powerlink's network to determine*

whether elements of its network were stranded during this current regulatory period. Where the Commission identifies that asset stranding occurred, it will provide an additional depreciation allowance to compensate for lost revenues."

Powerlink accepts that the ACCC's proposed approach will effectively address the asymmetric risk situation associated with asset stranding.

Powerlink supports the ACCC's approach for applying accelerated depreciation at the next regulatory reset to effectively deal with asset stranding risks faced by Powerlink during this coming regulatory period, given the particular uncertainties in the Queensland region of the NEM.

2.5.2 Third Party Liability Risks

In line with the ACCC's requirements, Powerlink has included costs associated with liabilities as a cash flow line, rather than by seeking asset risk premium.

Costs, excluding insurance costs already factored into the Opex are included in the Opex section of this submission.[†]

2.5.3 Self Insurance Costs

In line with the ACCC's requirements, Powerlink has now included costs associated with self-insurance of transmission lines in its Opex costs. These costs are included in the Opex section at this submission.[†]

While P.B. Associates identified Powerlink incurred additional costs in strengthening transmission towns in cyclonic areas, they also pointed out that Powerlink is exposed to risks associated with natural disasters. In their report PB Associates stated:

"Powerlink has made some provision in their projections for additional functions and for grid support costs but not for extra ordinary maintenance."

2.5.4 "Newness" Of The Regulatory Regime

Powerlink notes that the ACCC proposes not to include a risk factor for "newness" of the regulatory regime in its formulation of Equity Beta. Clearly the

[†] Costs associated with asset damage and liabilities have been forecast using a detailed risk evaluation model. Details have been forwarded to the ACCC In-Confidence.

regulatory regime has not settled as can be witnessed through the debate on easement valuation, bond rate duration and service standards. The risks associated with this uncertainty can be dealt with either by:

- an additional risk premium in the WACC, or
- as an explicit contingency allowance in the Opex cashflow.

In view of the ACCC's reluctance to allow the inclusion of a WACC risk premium, Powerlink proposes to make an allowance in the cashflow. A nominal 1% contingency on Opex is proposed for this regulatory period.

2.5.5 Summary

Powerlink agrees with adoption of the ACCC's Equity Beta of 1.0 proposed in the *Draft Decision*, subject to asymmetric risk being managed as follows:

- Asset stranding be dealt with by a backward looking accelerated depreciation allowance as proposed by ACCC in is Draft; and
- Other asymmetric risks being addressed by explicit cash flow allowances in Opex.

And subject to the resultant WACC outcome passing both reasonableness tests.

2.6 Conclusion

Reasonableness tests and comparisons show that the WACC outcome in the draft determination is:

- nationally inconsistent, and as such contradicts the ACCC's own statements of the need for national consistency. Such consistency is an absolute necessity for a national regulator.
- inequitable, in that it delivers unjustifiably lower outcomes for Powerlink than for TransGrid.
- internally inconsistent, in that it does not match the market risk premium and the debt margin to the (5 year) bond rate used for the risk free rate.

- internally inconsistent, in that it delivers financial ratios and credit ratings which are below investment grade and which result in higher actual costs of funds than the assumptions used in the WACC calculation.

To address the national consistency problems, the WACC for Powerlink should be at least 3.42% above the 10 year bond rate as it is for TransGrid. To address the financial ratings and credit ratings problems, the WACC needs to be at least 8.92% (at August 29) to deliver at least an investment grade “A” rating.

Thus, to pass both reasonableness tests, the WACC needs to be the higher of the 10 year bond rate plus 3.42%, and the WACC which would deliver a credit rating of “A” (presently, 8.92%)

We note that, since the draft determination, the 10 year bond rate has fallen significantly from 6.00% to 5.49% (August 29). A consistent WACC would be 3.42% above this level, and thus at August 29 would be 8.91% (vs 8.83% in the draft determination). This is below the 8.92% needed for an investment grade “A” rating, thus the applicable WACC would, at this date, be 8.92%.

Whilst this delivers a fair outcome to Powerlink, we believe it also delivers a reasonable price outcome to customers. At this level, the price path for the grid (excluding QNI) would decrease in real terms. This is a reasonable outcome for the most heavily loaded, most constrained grid in the NEM, where the transmission prices and revenue have to support a capital program which will deliver benefits to grid customers in the form of access to competitive energy prices and high levels of reliability in the face of high load growth.

For consistency and fairness, the WACC for Powerlink should be the higher of the WACC which would deliver an “A” rating (presently 8.92 %) , and 3.42% above the 10 year bond rate, as it is for TransGrid

3 Opening Asset Base

3.1 Jurisdictional Values

In its draft decision the ACCC states that the code places limits on the ability of the Commission to exercise its regulatory discretion in arriving at an opening value for the existing asset base. Powerlink believes that the ACCC is obliged to "have regard to" the Jurisdictional valuation but may use its discretion under certain circumstances.

In support of Powerlink's claim that the ACCC does have the discretion to accept Powerlink's revised valuation, Powerlink makes the following submissions:

- Clause 6.2 of the Code makes it clear that the Code does not limit or prescribe the methodologies to be applied by the ACCC in exercising its regulatory powers under the Code as long as the ACCC exercises its powers in a manner that is consistent with the objectives and principles set out in clauses 6.2.2 to 6.2.6.

- Clause 6.2.2 of the Code sets out the objectives relating to the transmission revenue regulatory regime. In particular, the clause provides that the transmission revenue regulatory regime must be implemented by the ACCC in a way that achieves a number of stated outcomes, which include:

  1. An efficient regulatory environment;

  2. An incentive-based regulatory regime which provides for a sustainable commercial revenue stream which includes a fair and reasonable rate of return; and

  3. An environment that fosters an efficient level of investment.

- Clause 6.2.3 of the Code then goes on to provide that the regulatory regime to be administered by the ACCC "must be consistent with the objectives outlined in clause 6.2.2" and must also "have regard to" a number of stated principles, one of which includes the following:

  "6.2.3(d)(4)(iii) subject to clauses 6.2.3(d)(4)(i) and (ii), assets (also known as "sunk assets") in existence and generally in service on 1 July 1999 are valued at

the value determined by the Jurisdictional Regulator or consistent with the regulatory asset base established in the participating jurisdiction provided that the value of these existing assets must not exceed the deprival value of the assets and the ACCC may require the opening asset values to be independently verified through a process agreed to by the National Competition Commission;"

- Clause 6.2.3(d) makes it very clear that the objectives and outcomes set out in clause 6.2.2 are paramount. It is also very clear that the application of the principles in clause 6.2.3(d) cannot be inconsistent with the overriding objectives in clause 6.2.2. In other words, the principles are subordinate to the objectives. What is important to note is that in administering the regulatory regime, the ACCC only has to "have regard to" the principles in clause 6.2.3(d). The ACCC is not required to adopt or follow any of the principles.

- Powerlink submits that if the adoption of the principles in clause 6.2.3(d) produces an outcome that would be contrary to one or more of the objectives set out in clause 6.2.2, then the ACCC is not under any duty or obligation to follow or adopt that principle. As long as the ACCC has had "regard to" the principle, it has properly performed its function.

- Powerlink submits that:

    1. The errors in the Jurisdictional valuation (as outlined in section 3.2) are material and significant;

    2. The adoption of the Jurisdictional valuation will produce outcomes that are inconsistent with the objectives stated in clause 6.2.2, and in particular will result in a rate of return on investment that is not fair or reasonable in the circumstances;

    3. In exercising its functions under clause 6.2.2 of the Code, the ACCC is not bound to follow the Jurisdictional valuation and it has the power to accept an alternative valuation that better achieves the outcomes set out in clause 6.2.2; and

4. Because the ACCC has engaged PB Associates as independent specialist consultants to examine the asset valuation, the ACCC is within its power to accept Powerlink's valuation.

Powerlink proposes that the ACCC adopt the Powerlink valuation for the purpose of best achieving the regulatory outcomes set out in clause 6.2.2.

