Economic Planning and Response to Disruptions in the Electricity System

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I. OVERVIEW

Extreme disruptions to the electricity system, such as Superstorm Sandy and Hurricanes Florence and Michael highlight the need to understand the effect of these events on energy infrastructure, the resilience in the energy systems, and the interactions between the electricity system and the social behavior of people affected by the disruption, including potential displacement. This paper studies the planning and economic restoration of the electricity system after a disruption event, considering the interdependencies to the transportation system, and the priorities set by planners and policy makers in the system.

II. METHODS

Our model is a mixed integer programming model (MIP), calibrated with empirical data from past disasters. We extend pour previous work in the area (Sedzro, Lamadrid, and Zuluaga, 2018) to a stochastic formulation of the problem with different scenarios for the disruptions that the planner may experience. We use the topology from the electricity system as a base for the transportation system, finding the shortest path between nods where resources are available and nodes where recovery is required. In terms of obtaining empirical data to evaluate the validity of our proposed solutions, we offer two approaches: surveys and statistical estimation.

For the surveys, we use expert elicitation, collecting information from local governments, utilities and emergency responders regarding their past experience, and their actions and chain-of-command based on past disruption events. We also use a survey of households to capture their perception and internalization after their last experienced events. Our electrical restoration model maximizes the criticality-weighted load, subject to the constraints obtained from the expert's survey, resource constraints and the physical characteristics of the system, as well as contractual characteristics such as demand response agreements.

III. RESULTS

We present a sequence of results, with analysis of the sensitivity to distributed generation, mobile resources and demand response availability. Our results are calibrated with information from surveys. We measure the social welfare obtained in this transient restoration stage, as the sum of the demand restored considering its importance (e.g., critical loads such as hospitals and emergency management centers have a higher priority than warehouse restoration). Each successive model adds a single feature at a time, and achieves an increase in social welfare as expected, but some spatial tradeoffs are revealed that require in some instance the use of policy rules.

IV. CONCLUSIONS

This proposal uses the information from surveys to better understand the management of the restoration process after an exogenous disruption. We use economic measures to model how decision makers implement the restoration process of the electricity system, considering couplings to the transportation system, and suggest a model for the optimal management of this process, informed by the surveys collected. The application of this work include its use for a wide array of disruptions, particularly in developing countries where disturbances are more common, and provides a baseline for future models of other energy systems, e.g., the gas network.

NOTES

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REFERENCES

Sedzro, K.S.A., A.J. Lamadrid, and L.F. Zuluaga. 2018. "Allocation of Resources Using a Microgrid Formation Approach for Resilient Electric Grids." *IEEE Transactions on Power Systems* 33:2633–2643.