Clustering of LV Feeders
Appendix J

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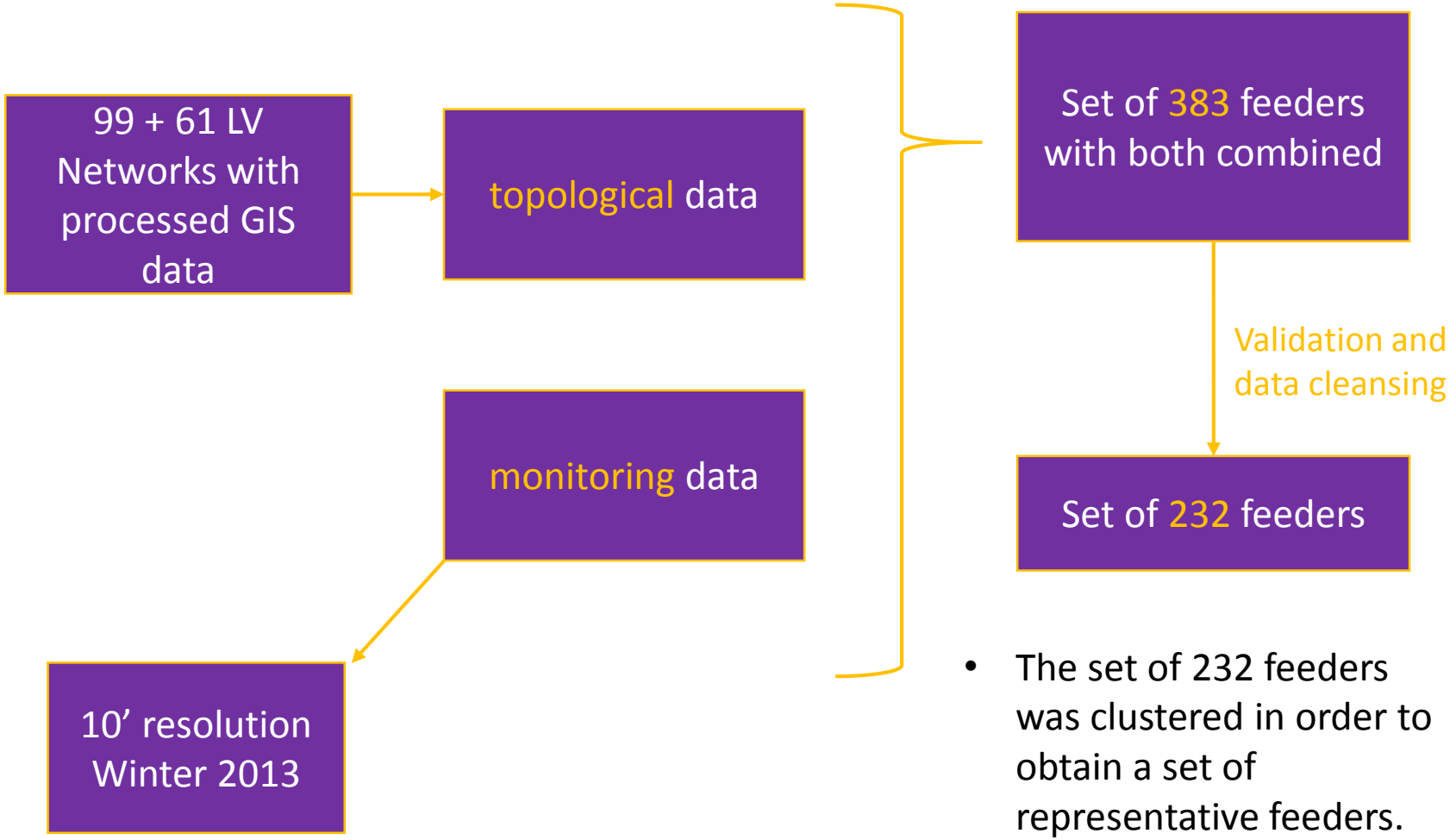
Outline

- Why clustering?
- Data overview
- Data cleansing and validation of feeders
- Clustering process
- Final clusters and representative feeders
- Key remarks

Why Clustering?

