# The Need for Local Ultrasonic Wind Speed Measurements

Weathe*R*ate uses local weather measurements to provide specific information on asset ratings and network compliance. This also provides an opportunity to quantify the use of rating parameters, such as the wind speed during periods of high demand.

## Deterministic Rating Calculations

The rating of overhead circuits may be calculated using a variety of methods specified in international standards [2],[3],[4] or local working group papers [1],[5]. Each method incorporates a variety of assumptions, such as the effective transverse wind speed, the ambient temperature, along with the solar radiation, emissivity and absorptivity coefficients for the transmission line conductors.

There are several documents that provide guidance on which parameters should be used in these calculations. For instance, [6] recommends a default effective wind speed of 0.6 m/s, an ambient temperature equal to the maximum annual value along the line route and a solar radiation of 1000 Watts per metre with an assumed conductor absorptivity of no less than 0.8. Additional guidance is provided in [4], which provides information on the impact of altitude, different soil surfaces and the impact of conductor age and condition.

Individual distributors may also apply specific assumptions to assist in rating electrical overhead assets. For instance, [7] assumes a maximum design temperature of 75 degrees Celsius using a wind speed of 1.0 m/s in Sydney and 0.5 m/s in the Hunter Valley.

Other utilities have assumed a maximum operating temperature of 75 degrees Celsius with a transverse wind speed of 0.5 m/s in inland regions, while 1.0 m/s is used in coastal and mountainous regions. Many of these utility standards also provide assumed noon and midnight ambient temperatures which should be used in the absence of firm data to the contrary.

## The Use of Weather Bureau Data?

It is very tempting to purchase historical or even real-time wind speed measurements from the local Weather Bureau in order to validate these assumptions. However, this approach does not provide an accurate representation of the conditions affecting a transmission line.

For instance, Fig 1 shows the one-minute average wind speed measurements which are taken over a 24 hour period with an ultrasonic transducer. It also shows the corresponding measurements that were obtained from the Weather Bureau's measurement station, which was very close to the ultrasonic measurement location.

This clearly shows that the Weather Bureau measurements are generally optimistic; they fail to account for the short-time variability of the wind speed, and are often provided with significant latency.

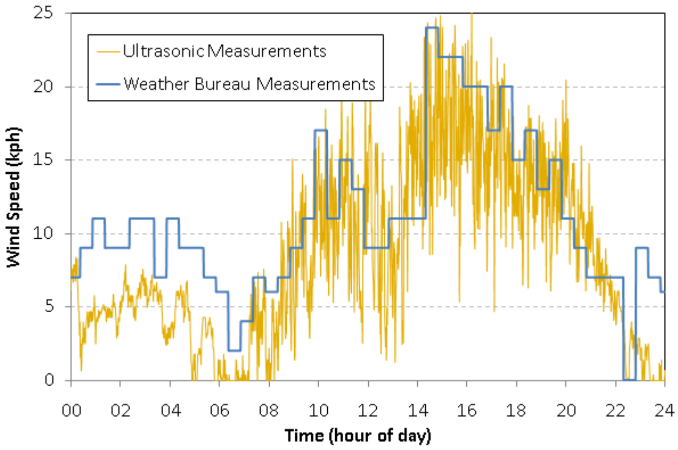


**Figure 1 – Comparison between ultrasonic wind speed measurements with nearby Weather Bureau measurements during a summer day.**

It is also noted that Weather Bureau sensors generally stall when the wind speed drops below around 0.5m/s. For comparison, most ultrasonic measurements have a tolerance of only 0.1m/s (0.36kph).

Such high resolution and high sampling rate measurements are very important when calculating conductor temperatures due to the significant cooling provided by only moderate wind speeds.

Fig. 2 demonstrates the issues associated with the use of standard Weather Bureau wind speed data. These Weather Bureau stations generally include anemometers which are intended to provide good resolution at high wind speeds, but also tend to stall at wind speeds that are of interest for line rating purposes. Consequently, it is necessary to use high resolution ultrasonic wind sped transducers when rating overhead conductors.

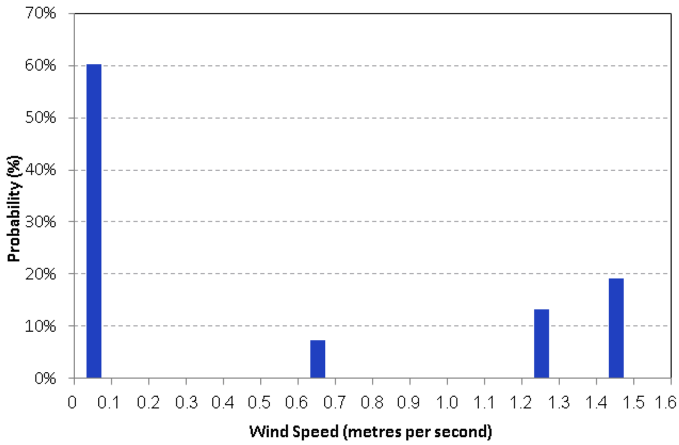


**Figure 2 – Histogram of wind speeds recorded by Weather Bureau measurements at a nearby airport over the course of six years.**

## Wind Speed Variability

The most restrictive line ratings apply during periods of low wind speeds. However, there is an interesting correlation between wind speed and ambient temperature, which often results in rating improvement on hot days.

