TransGrid

Service Standards Incentive Scheme: Review of data, methodology and parameters

21st December

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1. BACKGROUND

1.1 The scheme

The Ministerial Council of Energy (MCE) articulated a number of principles for the roles of transmission networks in its December 2003 Report to the Council of Australian Governments.1 This included:

- *Providing a transportation service from generators to loads*
- *Ensuring secure and reliable bulk electricity supply*
- *Facilitating competition between generators (even when located in different regions)*

In addition, the MCE also proposed a number of reforms, including that:

> *"...there would be valuable customer and investor benefits in more closely aligning transmission performance measures with their market impact. The MCE supports the current consideration by the ACCC of incentives for availability. Incentive arrangements should analyse the actual cost of constraints, set targets for circuit availability, and reward or penalise transmission companies for diversion from those target levels."*

In response to the MCE report, the electricity industry in Australia continues to evolve and as part of this evolution, market governance arrangements continue to change, especially for the transmission networks and in particular with respect to performance incentive arrangements.

The Australian Energy Regulator's (AER) November 2007 Service Target Performance Incentive Scheme (STPIS) sets out details of the performance incentive scheme for Transmission Network Service Providers (TNSPs). Under the AER's STPIS, TransGrid's revenue cap will incorporate a performance incentive scheme that would allow TransGrid to gain up to an additional 1% of revenue each year for above target performance, or lose up to 1% of revenue each year for below target performance.

The application of the scheme must be consistent with requirements of the National Electricity Rules (NER) clause 6A.7.4 and clause 1.4 of the scheme which provides an overview of the objectives. The operational aspects of the scheme are contained in clause 3.3 which relate to three key performance parameters for all of the TNSPs and identifies the items that each of the individual TNSPs need to provide as part of the determination process.

1 http://www.mce.gov.au/assets/documents/mceinternet/MCE%5FDec03%5FRpttoCOAG200312111714432004112416405 6%2Epdf

1.2 TransGrid's submission to the AER

TransGrid wrote to the AER in September 2007 advising that it did not wish to propose amendments, to add, remove or vary a parameter or the revenue at risk under the service component of the STPIS. However, TransGrid did recommend changes to the definitions in Appendix B to ensure that it comprehensively defines the parameters that apply to it under the scheme. In particular TransGrid recommended:

- Additional detail on exclusions;
- 14 day cap for transmission circuit availability outages where an underground cable was damaged by an external party who failed to enquire with "dial before you dig"; and
- 7 day cap on outages for the average outage duration parameter.

The AER also accepted TranGrid's suggestion of inclusion of transmission line availability (peak critical circuits) if the Market Impact Transmission Congestion (MITC) parameter is not finalised prior to the next regulatory period.

1.3 The AER's explanatory statement

Following TransGrid's submission, the AER released its consideration and decision in the scheme's explanatory statement in November 2007. The AER considered that the parameters applying to TranGrid under the current determination are generally suitable for application in the next regulatory control period. In particular:

- Exclusions for circuit availability parameter definition;
- 14 day cap for transmission circuit availability outages where an underground cable was damaged;
- ,Additional loss of supply frequency clarification amendments that will assist reporting; and
- 7 day cap on outages for the average outage duration parameter definitions is appropriate.

However, the AER noted that some of the parameter definitions could be defined more clearly. The AER has adopted TransGrid's proposed amendments to the parameter definitions, subject to some minor edits to ensure that it is clear which exclusions are relevant for each sub parameter.

1.4 Scope of this consultancy

Against this background, TransGrid have asked SAHA International to provide analytical advice in relation to setting proposed performance targets for the STPIS administered by the AER. In particular, SAHA have been asked to focus on the loss of supply event frequency parameter, reviewing: the methodology adopted in developing the targets; the feasibility of using alternate time horizons and increased sample size; and the impact of statistical outliers. SAHA was also asked to ascertain if there is a material incentive to improve performance (or will the potential improvement be marginal).