3.2 Powerlink Valuation

As pointed out in its application, Powerlink believes that there are four material errors in the jurisdictional valuation relating to the sunk assets as follows:

1. Easements
2. Substations
3. Transmission line
4. Finance during construction

3.2.1 Easements

The Jurisdictional valuation used an indexed book value approach rather than the optimised depreciation replacement cost (ODRC) methodology, recommended by their consultants, as the basis of valuing the transmission line easements. Powerlink believes that the indexed depreciated actual cost (DAC) methodology outlined in its application is the more appropriate and correct methodology to be used for the valuation of easements.

The ACCC consultants, PB Associates, agree that Powerlink's valuation methodology is the most rigorous of the three different valuation methods.

> *"Of the three easement valuations presented, we consider that Powerlink's valuation of easements is the most rigorous, …"*

3.2.2 Substations

Powerlink believes that the substation costs used in the Jurisdictional valuation did not adequately take account of locational factors and should be revalued to take into account these factors. Powerlink believes that its revised valuation is a fair reflection of the expected replacement costs based on its current project management and construction practices.

The ACCC consultants, PB Associates, have reviewed Powerlink's claim and cannot find any reasons why the deprival value of the network assets should be written down below the assessed ODRC value.

> *"During discussions with Powerlink and the Commission, nothing has come to PB Associates' attention to indicate that the deprival value of the network assets should be written down below the assessed ODRC value."*

3.2.3 Transmission Lines

Powerlink believes that the transmission line costs used in the jurisdictional valuation were lower than the actual costs associated with transmission line erection contracts and material costs. Powerlink believes that its revised valuation is a fair reflection of the expected replacement costs based on its current project management and construction practices.

The ACCC consultants, PB Associates, have reviewed Powerlink's claim and cannot find any reasons why the deprival value of the network assets should be written down below the claimed ODRC value.

> *"During discussions with Powerlink and the Commission, nothing has come to PB Associates' attention to indicate that the deprival value of the network assets should be written down below the assessed ODRC value."*

3.2.4 Finance During Construction

The Jurisdictional valuation used a simplistic model to determine a finance during construction (FDC) rate of 6.5%[10]. Powerlink believes that a rate of 7.6% is a more realistic rate for FDC and it has based this assessment on a study undertaken by PriceWaterhouseCooper (PWC).

The ACCC consultants, PB Associates have reviewed Powerlink's claim and support Powerlink's submissions in connection with FDC.

> *"We concur with Powerlink's view that 7.6% is a more realistic value for interest during construction than the 6.5% apparently used in the Consortium valuation"*

[10] Finance during construction is sometimes referred to as Interest during construction(IDC)

3.2.5 Summary of Powerlink's revised asset valuation

In summary, Powerlink submits that:

- The Jurisdictional valuation should be increased to correct the errors outlined above;
- The valuation errors impact significantly and materially on the total value of its asset base and its cash flow rate of return on its investment; and
- Its valuation is consistent with the regulatory asset base established in Queensland.

3.3 Easement Valuation Methodology

The ACCC have stated PB Associates as saying that they do not recommend Powerlink's easement valuation methodology be used for regulatory pricing.

> *"…while PB Associates notes that although Powerlink's approach is the most robust of the three methodologies it does not recommend it for regulatory pricing."*

What PB Associates actually said was,

> *"Of the three easements valuations presented, we consider that Powerlink's valuation of easements is the most rigorous, although we are unable to endorse the methodology as an accepted method for valuing easements for regulatory pricing purposes."*

Powerlink does not agree with the ACCC interpretation of this statement. Powerlink interprets the PB Associates statement as "the methodology is not, at the present time, a recognised method of valuing easements." This is largely because, until now, the methodology had not been presented to the ACCC for its consideration.

With PB Associates endorsement as being the most robust approach to valuing easements, Powerlink believe that the ACCC should adopt the underlying principles as part of its Regulatory Principles for the long term.

Powerlink's basic proposition is that, for valuation purposes, there are two distinctive components in Powerlink's easement values and these need to be treated differently:

(a) the land, and

(b) the costs of assembling the easements, including environmental studies, cultural heritage studies, survey etc.

Powerlink believes that (b) is conceptually the same as the engineering design work which is included in the asset value of transmission lines and substations, and should be valued on the same basis.

Indeed, it is evident that the boundary between environmental work and engineering design work is not clear. If the two are treated differently from a valuation perspective, it would create incentives for transmission entities to direct the costs of studies into the "engineering design" category, to gain a more favourable valuation.

We therefore believe that it is better regulatory practice for the ACCC to treat all such studies identically from a valuation viewpoint.

We note that PB Associates has proposed that all such costs be assigned to transmission lines (rather than some being arbitrarily assigned to easements). Such an approach would mean consistency of valuation, would remove incentives for gaming the boundary, and would leave "easements" as the land value only.

Powerlink supports this approach, and would be prepared to re-assign the relevant costs from easements to lines, both for existing values and for future asset recording.

Powerlink proposes that the ACCC take into consideration Powerlink's easement valuation methodology in determining the underlying principles of its Regulatory Principles for the long term.

3.4 Asset Roll Forward

The ACCC has noted that it will use Powerlink's actual acquisitions, depreciation and write offs for the 2000/2001 financial year in its final decision. Powerlink will provide this information to the ACCC under separate cover, following the (imminent) finalisation of the external audit of the Powerlink accounts for 2000/01.

4 Opex

Section 2 of this submission outlined a number of cashflow costs which were omitted from the opex forecast in Powerlink's Application (on the assumption that the ACCC would build these into the risk and debt premiums in the WACC).

In view of the ACCC requirement, outlined in its *Draft Decision*, to have these explicitly factored into the cashflow as specific costs, rather than in the WACC, a revised opex has been submitted.

The following additional factors have been included in the opex cashflow forecasts:

- non-interest cost of refinancing
- third-party liability risk costs
- self insurance costs
- contingencies to account for "newness" of the regulatory regime

4.1 Non-interest cost of refinancing

As a consequence of the regulatory regime, the most appropriate risk strategy is to refinance at the same time the risk free rate is reset, in order to minimise the risk of differences between the actual cost of debt and the “allowable” cost of debt. Difficulties associated with this strategy include the limited supply of bonds maturing close to regulatory reset dates. This limited supply may result in the use of derivative instruments, such as swaps, which will involve additional costs for Powerlink.

There are also costs associated with not being able to implement an appropriate hedging strategy due to the adoption of a 40 day moving average rate. As this average is calculated retrospectively, the date to commence a hedging strategy is uncertain and constitutes a significant risk to Powerlink.

A further risk facing Powerlink is having to borrow for future capital expenditure requirements over the regulatory period. Due to the uncertainty of the amount and timing of the capex requirement there could be costs to Powerlink if the interest rate at the time of the borrowing is higher than at the reset period.

Powerlink believes it is appropriate for the above risks to be compensated via a cashflow adjustment included in the opex allowance. Powerlink's advisor, QTC, has stated that it is appropriate to include an allowance for an additional financing cost of between 0.15% to 0.25% of the debt component of our capital base.

4.2 Insurance

As discussed in sections 2.5.2 and 2.5.3, the *Draft Decision* invited Powerlink to supply the ACCC with the cost of the increase to third party liability:

> *"…the Commission considers that at this stage, Powerlink should be able to supply the Commission with the cost of the increase to third party liability. This draft decision does not include an allowance for that increase in insurance costs but the Commission expects that it would be included in the final decision."*

Powerlink, in conjunction with an expert risk consultant, conducted a structured analysis to identify the major risks at Powerlink and quantify these risks in terms of likelihood, consequence and overall risk rating (or annual expected loss). For each loss event the likelihood, consequence and annual expected loss have been calculated both for the current situation and the situation in 2006/07 (as can be reasonably forecast from the expected growth in energy, assets and changes to third party liability).

Because this approach focuses on only the major events, it will underestimate the annual expected loss for *all events* because mid range and low consequence events are not captured in the analysis. Studies have indicated that only considering major events will result in 50% to 80% of the overall losses. Hence, the overall losses could be 25% to 50% higher.

Powerlink has adopted the low end (25%) in its forecast and <u>subtracted from this the costs already factored into the Opex</u>.

4.3 "Newness" of the Regulatory Regime

As noted in section 2.5.4, the regulatory regime has not settled. This can be witnessed through debate on easement valuation, bond rate duration and service standards. The risks associated with this uncertainty can be dealt with either by:

- an additional risk premium in the WACC, or
- as an explicit contingency allowance in the opex cashflow.