- ENWL has more than 2 million LV customers, 30,000+ LV substations and 180,000+ feeders.
- Analysing all the feeders (for whatever study) is not feasible.
- Hence, representative feeders can be used to carry out studies and extract rules that can then be extrapolated to the population they represent.
  - Less complexity
  - More detailed analysis from what is done now

Data Overview



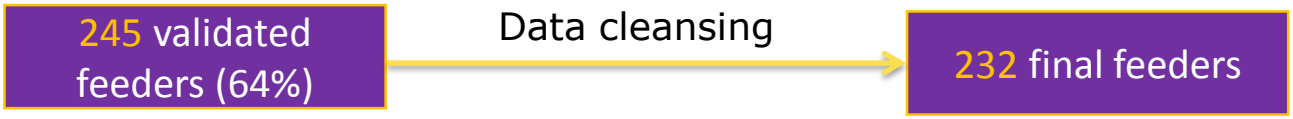
- The set of 232 feeders was clustered in order to obtain a set of representative feeders.

Data Cleansing and Validation of Feeders

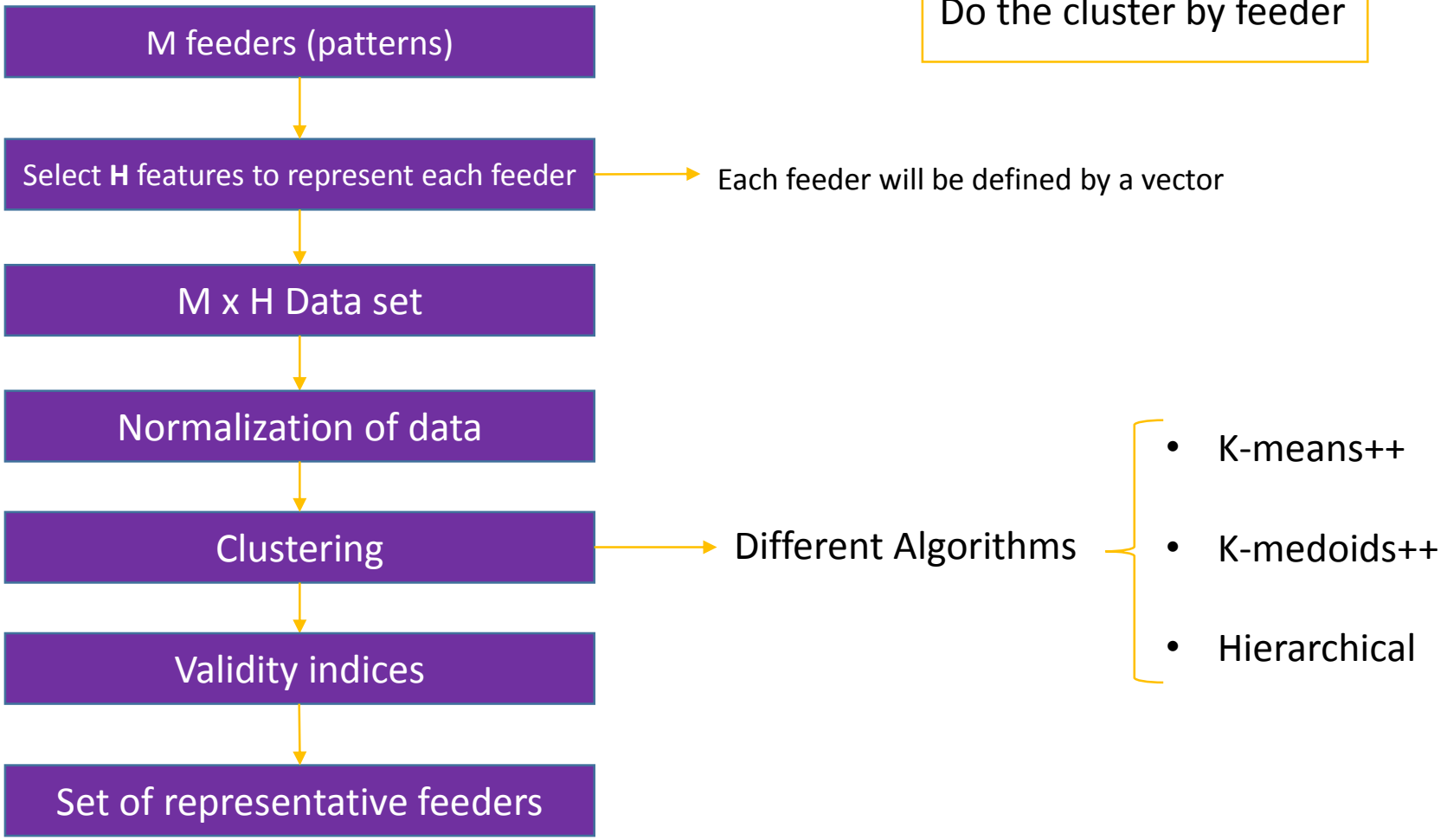
- Any sort of outliers need to be excluded.
  - An initial data cleansing process was applied to remove feeders with uncommon characteristics.