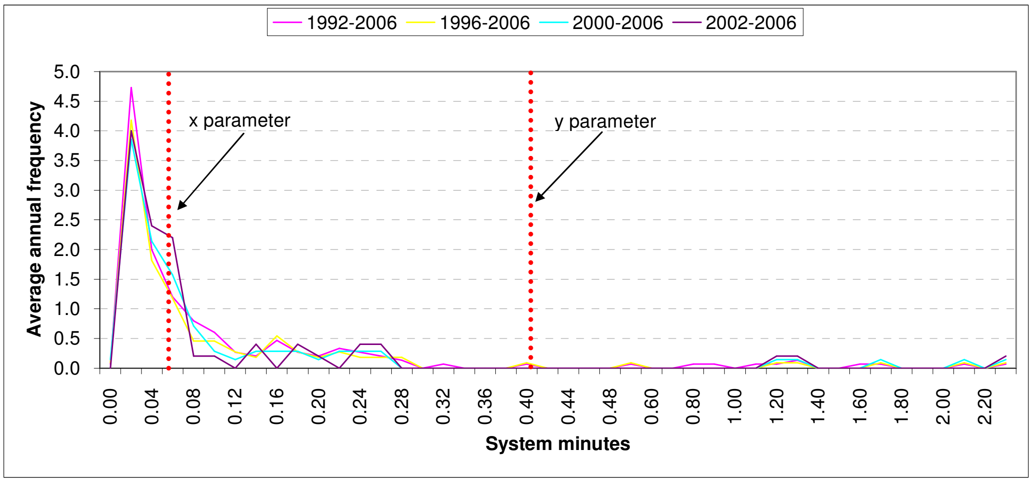
2. ANALYSIS AND REVIEW

2.1 Log normal and bimodal properties

Prior to developing performance measures, it is worthwhile analysing the nature and characteristics of the historical data on which the performance measures will be based as this understanding will greatly assist in developing performance measures that provide the correct incentives.

The following line histogram (see Figure 2-1) provides a distribution of annual average loss of supply event frequency by varying time horizons. It sets out the number of events recorded over the time horizon divided by the time horizon in years. It also shows the currently proposed parameter targets x and y.

Figure 2-1 Annual average loss of supply event frequency by varying time horizons



The histogram shows that loss of supply event frequency data has log normal properties. This was confirmed by testing an array of distribution functions against the data set by comparing the estimated and actual data. Analysis also shows that the data has a bimodal distribution. This suggests that outages will generally fall into two categories those that are resolved quickly and are brief in duration and as a consequence impact a small number of customers, and those that are more complex and require greater resources and time to correct and impact either a large number of customers or a small number of customers for an extended period of time. A review of outages to determine the extent that system minutes lost reflected operational outcomes; either protection equipment operation or system operator decisions was beyond the scope of this report, however, such a review merits consideration.

These log normal and bimodal properties are particularly relevant when setting parameter targets. The basis for having two performance targets x and y is to measure the TNSPs performance in managing the types of events that impact the transmission network and therefore customers. If the target parameters are too close, then one of the target parameters will be less relevant as they are effectively measuring similar performance issues to the first. Consequently, SAHA supports the objectives of reviewing the y parameter but notes that the actual target parameter must take into consideration its purpose of measuring complex outages that require greater resources and time to correct.

If the y parameter does not serve this function, then SAHA proposes reducing the weighting assigned to this parameter (potentially zero). However, TransGrid should continue to provide this data until the AER is satisfied that the y parameter is no longer relevant. To compensate for the reduced weighting assigned to loss of supply event frequency relative to other parameters, the weighting of the y parameter could be assigned to the x parameter so the impact is neutral.

2.2 Time horizon

It is important to have a sufficient sample size (number of frequency loss events) to obtain statistically reliable estimate of the performance target, caps and collars. This is consistent with statistical concepts such as the law of large numbers which guarantees stable long-term results for random events when a large number of observations are examined. In statistics there is no theory positing that a small number of observations will converge to the expected value, therefore the greater the number of observations considered in setting the parameters, the more likely that the estimates are unbiased. Reducing or eliminating bias has the additional benefit of reducing the probability that a wrong decision is made with respect to setting parameters either too high or low. In this context the sample size must be sufficiently large to ensure that the selected x and y parameters do not misrepresent the expected outcomes.

This is challenging given clause 3.3(g) of the scheme requires that performance targets must be equal to the TNSP's average performance history over the most recent five year period. Some previous reports have estimated the target, cap and collar (based on 5% and 95% values) using a best fit of only five observations relating to five years of data. SAHA has several concerns with this approach including:

- it is overly simplistic as it is plotting a straight line and developing a distribution based on 5 observations;
- statistical confidence of this approach is somewhat limited by the extremely small data set;
- it does not take into account potential outliers very well, due to its small sample size;
- there is a greater likelihood that the performance target is not reflective of the average performance history and limit parameters (cap and collar);

This in turn is likely to result in the development of a performance target that is very difficult to achieve and therefore dampening incentives or worse resulting in a financial penalty. Some of these limitations were acknowledged in previous reports but there were concerns regarding using a longer time horizon as the data may not be indicative, consistent and satisfy the NER principle to maintain reliability of the network.

