EXPECTATIONS FOR LOSS OF SUPPLY IN THE NEW ZEALAND POWER SYSTEM

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In New Zealand Transpower is the owner and operator of the country's high-voltage electricity transmission grid. This grid links the generators to distribution companies and the major industrial users. The core operating services are the management of the system security, energy scheduling and dispatch.

The problem presented to the group was the examination and analysis of New Zealand blackout data. Analysis of similar data from US indicates that the frequency of large blackouts is much greater than one might expect from the frequency of small blackouts. The data seems to indicate that the frequency of blackout follow a power law so that the probability of a blackout is proportional to its magnitude raised to some constant exponent. The implication of this is that the loss of supply has a finite but large mean which is significantly affected by extreme events.

On transmission investment, there are `reliability investments' which are carried out so that given grid reliability standards are met, and `economic investments' which are not necessary to meet reliability standards but make sense from an economic point of view by reducing losses or increasing reliability. The test for the latter is a net benefit test called the Grid Investment Test.

The Grid Investment Test estimates reliability by an expected probability multiplied by expected consequences in terms of lost energy, such as megawatt-minutes for whatever scenario that is being considered. The problem is that it is only practical to consider a few scenarios, so the `tail' of the probability distribution is being ignored. If the distribution follows a power law, the tail can have a very significant impact. Thus, the issue is how we should calculate the expected loss of supply accurately.

The problem is that we have to calculate the probability of large events from a data set of events none of which are large. Thus, somehow we must extrapolate in order to get a good estimate of this probability.

Transpower set the following tasks for the group:

- Review the work conducted by Transpower in analysing New Zealand blackout data to confirm that the underlying distribution is a power law distribution.

- Second, there is an upper bound on the size of an event, whereas there is no upper bound on the mathematics of the power law distribution itself. Thus, for practical use the distribution will not be a pure power law but rather a truncated power law distribution. Transpower can estimate the upper bound.

- Third, and perhaps most critically, the degree to which the statistics of a small sample of data (whether historical data, or forward-looking scenarios) are affected by an assumption that they form part of an underlying power law distribution.

The group started with the analysis of the data set supplied by Transpower. The data set is plotted as event size against rank, on a log-log scale, showing an almost linear tail. The focus of this research is the events in this tail and so the study is constrained to event sizes greater than 100 MWmin. A number of different models are considered to fit this data. The simplest model is an unlimited power law which constitutes fitting a straight line to the data. However, this may not be the most appropriate as while the tail is almost linear it is not entirely linear and seems to droop downwards towards the end of the tail. Also, there is an inherent maximum power outage that can occur which will not be taken into account if an unlimited power law model is fitted. Hence, a number of other models are considered, in particular, a lognormal and a truncated power law (with both power mass truncation and resampling truncation). Expected values were determined using all of the models with the unlimited power law giving the most pessimistic results.

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