- Feeder validation using monitoring data.
  - Monitored Energy vs. ENWL's Elexon-based profiles
  - Max difference from 2 periods compared:

$$E_{3\emptyset\ (all\ day)} \& E_{3\emptyset\ (5-8pm)} \leq 60\% \rightarrow Feeder\ is\ valid$$

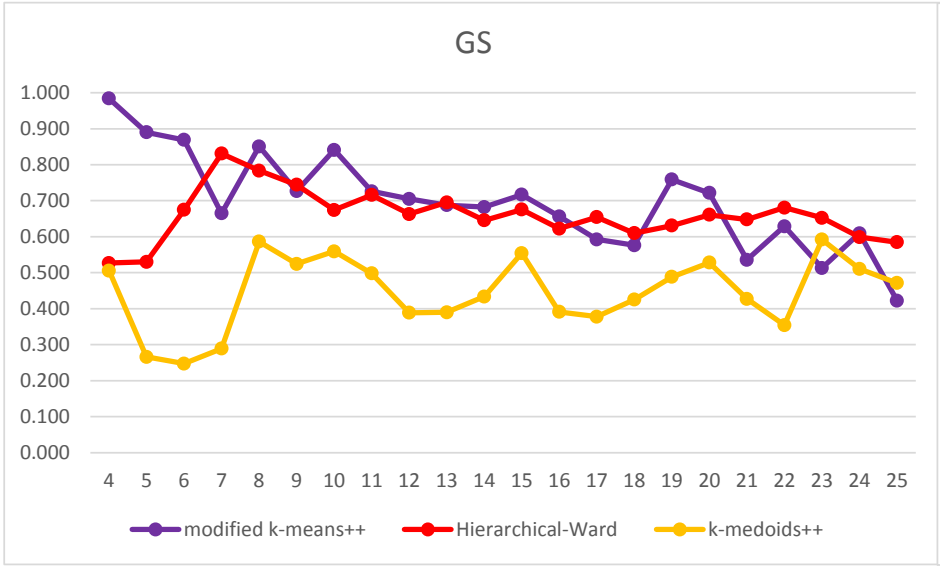


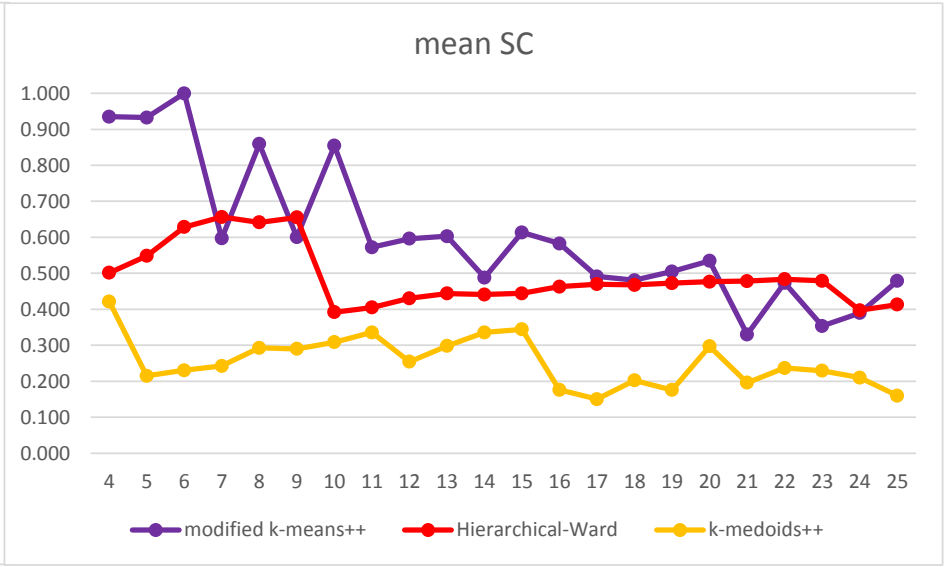
Clustering Process



Optimal Number of Clusters

- Multiple validity indices are used to assess the quality of different number of clusters
- Algorithms are compared to identify the optimal number



