A Constrained Topological Decomposition Method for the Next-Generation Smart Grid

School of Graduate Studies
University of North Dakota

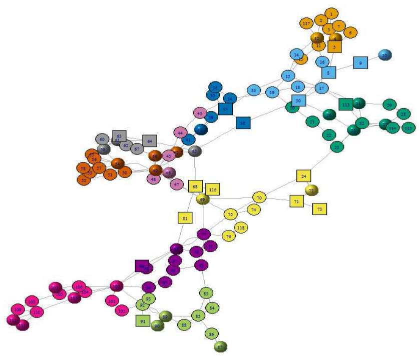
Arun Sukumaran Nair, Mitch Campion, Prakash Ranganathan

Electrical Engineering

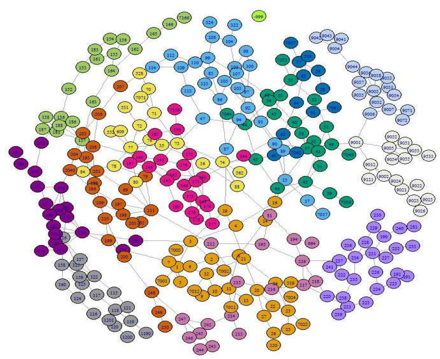
Introduction

Economic load dispatch (ELD) is often used to schedule and match the generator outputs to variable demands meeting system and transmission line requirements. Effective scheduling of generation sources is a key to significant savings on operating cost (e.g., fuel and transportation cost) and to enable appropriate demand response mechanisms. This work uses a two step process: 1) perform decomposition of a sample IEEE test grid, and 2) apply Linear programming techniques to solve the economic dispatch problem considering topological constraints. The next part of the research involves quantifying the uncertainty associated with renewable energy sources and to develop an economic dispatch model with modified constraints which takes into account these uncertainties

Grid Decomposition



IEEE 118 Bus system clustered using Girvan-Newman algorithm



IEEE 300 Bus system clustered using Girvan-Newman algorithm

Generation/Load ratio	L-GN	A-GN	NGGN
Maximum value (%)	198.61	277.08	124.48
Minimum value (%)	49.62	47.22	50.63

Generator/Load ratio of the IEEE 118-bus system clusters

	L-GN	A-GN	NGGN
Number of clusters	10	11	5
Generation Cost	\$9,074.86	\$9,137.03	\$9,148.06
Tie-line flow cost	\$262.871	\$87.725	\$36.45
Total Cost	\$9,337.73	\$9,224.76	\$9,184.51

Optimal Cost Analysis of 118 bus system clusters

Generation/Load ratio	L-GN	A-GN	NGGN
Maximum value (%)	616.61	616.61	411.86
Minimum value (%)	61.90	61.90	86.96

Generator/Load ratio of the IEEE 300-bus system clusters

	L-GN	A-GN	NGGN
Generation Cost	\$141,704	\$141,704	\$123,824
Number of clusters	22	14	8
Tie-line flow cost	\$233.089	\$233.089	\$163.361
Total Cost	\$141,937	\$141,937	\$123,988

Optimal Cost Analysis of 300 bus system clusters

Problem Formulation

Multi-Area Economic Dispatch (MAED) problem that minimizes the total cost, while satisfying load demand, generation, and line flow constraints.

Total cost of generation $F = \sum_{i=1}^{n_g} F_i(P_{Gi})$ $\qquad F_i(P_{Gi}) = a_i P_{Gi}^2 + b_i P_{Gi} + c_i$

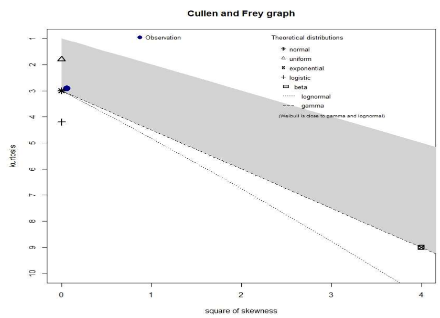
Objective function Min $F = \sum_{i=1}^{n_g} F_i(P_{Gi}) + \sum_{j=1}^{t} C_j T_j$

Constraints $P_{Gi_{\min}} \le P_{Gi} \le P_{Gi_{\max}} \quad i = 1 \ldots n_g$

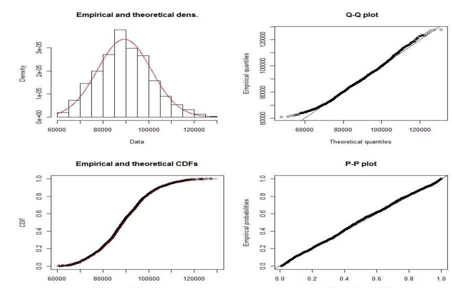
$$T_{mn_{\min}} \le T_{mn} \le T_{mn_{\max}}$$

$$\sum_{i=1}^{n_g} P_G = D \qquad \sum_{i=1}^{l_g} P_{Gi} + \sum_{k=1}^{m} T_k = D$$

PJM Load Data distribution fitting



Cullen and Frey graph



Normal distribution

Conclusion

The next generation smart grid requires an efficient method to divide the grid system in to smaller microgrids for better control and resource allocation. The research discussed the different clustering techniques and the economic dispatch on the obtained microgrids. The smart grids require a more efficient resource allocation mechanism in the presence of renewable energy sources, the future research will be focused on improving the constraints of the economic dispatch problem and to develop a novel method to quantify the uncertainty associated with renewable energy sources.

ACKNOWLEDGMENT

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