Compliance with Probabilistic Planning Criteria

WeatheRate provides the opportunity for a Network Service Provider to quantify compliance with probabilistic planning criteria. As a result, you can accurately calibrate capital expenditure with probabilistic planning 'needs dates'.

Application of Planning Criteria

Network service providers apply various criteria and standards when planning and designing developments within the power system. The primary objective of this analysis is to ensure that load is secured to an appropriate level of risk. For instance, the 'Design, Reliability and Performance Licence Conditions' [1] are applied in New South Wales to provide specific planning criteria for distribution network service providers. Among other requirements, this document stipulates that the forecast demand of a zone substation or overhead feeder network may exceed the N-1 capacity for up to 1% of the year following the failure of a single critical element *(N-1 conditions)* in systems that supply more than 10MVA. This correlates with a total aggregate time of 88 hours per annum if the peak load does not exceed the N-1 capacity by more than 20%. These licence conditions also stipulate that NSW distributors must be as compliant as practicable by 1 July 2014 and fully compliant by 1 July 2019.

Using Local Weather Measurements

The Transmission Network Design and Reliability Standard for NSW [2] stipulate that Transmission Network Service Providers (TNSP's) "*shall install ambient condition monitors on critical transmission lines to enable the application of real-time line conductor ratings*".

This is an important requirement for network planning and operations. Monitoring provides an opportunity to maximise operational flexibility while also allowing for an assessment of the asset utilisation for planning purposes.

Sub-transmission Feeder Compliance

Consider a hypothetical 33kV sub-transmission system which supplies a summer-peaking 33/11kV zone substation. The peak demand of this substation is 50MVA, while the substation demand also marginally exceeds 42MVA for more than 88 hours in the year (1% load duration). The firm sub-transmission capacity is thermally restricted by statutory clearances to 42MVA on both feeders by the use of twin 19/3.25 AAC conductors with a design temperature of 75 °C. Consequently, load would either need to be transferred to a neighbouring zone substation or a capital project initiated to increase the sub-transmission capacity.

In order to comply with the planning criteria, Network Service Providers should calculate the portion of the substation load duration curve which is expected to exceed the rating of the overhead transmission line for more than 1% of the time.

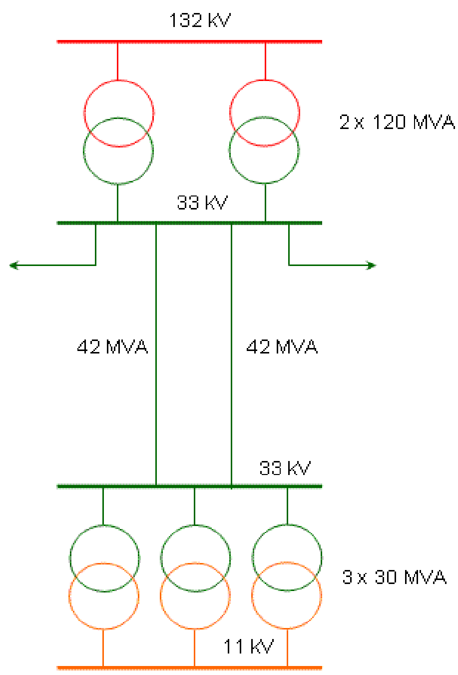

Figure 1 – Network topology supplying a 33/11kV zone substation

For example, Fig. 2 shows a load duration curve from a 33/11kV substation, where the peak demand has been projected to correspond with the load forecasts. In this case, the 1% load duration matches the documented summer rating of the transmission line (42MVA).

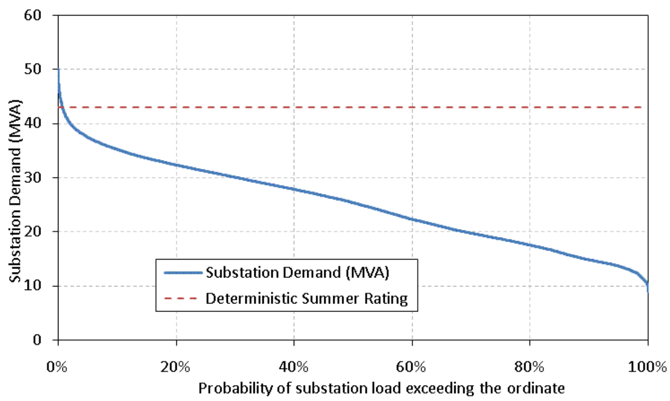

Figure 2 – Load duration curve of a 33/11kV substation

Calculation of Feeder Ratings

Deterministic feeder ratings are often calculated using IEC, IEEE, CIGRE or local standards. The application of each method incorporates a variety of assumptions, such as an assumed ambient temperature and a transverse wind speed, along with direct and indirect solar radiation, emissivity and absorptivity coefficients.