SAHA has analysed TransGrid's data and acknowledges that there have been improvements in network performance over time. However, the application of the performance target formula does not result in material differences when longer time periods are used say up to 11 years. The charts below demonstrate this by viewing the average annual loss of supply event frequency from two perspectives. The first chart shows the data by the actual system minute threshold (Figure 2-2) while the second chart is a cumulative measure that shows events above the threshold (Figure 2-3) as required for performance reporting. The x and y parameters have also been included for comparative purposes.

Figure 2-2 Average annual loss of supply event frequency by system minute threshold

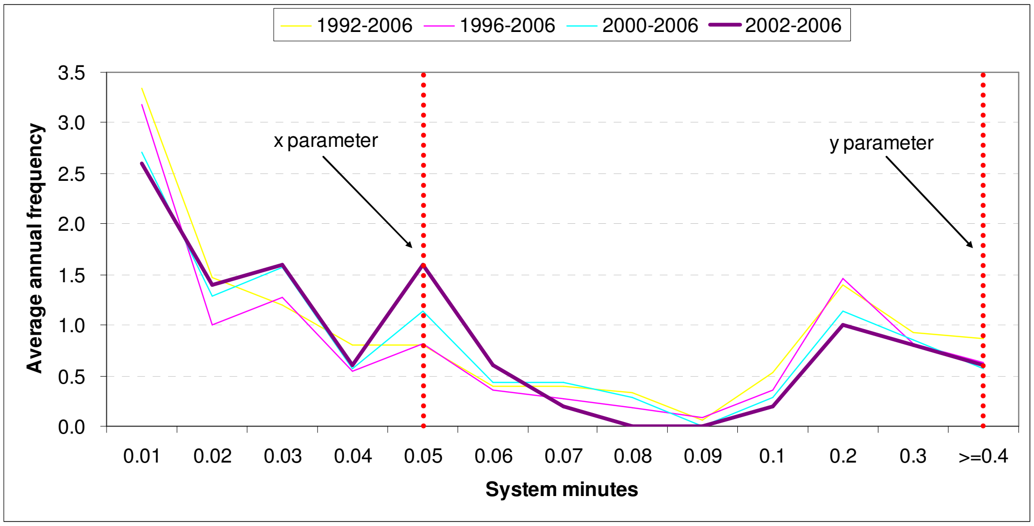
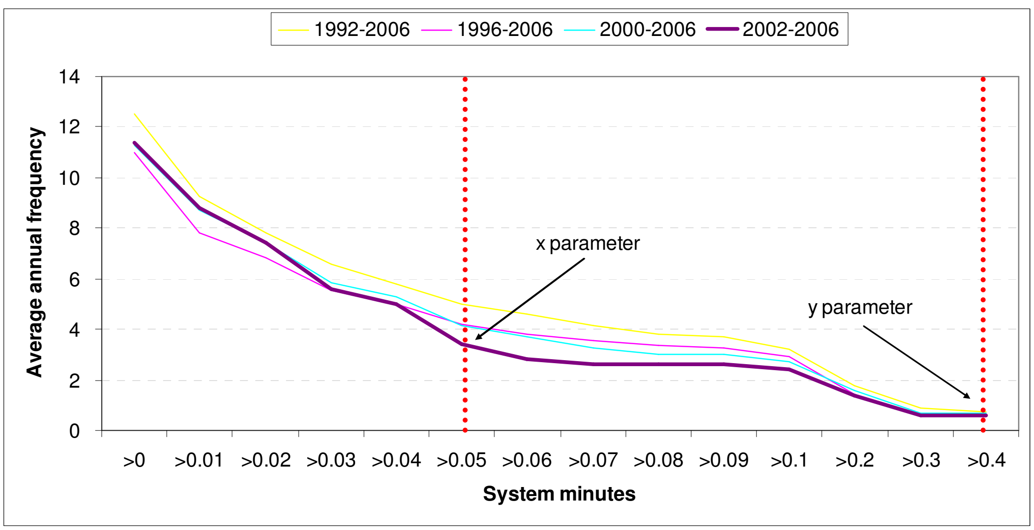


