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Sandia National Laboratories

Accuracy of Clustering as a Method to Group Distribution Feeders by PV Hosting Capacity

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Background and Motivation to use Clustering

Utility Service Territory

Data for all distribution feeders (3000+)

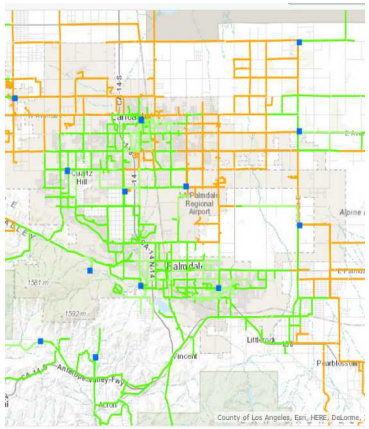
Cluster the feeders into groups (~30)

Identify representative feeder for each group

Detailed studies to determine hosting capacity for each representative feeder

Assign hosting capacity values to the rest of the feeders in each cluster to create a hosting capacity map for service territory

Hosting Capacity Map

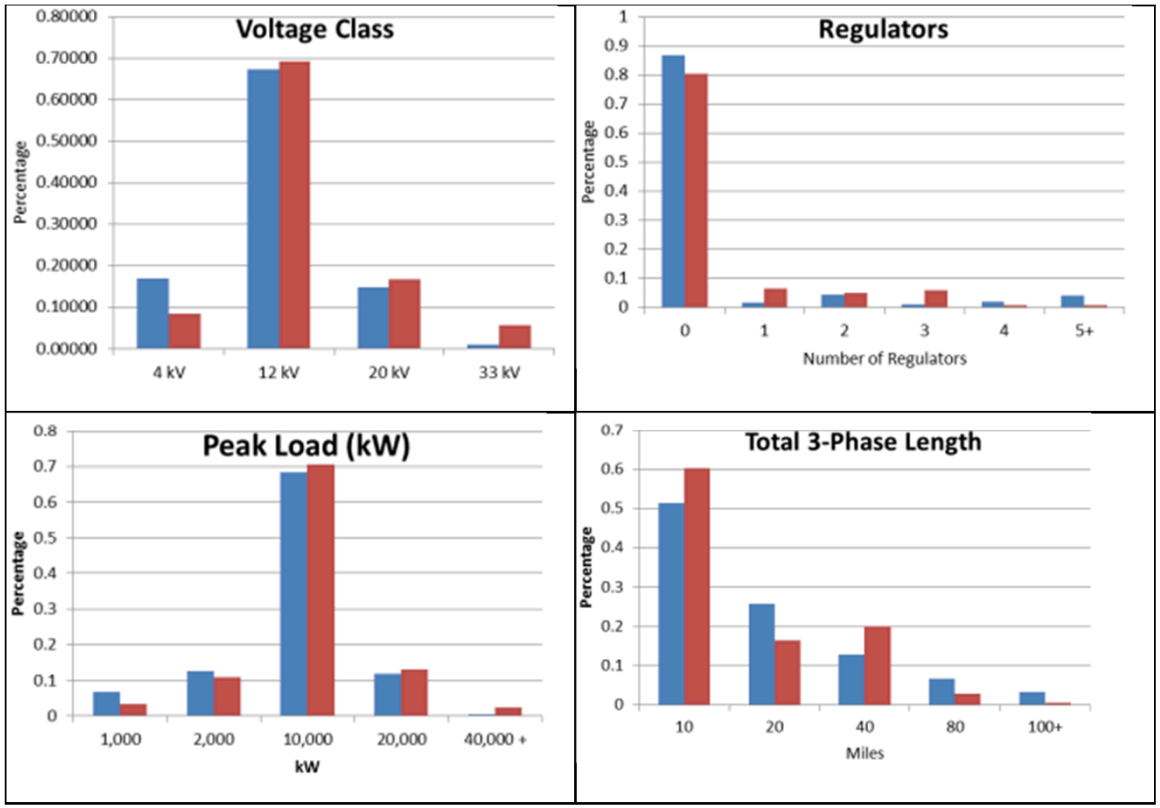


Study Data

Example utility feeder data

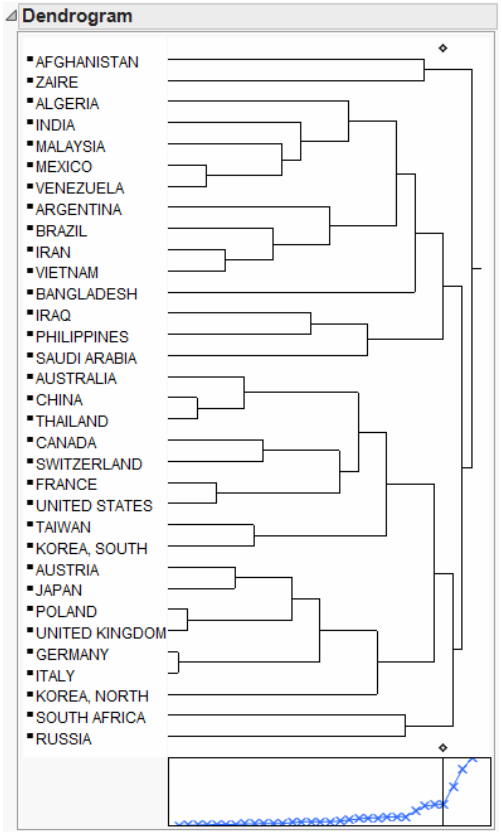
Feeder Topology	Primary Voltage Type of Feeder Total 3PH Miles OH 3PH Miles Total 1&2PH Miles OH 1&2PH Miles
Voltage Control	Regulators Capacitors Boosters Stepdowns
Protection	SCADA Breaker Fuses Reclosers Sectionalizers Interrupters
Customer Info	# Dom Cust # Com Cust # Ind Cust # Agr Cust Other Customer Total Customers
Load and Capacity Info	Transformer Count Summer Peak kW Summer KVA Capability Winter Peak KW Winter KVA Capability
DG and PV Data	DG kW PV kW # of DG # of PV 0-20kW PV 20-200kW PV >200kW PV kW DG as % of Max Feeder Kw kW PV as % of Max Feeder Kw

Feeder characteristics for full set of 8143 feeders (Blue) and 214 study feeders (Red)