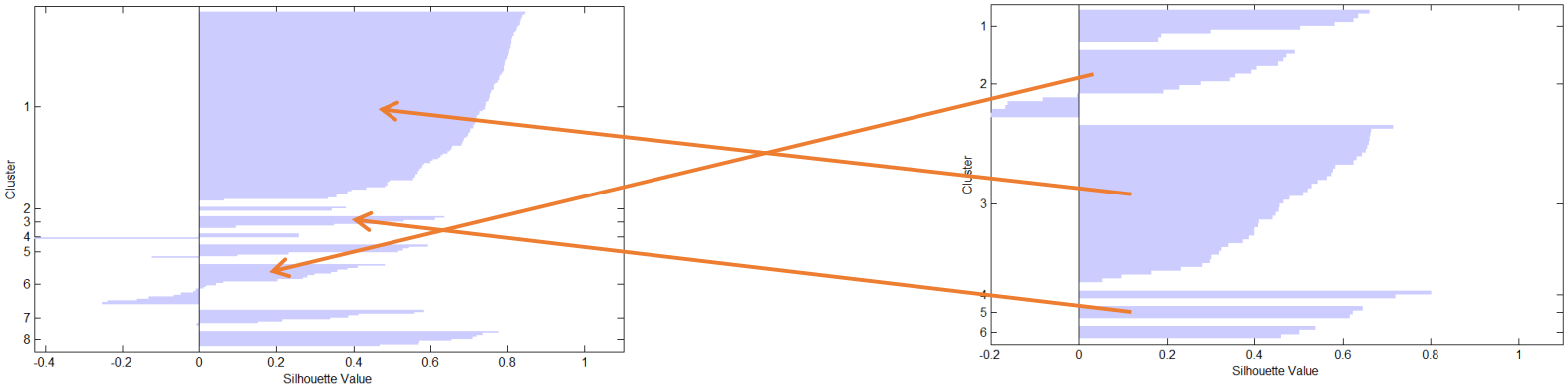


Macro-Partitions (with/without DG)

