CIGRE PARIS 2022

Study Committee B1

Insulated Cables

10512_2022

Lightning strikes to ground affecting underground power cables

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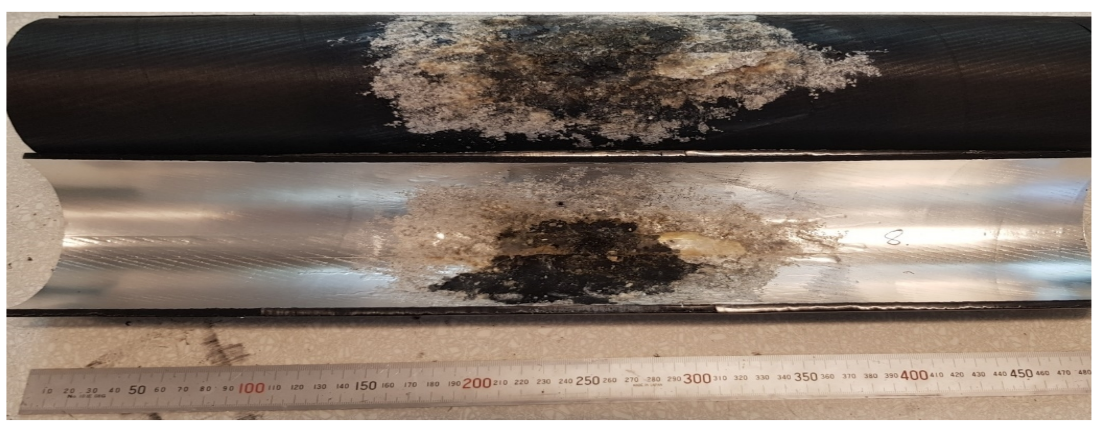
Motivation

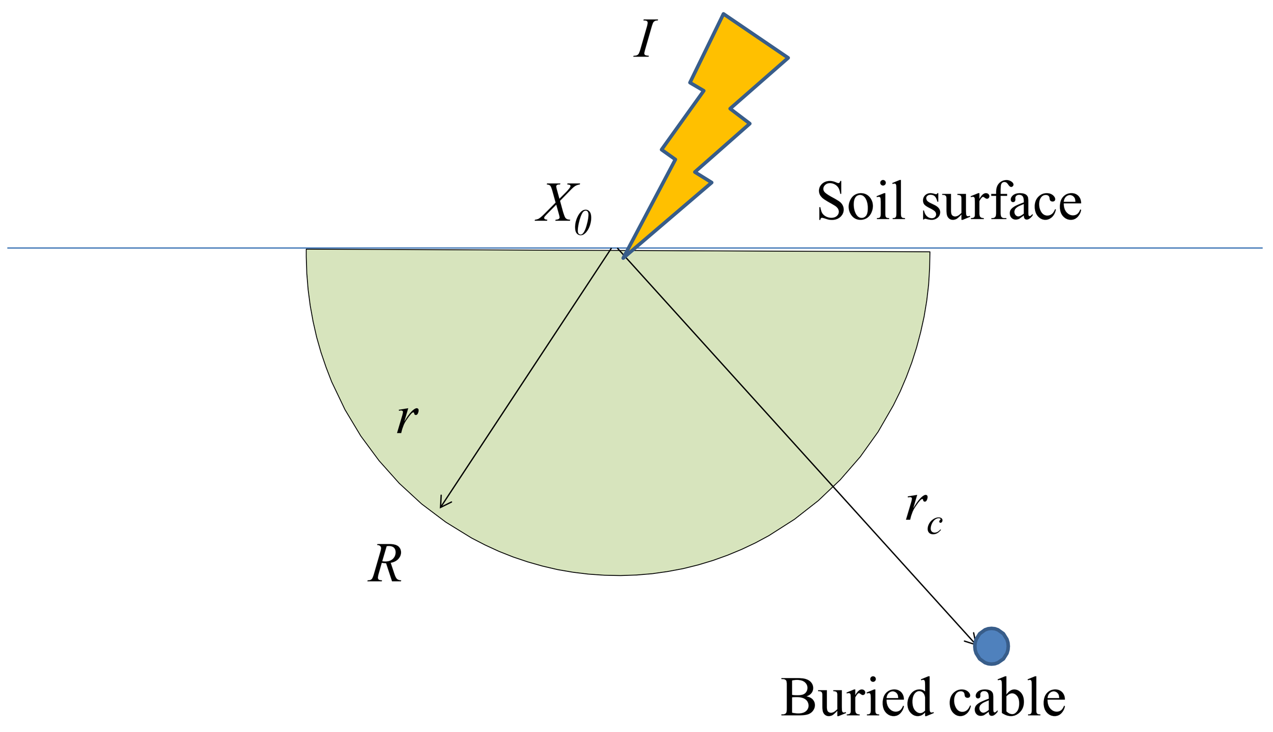
- Multiple cable sheath damages were discovered in underground HV cable systems



