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

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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

System Decomposition (Randomized)

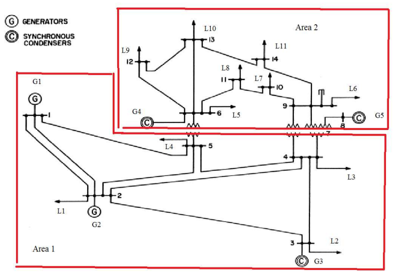


Fig. 1. Two Grid Decomposition Model.

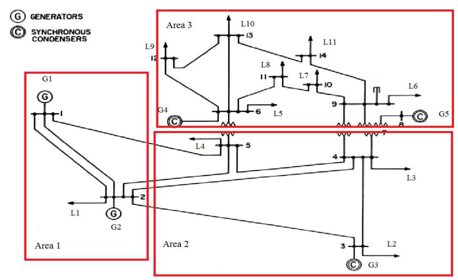
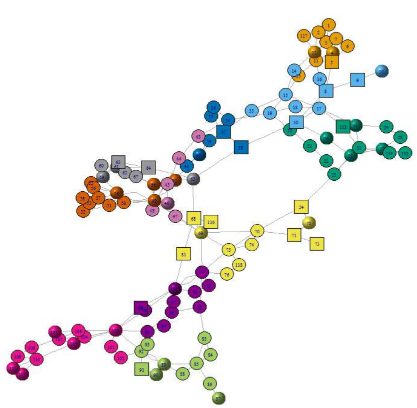
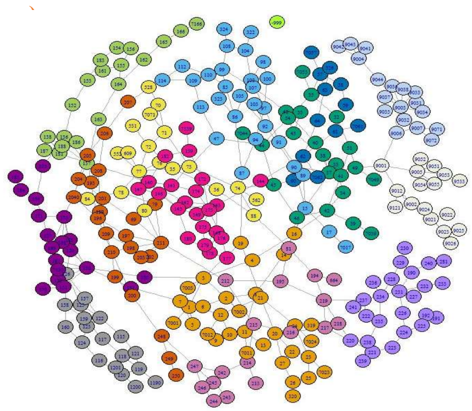


Fig. 2. Three Grid Decomposition Model

System Decompositions (Girvan-Newman algorithm)



IEEE 118 Bus system clustered using Girvan-Newman algorithm



IEEE 300 Bus system clustered using Girvan-Newman algorithm

Problem Formulation

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

$$F_i(P_{Gi}) = a_i P_{Gi}^{\ 2} + b_i P_{Gi} + c_i$$

Total cost of generation $\quad F = \sum_{i=1}^{n_g} F_i(P_{Gi})$

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

Constraints

$$P_{Gi_{\min}} \le P_{Gi} \le P_{Gi_{\max}} \qquad i = 1 \ldots . n_g$$

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

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

Preliminary Results: Decomposition Effects on Economic Dispatch

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

ACKNOWLEDGMENT

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