

Study Committee C4
POWER SYSTEM TECHNICAL PERFORMANCE
 Paper ID_10528

Lightning Performance Assessment of Japanese Medium-Voltage Overhead Distribution Lines Considering Regional Characteristics

K. Ishimoto¹, K. Michishita², T. Eguchi³, T. Sato⁴, H. Sugimoto⁵, Y. Kokubo⁶

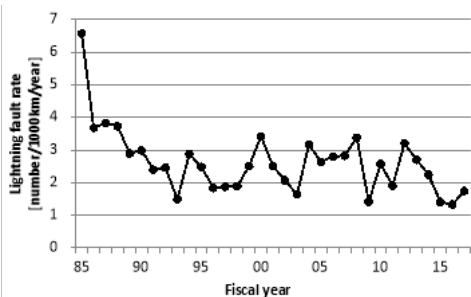
¹CRIEPI, ²Shizuoka University, ³Tokyo Electric Power Company HD, ⁴Tohoku Electric Power NW, ⁵Hokuriku Electric Power Company, ⁶Tokyo Kansai T&D

Motivation

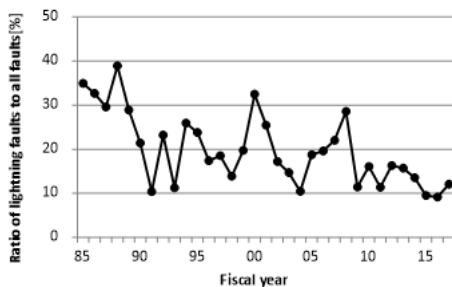
- Lightning faults on medium-voltage (MV) distribution lines can be classified into indirect and direct lightning. For achieving the cost-effective lightning protection measures, accurate assessing lightning performance in each region is important. To evaluate the validity of the existing lightning performance assessment method, comparing the expected annual number of lightning faults with the actual ones is important.
- In this work, the regional characteristics of lightning faults based on the field survey results are discussed. Next, an improved lightning performance assessment method is proposed considering the regional characteristics, and an example of comparison with the actual fault rate is illustrated.

Survey of lightning faults

- In Japanese MV distribution lines, in many cases, surge arresters are installed at constant intervals of 200m or less, and multipoint grounded overhead ground wires are also installed. As a result, while lightning faults accounted for approximately 30% of all faults in the late 1980s, this ratio has dropped to approximately 10% in the recent years.
- Field observation results show that direct flashes caused 83% of the faults, which suggests that direct lightning is the major cause of line faults. Furthermore, 48% of all direct events resulted in faults, whereas only 3% of all indirect events resulted in faults.



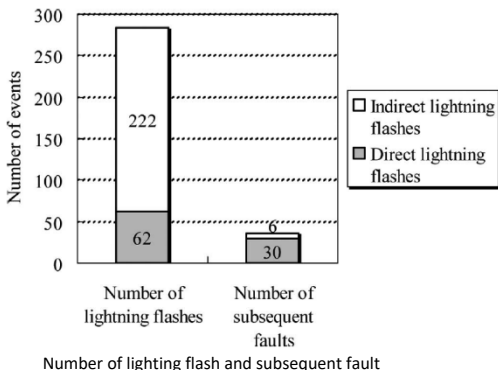
Failure rate of MV distribution line in Japan



Ratio of lightning faults to all faults



Direct lightning to distribution lines



These survey results suggest that importance of direct lightning performance assessment for these well-protected MV distribution lines.