In view of the ACCC's reluctance to allow the inclusion of a WACC risk premium, Powerlink proposes to make an allowance in the cashflow. A nominal 1% contingency on opex is proposed for this regulatory period.

4.4 Summary

Forecast additional opex costs for the above items are:

	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Real "unsmoothed" costs ($'000)	5,065	5,652	5,871	6,090	6,309	6,527
Nominal smoothed costs ($'000)	5,919	6,051	6,185	6,323	6,463	6,607

Powerlink will supply the ACCC with an attachment that substantiates these costs. However, due to the sensitive nature of insurance information, this attachment is marked Confidential.

5 Service Standards

In making this response to the ACCC's Draft Decision, Powerlink would like to make the following points:

- Powerlink supports the ACCC's intention to further develop service standards to use for regulatory purposes as outlined in the *Draft Regulatory Principles*. Powerlink welcomes the opportunity to participate in the consultation process to develop a framework where meaningful indicators can be adopted and used;

- Powerlink is supportive of recording and reporting on the proposed statistics and will proceed to set up and update systems to report on a peak / off-peak basis;

- However, Powerlink cannot support the use of "simplified" annual targets for loss of supply events, as they defy sound statistical principles and, as such, can lead to incorrect conclusions. Powerlink has obtained independent expert advice from a statistician on the appropriateness of these targets in the *Draft Decision*. This independent advice supports Powerlink's statistical approach and warns against the use of "simplified" targets which are not statistically sound;

- Powerlink proposes to measure and monitor, on a *quarterly basis*, the number of loss of supply events greater than 0.2 and 1.0 system minutes (separately for summer and winter) and that they should be analysed for significant variances using standard Poisson control charting techniques with the following Poisson means:

Total number of loss of supply events greater than 0.2 system minutes - summer	1.3
Total number of loss of supply events greater than 0.2 system minutes - winter	0.8
Total number of loss of supply events greater than 1.0 system minutes - summer	0.4
Total number of loss of supply events greater than 1.0 system minutes - winter	0.07

5.1 The ACCC's Draft Regulatory Principles

In its *Draft Regulatory Principles*, the ACCC states the following reasons for setting service standards targets and their continual monitoring:

> *"Under a CPI-X revenue cap regulatory approach, a monopoly TNSP may attempt to supply a lower quality of service than that which has been included in the regulatory compact with the regulator, in order to boost earnings.";*
>
> *"Effective incentive-based regulation will include an explicit level of service, for which the TNSP has been provided by the regulator with sufficient income to maintain the assets necessary to provide that level of service."*

and

> *"The measurement and monitoring of service standards is essential in order to ensure that cost reductions derived from falling service standards are not mistaken for increases in efficiency."*

It follows from the above overall principles that the service level indicators and targets chosen for regulatory purposes should be robust in indicating the TNSP's performance. In particular, the aim is to prevent TNSPs from lowering the quality of their service to reduce costs. Meeting the targets should be sufficient to indicate that the TNSP has performed appropriate maintenance and delivered an appropriate level of quality of service. Not meeting the targets should indicate that the TNSP's practices have been inadequate. The approach should be robust enough to differentiate between a reduction in service standards as a consequence of the TNSP's actions and normal variations in the measures.

The challenge is to find indicators that fulfil these requirements and reject indicators that do not. The *Draft Regulatory Principles* are far from finalisation on this matter.

Section 7.7 of the *Draft Decision* outlines PB Associates' concerns with this area of the *Draft Regulatory Principles*. The ACCC then goes on to state its intentions to further develop the service standards to be used for regulatory purposes in consultation with all TNSPs. Powerlink supports this and welcomes the opportunity to participate in the consultation process to develop a framework where meaningful indicators can be developed and used.

5.2 Draft Decision Statistics

In Section 7.8 of the *Draft Decision*, the ACCC states a requirement for Powerlink to report annually on the following statistics until such time that they are superseded:

- system minutes not supplied,
- the ten-year rolling average of system minutes not supplied,
- transmission circuit availability overall and for each voltage (330kV, 275kV, 132/110 kV) broken down into northern, central and southern areas,[11]
- transformer availability, overall and broken down by voltage (at the high voltage terminals) and area as above,
- connection point interruption frequency (averaged for all connection points), overall and broken down by area,
- connection point interruption duration (averaged for all connection points), overall and broken down by area, and
- percentage of unplanned connection point interruptions not restored within three hours, overall and broken down by area.

The above statistics are to be provided identifying peak and off peak occurrences.

Powerlink is supportive of recording and reporting on the proposed statistics and will proceed to set up / update systems to report on a peak / off peak basis as required.

5.3 Loss of Supply Targets

A statistical analysis of loss of supply events has shown that, on its own, system minutes lost is not a useful measure. However, the frequency of loss of supply events follow a Poisson distribution, and as such can be measured and monitored using proven statistical methods. Consequently, Powerlink has applied Poisson control chart techniques to monitor the frequency of loss of supply events.

Powerlink has proposed monitoring 2 categories of events - "large" events, being those with an impact of greater than 1.0 system minute, and "moderate" events, being those with an impact of greater than 0.2 system minutes.

Because of observed seasonality in such events, Powerlink monitors and measures on a quarterly basis.

The control chart measures the observed occurrences against the long term historical mean, and can therefore objectively identify whether movements away from this mean are statistically significant (ie a change in supply quality) or insignificant (ie the normal variations in data of this kind).

In reviewing this methodology, PB Associates have made 2 errors in statistics. Firstly, by misinterpreting the Poisson means as an average between the two winter quarters, and secondly, by converting those long run averages to annual targets and rounding to integer values:

Total number of loss of supply events greater than 0.2 system minutes - summer	3
Total number of loss of supply events greater than 0.2 system minutes - winter	2
Total number of loss of supply events greater than 1.0 system minutes - summer	1
Total number of loss of supply events greater than 1.0 system minutes - winter	0

In making these recommendations, PB Associates have misunderstood the meaning and application of the mean performance targets. These targets are **not** a mean value to be achieved in a particular year as suggested by PB Associates. They represent the **long term average** of events which exhibit a Poisson distribution. Whilst each event has an integer value, the long term average can be, and typically is, non-integral. The mean is used in analysing trend movements in the performance. Powerlink uses Poisson control chart techniques to monitor the trend in reliability. Powerlink stated the target mean for the total number of loss of supply events greater than 1.0 system minutes for winter to be 0.07. This number should be interpreted as *"the long term average number of events for a winter quarter will be 0.07."*

Monitoring performance against "rounded" integer targets will not differentiate between normal variations and a reduction in service standards through

[11] The *Draft Decision* contains a typographical error and refers to 220kV instead of 275kV.

inappropriate behaviour by the TNSP and are, thus, unsuitable for regulatory purposes.

Powerlink engaged Dr Margaret Mackisack, a chartered statistician, to provide expert views on the Powerlink proposed methodology compared with the simplifications made by PB (the report is attached). The consultant's advice is that:

- The use of control charts is a widely used and accepted method of monitoring quality (appearing in Australian Standards) and should be given serious consideration for the purposes of monitoring service standards:

  "Control charts are one method for assessing whether particular observed statistics measured about some process represent random fluctuations (or noise, as engineers typically term this) or are an indication of some change in the process being monitored which should be the target of action."

- Powerlink's approach to monitoring the quality of its service by the use of control charts conforms with accepted practices;

- The simplistic approach recommended by PB Associates is statistically unsound and could lead to incorrect conclusions;

  "The apparent aim of the modifications proposed by PB Associates is to simplify (move from difficult fractions representing events of low probability, to simple whole numbers) and to smooth (move from a graph showing big changes from year to year to a smoothed picture which gives the appearance of relative constancy). However,

  - *methods for tracking data which vary over time have been developed extensively since the Second World War and are available in tutorial form in Australian Standards, so there would appear to be no impediment to adopting this approach which has the advantage of wide international acceptance and understanding; and*

  - *the alternative method offered by PB Associates and adopted by the ACCC is a dangerous innovation with undesirable properties which have been known for over 70 years and are such as to make it wholly unsuitable for control purposes."*

- More work needs to be done by the ACCC in developing its regulatory principles if the measures are to be meaningful in indicating under and over performance by the TNSP.