Some documents provide guidance on which parameters should be used in these calculations. For instance, CIGRE Technical Brochure 299 recommends a default "*effective wind speed of 0.6 m/s, an assumption of ambient temperature equal to the maximum annual value along the line route and a solar radiation of 1000 W/m with an assumed conductor absorptivity of no less than 0.8".* Nevertheless, this document also recognises that rating conditions in certain areas or locations can be more favourable and that the use of monitoring equipment and data analysis may be used to justify the application of higher ratings if more favourable conditions exist.

Weather-Based Line Ratings

An improvement in ratings can often be achieved when the network loads are high. For instance, Fig. 3 shows an annual distribution of ratings which could have been applied through the use of local monitoring equipment to measure wind speed and ambient temperature. In this case, the rating of these 33kV feeders could have exceeded 42MVA for more than 99.5% of the time.

It is also well known that there is a correlation between temperature and demand [3]. For instance, the relationship which can exist between wind speed and ambient temperature is shown in Fig. 4. Consequently, high summer demands are generally more likely to correspond with moderate wind speeds that act to cool the conductor and improve the ampere rating of the feeder.

Deferral of Capital Expenditure

In this example, weather data should be considered over the course of one calendar year. In many cases, this would show that the likelihood of the loading of the feeder under (N-1) conditions would exceed rating no more than 0.2% of the time.

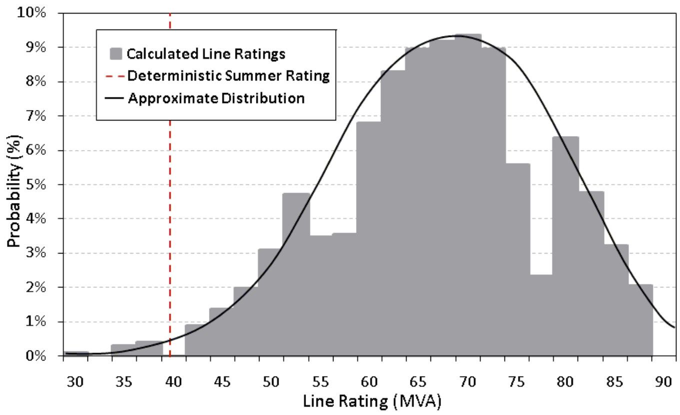

Figure 3 – Probability distribution of feeder ratings

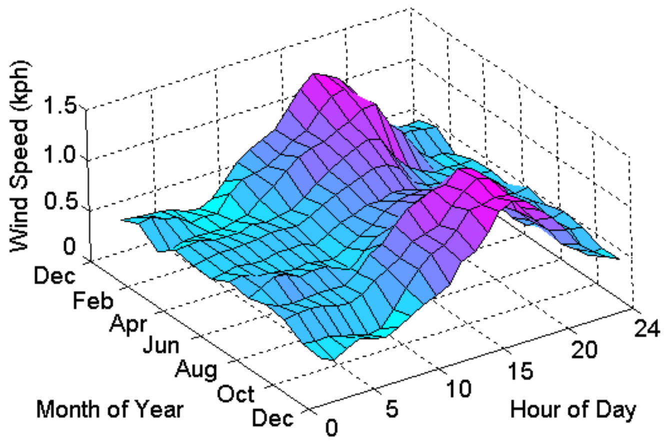

Figure 4 – Distribution of average wind speeds

Moreover, assuming the weather is indicative of future weather patterns and that the Load Factor does not increase, this substation demand could increase to more than 62MVA before the load is expected to exceed the firm sub-transmission capacity for more than 1% of the time (*refer to Fig. 2*).

Even higher substation loads can be accommodated with the inclusion of short-time ratings in the compliance assessment on the assumption that load can be transferred within 10 minutes of a contingency.

Consequently, the regular calculation of line ratings, in conjunction with probabilistic planning assessments can provide significant opportunities to defer capital expenditure in accordance with planning criteria.

Weathe*R*ate provides Network Service Providers with the opportunity to quantify their compliance with probabilistic planning criteria.

References

[1] "Design, Reliability and Performance Licence Conditions Imposed on Distribution Network Service Providers by the Minister for Energy and Utilities", 1 December 2007.

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[3] ESAA publication D(b)5:1988 - Current rating of bare overhead conductors.

[4] AS 3865:1991 "Calculation of the effects of short circuit currents"

[5] AS7000:2010 "Overhead Line Design"

[6] CIGRE Technical Brochure 425 "Increasing Capacity of Overhead Transmission Lines – Needs and Solutions", CIGRE JWG B2/C1.19, August 2010

[7] IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors Document Number: IEEE 738-2006 Institute of Electrical and Electronics Engineers 31-Jan-2007 ISBN: 0738152706

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[11] V.T. Morgan, "Effect of mixed convection on the external thermal resistance of single-core and multi-core bundled cables in air" IEE Proceedings C, Generation Transmission and Distribution, Mar 1992, Vol 139 Issue 2, pp 109 – 116