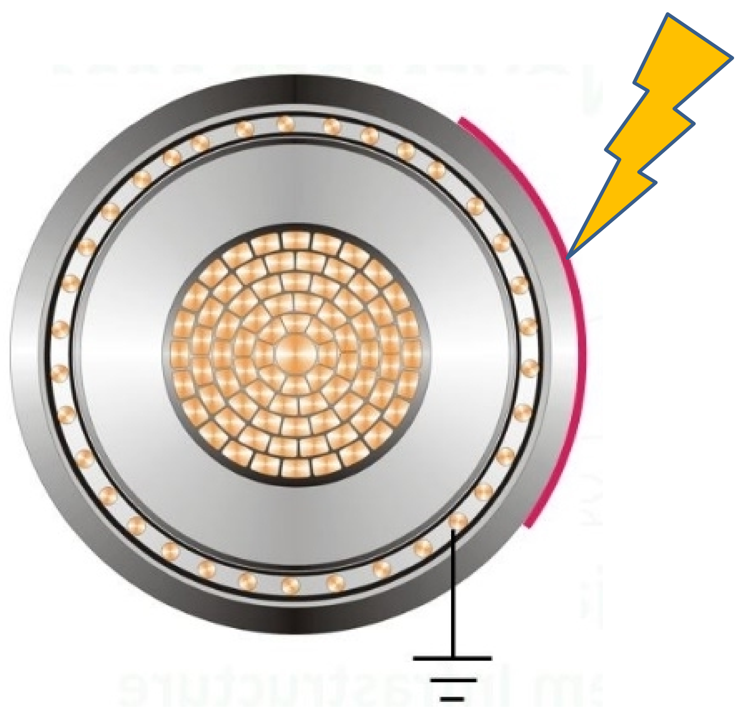
- Root cause: Lightning flash into ground nearby
- Is this a problem?

Mechanism of lightning impact

- A lightning strike into ground forms a hemispherical potential distribution in the soil



- The potential distribution hits the cable sheath with up to several hundred kV
- A breakdown may occur between the soil on high potential and the grounded screen, through the cable sheath



- The soil resistivity defines a corridor along the cable route in which a direct lightning impact can be dangerous for the cables.

Background

- 12 cable sheath damages were discovered in a system of underground HV cables close to each other (within 20 m distance)
- In some of the damage spots the aluminium foil of the screen was punctured/burned, and water/humidity was found inside
- No breakdown of the main insulation had occurred.

Goal of investigations

- Identify the mechanism of lightning impact on underground cable systems
- Estimate the probability of lightning strikes affecting underground cable systems
- Impact on the operational availability of cable systems
- Countermeasures.

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How often does this happen?