As a result, Powerlink proposes that it continues to measure and monitor, on a *quarterly basis*, the number of loss of supply events greater than 0.2 and 1.0 system minutes (separately for summer and winter) but that the targets be statistically sound and statistically consistent with the population from which the historical data is drawn. Hence, the variances from the long run averages should be analysed for significant variances using standard Poisson control charting techniques (as described in Australian Standards, eg AS 3940) with the following Poisson means:

Total number of loss of supply events greater than 0.2 system minutes - summer	1.3
Total number of loss of supply events greater than 0.2 system minutes - winter	0.8
Total number of loss of supply events greater than 1.0 system minutes - summer	0.4
Total number of loss of supply events greater than 1.0 system minutes - winter	0.07

APPENDIX 1

SERVICE STANDARDS

REPORT

SERVICE STANDARDS REPORTING: REVIEW OF METHODOLOGY

Report prepared on behalf of
Unisearch Limited

on

Service Standards Reporting: Review of Methodology

by

Margaret Mackisack

for

Powerlink

August 2001

Job No.52947

COMMERCIAL-IN-CONFIDENCE

Table of Contents

1 Summary and Recommendations

- This report presents an explanation of the difference between the Powerlink Queensland approach to setting standards, based on the use of control charts, and that proposed by PB Associates using rolling averages.
- PB Associates recommend that variation from year to year should be smoothed to eliminate large deviations. Their proposed technique, using a ten-year rolling average, is well known to have the undesirable property of introducing spurious swings and oscillations into a series of data, making it very inappropriate as a control technique. (See Sections 3.1.2, 4.2, 5.2, 5.3.1.)
- The presence of obvious variation from year to year does not preclude the assessment of whether there are trends in performance. Smoothing is unnecessary to achieve this. Such methods for tracking data which vary over time are called control charts: they have been developed extensively since the Second World War. Control chart methodology is available in tutorial form in Australian Standards, so there would appear to be no impediment to adopting this approach which has the advantage of wide international acceptance and understanding. This approach has been adopted by Powerlink and its use is supported. (See Sections 3.1.1, 3.1.3, 4.1, 5.3.3.)
- An attempt appears to have been made to simplify standard setting, in part by using non-technical vocabulary, for example speaking of “targets” (suggesting large striped archery targets with a bulls-eye to be aimed at). This disguises the inherent complexity of the situation and leads to misunderstanding. The parties proceed to discuss targets assuming that they all mean the same thing by this word, when in fact there appear to be at least three and possibly more meanings floating around, sometimes more than one meaning being used in the same document.

It is *recommended* that:

- smoothing techniques NOT be adopted, and in particular the use of rolling averages be abandoned;
- the relevant Australian Standards be referenced and incorporated in future proposals since they provide a formal validation for the use of control chart techniques;
- standard terminology be used in referring to the components of control charts;
- the use of the word “target” be discontinued, as its potential for ambiguous interpretation appears to be adversely affecting the quality of logical arguments presented;
- since the CUSUM technique is sensitive to small changes in mean that this be investigated as an additional indicator when such small changes require to be monitored.

2 Introduction

2.1 Terms of reference

This report is prepared at the request of Frank Montiel of Powerlink Queensland as a review of the statistical component of documents related to proposed service standards as listed in Sources of Information below.

2.2 Aims

The aim of this report is to provide a careful explanation of the difference between the Powerlink Queensland approach to setting service standards and that of PB Associates, the ACCC consultants, spelt out with examples in terms understandable by non-experts

2.3 Sources of Information

The present report is based on documents provided by Powerlink as follows:
Powerlink Queensland *Application, Transmission Network Revenue Cap Commencing January 2002*
PB Associates *Powerlink Queensland: Review of Network Service Standards*
Powerlink Queensland *Comments on PB Associates Report*
ACCC *Powerlink Queensland Draft Decision*
Sharp, B. Various papers on methodology for reliability monitoring.

Other information sources are several Australian Standards on Control Charting and standard statistical textbooks as referenced.

2.4 Scope and format of Report

2.4.1 Scope

The reports provided for review are at issue on a number of matters. The present report is restricted to those questions of a statistical nature. In particular, whether or not particular statistics are suitable as measures of the engineering system is outside the scope of this Report, which addresses only the question of what are statistically sound measures of performance.

2.4.2 Format of Report

The present Report has the following structure. In Section 3, extracts are presented to outline the positions of the parties whose work is being reviewed with respect to statistical matters. Then (Section 4) material from relevant Australian Standards is summarised, and some elementary properties of recommended statistical procedures are reviewed. Section 5 presents discussion of the issues.

3 Background to points at issue

The following outlines the positions of the parties (Powerlink Queensland, PB Associates, and ACCC) on issues with a statistical component.

3.1.1 Powerlink *Application* - Chapter 11 - Service Standards

Traditional annual supply quality statistics are asserted to not be a suitable basis for service standards targets, among other reasons because they are not statistically sound as measures of performance.

As a matter of philosophy, Powerlink Queensland assert that if service standards are supposed to be measuring operating performance, the operators should be held accountable for things within control. Since this issue is related to the statistical one of the role of variability and the usage of statistical measures to deal with variability, it is within the scope of the present report to address some of its implications,

The traditional measure of performance of which the statistical characteristics are investigated is System Minutes, (SM) defined as

SM=(Demand unsupplied x loss of supply duration)/Max system demand

Annual figures for this measure are compared in the Powerlink Application, while recommendations are made for comparing monthly or quarterly data.

The following quotations from the Powerlink Application outline the statistical reasoning used to move from a system minutes measure to measuring number of large events.

> The data fits within the probability distribution of Figure 11.3 (not shown here). From this plot it can be seen that the mode (i.e. the typical score) will be around 2 to 4 system minutes lost. However, because of the long tail at the right, the long term average will be much higher, and in fact it can be shown that it tends to infinity. Detailed analysis shows that a single event of 9 system minutes or greater is a one in 6 year event. Consequently, every 6 years on average, a target of 9 system minutes will be exceeded. Therefore, setting an annual target for system minutes lost, like setting a maximum flood level not to be exceeded, is meaningless.
>
> However, like floods, it is the number of large events, not the size of events themselves, that is important. It can be shown mathematically that reliability can be effectively monitored by monitoring both the total number of events per quarter greater than 0.2 system minutes, and the total number of events greater than 0.1 system minutes. The 0.2 and 0.1 system minutes have been chosen because two points are needed to fully define the reliability characteristic. These points have been selected such that a reasonably quantity of data will be available on a quarterly basis.
>
> ...quality statistics are needed both at the network level and at the connection point level. Because of the limitations of these statistics as TNSP performance measures, we suggest that when adopting these statistics, rolling averages or other statistical variants which deal with the stochastic and long term nature of the measures be employed. For example, an event which has a probability of 0.1 per annum will never manifest itself 0.1 times each year: either it will happen (1.0) or it will not occur (0).
>
> Statistically sound measures have been developed within Powerlink to allow the effectiveness of "controllable" operation and maintenance practices to be assessed on a regular basis. These measures are used as part of the decision making process and include:
> Total number of events (loss of supply) greater than 0.2 sys min
> Total number of events (loss of supply) greater than 0.1 sys min
> Both of the above are plotted with a ten year history as Poisson based control charts with control limits regularly reviewed.

Measure	Target mean
Total number of events (loss of supply) greater than 0.2 system minutes (per quarter)	1.3 (summer) 0.8 (winter)
Total number of events (loss of supply) greater than 0.1 system minutes (per month)	0.4 (summer) 0.07 (winter)
Static Var Compensator Events (per month)	2.2
Equipment events per 1000 circuit breakers (per month)	4.3
Secondary system events per 1000 circuit breakers (per month)	3.1
Incident (human error) events per 1000 circuit breakers (per month)	2.4
Total internal events per 1000 circuit breakers (per month)	10.1
Total external events per 1000 circuit kms (per month)	0.6 (summer) 0.4 (winter)

3.1.2 PB Associates *Powerlink Queensland: Review of Network Service Standards*

PB Associates take issue with Powerlink's philosophical approach that accountability should only be for controllable events. They assert that

> Powerlink should be fully accountable for managing all external and environmental risks that it is in a better position than other participants in the industry to mitigate. Powerlink's ability to manage such risks is a legitimate matter for regulatory oversight. On this basis Powerlink should be fully accountable for the availability of the network, and for all power outages, whether planned or unplanned, due to the failure or unavailability of network elements. Regulatory targets for service standards should reflect this accountability.