Figure 2-3 Average annual loss of supply event frequency above the threshold



The first chart (Figure 2-2) provides additional support to the bimodal properties discussed earlier. It also demonstrates that there is a consistent pattern of system minute outages with some volatility. The second chart (Figure 2-3) shows no difference using different time horizons for the existing y parameter >0.4 system minutes. The variance is still immaterial at the x parameter >0.05 at less than one event. These observations suggest that the data is comparable over varying time horizons. Accordingly, the AER could consider using a longer time frame as the variations in the performance target measure are small.

Despite extending the timeframe up to 11 years, this still results in few observations. The next section proposes the use of individual data.

2.3 Individual data

As discussed in the previous section, it is important to have a sufficient sample size to obtain a statistically reliable estimate of the performance target, caps and collars. SAHA in its previous work on circuit availability parameters used more granular data. Likewise, the same approach can be used to determine the average annual loss of supply event frequency parameter. The input into developing this parameter is based on outage data reported at a localised region. There have been 57 observations (11.4 annual average) in the last 5 years (2002-2006), 122 observations (11.9 annual average) in the last 11 years (1996-2006) and 189 observations (12.6 annual averages) over the last 15 years of reporting transmission network performance (1992-2006). This equates to one outage per month, most of which are minor in duration as shown by the charts above. These sample sizes are sufficient to obtain statistically reliable estimates.

It is conceptually sound to use the input data at a granular level. Firstly, the assumption of network diversity does not apply when aggregating individual outage events. It is also more relevant to measure and provide incentives for network performance on a localised basis rather than a system basis with diversity assumptions as the later could conceal the impact on customers.

Consequently, SAHA suggests that the AER consider the use of individual outage data over a longer time horizon (for example 11 years) to ensure target parameters, caps and collars are statistically more reliable.

2.4 Statistical outliers

Clause 3.3(k)(1) of the scheme enables reasonable adjustments to the proposed performance targets to take into consideration statistical outliers. However, it is important to define these data points carefully as it will impact the target level and limits.

Deleting outliers is arguably an inappropriate procedure and as a practice is rejected by many scientists and statisticians. While a range of statistical measures are available to provide an objective basis for data rejection, the practice remains methodologically unsound, especially in small data sets or where a normal distribution cannot be assumed such as for loss of supply events.

The following two charts provide a scatter plot of loss of supply event frequency by calendar year by duration in system minutes and the x and y parameter targets. The difference between the two charts is the vertical scale. The later chart more clearly shows outages with a shorter duration.

The charts also show that despite an overall improvement in network performance over time, on occasion there will be unfavourable years (see shaded area on charts) and these are not outliers. TransGrid has recorded 3 unfavourable calendar years in the last 15 years or 1 in every 5 years on average. From a statistical perspective, it is reasonable to expect a similar result in the near future or next regulatory control period. Consequently, it is recommended that these events are included in the data set rather than being defined as outliers or anomalies.

Figure 2-4 Average annual loss of supply event frequency above the threshold (scatter plot)