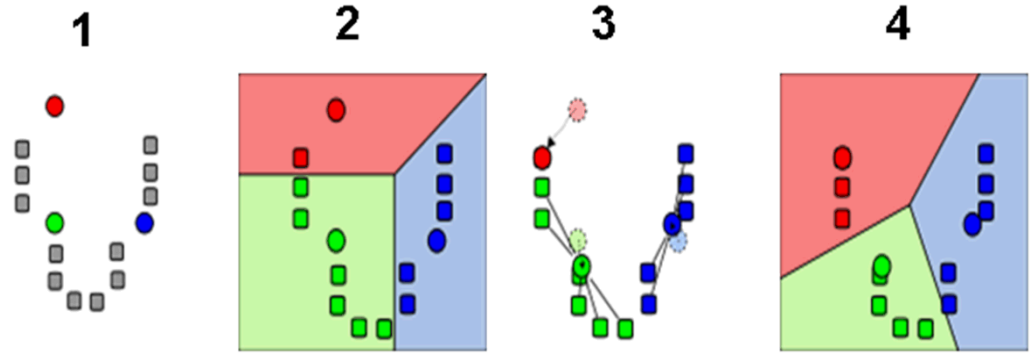


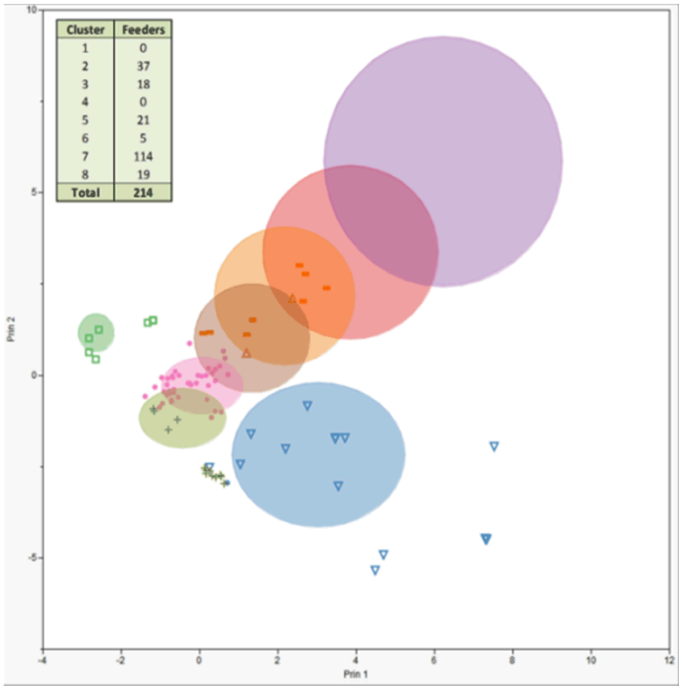
Clustering Methods

- **Hierarchical Clustering**

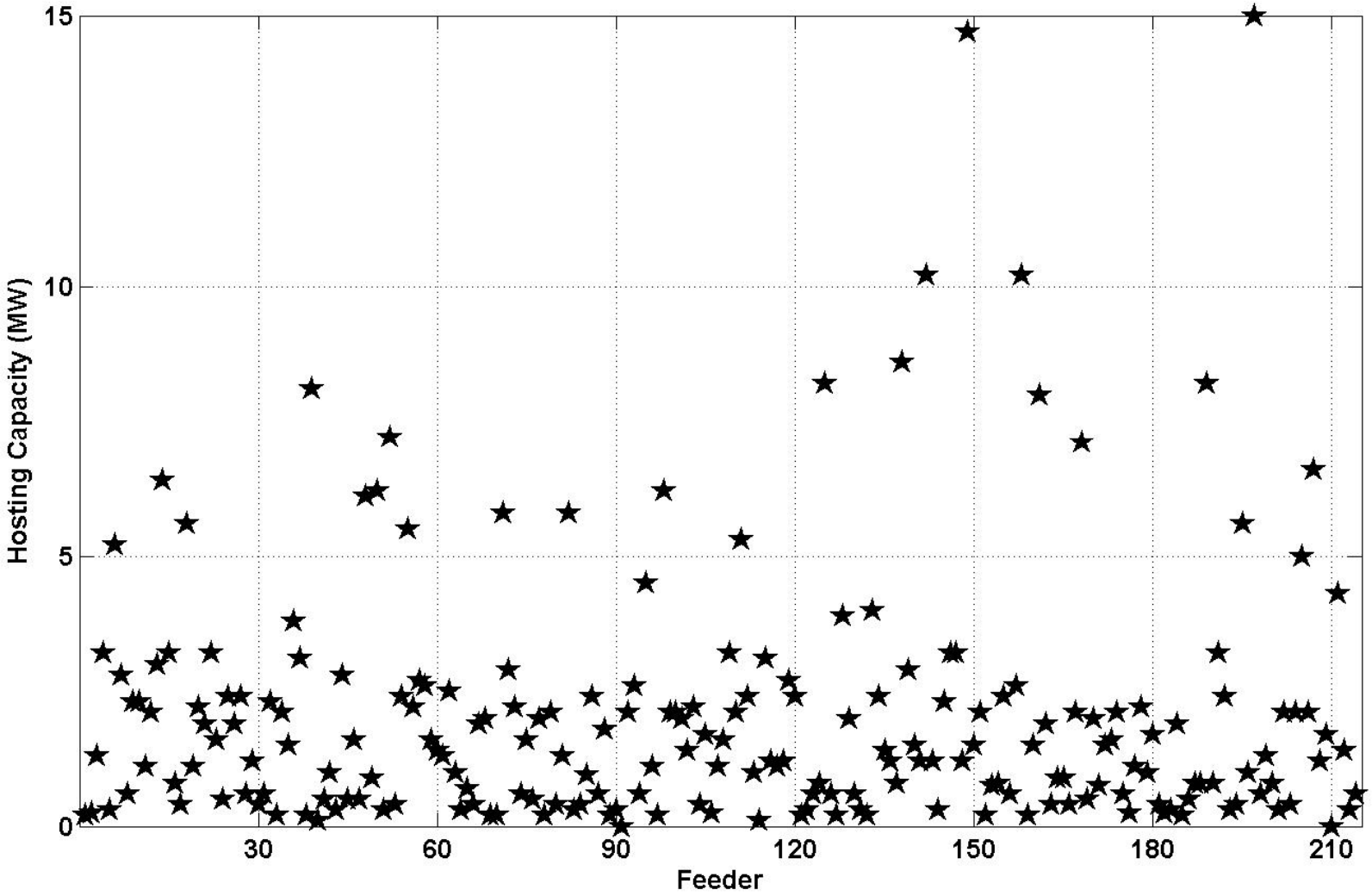


- **K-Mean Clustering**

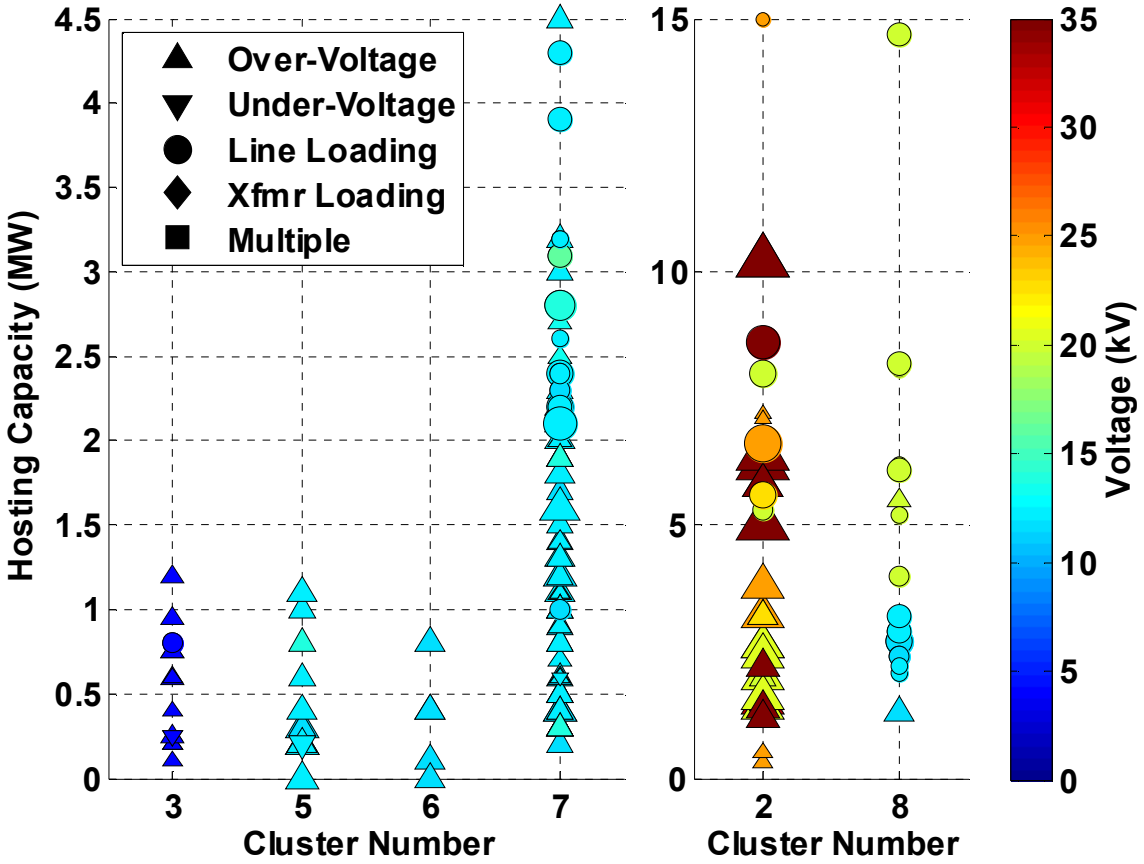




Bi-plot of the 8 cluster solution for 8,143 feeders with 214 study feeders shown by markers


15
10
5
0
Hosting Capacity (MW)
30
60
90
120
150
180
210
Feeder

Cluster Results



Hosting capacity violation type shown by marker shape for each feeder in the same 6 clusters.

Conclusions

- Methods explored:
  A. Dependence of hosting capacity accuracy on the number of clusters.
  B. Dependence of hosting capacity accuracy on weighting of key cluster variables.
- The accuracy of K-Means clustering as a method to group distribution feeders was relatively inaccurate with the best solution showing an average hosting capacity variation of 77%.
- K-Means clustering is still useful as it provides good separation between clusters in many cases, but it has its limitations.
- Clustering will never perfectly group feeders such that all unique characteristics match with a single PV hosting capacity for the feeder, but it can provide a rough estimate of the hosting capacity for similar types of feeders.