CEATI

Optimal Placement of Anti-Cascading Structures in Overhead Line Design

Overview

Equipment failure can release a lot of energy and produce large dynamic loads on a structure. The dynamic secondary loads can far exceed the structure's capacity, triggering a catastrophic failure event in the system that extends beyond the location of the initial failure point.

Since the dynamic load effects usually are not considered, the post-elastic response and the force distribution are often unknown. This report presents a systematic methodology for determining the containment loads on the surviving structure after a cascade and the optimum location of an anti-cascade structure that can resist these loads after a cascade event.

Overhead Transmission Design Interest Group

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How to use this research

This report guides a better understanding of cascade phenomena, mechanisms, and various failure modes of overhead lines. In addition, this guide includes the determination of the containment loads on the surviving structure after a cascade.

- Personnel will be able to secure an optimal placement of an anti-cascade structure
- They will also be able to practice mitigation techniques effectively and allocate funds and resources as needed
- Overhead line design engineers in the design of HV and EHV transmission lines will be able to provide a better line security

Key questions Addressed

- What are the gaps of the current standards concerning the optimum placement of containment structures?
- How does one determine the containment loads – approximate versus numerical models?
- How does one select the optimum spacing of a containment structure?
- What are the key parameters that influence the optimum placement of containment structure?
- How does one use the methodology of optimum placement of containment structure in a real-life example problem?

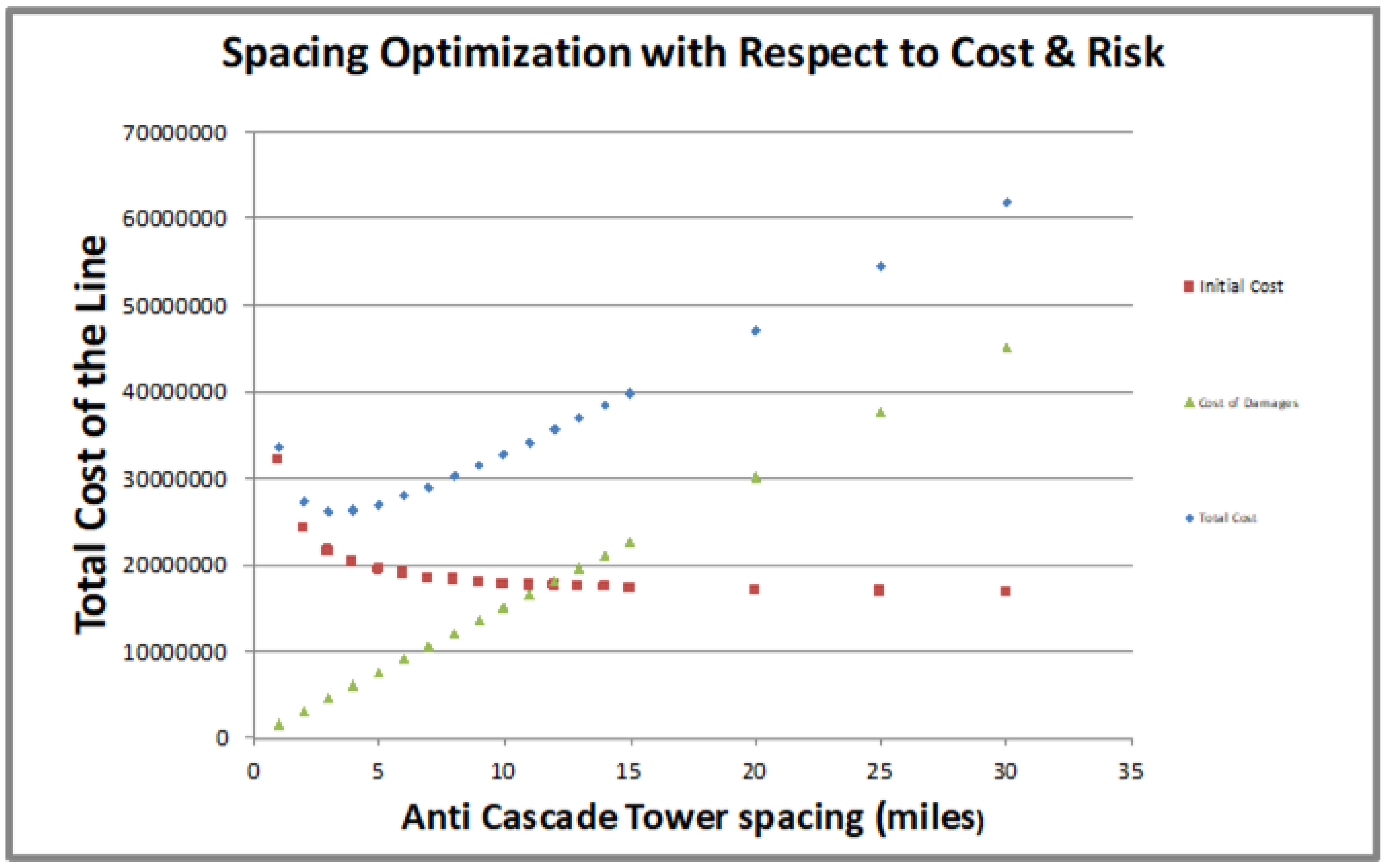
Research Summary

This report presents a systematic methodology for determining not only the containment loads on the surviving structure after a cascade but also the optimum location of an anti-cascade structure that will be able to resist these loads after a cascade event.

The methodology is based on balancing the initial cost of a line, including the costs of anti-cascade structures, against the future costs of losses due to cascade failure. This includes the expected costs of replacement of the failed section of the line and the expected energy not supplied. It is also based on the annual probability of failure of a line cascade and the estimation of the number of towers that may fail within a segment during a cascade event.

The expected number of tower failures is determined based on a triangular distribution. Additionally, the results from an optimization model, which include a sensitivity study that identifies the impact of key parameters on the selection of optimum spacing of anti-cascade structures, are presented. The results from the model runs show that the optimum spacing is most influenced by the recovery rate parameter after a failure, followed by the annual probability of line failure and the maximum power that needs to be transferred. A cost benefit study of an existing line, which is intended to reduce cascade risk, is presented.

The methodology developed from this study explores how a rational decision can be made on whether the mitigation should be to upgrade an existing suspension tower to a containment structure to withstand increased longitudinal loads, or to install new anti-cascade towers at optimum spacing intervals. Results of the analysis show that both options are feasible and costs can be justified, although the upgrading option is significantly less costly. The report also presents information on cascade and failure mode identification, current industry practices, and a review of various design standards and specific case studies on cascade failures. Finally, the report presents a literature review on various mitigation strategies that use anti-cascade devices to reduce the likelihood of a cascade.



Optimum Spacing of Anti-Cascade Tower

About CEATI Research

CEATI facilitates the planning and implementation of collaborative R&D projects among its electric utility members. This approach enables members to solve shared challenges and maximize their return on investment.

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