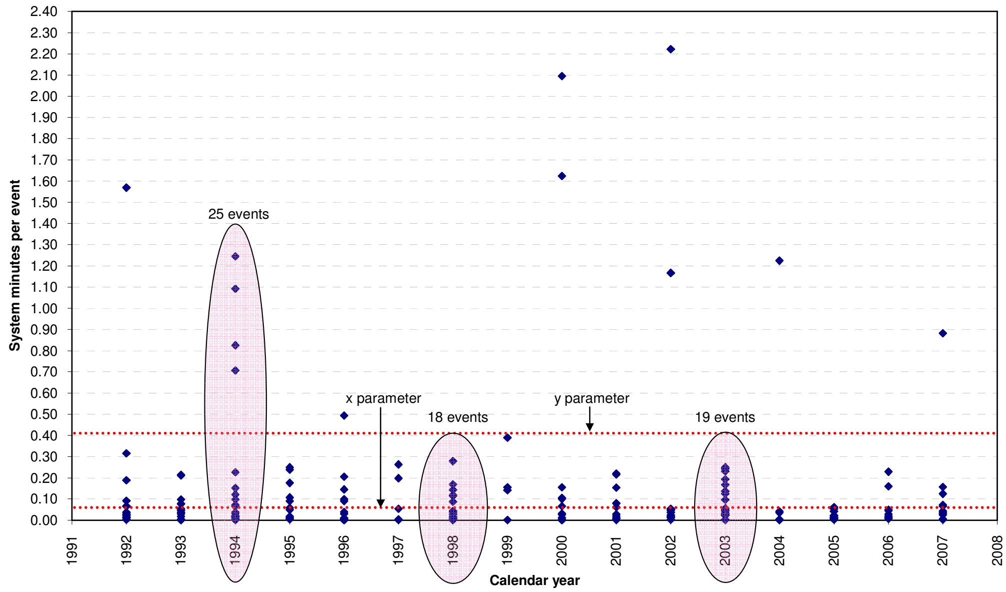
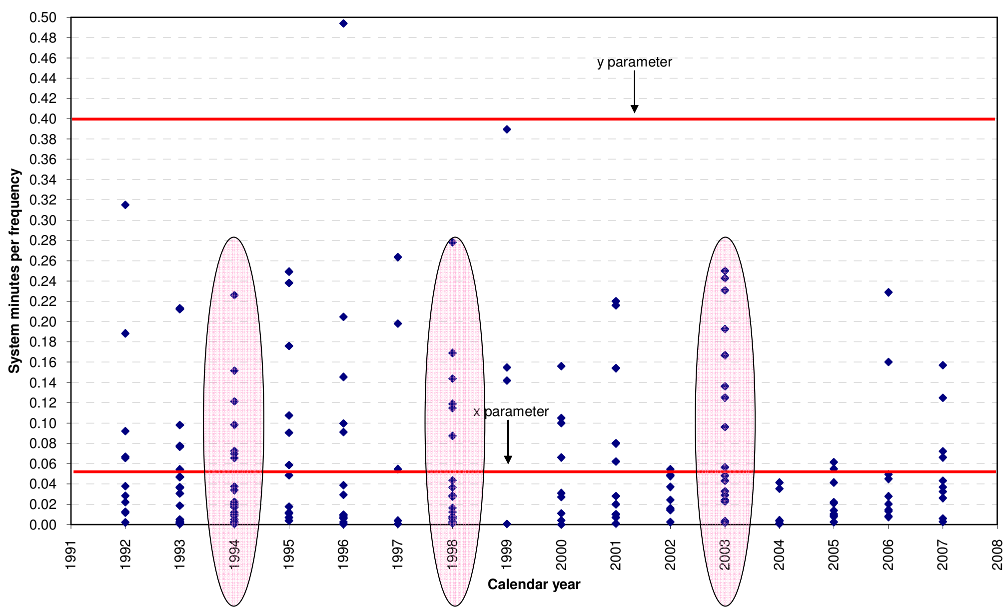


Figure 2-5 Average annual loss of supply event frequency above the threshold (scatter plot) lower threshold



This recommendation stems from our earlier discussion that regulated asset management is based on a regulated revenue approval process that takes into account the costs, benefits and residual risk of a planned capital works and maintenance program over a regulatory control period. Consequently, the

TNSP can not be expected to accommodate every event or scenario as this would be cost prohibitive and unlikely to be approved as regulated revenue.

Any additional capital works or maintenance by the TNSP that has not been approved by regulator must be weighed up against the incentive framework which is subject to greater uncertainty associated with setting the performance target, caps and collars and poor performing years being classified as outliers. As the TNSP's additional revenue is capped at 1% but the cost of improving network performance is likely to be significantly more, this would expose the TNSP to greater revenue risk.

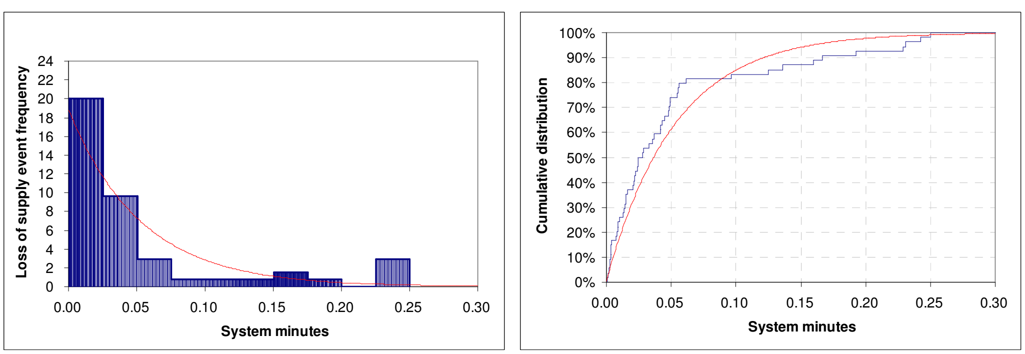
3. SETTING THE PARAMETERS

This section proposes the x and y parameter targets for the next regulatory control period. It draws on the analysis provided earlier and additional statistical analysis.

