OPTIMAL POST-DISASTER RESTORATION OF POWER NETWORKS IN PUERTO RICO

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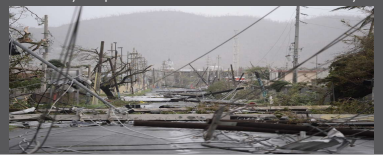
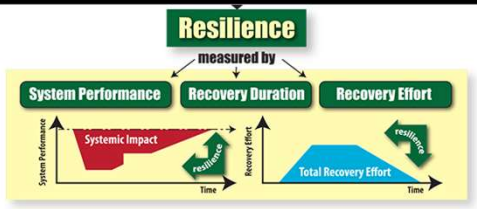
Background & Objectives

Disasters such as hurricanes cause huge losses in terms of both physical assets and lives and a significant portion of the adversarial effects is due to failure in infrastructure systems such as power and water networks. In this research, we study the issue of optimal recovery of power networks with a case study in Puerto Rico using mathematical optimization models.

Challenges in this research are as follows:

- The water network and its interdependence with power network should be modeled.
- Joint restoration of coupled water-power network should be considered
- Societal impacts of natural disasters in communities should be considered.





Approach

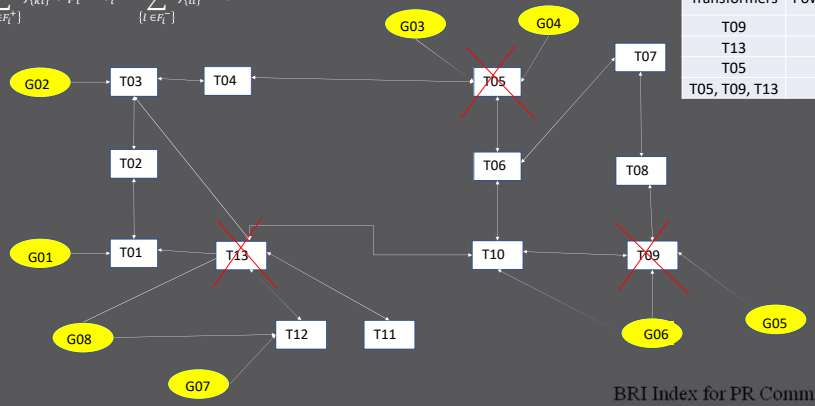
Network flow models to mimic behavior of power networks after disaster

$$\sum_{\{k \in F_i^+\}} f_{(ki)}^t + p_i^t - s_i^t - \sum_{\{l \in F_i^-\}} f_{(il)}^t = 0$$

$$f_{ij}^t \le f_{ij}^{max}\, w_i^t$$

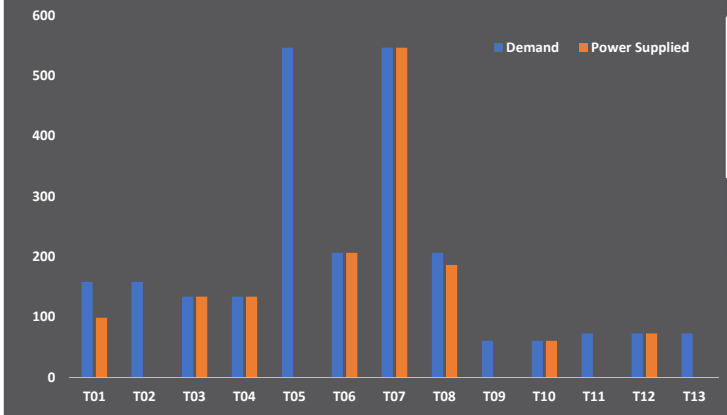
$$s_i^t \le d_i^t\, w_i^t$$

$$p_i^t \le p_i^{max}\, w_i^t$$

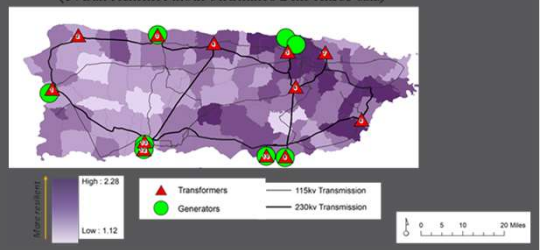


Failed Transformers	Supplied Power (MW)	Unmet Load (MW)	Figure of Merit
T09	2,368	61	97.49%
T13	2,283	146	93.99%
T05	1,882	547	77.48%
T05, T09, T13	1,438	991	59.20%

Sequence	Outage Cost (k$)
T05, T09, T13	53,694
T05, T13, T09	50,293
T09, T05, T13	81,805
T09,T13, T05	97,835
T13, T05, T09	66,323
T13, T09, T05	85,755



BRI Index for PR Communities
(Overall resilience index determined from census data)



Sequence	Outage Cost (k$)
T05, T09, T13	93,674
T05, T13, T09	87,347
T09, T05, T13	143,453
T09,T13, T05	172,760
T13, T05, T09	116,654
T13, T09, T05	152,287

Summary & Future Research

- Optimal restoration sequence can lead to huge savings in outage cost penalties. Thus, it is important to find the optimal restoration order using mathematical models.
- While for Puerto Rico case study, the inclusion of human factor did not change the rank of solutions, in general this is not the case.
- Higher resolution network in western Puerto Rico changed the dispatch values and the impact of failures. More detailed analysis using this higher resolution network topology seems promising.
- Extending methodology to model water network and its interconnection to power and joint restoration of coupled water-power network is another interesting direction for future research. This is specially as joint restoration of coupled power-water networks is not studied enough.
- Considering uncertainty in failures and the implication of this uncertainty is another promising extension. This specially true as in reality, the propagation of natural hazard and as a result the damages it causes to the network is
- Finally, analyzing the network and proposing topological changes to the network in order to increase its resiliency against disasters would an interesting direction for future research.

References

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3. [3] Government of Puerto Rico's http://www.gis.pr.gov/descargaGeodatos/Infraestructuras/Pages/Electricidad.aspx
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