PB Associates refer to *the regulatory incentive for Powerlink to do what it can to minimise the probability of (such) high impact events* (that is, tornadoes, major bush fires, and other extreme environmental disasters).

PB Associates observe with disapproval the variation from year to year in the Powerlink performance statistics:

> It can be seen that there is a wide variation from year to year. In 1996 the total system minutes not supplied was 0.2 minutes whereas in 1992 the total system minutes not supplied was 23.9 minutes, a reliability apparently one thousand times worse. The worst case reliability over the 7-year period 1993-99 was in 1995 when 7.1 system minutes were not supplied. However in 1992 and 2000, the two years immediately outside this period, the annual system minutes lost was 23.9 and 21.7 respectively. Clearly there is a wide variation in system minutes not supplied from year to year. As a result, it is difficult to discern a trend in network reliability by examining the annual system minutes lost over the period 1984-2000.

They state without giving any explicit reason for doing so that

> Notwithstanding Powerlink's mathematical analyses, it is our view that the traditional and widely used system minutes approach be followed.

They then propose as an alternative

> A preferred approach would be to base a target on a ten year rolling average of system minutes lost. Over the period 1993/2000 the ten-year rolling average of system minutes lost varied between 5.78 and 7.94 and there were no statistical outliers. Examination of Table 4.4 shows a clear improvement in reliability over the period 1993-99, although the equipment failures in 2000 brought this improvement to a halt. Nevertheless the 10-year rolling average in 2000 was still comparable to that over the period 1993-95.
>
> If a ten-year rolling average of system minutes lost is accepted as a reasonable measure of network performance, it is still necessary to determine a reasonable target. The average annual

system minutes lost over the period 1984-2000 were 7 minutes. Achievement of an annual system minutes lost of 7 minutes in 2001 would bring the 10- year rolling average back down below 7 minutes. This suggests that a 7 minute 10-year rolling average is a fair reflection of the current level of reliability on the Powerlink network. It is therefore proposed as a suitable regulatory target, given the Commission's intention to regulate only for a basic level of service at this time.

PB Associates object to the Powerlink proposed targets on the following grounds.

In the case of loss of supply events annual targets based on the mean performance over long period of time have limited usefulness as annual targets, where only the events that occur in a single year are taken into account. This can be illustrated by considering the proposed target of point 0.07 for the winter loss of supply events per quarter. There are only two winter quarters in any one year and you cannot have a fraction of an event. If there are no qualifying winter outages in any year the reported mean will be 0.0. If there is one qualifying outage the reported mean will be 0.5. No intermediate values between 0.0 and 0.5 are possible so, in this context, a target of 0.07 is meaningless.

One approach to overcome this difficulty would be to report a rolling average over a number of years, using a similar approach to that proposed for system minutes. Powerlink does not favour this approach and argues that it is not sound as it does not effectively filter out background noise to give an underlying reliability trend. As discussed in Section 5.4, we do not believe this would be a problem providing the rolling average is taken over a sufficiently long period.

An alternative approach would be to express the target in terms of the number of events in a particular year. If this approach is taken the annual targets could be expressed as shown below:
Total number of loss of supply events greater than 0.2 system minutes – summer 3
Total number of loss of supply events greater than 0.2 system minutes – winter 2
Total number of loss of supply events greater than 1.0 system minutes – summer 1
Total number of loss of supply events greater than 1.0 system minutes – winter 0
We consider these targets to be more meaningful for regulatory purposes than those proposed by Powerlink and recommend that they be adopted in the interim.

3.1.3 Powerlink Queensland *Comments on PB Associates Report*

Powerlink comments on the above recommendation regarding targets as follows.

In making these comments, PB has misunderstood the meaning and application of the mean performance targets. These targets are not a mean value to be achieved in a particular year as suggested above. They represent the long term average of events which exhibit a Poisson distribution. Whilst each event has an integer value, the long term average can be, and typically is, non-integral. The mean is used in analysing trend movements in the performance. Powerlink use Poisson control chart techniques to monitor the trend in reliability. The target of 0.07 should be interpreted as

"*The long term average number of events for a winter quarter will be 0.07*".

The mean for a two-quarter period is not determined as it is not a meaningful figure. Rather the actual number of events occurring is tested for the hypothesis that there has been no change in the level of reliability given the target long run average.

The application of this number is as follows –

Given that the mean is 0.07, then the Poisson distribution can be used to determine that the probability of having 0, 1, 2 etc events in a winter quarter is as follows –

No. of Events	0	1	2
Probability	93%	7%	0.2%

Therefore, it would normally be expected that there will be 2 or less events per quarter. Normal control chart techniques could be used to determine whether trends were occurring (ie two quarters in a row with 1 events etc).

The Powerlink approach is based on sound statistical principles – we believe that PB, in an attempt to simplify the underlying statistical nature of the data, has actually proposed targets which are not supported by the underlying statistics. Powerlink recognises that the use of statistical mathematics may add a degree of complexity – but that any serious measurement of system performance cannot avoid that.

3.1.4 ACCC *Powerlink Queensland Draft Decision*

The ACCC comment as follows:

While the Commission welcomes Powerlink's commitment to developing service standards along the lines of those proposed in the *Draft Regulatory Principles*, the Commission notes the concerns raised by PB Associates in its assessment of Powerlink's proposals.

In this context 'note' appears to mean 'accept' since the ACCC reject Powerlink's proposals in favour of those by PB Associates, concluding:

Powerlink is required to report annually on the following statistics until such time that they are superseded:

- system minutes not supplied,
- the ten-year rolling average of system minutes not supplied,
- transmission circuit availability overall and for each voltage (330 kV, 220 kV, 132/110 kV) broken down into northern, central and southern areas,
- transformer availability, overall and broken down by voltage (at the high voltage terminals) and area as above,
- connection point interruption frequency (averaged for all connection points), overall and broken down by area,
- connection point interruption duration (averaged for all connection points), overall and broken down by area, and
- percentage of unplanned connection point interruptions not restored within three hours, overall and broken down by area.

All of the above information must be provided to the Commission identifying peak and off peak occurrences, where peak occurrences are defined as those occurring between 7am and 10pm.

Powerlink is also required to meet the following targets for loss of supply events.

Total number of loss of supply events greater than 0.2 system minutes – summer	**3**
Total number of loss of supply events greater than 0.2 system minutes – winter	**2**
Total number of loss of supply events greater than 1.0 system minutes – summer	**1**
Total number of loss of supply events greater than 1.0 system minutes – winter	**0**

3.1.5 Background research by B. Sharp

Components of the research are:

- requirement for normalisation of data to compensate for changes in size of system (to normalise event data) or of maximum demand (included in SM definition);
- development of control chart for monthly (or other time-period) event data based on Poisson distribution;
- development of control targets for SM based on the Cauchy form of the extreme value distribution, with parameters obtained by fitting a line to the quantile plot of the Powerlink data;
- conclusion that by monitoring the number of events per year greater than a given size, it is possible to monitor the reliability. Because the extreme value curve is a straight line, only two points need to be monitored. In monitoring reliability, it is the not the size per se of the event that is important, but the frequency that events of a certain size occur.

The research has implicit a control chart, as explained in AS3940 since it produces a set of numerical boundaries with which observations are compared.

> The term 'chart' is conventionally used to describe the control procedures discussed in this Standard and used in AS 3941. However, it should be noted that the use of non-graphical forms of tabular presentation is an accepted alternative.

The relationship of the research with the Australian Standards on Control Charting is discussed below in Section 5.

4 Background on Elementary Concepts

4.1 Australian Standards on Control Charting

Powerlink's recommended procedures include the use of control charts. These are rejected by PB Associates and their favoured alternative approach is proposed. This section presents some extracts from several of the Australian Standards for Control Charting as background to discussion of why this might be a preferred approach.

