STOCHASTIC OPTIMIZATION OF DISTRIBUTED GENERATOR LOCATION AND SIZING IN AN ISLANDED UTILITY MICROGRID DURING A LARGE-SCALE GRID DISTURBANCE

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Overview

Natural disaster-prone locations can experience widespread power outages when the disasters cause large-scale damage to the existing power grid. Such damages can hinder a utility company's ability to provide power to essential public resources (e.g., hospitals, grocery stores, fire, police and gas stations) of the utility's serviced area. Backup generators, which provide power to these essential public resources during the outage, have limited capacities and can suffer from such failures as well. Microgrids, defined as localized power grids that can operate independent of the main grid, can help utilities provide disaster relief power supply to the essential public resources to improve their resiliency during the outage. This research investigates a multi-source capacitated facility location coverage problem (MS-CFLCP) that models a utility-owned microgrid that is operating independent of the main grid due to a large-scale main grid disturbance. The islanded microgrid is tasked with maximizing the power demand coverage of the of essential public resources in a city/town network during a prolonged outage caused by a disturbance to the main grid.

Methods

The developed MS-CFLCP optimizes the location, sizing, assignment and the number of distributed generators (DGs) within the utility-owned microgrid, and aims to minimize the following total costs of the microgrid: (1) investment costs; (2) operation and maintenance costs; (3) distance traveled for power supply costs; (4) the unmet demand penalty costs; and (5) excess DG penetration penalty costs. The MS-CFLCP is solved with two-stage stochastic programming, specifically with the use of the L-shaped method, while considering the uncertainty in DG power output and essential resource demand. A budget constraint is included to capture practical financial considerations of the utility company when establishing the microgrid.

Results

We apply the model to a case study, using solar/photovoltaic-based DGs, to show its effectiveness and benefit to utilities. Results show that, given a $15 million budget, a utility can optimally implement and operate an islanded microgrid which can provide up to 71% demand coverage each hour between 6am and 6pm for a city/town network of essential public resources. Results also show that incorporating penalty costs for unmet demand and excess renewable penetration help the microgrid maximize it's demand coverage while also limiting the amounts of utility-scale reverse power flow into the grid from excess renewable penetration.

Conclusions

We conclude that the model developed in this research can adequately assist utilities in modelling the economics and reliability of microgrids. The flexibility of the model allows the utility to design the microgrid according to utility's budget limitations and according to the size of network the utility services.

References

See References section of paper.