Optimal Network Islanding & Restoration

The power systems are usually subject to disturbances which may lead to loss of synchronization between groups of generators and possibly blackouts. The system islanding refers to the condition in which some areas of the transmission or distribution system are disconnected from the main grid however the power supply continues in that region by local generating facilities. It may automatically happen after some transmission lines are tripped by local relays [1] to isolate the faulted region. The role of system operator is to optimally maintain the balance between the generation and demand in each island. The main idea is to reduce the total amount of load shedding to maintain such a balance and avoiding the blackout. There are two types of islanding namely intentional and unplanned islanding as follows:

Intentional islanding

It is done to determine optimal splitting points (or called splitting strategies) to split the entire interconnected transmission network into islands ensuring generation/load balance and satisfaction of transmission capacity constraints when islanding operation of system is unavoidable [1]. It is considered as an emergency response for isolating failures that might propagate and lead to major disturbances [2].

[1] Kai Sun, Da-Zhong Zheng and Qiang Lu, "Splitting strategies for islanding operation of large-scale power systems using OBDD-based methods," in IEEE Transactions on Power Systems, vol. 18, no. 2, pp. 912-923, May 2003.

[2]. Pahwa, Sakshi, et al. "Optimal intentional islanding to enhance the robustness of power grid networks." Physica A: Statistical Mechanics and its Applications 392.17 (2013): 3741-3754.

Model: **DC-based islanding + AC-load shedding**

Class: MILP

Software: CPLEX + PSAT

[3] Trodden, P. A., et al. "MILP formulation for controlled islanding of power networks." International Journal of Electrical Power & Energy Systems 45.1 (2013): 501-508.

[4] Fan, Neng, et al. "A mixed integer programming approach for optimal power grid intentional islanding." Energy Systems 3.1 (2012): 77-93.

[5] Trodden, P. A., et al. "MILP formulation for controlled islanding of power networks." International Journal of Electrical Power & Energy Systems 45.1 (2013): 501-508.

Model: **Piecewise linear AC islanding**

Class: MILP

Software: CPLEX

[6] Trodden, P. A., Bukhsh W. A., Grothey A., McKinnon K. I. M. (2014): Optimization-based islanding of power networks using piecewise linear AC power flow. Power Systems, IEEE Transactions, 29, 1212-1220.

Unplanned islanding

This is an unplanned condition which should be avoided [7]. The islanding detection techniques are applied to reduce the risk of this event. This phenomena is due to line tripping, equipment failure, human errors and so on [8].

Morphology-based islanding detection

[7] M. A. Farhan and K. Shanti Swarup, "Mathematical morphology-based islanding detection for distributed generation," in IET Generation, Transmission & Distribution, vol. 10, no. 2, pp. 518-525, 2 4 2016.

[8] Li, Canbing, et al. "A review of islanding detection methods for microgrid."Renewable and Sustainable Energy Reviews 35 (2014): 211-220.

Optimal Network Restoration

The optimal network restoration is called to a class of actions taken by network operator to bring back the power system into its normal condition following a complete or partial collapse. Intentional system islanding can one of these actions.

Model: Robust restoration approach

Class: MIQCP

Software: CPLEX

[9] K. Chen, W. Wu, B. Zhang and H. Sun, "Robust Restoration Decision-Making Model for Distribution Networks Based on Information Gap Decision Theory," in IEEE Transactions on Smart Grid, vol. 6, no. 2, pp. 587-597, March 2015.

Class: MILP

Software: IBM ILOG CPLEX 12.5

[10] X. Chen; W. Wu; B. Zhang, "Robust Restoration Method for Active Distribution Networks," in IEEE Transactions on Power Systems , vol.PP, no.99, pp. 1-11

Mixed integer second-order cone programming problem

Modelled in AMPL

Software: CPLEX

[11] R. Romero, J. F. Franco, F. B. Leão, M. J. Rider and E. S. de Souza, "A New Mathematical Model for the Restoration Problem in Balanced Radial Distribution Systems," in IEEE Transactions on Power Systems, vol. 31, no. 2, pp. 1259-1268, March 2016.

Heuristic algorithms

A greedy algorithm

[12] Y. Xu, C. C. Liu, K. P. Schneider and D. T. Ton, "Placement of Remote-Controlled Switches to Enhance Distribution System Restoration Capability," in IEEE Transactions on Power Systems, vol. 31, no. 2, pp. 1139-1150, March 2016.

Particle Swarm Optimization

[13] L. Sun et al., "Optimisation model for power system restoration with support from electric vehicles employing battery swapping," in IET Generation, Transmission & Distribution, vol. 10, no. 3, pp. 771-779, 2 18 2016.

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