Control Charts are one method for assessing whether particular observed statistics measured about some process represent random fluctuations (or noise, as engineers typically term this) or are an indication of some change in the process being monitored which should be the target of action. As AS 3940 expresses this,

> A quality control chart is used to determine whether or not a process producing either goods or services is stable, as measured by statistical criteria. The points plotted on a quality control chart are values computed from a measure taken on samples of either goods or performance of services. (The samples may be selected successively or from subgrouping to some rational plan.) The plotted values are compared with control limits to determine whether the process is 'in statistical control'.
>
> NOTES:
>
> 1. The emphasis is on the process being 'in statistical control' rather than being acceptable with respect to any specified tolerance. The control chart can, however, be used in an 'acceptance' sense calling for action or investigation when a process is deemed to have changed from its standard level.

For Powerlink, the quality control chart monitors the frequency of events of particular undesirable type, namely loss of supply events greater than 0.2 SM and total number of events greater than 0.1 SM, in a given time period (six monthly, summer or winter separately). In the terms of AS 3940, an event of one of these types is considered a non-conformity.

Application. Control charts for number nonconforming (as in AS 3941) can be applied to any process producing items which can be categorised as conforming or nonconforming. Under normal production conditions the following apply:
(a) A small proportion of nonconforming items is allowable — the process is deemed to be acceptable when operating at this level.
(b) An 'action' decision is required when the process proportion nonconforming increases above the allowable or target value.

2.4.2.2 *Method of use.* In AS 3941, samples are taken from the process at regular intervals. On the basis of the number of nonconforming items observed in the sample, two possible conclusions can be reached: either —
(a) the process is satisfactory in that the process proportion nonconforming is not greater than the expected (or target) value, and production can continue; or
(b) the process proportion nonconforming is greater than the expected (or target) value.

Because of the variation that is inherent in the sampling process, the number of nonconforming items occurring in a sample will vary from sample to sample even if the underlying proportion nonconforming is constant. The pattern of this variation is explored in more detail in paragraph A1.1 of Appendix A, but its presence gives rise to two types of risk when the number nonconforming in a sample is used as a criterion for controlling the proportion nonconforming in the underlying process.

These risks are as follows:

(a) *Type I risk* — the risk that a sample with a fortuitously high number of nonconforming items will give a spurious 'action' decision when no deterioration has in fact occurred.
(b) *Type II risk* — the risk that a sample with a fortuitously low number of nonconforming items will fail to signal a deterioration in the process.

The design of any control charting scheme is a compromise between these two opposing risks. AS 3941 uses a Type 1 risk of about 1 in 200, a value that experience has shown to be satisfactory. On the other hand the setting of Type II risks tends to be a value judgement; for example, Type II risks tend to be high where the process average deviates from the target value by a small amount and low where the process average differs substantially from the target value. The Type II risk associated with a control chart should not be viewed in the same manner as the Type II error in statistical hypothesis testing. A relatively high Type II risk for a single sample is less important than a high Type I risk. The latter results in excessive unwanted intervention in process operations with a resulting increase in variability and reduction in process capability, but it must be remembered that there is a substantial penalty associated with the Type I risk. The only way to decrease the Type II risk is to increase the Type I risk.

Control charts for nonconformities assume that the nonconformities are generated by a 'homogeneous Poisson process' where, when the process is in control, the rate at which nonconformities occur is constant, and the individual nonconformities are independent of each other. In such a process it is possible to define the expected number of nonconformities (m) in the sample, and the Poisson distribution gives the probability of any specified number of nonconformities occurring in the sample. A control chart as in AS 3941 will then be used to detect any change in the rate at which nonconformities are occurring (i.e. the onset of any non-homogeneity in the process).

Control charts are most usually based on samples from a process. In the Powerlink case the data consists of a complete record of all events. In common control charts, the control limits represent a sum of measures of both the physical uncertainty and the sampling uncertainty which induce the variations which are observed. For Powerlink’s data there is no sampling uncertainty present, so the observed variation is entirely due to physical (human or natural) sources. This issue is discussed further below.

The Poisson control chart which would be applicable to a process where the mean number of incidents is 0.07, which is the situation adverted to with disapproval by PB Associates, would be derived from the first line in the table below, extracted from AS 3941. The interpretation is that if two or more events occur (count > 1.7), the system fails to meet the target. If one event occurs, a warning is issued. If two warning events happen in successive periods this is also a failure to meet the target (that is, there has not been a Critical gap of at least one period between warning samples).

TABLE 1 CONTROL LIMITS

1	2	3	4	5
Average number of nonconforming items expected per sample	**Control limit**	**Warning limit**	**Critical gap between successive warning samples**	**Indication of use**
> 0.10	1.7	0.7	1	Group I
0.33	2.7	1.7	2	
0.67	3.7	2.7	2	
1.08	4.7	3.7	3	Group II
1.53	5.7	4.7	3	
2.04	6.7	5.7	4	
2.57	7.7	6.7	4	
3.13	8.7	7.7	4	
3.72	9.7	8.7	4	
4.32	10.7			Group III (Check limits only)
4.94	11.7			
5.58	12.7			
6.23	13.7			
6.89	14.7			
7.57	15.7			
8.25	16.7			
8.94	17.7			
9.64	18.7			
10.35	19.7			

NOTES:

1. If the exact calculated average number of nonconforming items is not shown in Column 1, the lowest value in Column 1, which is greater than the calculated value is used.

2. Group control limits are as follows:

(a) The control limits in Group I are likely to be used only in special cases when the sample size is necessarily small. In such cases a chart for the moving total number of nonconforming items should also be used (see Clause 4.3).

(b) The control limits in Group II are for general use.

(c) The control limits in Group III are for use only in moving total charts and no warning limits are provided. Warning limits are
inappropriate for moving totals because of the way in which the charts are constructed; each total is the previous total with the new number of sample nonconforming items added. Thus the new moving total value depends strongly on the previous value.
The warning limits apply only when the values are independent.

3. The critical gap in Column 4 is the minimum number of non-warning samples that should occur between any two successive warning samples before the second warning can be interpreted as not requiring action.

The Standard indicates that for Group I, into which the Powerlink system falls, a chart for the total number of nonconforming items, as described in Clause 4.3, should also be used. This clause is presented below. It is of critical importance to observe that this is NOT the same as using a rolling average as recommended by PB Associates.

> **4.3 MOVING TOTAL CHARTS.** The precision or reliability of a sample result increases with the size of the sample and this fact can be used to assist correct interpretation of results on a control chart as follows:
>
> (a) Ascertain the total number of nonconforming items found in a compound sample consisting of the last two to five samples depending on the sensitivity and response time required. This procedure results in an overlap between successive compound samples so that they have all but one of their constituent items in common. The total numbers of nonconforming items in the sequence of compound samples are the data plotted in moving total charts.
>
> (b) Find in Table 1 a control limit, based on the number of nonconforming items that would have been expected in this compound sample.
>
> For example, if there is an average of 1.27 nonconforming items per sample and 3 samples are combined to form a compound sample, the new control limit is based on 3 $\cdot$ 1.27 = 3.81 nonconforming items per sample. Reference to Table 1 gives a control limit of 10.7 for the total number of nonconforming items in the compound sample. Note that this limit is not 3 times the limit of an individual sample which is 5.7.
>
> The moving total chart is treated in the same manner as a single sample control chart.

This approach, using numbers of nonconformities, may be taken if it is considered essential to deal with frequencies of events. However, this is not the only possibility. As AS 3940 points out, there are a number of reasons why one might use measured rather than counted (frequency) attributes.

4.2 Properties of Rolling Averages

The use of "rolling averages", known technically as "moving averages", has a long history in economics and other areas as a smoothing technique. PB Associates strongly recommend the use of this technique to smooth the Powerlink data which they consider to be unacceptably variable from year to year, and the ACCC accept this recommendation and require the use of a ten year rolling average as one of the annually reported statistics.