Nevertheless, there is also a high variability in the wind direction when the wind speed is low, such that the wind almost behaves as a random parameter. Consequently, there is a common misconception that wind speed measurements cannot produce adequate line rating calculations since wind speeds are not uniform within a geographic region.

These arguments fail to consider the impact of the thermal inertia of the overhead conductors. The impact of this thermal inertia is commonly referred to as the conductor thermal time constant.

Interestingly the exponential constant is not actually a constant as the rate of rise or decay is primarily a function of wind speed and the conductor current. For instance, the effective time constant of a Neptune (AAC 19/3.25) conductor is approximately 8 minutes when loaded to its ampere rating with low wind speeds. Similarly, the effective time constant of a Mango (ACSR/GZ 54/7/3.0) conductor is approximately 15 minutes under the same conditions.

## Conductor Thermal Inertia

Due to the thermal inertia of overhead conductors, it is not possible to derive the conductor temperature or the conductor rating without considering historical wind speed and ambient temperature parameters.

Conductor tracking algorithms are an elegant solution to this problem. However, it is often difficult to visualise the impact of thermal inertia when analysing raw wind speed and ambient temperature data. For this reason, the following analysis considers the effects of averaging the recent wind speed.

Fig 3 shows the temperature of a Neptune (AAC 19/3.25) conductor, which has been accurately calculated from data obtained on a day with gusty winds. Similar calculations have been conducted using an average of the historical data to estimate the conductor temperature. This analysis reveals that the thermal inertia is analogous to the application of a 10 minute averaging filter on the wind parameters.

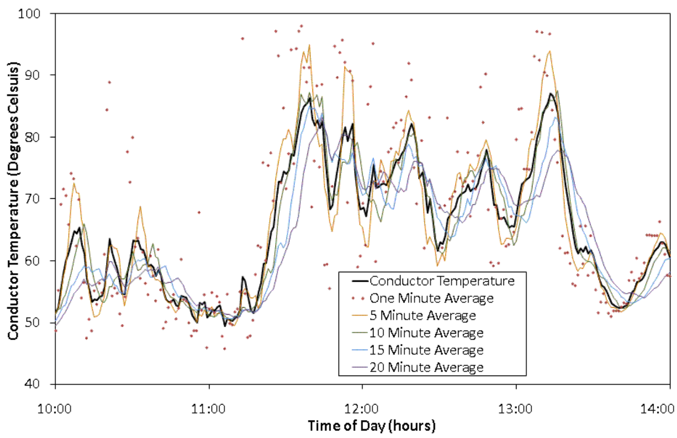


**Figure 3 – Comparison between the computed conductor temperature of Neptune (AAC 19/3.25) and estimates that are based on recent weather data averaging. These calculations include an assumed conductor current of 450A.**

Similar analysis in Fig. 4 reveals that a 17 minute average of recent wind speeds is approximately analogous to the impact of the thermal inertia for Mango (ACSR/GZ 54/7/3.0) conductors. It is for this reason, that several references, including [5], identify the need to apply an averaging routine to the input parameters.

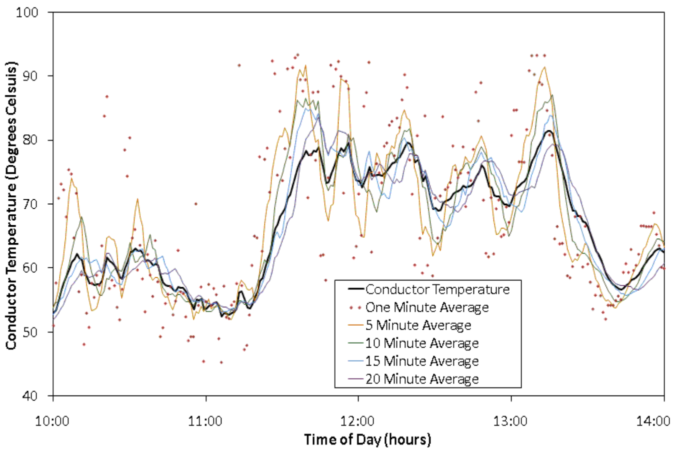


**Figure 4 – Comparison between the computed conductor temperature of Mango (ACSR/GZ 54/7/3.0) and estimates that are based on recent weather data averaging. These calculations include an assumed conductor current of 800A.**

This simple analysis has demonstrated that wind speed variability is readily accounted for by the thermal inertia of the conductor. Moreover, it is possible to apply wind speed measurements from zone substations to nearby transmission lines on the assumption that the average wind speeds will be similar at the substation and the line. Additional conservatism in wind speed magnitudes may be added by using a wind speed shielding factor, if required.