Set of 323 feeders

157 feeders without DG

76 feeders with DG

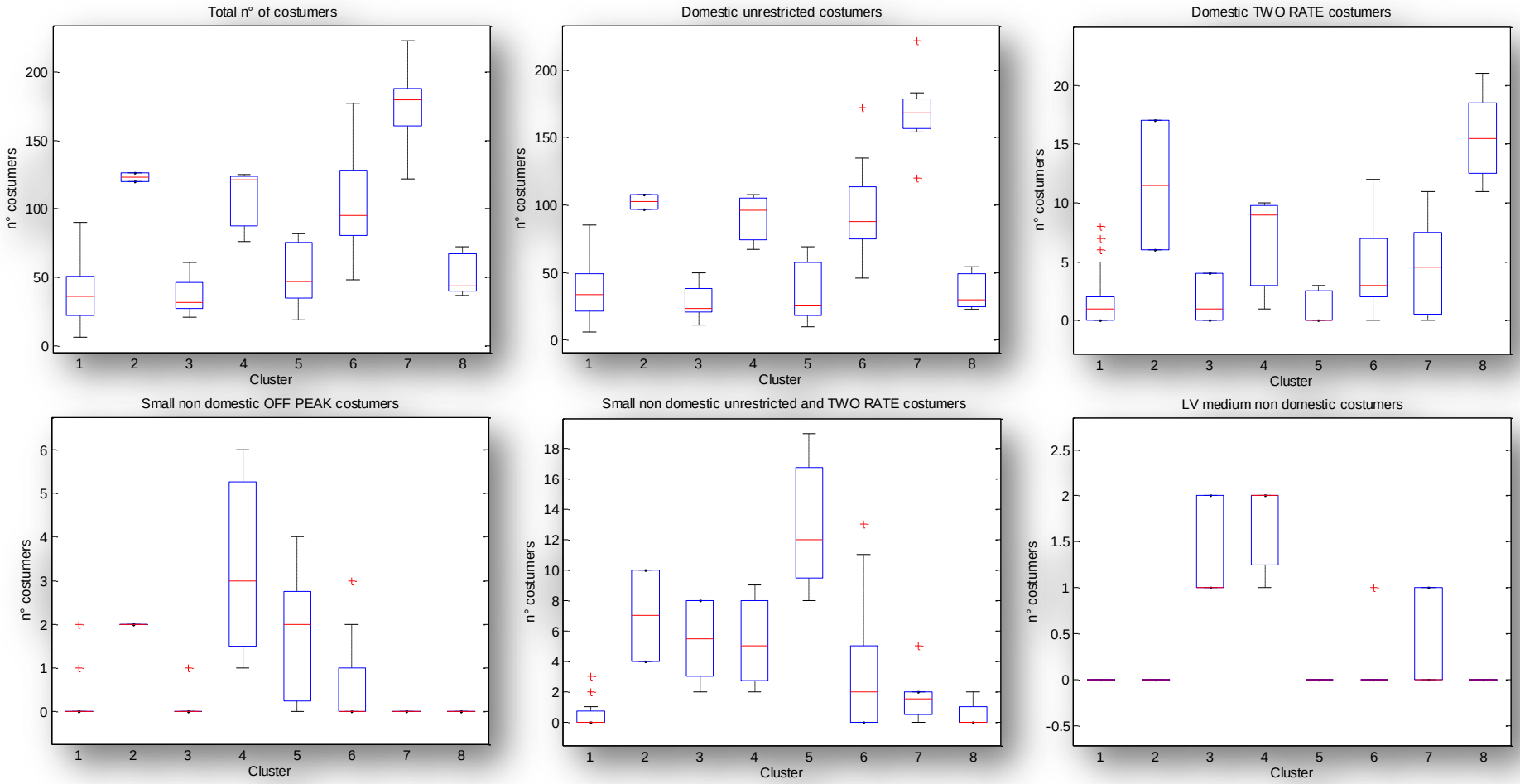


9 clusters

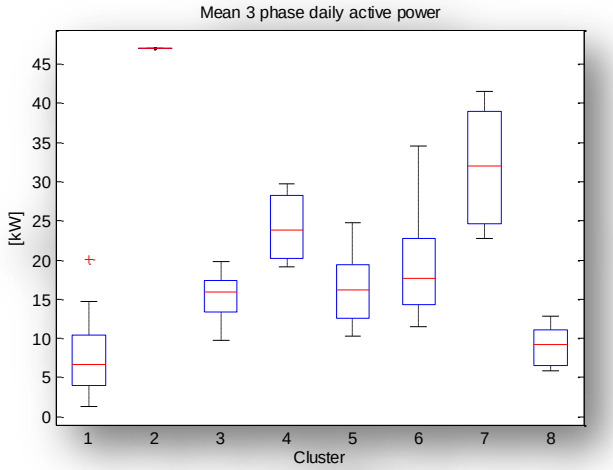
3 separated clusters

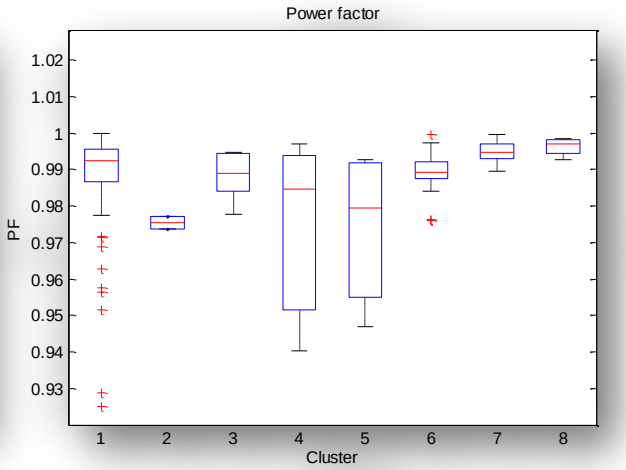
- In which conditions a **new group** of representative feeders could be created in base of the **presence of DG units**.

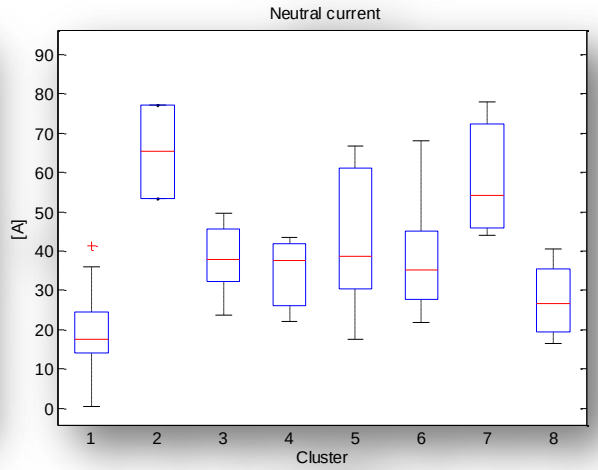
Characteristics of Clusters – without DG

