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Sheltering from Thunderstorms

An Evaluation of Lightning Locating Systems to Prevent Risk

Sheltering from Thunderstorms

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Wind farms are known to be particularly exposed during thunderstorms and workers on site are prone to lightning strikes. Thunderstorm warning systems are widely used to prevent lightning related accidents and are already employed in several sectors such as industry, utility networks, leisure activities, transport and civil protection. This article outlines how lightning locating systems can provide an early warning, taking into account the needs of the operators to be notified with a sufficient lead time to apply safety procedures.

Figure 1. A wind farm being hit by lightning (Santilly le vieux, France, image courtesy Xavier Delorme)

Weather forecasts allow risk to be evaluated, typically 24 hours in advance or more, but thunderstorms can be complex to predict. In particular, determining their coverage area and time evolution has proven difficult. Nevertheless, an accurate prediction can be obtained with nowcasting techniques, thanks to observation networks which detect lightning activity in real time.

Detecting Lightning Strikes

These networks appeared at the end of the 1980s and replaced human observers who were still registering the thunderstorm activity at this time. Composed of strategically located sensors, they allow countries to be covered. These lightning locating systems can detect lightning discharges as soon as they occur, tracking the typical electromagnetic signature of cloud-to-ground or cloud-to-cloud discharges.

All the cloud discharges emit radio signals over a wide frequency range. High current events radiate at the low frequency and very low frequency ranges. As the signal propagation is excellent in those frequency ranges, the event can be tracked from hundreds or even thousands of kilometres. A sensor will report the azimuth or bearing for each event. A minimum of three sensors is required to determine a location by using triangulation over a single site.

The principle of the 'time of arrival' can also be employed. This technique is based on the travel time of the radio signal. The technique requires more sensors to cover the same area but delivers a better location accuracy.

In the past ten years, some lightning locating systems which combine radiogoniometry and the time of arrival, have proven their ability to detect more than 95% of cloud-to-ground strikes, with a median location accu-

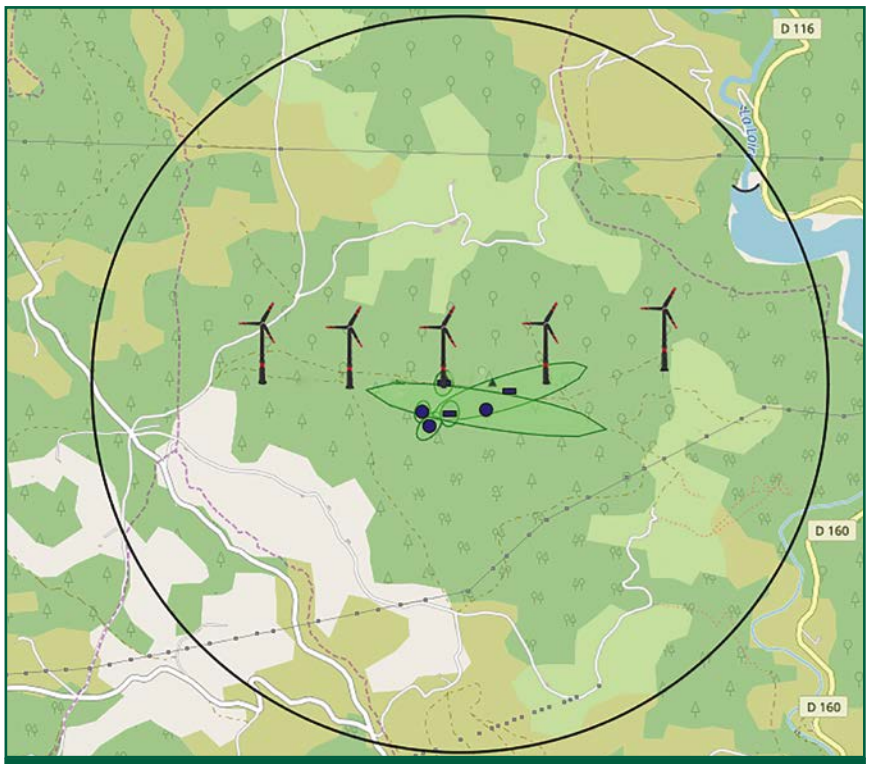

Figure 2. Localisation of lightning discharges on a wind farm

racy better than 100 metres. At this level of performance, it becomes possible to confirm whether a lightning strike has resulted in damage, and in some cases to correlate with the machine hit.

To Warn

Observing thunderstorms and modelling their behaviour in real time allows the anticipation of their arrival at a given location, typically up to one hour ahead. A monitoring area is created around a wind farm, and a warning is triggered as soon as a lightning flash occurs in this area.

