APPLICATION NOTE

KEEPING WIND FARMS SAFE

Effective earthing is essential for the safe operation of wind farms, but accurately measuring earth resistance at these locations presents multiple challenges. Ahmed El-Rasheed from Megger, explains how Megger and SSE are working together to address these.

When they are operating normally, the hazards wind farms pose to the general public are minuscule. But, like any other type of electrical installation, wind turbines can develop faults and these can, albeit very rarely, lead to large currents flowing in their earthing system. This will have been designed to take into account the local earth resistance at the site and can be expected to handle the fault currents safely provided that this resistance has not changed significantly.

If the earth resistance has significantly increased however, possibly due to a long spell of dry weather, faults can lead to hazards that could imperil members of the general public who happen to be in the vicinity. This is a particular concern in Scotland where "Right to Roam" legislation means that the public has almost unrestricted access to all areas of the countryside.

Two key issues related to wind farm faults are step voltage and touch voltage. Current flowing in the earth leads to a potential gradient at the surface of the earth. Because of this, anyone walking in the area affected will experience a potential difference – the step voltage – between their feet. A combination of high earth current due to a fault and unexpectedly high earth resistance can produce a step voltage large enough to cause a dangerous electric shock.

Touch voltage is similar, but relates to the voltage between an earthed object – for example, a metal fence surrounding a wind farm – and a person who touches it. Once again, this voltage results from current flow in the earth and its magnitude depends to a large extent on earth resistance.

Wind farm operators go to great lengths to eliminate these hazards. Before a wind farm is constructed, detailed earth resistance surveys are carried out and the earthing systems are designed, with the results of these surveys in mind, to deal with worst-case fault conditions. However, as has been mentioned, earth

resistance can change over time. To ensure that wind farm earthing systems remain safe and effective it is therefore, highly desirable to make regular measurements to confirm that the earth resistance has not increased significantly.

Unfortunately, such measurements are far from easy to make. While the wind turbines are operating, they produce electrical noise in the earth surrounding them, and this makes accurate earth resistance measurement difficult. The seemingly obvious solution of stopping the turbines while the measurements are being made is impractical, for operational reasons and also because of the high costs associated with shutting down a complete site.

Another problem relates to lead length. To deliver accurate results in wind farm applications, the fall-of-potential method of determining earth resistance must be used. This is a three-pole test – one connection is made to the earth bar of the turbine whose earth system is being tested, and a second to a temporary earth spike outside the sphere of influence of the earth system. In practice, this means at least 500 m away from the first connection. The third connection is made to another temporary earth spike, which is moved between the other two connections in 10% distance increments, with readings taken at each increment.

In order to make it easy to handle, the lead for the moveable spike is accommodated on a cable drum but, particularly when the spike is close to the turbine, the coil of the wire round the drum adds a considerable amount of inductance to the test circuit. Practical experience has shown that this can lead to measurements indicating that the earth resistance is lower than its true value – a situation that is potentially dangerous.

With all of these issues in mind, Megger and SSE, one of the UK's largest energy companies, have been carrying out trials with the primary aim of determining whether it is possible to make reliable earth resistance measurements on wind farm sites without taking the site out of service.

The trials were performed on a site in Scotland where 16 wind turbines are in operation. Measurements were made using Megger instruments and, for comparison purposes, non-Megger instruments. The first step was

to make measurements of the electrical noise present in the earthing systems at various locations around the site.

As expected, these tests revealed the presence of significant levels of noise, much of it concentrated around harmonics of the supply frequency. The Megger engineers were confident, however, that the noise would not affect the results delivered by the high-end earth resistance test sets in the Megger range, which are designed to provide accurate and repeatable measurements even in difficult conditions.

The results of the tests were illuminating. The measurements made with Megger's DET4 were unstable and consistently lower than those produced by the other Megger instruments used in the trial. This was not altogether unexpected. The DET4 is a cost-effective instrument that has proven itself to consistently meet the needs of users in "standard" applications. It was never intended for use in challenging locations such as in-service wind farms.

In contrast, the Megger DET2/3, a high performance instrument developed for use in even the most demanding conditions, delivered consistent and credible results in all of the tests. It was, in fact, the only instrument to do so – the non-Megger instruments in the trial performed no better than the DET4.

As further validation of the results produced by the DET2/3, these were compared with the historical earth resistance measurements made when the wind farm site was initially surveyed. Excellent agreement was found in every case, confirming that the DET2/3 can be relied upon for measuring earth resistance in wind farm installations, even while the turbines are in service.

There is, however, one caveat. For this initial trial, SSE and Megger elected to carry out measurements on the earth systems associated with turbines around the edge of the site, largely because of the difficulty in achieving sufficient spacing for the test electrodes at the centre of the site, where the turbines are closer together. Work is ongoing to address this limitation.

In the meantime, both SSE and Megger consider the results produced to date to be of great value and significance, not least because it is unlikely that the centre of a wind farm site would be affected by conditions

so localised that they would materially change its earth resistance without this change being reflected, to some extent at least, by a change in the earth resistance of the peripheral areas of the site.

The joint trials carried out by Megger and SSE have shown that earth resistance measurement on an in-service wind farm is every bit as challenging as had been expected. Nevertheless, with commercial equipment that's readily available right now, it is possible to obtain accurate, reliable results, making routine periodic testing a realistic and financially viable option. Such testing has a major role to play in helping operators keep their wind farms safe, and to minimise risk to the public, even under fault conditions.

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