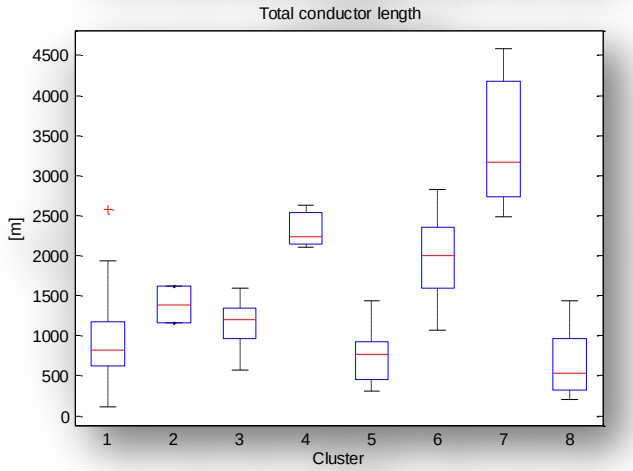


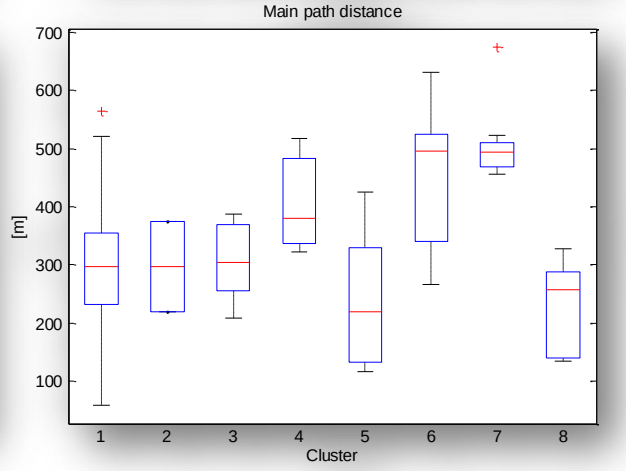
Characteristics of Clusters – without DG

