Engineering Risk Analysis Group
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MSc thesis

Propagation of Multi-hazard Damages in Interdependent Lifeline Systems in the Valparaíso Region, Chile

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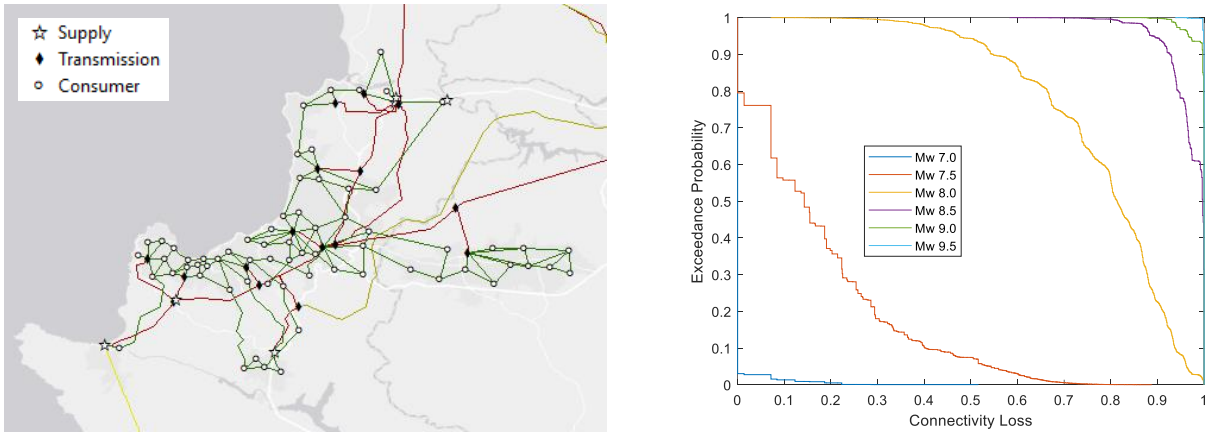
Background

Lifeline systems grow continuously in size, complexity and interconnectedness, which can significantly impact their reliability. Improving the understanding of interdependencies and analyzing their impacts pose significant challenges. Damages in interdependent electric power and potable water systems in Valparaíso, Chile, were assessed under the effects of seismic and tsunami hazards. The adopted approach extends an established method to account for the effects of multiple natural hazards and models their impacts on both the transmission and distribution level of the two networks.



Left: Detail of the Valparaíso power network (Basemap: Esri). Right: Exceedance probability of connectivity loss in the power network for hazard scenarios of increasing severity.

Methodology

The evolution of damages is studied using the network-based approach of the Interdependent Fragility Assessment algorithm. The interaction between the hazards is characterized as independent conditional on their common trigger factors. The method accounts for the direct impact of the two hazards, with the help of fragility functions, as well as for damage propagation within and between the individual networks. The response of each network under perturbation is evaluated in terms of two performance measures: connectivity loss and impact on population.

Conclusion

The networks' vulnerabilities are severely influenced by the exposure and fragility of their components to the respective hazard intensities. As a result, the power network exhibits a higher vulnerability than the water network to increasingly severe hazard events. Failures from the direct hazards reflect similarly in connectivity loss and population impact in the water network. In contrast, reductions in power network connectivity do not equally affect its consumers. Furthermore, interdependence effects play only a minor role in the overall vulnerability of the water network for the investigated hazard scenarios.

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