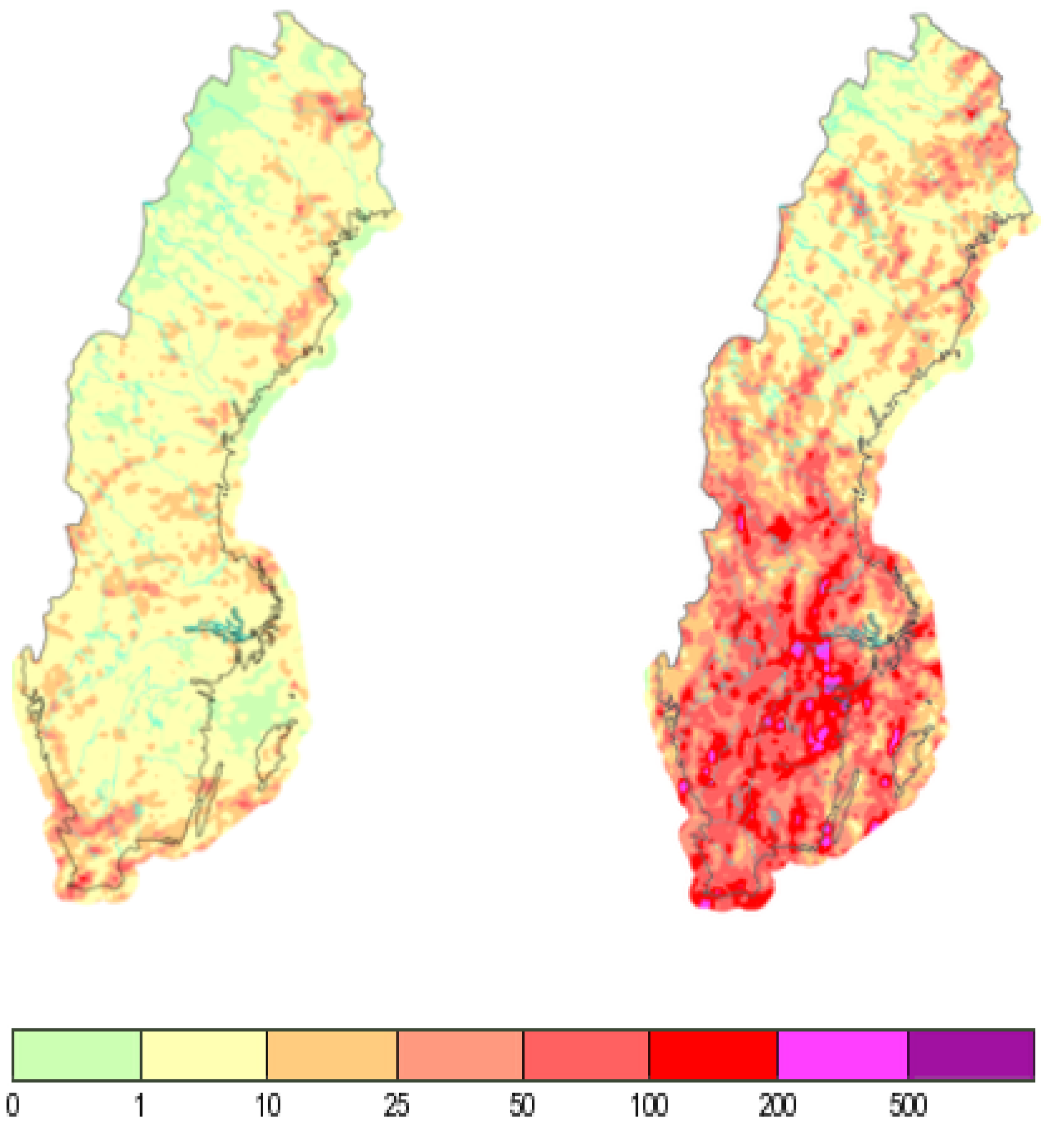
- Important information for the cable operator
- How will the cable availability be affected?
- Economic impact?
- Investments in countermeasures.

Input data for a probability assessment:

- Local value of electric soil resistivity in the cable route
- Local lightning strike frequency
- Statistical distribution of strike magnitude.

Number of strikes in Sweden 2017 (left) and 2019 (right), per year and 100 km^2

Source: www.smhi.se



Statistical assessment step by step

1. For each strike magnitude, define the width of the corridor where a strike can damage the cable system
   Note: this should be done space-resolved since the electrical resistivity may change along the cable route.
2. Find out how many strikes per year and area unit can be expected along the cable route
   Note: this should be done space-resolved.
3. Apply strike magnitude distribution information and find out, how many “dangerous” strikes can be expected in the corridor.
4. Sum up the number of “dangerous” strikes over all strike magnitudes.
5. As a result, you get the total number of dangerous strikes along the cable route.

Results

- Assumptions: 1 strike/yr.km^2
  soil resistivity $\rho_s = 500\ \Omega\text{m}$
- → $N = 2.4$ possibly dangerous strikes per year in a cable route of 100 km
- This can critically affect the availability of the cable system.

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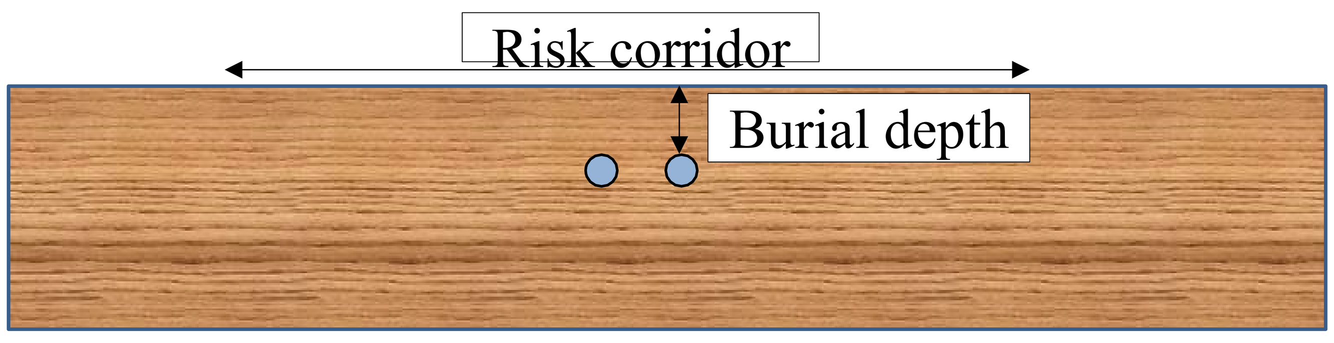
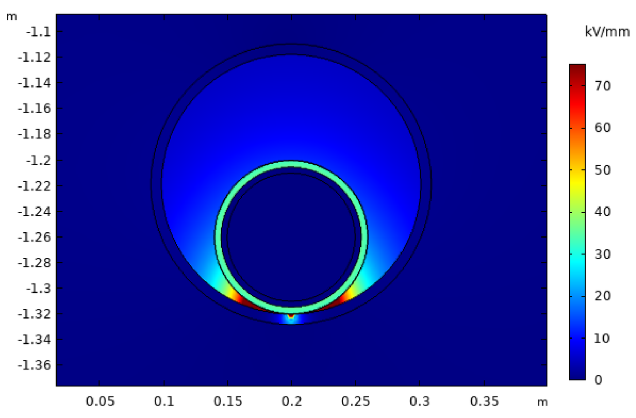
Mitigation