Study Committee C4

POWER SYSTEM TECHNICAL PERFORMANCE

Paper ID_10528

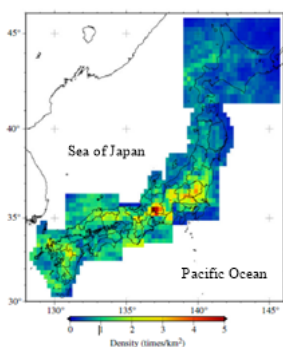
Lightning Performance Assessment of Japanese Medium-Voltage Overhead Distribution Lines Considering Regional Characteristics

K. Ishimoto¹, K. Michishita², T. Eguchi³, T. Sato⁴, H. Sugimoto⁵, Y. Kokubo⁶

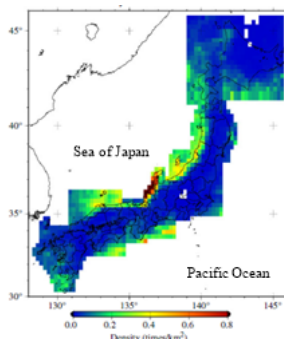
¹CRIEPI, ²Shizuoka University, ³Tokyo Electric Power Company HD, ⁴Tohoku Electric Power NW, ⁵Hokuriku Electric Power Company, ⁶Tokyo Kansai T&D

Lightning flash characteristics of each region

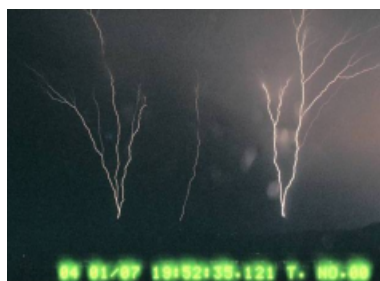
- In Japan, the distribution of lightning strike locations differs between summer and winter. Winter lightning has large charge transfer due to its long duration, and it frequently causes catastrophic lightning faults.



Ground flash density in summer



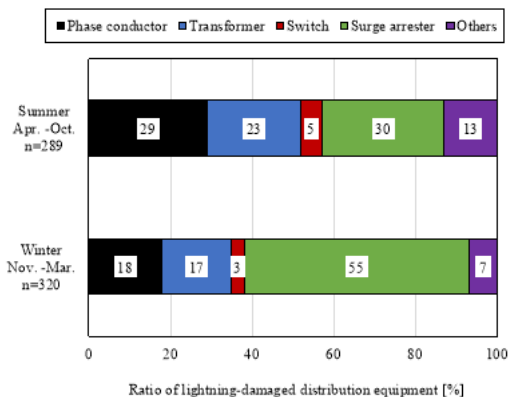
Ground flash density in winter



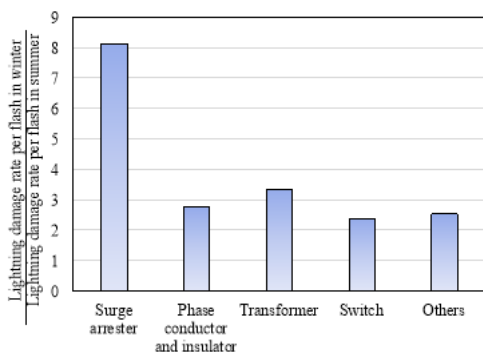
Typical winter lightning

Seasonal characteristics of lightning faults

- The ratio of lightning damage of surge arresters is higher in the winter than in the summer. The damage of surge arresters is caused by an excess of absorption energy, which is caused by the winter lightning with high amplitude current and long duration of the current waveform.
- In winter lightning area, the lightning damage rate per lightning flash for all distribution equipment in the winter period is three to four times higher than in summer. The difference in damage rate between summer and winter for surge arresters is especially large, which is about eight times higher. These results also suggest that surge arresters are vulnerable to burnout by high-energy winter lightning.



Seasonal ratio of lightning-damaged distribution equipment



Seasonal ratio of lightning-damaged distribution equipment

These results indicate that it is important to consider the lightning characteristics of each region in order to accurately assess lightning performance.