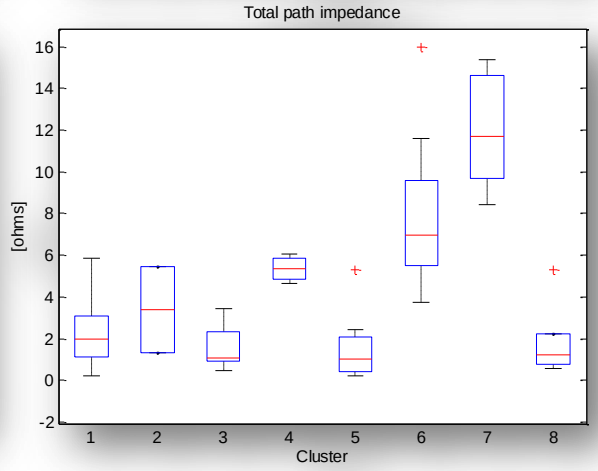




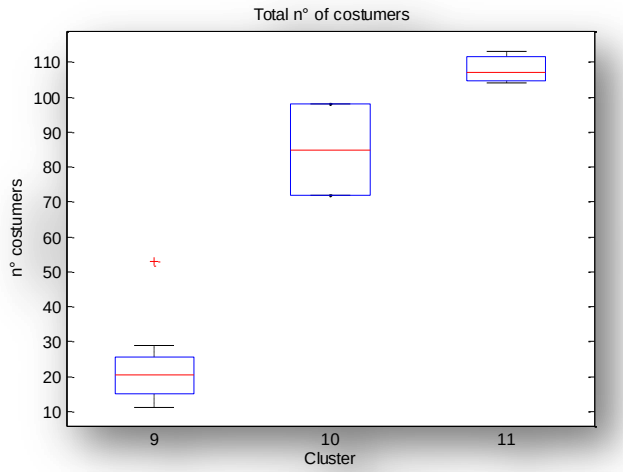


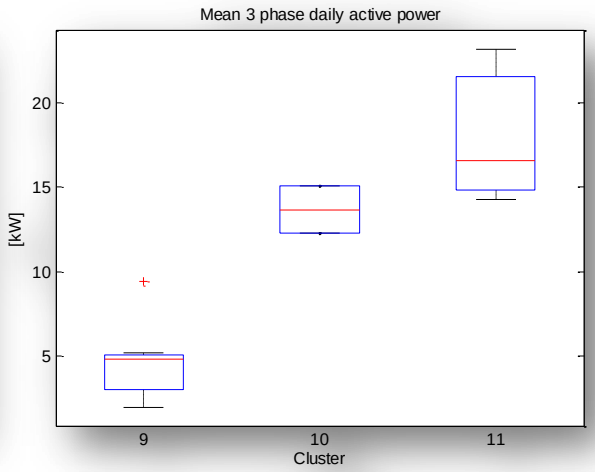


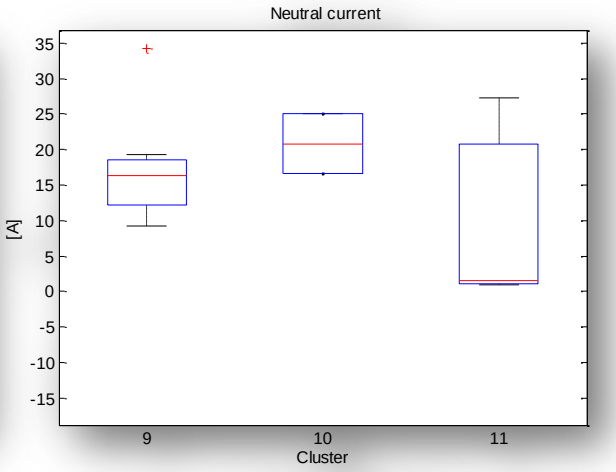


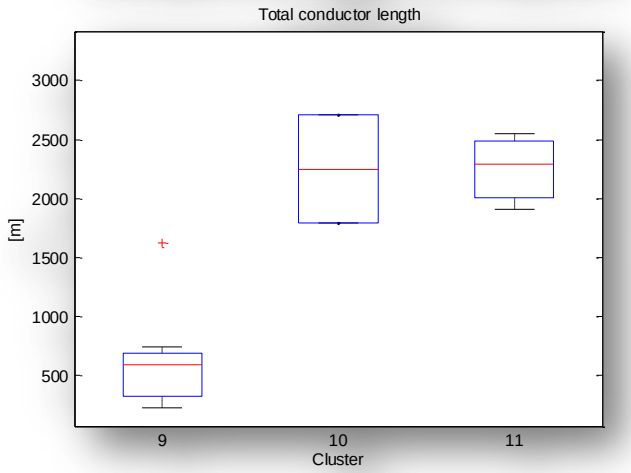


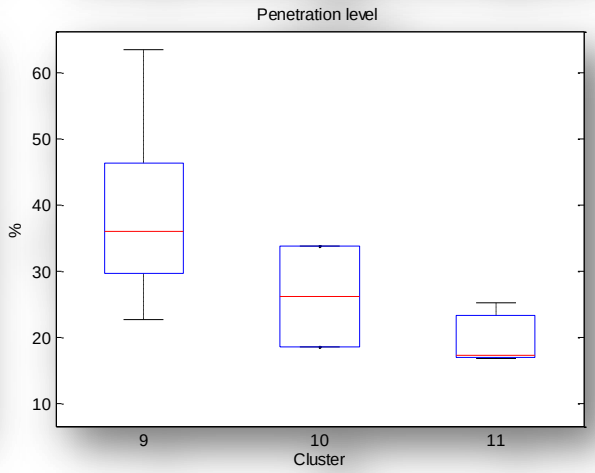
Characteristics of Clusters – with DG

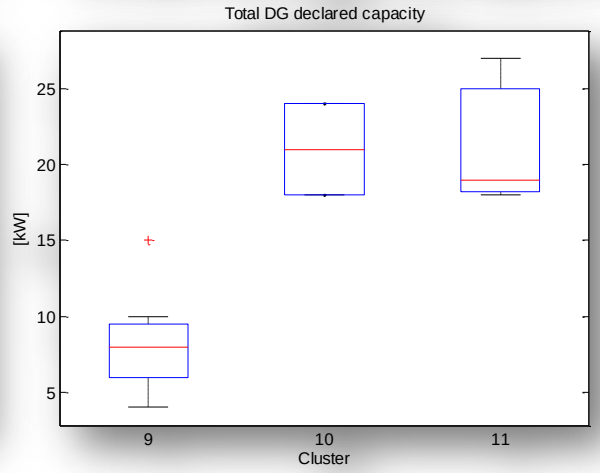






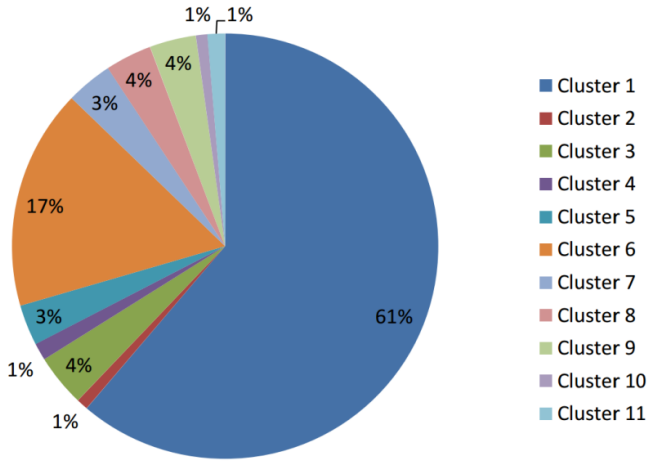






Final Set of Representative Feeders

K	Total cable length	N° of costumers	Type of costumers	Power consumption	Observations
1	Small	Low	Domestic (mainly domestic unrestricted)	Low	N/A
2	Small-medium	Medium-high	Domestic (presence of some low consumption non-domestic and LV medium non domestic costumers)	Highest	Highly density area - High neutral current
3	Small	Low	Domestic (presence of some low consumption non-domestic and LV medium non domestic costumers)	Medium	High neutral current
4	Large	Medium	Domestic-non and domestic (considerable presence of LV medium non domestic costumers)	Medium-high	N/A