The log normal and bimodal properties of TransGrid's loss of supply event frequency data demonstrates that it is important to have both x and y parameters to assess network performance. It is also important that the target parameters are not close; otherwise one of the target parameters will become less relevant as they are effectively measuring similar performance.

The charts below show frequency histograms and cumulative distribution graphs for both 5 and 11 year time horizon respectively (see Figure 3-1and Figure 3-2). Both charts show that the x parameter which is currently set at the >0.05 system minute threshold is reasonable as it is very close to the mean value. The mean for the 5 year data set (2002-2006) is 0.053 system minutes, while the 11 year data set (1996-2006) is slightly higher at 0.062 system minutes. The average annual number of events at the >0.05 system minute threshold is 3.4 and 4.2 for the 5 and 11 year data sets respectively. SAHA recommends that this target threshold remain unchanged for the next regulatory control period.

Figure 3-1 Histogram and cumulative distribution graph of loss of supply event frequency (2002-2006) all data set



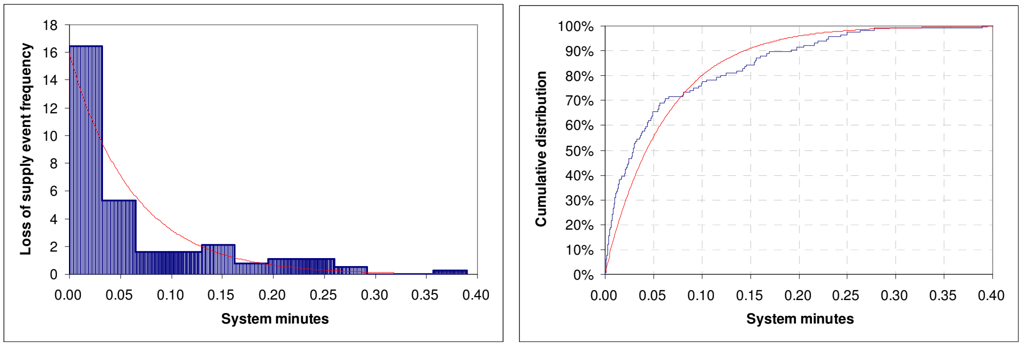


Figure 3-2 Histogram and cumulative distribution graph of loss of supply event frequency (1996-2006) all data set

The y parameter which is currently set at the >0.4 system minute threshold is no longer relevant as it is measuring <1% of events when the complete data set is used. However, given the bimodal nature of the data, the tail events which appear to be values >0.1 system minute threshold will not be estimated correctly. The statistical process to provide a better estimate for the tail events is to create a separate distribution for them. The charts (see Figure 3-3 and Figure 3-4) below provide a separate distribution for the tail events >0.1 system minutes for both 5 and 11 year time horizons.

Using a separate distribution for the tail events of the bimodal data set, SAHA proposes that the y parameter be set at 0.25 system minutes. At this threshold, approximately 2 events per calendar year were reported for the respective time horizon. From a benchmarking perspective, setting the y parameter at this level is comparable with other TNSPs in the NEM.