In addition to the possibility of delivering an early warning, one of the other key benefits of this system is the ability to determine more efficiently than a human observer when it is possible to resume activity, limiting the idle time and the economic losses. It is thanks to the combination of these advantages (security of people and optimisation of operations) that this system is used by lots of multinational companies in domains such as energy, industry, and oil and gas. This type of service has been used for more than 25 years, and with a statistically significant dataset, Meteorage conducted a study to evaluate the efficiency of the early warnings.

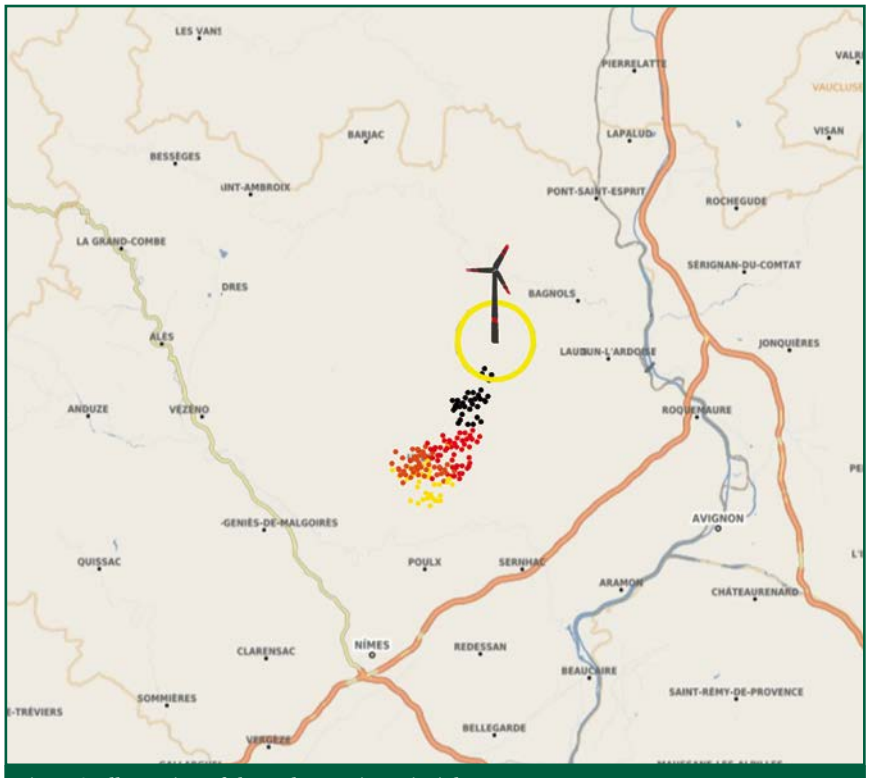

Figure 3. Illustration of the early warning principle

As each thunderstorm is unique and the lightning climatology varies from one location to another, especially at a continental scale, it was important to confirm the validity of the method used by lightning locating systems.

The company's goal was to verify whether lightning locating systems are able to provide the same efficiency to a worker operating in Portugal and a worker operating in Scotland, who both need warnings 20 minutes in advance to evacuate from the nacelle or the turbine.

Early Warning Performance

Meteorage randomly selected 140 wind farms currently in operation all over Western Europe and analysed more than 4,500 thunderstorms that produced lightning strikes in the immediate vicinity of the wind farms during a 10-year period (2007–2016).

The results show that the probability of detection of a thunderstorm before the occurrence of a cloud-to-ground flash in the vicinity of the wind farms was more than 96% for this period.

On average, only one thunderstorm episode every ten years per wind farm was unpredictable with this technology.

The company also calculated the time interval between the appearance of each thunderstorm in the monitoring area and the occurrence of a cloud-to-ground strike close to each wind farm. Here again, the statistical analysis revealed that 92% of these thunderstorms would have been predicted more than 20 minutes in advance, which is vital when a worker must go down from the nacelle or the turbine.

Although there was some variation, every country showed results above 93% in terms of probability of detection of a thunderstorm before its appearance on a windfarm.

Figure 4. Maps of random locations used for the current study

Sudden Thunderstorms?

Based on the 140 locations it analysed all over Western Europe, Meteorage considers that 'sudden thunderstorms' are rare.

Thunderstorms which develop overhead at a site without any precursor activity in the monitoring area represent less than 10% of the episodes without any significant variation related to location.

So, 90% of the thunderstorms affecting wind farms in Western Europe would have been predicted more than 20 minutes in advance.

Taking into account recent technological progress in terms of lightning detection and the deployment of new networks, the company believes it is reasonable to assume that this percentage will increase further

Conclusion

The performance complies with the IEC 61400-24 recommendations in terms of lightning protection on wind energy systems but above all clearly points out the fact that teams could be efficiently protected during construction and maintenance activities.

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