## Conductor Tension Measurements

Other line rating systems utilise conductor tension measurements as the key variable behind line rating calculations. The most notable drawback with these techniques is the inability to derive short-time ratings from tension data as the thermal inertia is a function of the local weather parameters.

It is also often argued that span parameter measurements provide greater accuracy as the conductor is being used as a local 'anemometer'. However, span tension or clearance measurements are often more geographically localised than equivalent substation weather measurements. For example, consider a study conducted using temperature measurements on four spans of a 6.4 km 115 kV transmission line [9]. It was concluded that no one span was consistently the hottest and that weather data from either end of the line could be used to provide a reasonable estimate of the actual dynamic thermal line rating distribution [9].

## The Need for Local Measurements

Consider a 132kV transmission line constructed with a single SCA Panther (30/7/3.00) phase conductors. This line is 15km long and supplies a substation load of approximately 100MVA.

Moreover, assume that weather stations are installed in both the sending and terminating substations. For this scenario, Fig 5 presents the observed wind speed at each location on a particular day during summer.

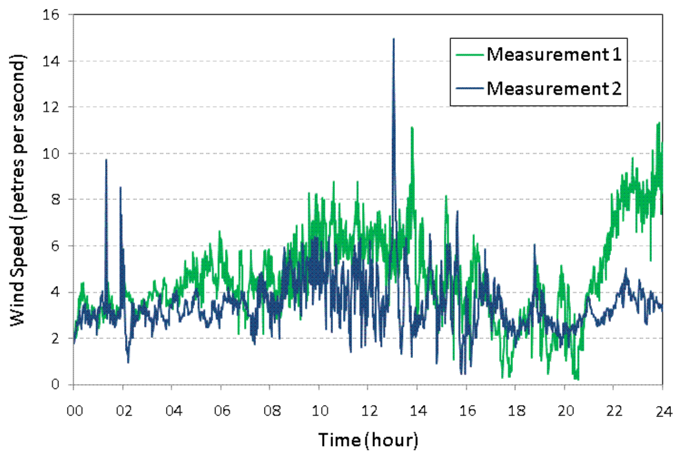


**Figure 5 – Wind speed measurements at each end of the transmission line (one-minute average values)**

By considering the corresponding ambient temperature, wind speed and wind direction at each measurement point, it is possible to calculate the effective line rating at each of the measurement locations. These effective conductor ratings are shown in Fig.6.

These results clearly show that there is a general correlation in ratings obtained from weather observations at each end of the line. By utilising the lowest ratings from each of the measurement locations, it is then possible to define continuous and short-time ratings for the circuit.

Increased accuracy can be obtained by installing additional weather monitoring stations at intermediate locations along the line route, such as nearby zone substations.

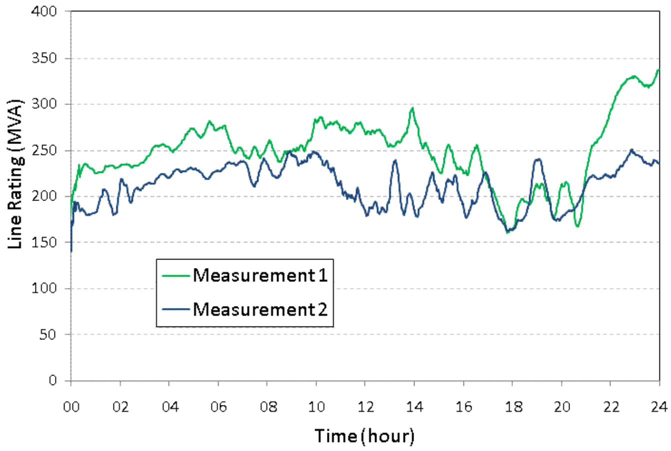


**Figure 6 – The calculated line ratings at each measurement location**

# References

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

[2] IEC Technical Report "Overhead electrical conductors – Calculation methods for stranded bare conductors" IEC/TR 61597:1995

[3] IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors, IEEE Std 738-2006 (Revision of IEEE Std 738-1993), Jan. 30, 2007

[4] R. Stephen, D. Douglass, M. Gaudry et al., "Thermal Behaviour Of Overhead Conductors", CIGRE Working Group 22.12, paper 207, 2002

[5] TNSP Co-operative Charter Plant Rating Working Group. (2009). TNSP Operational Line Ratings. [Online]. Available: http://www.aer.gov.au/

[6] "Guide for Selection of Weather Parameters for Bare Overhead Conductor Ratings", CIGRE Working Group B2.12, paper 299, 2006

[7] "Amendments to Ausgrid's Network Standard NS 0109, Design Standards for Overhead Developments, 1 February 1998", Network Standard Advice No. 1325 18/04/2004.

[8] P. M. Callahan, D. A. Douglass, "An experimental evaluation of a thermal line uprating by conductor temperature and weather monitoring," Power Delivery, IEEE Transactions on , vol.3, no.4, pp.1960-1967, Oct 1988