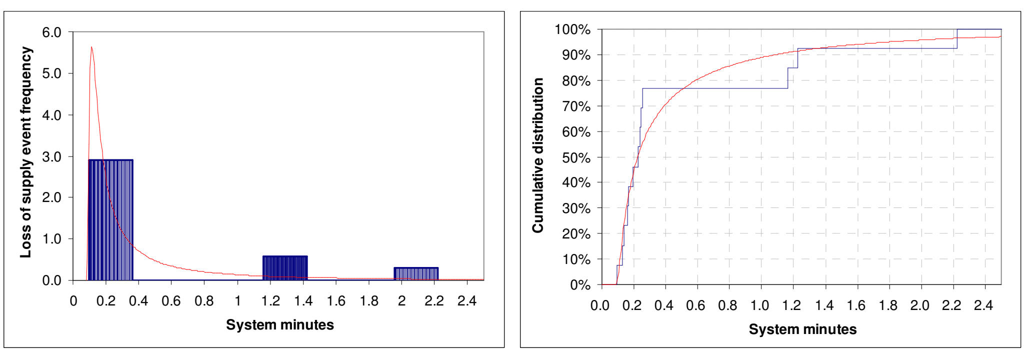
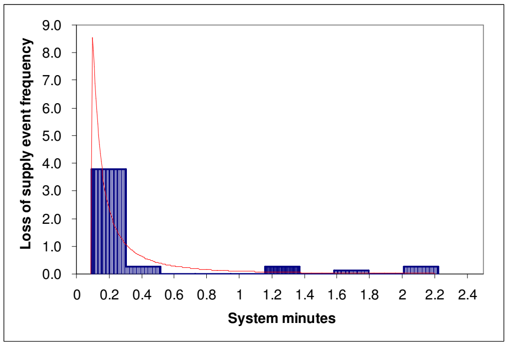
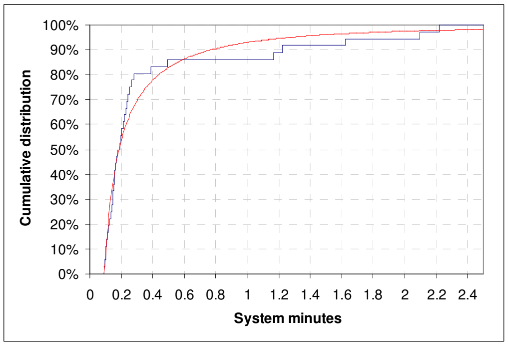


Figure 3-3 Histogram and cumulative distribution graph of loss of supply event frequency (2002-2006) for tail events >0.1 system minutes

Figure 3-4 Histogram and cumulative distribution graph of loss of supply event frequency (1996-2006) for tail events >0.1 system minutes





4. RECOMMENDATIONS

SAHA's recommendations are based on careful consideration of TransGrid's underlying data set which has show both lognormal and bimodal properties.

1. Our analysis has shown that the data is consistent over both 5 and 11 year timeframes. However, extending the timeframe does not materially increase the sample size. Instead SAHA proposes developing targets based on individual data reported on a localised region. This approach would incentivise the TNSP to manage outage risk for the entire network.

2. SAHA's review of the available data set highlighted the importance of determining whether data points were outliers or part of the expected distribution of events. We believe that events that might be considered as outliers are not outliers and must be considered in determining the STPIS parameters.

3. Finally, in order to set meaningful x and y parameters the thresholds can not be close and the tail events must be based on a separate distribution to provide a more accurate estimate. SAHA recommends that the x parameter remain unchanged while the y parameter should be reduced to >0.25 system minutes for the next regulatory control period. From a benchmarking perspective, setting the y parameter at this level is comparable with other TNSPs in the NEM.

5. SERVICE TARGET PERFORMANCE SCHEME - OTHER ISSUES

The National Electricity Rules Chapter 6A.7.4 (b) sets out a number of principles that the STPIS must meet. These include:

> *"(1) provide incentives for each Transmission Network Service Provider*
>
> *to:*
>
> > *(i) provide greater reliability of the transmission system that is owned, controlled or operated by it at all times when Transmission Network Users place greatest value on the reliability of the transmission system; and*
> >
> > *(ii) improve and maintain the reliability of those elements of the transmission system that are most important to determining spot prices;"*

Conceptually, this requires the STPIS to provide incentives for TransGrid to modify current work practices with respect to capital and maintenance programs. The incentive that is currently provided is for TransGrid to receive a maximum of 1% of allowed revenue or approximately $6 million per annum.

TransGrid's current corporate objectives with respect to electricity supply are:

1. Ensuring the safety of staff, contractors, and the general public;

2. Maintaining the security and reliability of the power system under the control of TransGrid;

3. Ensuring all activities are undertaken in a manner that ensures compliance with all environmental obligations; and

4. Minimizing the impact the transmission system has on the outcomes in the national electricity market.

This raises the legitimate question of whether STPIS creates sufficient incentive for TransGrid to modify their current objectives relating to electricity supply. In particular, whether TransGrid's existing network management plans and system operating policies and procedures are likely to be subject to change in response to STPIS outcomes. Allied to this is a further concern that the STPIS may achieve the desired outcome in terms of reducing the number of small events, but place the power system at greater risk of major outages.