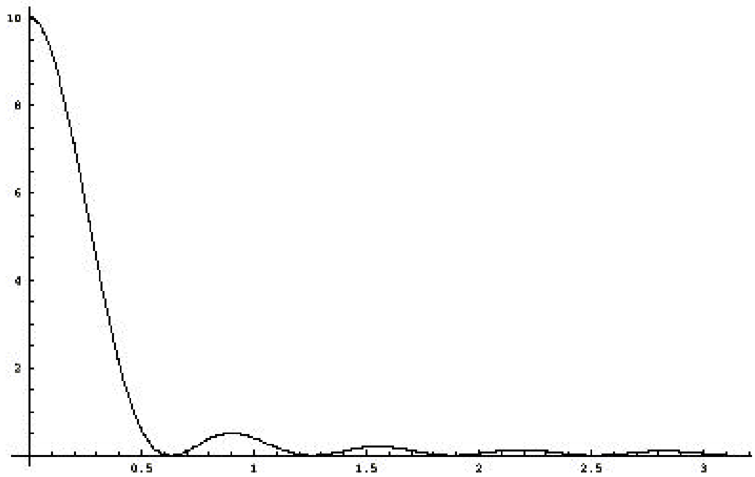
Taking a rolling average (that is, averaging over a fixed number of successive periods) is a technique for smoothing out irregularities in a time series of data. In engineering terms, it is a "linear filter", that is, it takes a set of numbers (the input), applies some simple additions and multiplications to produce a result (the output).

Now, it is well known in the field of engineering signal processing that each such filter has associated with it a "transfer function" which has certain properties which it imparts to the output. These properties may include, for example, smoothing the output (as in the current situation); removing a regular oscillation from the output (such filters are used in economics to "seasonally adjust" observed time series); de-trending a series, among the simpler applications.

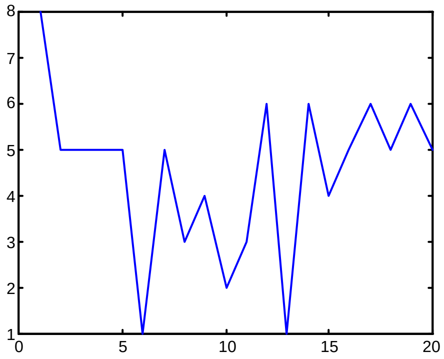
However, it is also well known that such filters are not perfect. In may cases they have additional, unwanted effects on the input series. It was discovered as long ago as 1927 that the apparently simple technique of taking a rolling average can introduce spurious features such as apparently systematic fluctuations into an otherwise random sequence. Kendall M.G. 1976, Time Series, 2nd ed., Pub. Charles Griffin & Co. Ltd, London, p.41, states:

> The realisation that apparently systematic fluctuations can be generated merely as the average of random events came as something of a shock when Slutzky and Yule in 1927 first called attention to the fact, especially as Slutzky was able to mimic an actual trade "cycle" of the nineteenth century very closely by a moving-average process.

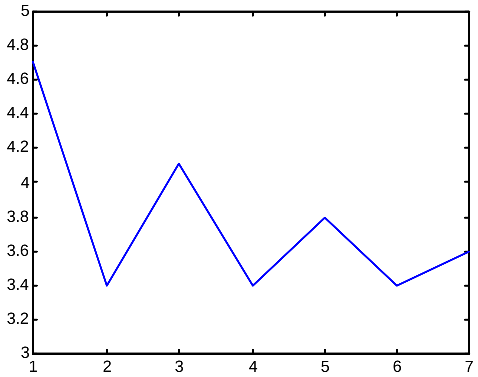
The ten-year rolling average proposed by PB Associates and adopted by the ACCC has the following frequency response for its transfer function (only the positive half shown here). It can be seen that the peak at frequency zero, associated with the smoothing average, has power spread into non-zero frequencies, indicating that such a filter may introduce cyclical oscillations into the output which have no relationship to the input.



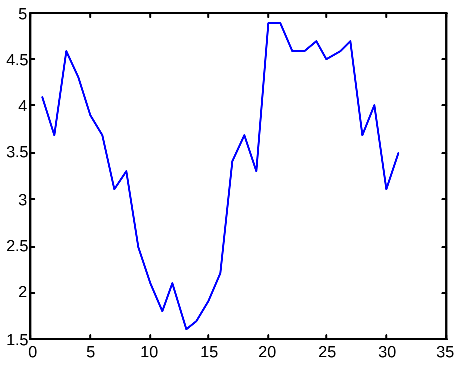
It would be extremely unfortunate if a regulatory approach were to be adopted which led to the requirement for an organisation to react to spurious features which are simply the characteristic of a transfer function rather than of the input data. The following graph shows an example of a set of data representing a random series of events (homogeneous Poisson process) with an average of four per year recorded over 20 years, similar to the extent of data available for Powerlink.



The next graph shows the first seven years of rolling average of data from this example. It appears that the system is improving: the rolling average is trending downwards.



Looking at the rolling average over a different and slightly longer period, one sees the sort of smooth swing that the Slutzky-Yule effect predicts. It would be very unsurprising if it were to be treated in reality as a decline which was arrested by some action of the system management, leading to an improvement which was maintained for several years before lapsing to a lower level once more. However, to re-iterate, *the underlying data sequence is completely random and this cycle effect is completely due to the ten-period rolling average filter*.



5 Discussion

5.1 Minimising the probability of high impact events

Engineering data are subject to uncontrollable variation, leading to uncertainty which must be taken into account in designing and operating equipment and systems. It is important to be able to distinguish whether uncertainly is due to human or natural causes. While it may be possible to eliminate some of the former, the latter may often only be mitigated to some extent. It is undesirable to put effort and expense into trying to improve a situation that is inherently subject to uncontrollable physical uncertainty. And it is not sensible to require, as PB Associates suggest, that regulations should include incentives for "Powerlink to do what it can to minimise the probability of (such) high impact events".

If the probability of tornadoes, earthquakes or major bushfires could be reduced by human effort it would not be just Powerlink who would benefit. In fact altering the probabilities of such events is outside the power of all human endeavour: hence it seems unreasonable to assert that Powerlink are more able to do so than other participants in the Electricity Supply Industry and that therefore they should be held accountable for their failure to do so.

5.2 Smoothness of recorded statistics

When, as is common, a system is subject to uncertainty from several causes, and particularly when most of those causes which *can* be controlled *are* subject to a high level of control, the variability observed will follow the patterns of the remaining underlying causes. If these are extreme weather events, then the variation from year to year is likely to be considerable. All industries which are exposed to the impacts of extreme weather will reflect this variation, although the approaches that are taken to mitigate it may differ.

PB Associates disapprove of the degree of variation apparent in the Powerlink SM records from year to year, and require that the results be smoothed by taking a ten year moving average. This, they assert, will make it possible to "discern a trend in network reliability". As explained above in Section 4.2, this will also incorporate features of the moving average transfer function and will make it impossible to separate those from any actual trend in network reliability that may be present.

The correct method for determining whether ongoing processes subject to random variation are subject to trends is to use a control chart with suitably calibrated control limits which take account of the level of variability actually present in the data, rather than trying to smooth it away.

If PB Associates, or the ACCC, expect that regulation is going to result in a uniform low level of SM or of any other reliability indicator from year to year then this is indicative of a completely false understanding of the impact of natural variability on real-life processes and systems. The desire for a smoothed form of indicator has lead in the present case to recommendation of a potentially highly misleading alternative statistic.

5.3 Target values

5.3.1 Rolling Averages

PB Associates adopt an amazingly cavalier attitude to the setting of targets in their discussion of the desirable limits for their proposed rolling average statistic:

> If a ten-year rolling average of system minutes lost is accepted as a reasonable measure of network performance, it is still necessary to determine a reasonable target. The average annual system minutes lost over the period 1984-2000 were 7 minutes. Achievement of an annual system minutes lost of 7 minutes in 2001 would bring the 10- year rolling average back down below 7 minutes. This suggests that a 7 minute 10-year rolling average is a fair reflection of the current level of reliability on the Powerlink network. It is therefore proposed as a suitable regulatory target, given the Commission's intention to regulate only for a basic level of service at this time.

While PB Associates have not pursued the matter, it is nonetheless the case that the measure that they are recommending is a statistic calculated from data and like all statistics it has an associated sampling distribution which governs its behaviour and which determines among other things the frequency with which particular target values will be exceeded. This distribution and its properties are knowable facts, and could be applied to determine the frequency with which the arbitrary limit of 7 SM lost per annum would be exceeded. Without knowing whether the recommended level is expected to be exceeded once in a year, once in a century or once in a millennium it is not sensible to use it as a target.