Study Committee C4
POWER SYSTEM TECHNICAL PERFORMANCE
 Paper ID_10528

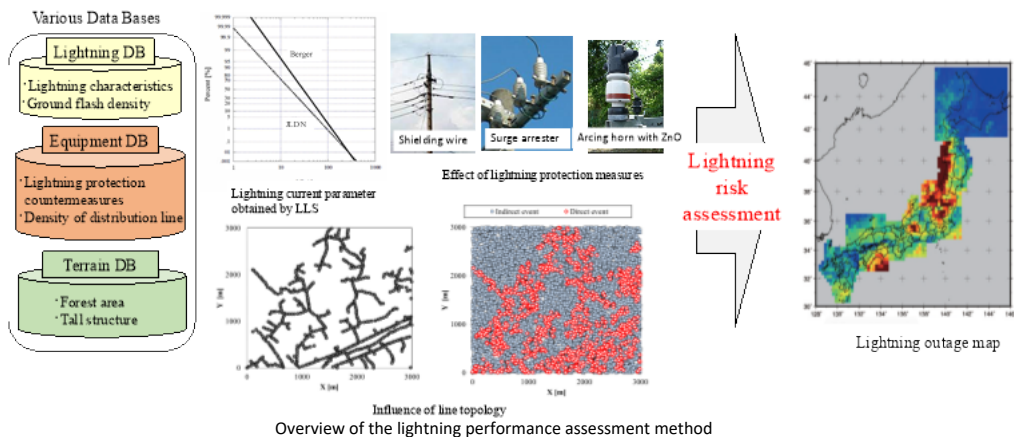
Lightning Performance Assessment of Japanese Medium-Voltage Overhead Distribution Lines Considering Regional Characteristics

K. Ishimoto¹, K. Michishita², T. Eguchi³, T. Sato⁴, H. Sugimoto⁵, Y. Kokubo⁶

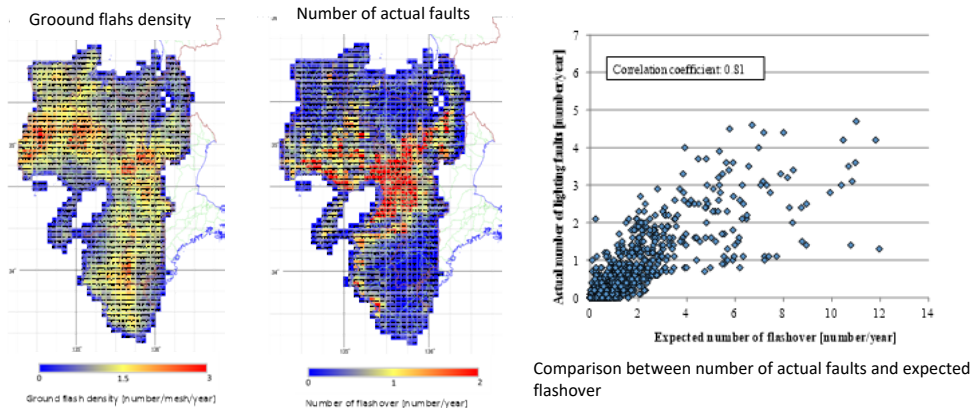
¹CRIEPI, ²Shizuoka University, ³Tokyo Electric Power Company HD, ⁴Tohoku Electric Power NW, ⁵Hokuriku Electric Power Company, ⁶Tokyo Kansai T&D

Lightning performance assessment considering regional characteristics

- Based on the survey results, we assessed flashover rate due to the direct event by means of EMTF. For accurate assessment, we proposed a method for evaluating the direct lightning performance considering regional characteristics. The proposed method considers the following factors
 - ✓ Lightning characteristics – Obtained by lightning detection network
 - ✓ Topology of MV line and lightning protection countermeasures of each region obtained by equipment DB
 - ✓ Shielding effect of the structures around the MV distribution lines estimated by terrain DB



Example of lightning fault calculation in summer lightning area (about 30,000m²)



Conclusion

- The results of a long-term field survey revealed that the lightning faults associated with indirect lightning are less frequent, and thus, we should focus on direct lightning to improve the lightning performance in Japanese MV distribution lines.
- Based on these survey results, we also proposed an assessment method for evaluating the direct lightning performance considering regional characteristics. The proposed method can well estimate the trend of the lightning outages rates for each region