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Probability of lightning strikes to wind turbines in Europe during winter months

Gerhard Diendorfer

OVE Service GmbH, ALDIS, Vienna, Austria (g.diendorfer@ove.at)

Upward lightning triggered by elevated objects, such as wind turbines (WT), may increase significantly the number of lightning strikes to these objects. In the recently published 2nd edition of the international standard IEC 61400-24 an environmental factor C_{DWL} for winter lightning conditions was introduced to account for this additional lightning risk in the lightning exposure assessment of a WT. Values for C_{DWL} should be 4 (in medium winter lightning activity areas) or 6 (high activity areas) or even higher in special cases. The main challenge is to get reliable data about the winter lightning activity for a given region and for first estimates maps of winter lightning activity for the continents are given in IEC 62400-24, Annex B.

A different approach is used in this contribution. As there is already a high number of WT installed in Europe, we have investigated the number (percentage) of existing WT that was at least struck one time in the winter periods of 2017/18 and 2018/19 based on data of the EUCLID lightning location system.

We have extracted the locations of 10.225 WT sites in Europe in the area from 45°N - 50°N and 10°W - 30°E from OpenStreetMap database. Then we checked if there were any lightning strikes located by EUCLID within a 0.003° circular area (is about a 300 m radius) around each of these turbines during the cold season (October to April) in 2017/18 and 2018/2019, respectively. Out of the 10.225 WT 1.131 (11,1 %) and 913 (8,9 %) have been struck by lightning in cold season 2017/18 and 2018/19, respectively. It is worth noting, that only 101 WT (1%) were struck in both seasons, indicating that it is more a dependency on regional meteorological conditions changing from year to year, rather than on a specific group of WT. EUCLID detected flashes are likely to represent only about one half of the real occurring upward flashes from the WT. ICC_{Only} type upward lightning, which are discharges with current waveforms not followed by any return strokes are typically not detected by lightning location systems, and on instrumented towers this type of discharges makes up about 50% of all upward lightning. But there is a high chance, that a large fraction of this ICC_{Only} discharges were triggered by the same WT, where EUCLID detected some strokes.

In terms of dependency of the altitude of the WT site above sea level we observe a clear increase of probability of WT lightning with increasing altitude. About 10 % (29/315) of the 315 WT at altitudes up to 50 m ASL are struck by lightning increasing to almost 50 % (15/31) for WT at sites of 950 to 1000 m altitudes ASL. No clear trend is observed for higher altitudes, likely due to the low number of WT above 1000 m.

The obtained 10 % of the WTs triggering at least one upward lighting per cold season demonstrates the high probability of lightning to WT and emphasizes the need of proper protection of the WTs mechanical structure (rotor blades) as well as the entire electrical installation.