5.1 Network Management Plan

In common with TNSPs in many countries, TransGrid prepares a five year Network Management Plan (NMP) that sets out how it intends manage and develop its assets given the strategies outlined above. This plan is developed following consultation with customers and in large part reflects their requirements from the transmission system, especially with regard to network upgrades. Given the changing needs of customers, this document is by necessity subject to regular change.

In addition to the electricity supply strategies, TransGrid also has in place a number of supporting strategies such as human resources, information technology and supply chain that support the successful achievement of the NMP.

SAHA would query whether the STPIS is capable of changing asset management behaviour. By its very nature, the STPIS loss of service component is a lagging indicator. Given the lead time required to plan and execute both capital and maintenance plans and the effort required in terms of asset condition assessment and monitoring, little flexibility exists to change aspects of a work program in any reasonable timeframe in response to a loss of service. In all probability, the situation that gives rise to an outage is likely to have previously been identified and will already be captured in the NMP. The existence of the STPIS will therefore be unlikely to result in material changes to the NMP or system performance outcomes.

With approximately $400 million in capital expenditure and $65 million in maintenance expenditure in fiscal 2007/08, successfully completing these projects should remain TranGrid's focus.

5.2 System Operation

Large interconnected transmission networks require protection and monitoring to safeguard against failures may occur for a number of reasons including:

- Environmental causes such as lightning, trees, and wind,
- System causes such as damaged transmission lines, incorrect operation of circuit breakers, short circuits etc, and
- Human causes.

This protection takes two forms – the installation of physical protection equipment on the system and the training of system operations staff that have the responsibility for the oversight of the operation of the network. Both forms of protection aim to ensure that the impact of an event is minimized and does not lead to a cascade failure.

Protection devices are installed with the aim of protecting assets, and ensuring that the supply of energy to consumers can be maintained. The design of protection devices installed on TransGrid's network is therefore a critical aspect of management of potential loss of supply events. Different strategies are also considered for protecting the different parts of the system, with large urban areas having different protection settings to those that might be found in rural regions. For example, urban areas may have redundant and independent protective systems, while a radial line supplying rural customers may have simpler and lower-cost protection.

While unnecessary operation of protection equipment or erroneous system operator decisions leading to customer outages is to be regretted, the consequences of protection equipment not operating as designed or failing to take timely action as a system operator can be significantly more damaging. In recent years there has been any number of major power outages[2] resulting from both a failure of protection equipment and a failure of operating staff to take actions necessary to protect against cascading power failure.

The STPIS scheme needs to avoid an unintended consequence where it leads engineers to focus their effort on avoiding the smaller and more frequent events that fall within the scope of the scheme, but in doing so increased the risk of a major power outage.

5.3 The Potential for Large Blackouts

Power outages frequently act as the stimulus for an increase in grid investment to protect against future outages. However, research suggests that such an approach may put the system at risk of larger power outages.[3] While a TNSP may take actions to avoid future outages and especially to avoid repeated outages with similar causes, eventually load growth reduces the benefits achieved and the system returns to state with a similar probability of outage.

The researcher's findings suggest that:

> *… The power grid may be a self-organized critical (SOC) system, a system that perpetually steers itself toward a dynamic equilibrium, where small perturbations have long-range effects. If the power grid is indeed an SOC system, then large power outages are more likely than traditional risk analysis predict…*

Therefore addressing the cause of an outage without addressing the wider dynamics of the power system might do little to prevent similar events in the future and could even make matters worse. The risk therefore exists that in setting out to address causes of loss of supply events being measured in the STPIS, TransGrid may reduce the risk of a small outage but place the system at greater risk of a large outage.

SAHA suggests that the AER should also be encouraging TNSPs to implement policies that address more than the causes of localized outages captured under the STPIS. Policies should also require investment, changes to operating policies, and changes to protection settings to avoid the implications of rare events such as a cascade failure, an increased possibility giving the increasing level of stress on the transmission system.

[2] For example the major outages in Eastern North America, Denmark and Sweden, Italy
[3] Evidence for Self-Organized Criticality in a Time Series of Electric Power System Blackouts; Benjamin A. Carreras, David E. Newman, Ian Dobson, and A. Bruce Poole