In view of the highly undesirable properties of the rolling average filter as described above, it seems unnecessary to derive this frequency. However, in general it is completely unacceptable to present a target in this manner without any consideration of the distribution of the statistic concerned, particularly since modern computing software has made it possible to establish the sampling distribution for any statistic of interest to quite reasonable accuracy.

5.3.2 Risk associated with setting control limits

The simplistic interpretation of an event where a service provider does not meet a set target is that they have failed to provide a suitable standard of service in spite of having been provided with the money to do so. This simplification is a falsification of the reality, which is, as usual, more complex. There are several issues to be disentangled here, of which the first relates to the meaning of targets for observed data series subject to random variation.

AS 3940 explains that because of the variation inherent in sampling, the number of nonconforming items in a sample will vary from sample to sample even if the underlying proportion nonconforming is constant. In the case of observations from a random process such as power outages, the variability arising from the impact of the environment on the system means that even though there may have been no change in the system reliability there will most likely be different numbers of SM greater than 0.2 in different years. The pattern of variation has been studied and reported for example in B. Sharp, *Monitoring system reliability using statistical methods*, CEPSI, Bangkok, Thailand, Nov. 1998. The presence of such variation gives rise to two types of risk, as explained in the Standard.

> These risks are as follows:
>
> (a) *Type I risk* — the risk that a sample with a fortuitously high number of nonconforming items will give a spurious 'action' decision when no deterioration has in fact occurred.
>
> (b) *Type II risk* — the risk that a sample with a fortuitously low number of nonconforming items will fail to signal a deterioration in the process.
>
> The design of any control charting scheme is a compromise between these two opposing risks. AS 3941 uses a Type 1 risk of about 1 in 200, a value that experience has shown to be satisfactory.

The Type I risk is also referred to as the Producer's Risk: that is, it is the risk that the producer of goods or services will be assessed as having failed to achieve a target when no deterioration has in fact occurred. In the Standard, a Type I risk of 1 in 200 is used. Whether this is appropriate for regulated service standards is an issue for discussion: other risk levels have also been used in practice.

> On the other hand the setting of Type II risks tends to be a value judgement; for example, Type II risks tend to be high where the process average deviates from the target value by a small amount and low where the process average differs substantially from the target value.

Type II risk is referred to as the Consumer's Risk: that is, it is the risk that the product being supplied will be assessed as having complied with the target when in fact a deterioration of service has occurred. AS 3940 states:

> A relatively high Type II risk for a single sample is less important than a high Type I risk. The latter results in excessive unwanted intervention ... it must be remembered that there is a substantial penalty associated with the Type I risk. The only way to decrease the Type II risk is to increase the Type I risk.

That is, if the Producer (in this case Powerlink) is prompted unnecessarily to adjust the system characteristics, penalties are applied and costs incurred attempting to restore service to an acceptable standard when in fact the observed data are quite compatible with the long term ongoing level of random variation affecting the process.

One of the many advantages of using a formal, well-studied technique such as a control chart rather than an ad-hoc invention is that these risks are quantified.

There is a temptation for regulators and customers to require that Type II risk be eliminated, that is, to make sure that under no circumstances can a deterioration of service standards occur which is not immediately reflected by a failure to meet the set target. As AS 3940 explains, the only way to decrease the Type II risk is to increase the Type I risk. This would mean that the Producer was penalised for every single nonconformity regardless of the fact that these nonconformities were a consequence of natural causes of physical uncertainty beyond the control of the Producer or anyone else.

One of the lessons that a competitive market for goods has taught is that the cost of extreme reduction in Type II risk is ultimately paid for by the Customer, since dealing with higher Type I risk increases the cost of producing the goods. A balance is usually found between acceptable levels of the two risks, and the value 1 in 200 for Type I risk used in AS 3941, with its associated Type II risk levels, has been found to be appropriate in sufficient different situations to have formed part of the Standard.

It has been established (see Brian Sharp, *Monitoring system reliability using statistical methods*, CEPSI, Bangkok, Thailand, Nov. 1998) for SM recorded over a given period that the pattern of variation includes occasional extremely large values due to quite exceptional meteorological conditions. In this case, the next step in the use of control charts comes into play: when an event occurs that causes the number of nonconformities to exceed the control limit, *the cause of this exceedance is investigated*. When the cause has been identified, steps are taken to bring the process back under control. It is possible that there is no special cause and that the exceedance is simply an isolated extreme event; the underlying state of the system has not in fact deteriorated and it will revert to its usual performance level with no intervention. Control charts are not a mindless tool.

5.3.3 Interpretation of targets

PB Associates rejected the use of mean numbers of loss of supply events per quarter because the target means are small fractions. They argue that there can be only whole numbers of events (quite true) and hence that the targets must be set for whole numbers of events. They state that having a fractional target is meaningless.

However, Powerlink explain clearly in their *Comments* the way in which the "target" of 0.07 winter loss of supply events should be interpreted, as the long run acceptable average on which a Poisson control chart is to be based (quoted in Section 3.1.3 above). If a control chart is to be used (and this is strongly recommended), then a fractional mean is not only sensible in this case but essential.

There appears to have been confusion generated by the use of the word "target" to mean, in the case of PB Associates, something about the position of control or warning limits, and in the case of Powerlink, the average number of nonconformities expected per sample. It would appear that PB Associates have rejected the Powerlink proposal based on a misunderstanding which has arisen from the ambiguous use of the word "target".

It should be noted that Table 1 in AS 3941, which gives control limits for Poisson control charts, associates control limits with mean values in bands. The value of 0.07 which is particularly discussed by Powerlink and PB Associates places the system in the first row of the Table, mean values <0.10. The next band (second row of the table) covers values between 0.10 and 0.33, with subsequent bands 0.33 to 0.67, 0.67 to 1.08, and so on.

The varying widths of the bands are a consequence of the discrete (whole number) nature of the events being tracked. That is, a control limit of 1.7 is appropriate for a band of mean values up to 0.10: the control chart technique cannot distinguish between different values in the range 0 to 0.10 (or between different values in the range 0.10 to 0.33, etc). If more subtle distinctions are required to be drawn, an alternative technique is required (see next Section).

When an event occurs that causes the number of nonconformities to exceed the control limit in a control chart, *the cause of this exceedance is investigated*. It is possible that the exceedance is the consequence of an isolated extreme event; the underlying state of the system has not in fact deteriorated and it will revert to its usual performance level with no intervention. The control chart is not an automatic device in this sense: an exceedance is not necessarily evidence that the system has deteriorated. One of the non-statistical issues between the parties in the present case is whether or not the service standards are tracking the underlying state of the system, so that if it has not deteriorated then all is well

5.4 Alternative control techniques

It should be noted that the CUSUM technique, explained in detail in AS 3940, is an alternative to the usual control chart. The CUSUM chart has the property that it is very good at illustrating and detecting fairly small changes in the mean level (although it may not do this immediately the level has changed, it is more sensitive than the control chart for this purpose): it may be inferior to the control chart for detecting large changes.

6 Conclusions

The apparent aim of the modifications proposed by PB Associates is to simplify (move from difficult fractions representing events of low probability, to simple whole numbers) and to smooth (move from a graph showing big changes from year to year to a smoothed picture which gives the appearance of relative constancy). However,

- methods for tracking data which vary over time have been developed extensively since the Second World War and are available in tutorial form in Australian Standards, so there would appear to be no impediment to adopting this approach which has the advantage of wide international acceptance and understanding; and
- the alternative method offered by PB Associates and adopted by the ACCC is a dangerous innovation with undesirable properties which have been known for over 70 years and are such as to make it wholly unsuitable for control purposes.

To a considerable degree the disagreement between Powerlink and PB Associates on the appropriate form of targets appears to be based on a misunderstanding which would be averted if closer attention was paid to clearly defining terms and to using technically correct vocabulary where this is available. This is another advantage that would accrue if the relevant Australian Standards were used as a guide. Attempting to make the presentation more digestible by using non-standard words for technical concepts disguises the inherent complexity of attempting to track and control a randomly varying process.

7 References

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