- Thicker cable sheath
  → slightly reduced *N*
- Backfill with lower electrical resistivity
  → helps little but the resistivity of the surrounding native soil is much more important
- Larger burial depth



→ does not reduce the width of the risk corridor substantially

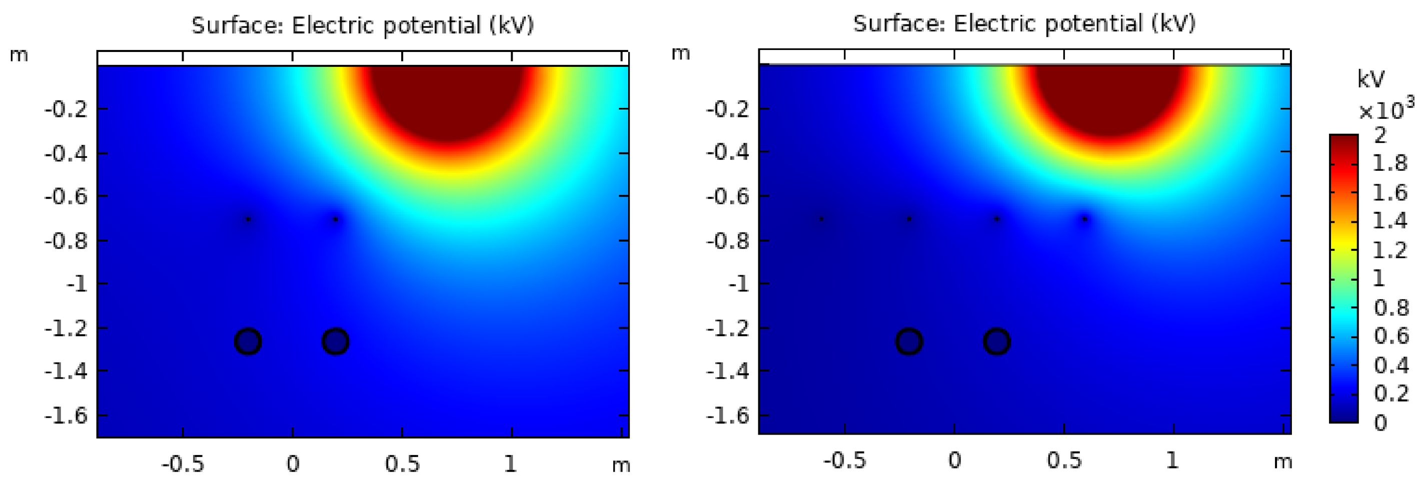
- Cable rerouting into shielded areas (cities, forests, deep valleys)
  → probably way too expensive.
- Cables installed in plastic ducts



→ Unclear result due to high field concentration in the gap between cable sheath and plastic pipe.

Shield wires

- Bare copper wires laid above the power cables



The picture shows the influence of 2 or 4 shield wires over a pair of HVDC cables.

Conclusion

- Direct lightning strikes into the ground can impact the cable system availability dramatically
- Of all considered countermeasures, only the installation of shield wires seem to provide a substantial improvement
- The usefulness of shield wires can vary strongly under different basic assumptions.

Reduction of risk exposure by shield wires (Assumptions as before)

Configuration	No of expected dangerous strikes	Risk reduction
Pair of cables, no shield wires	*N* = 2.4 strikes/yr.100 km	-
Pair of cables, two shield wires	*N* = 0.83 strikes/yr.100 km	65 %
Pair of cables, four shield wires	*N* = 0.51 strikes/yr.100 km	78 %