5	Small	Low	Domestic and non-domestic (30% small non-domestic costumers)	Medium	High neutral current
6	Large	Medium	Domestic (mainly domestic unrestricted)	Medium	N/A
7	Largest	High	Domestic (mainly domestic unrestricted)	High	Low neutral current
8	Small	Low	Domestic (big presence of domestic two rate costumers)	Low	Main cable path represents 50% of the total cable length
9	Small	Low	Domestic (mainly domestic unrestricted)	Lowest	High PV panels penetration level (~40%)
10	Medium	Medium	Domestic-non and domestic (presence of LV medium non domestic costumers)	Low	Medium PV panels penetration level (~30%) - Low neutral current
11	Large	Medium-high	Domestic (mainly domestic unrestricted)	High-Medium	Low PV panels penetration level (~20%) - insignificant neutral current



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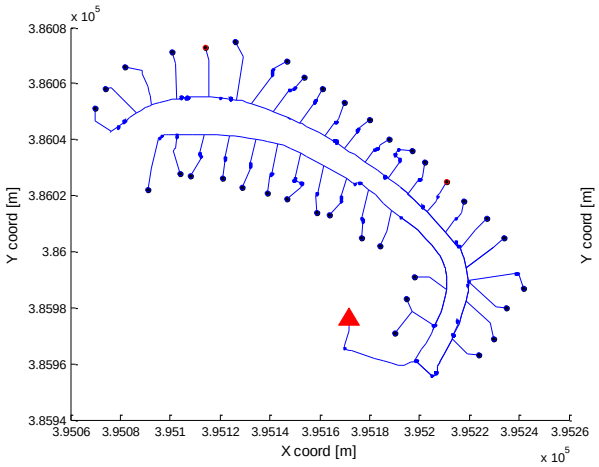

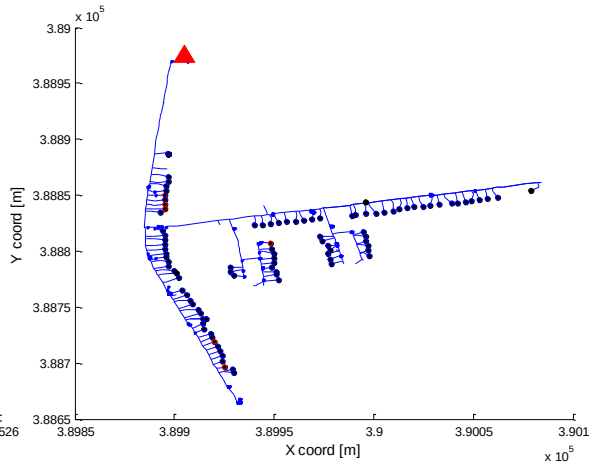

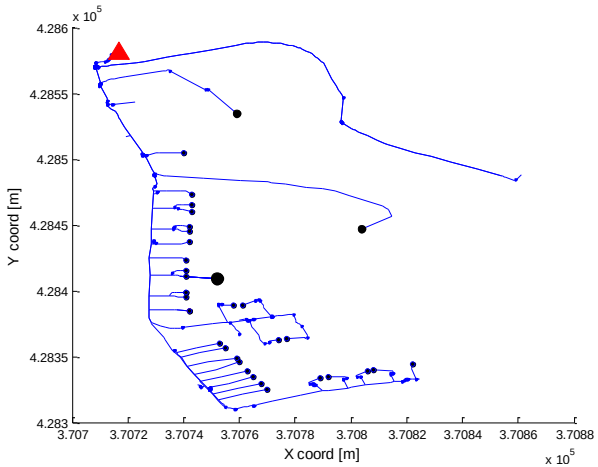

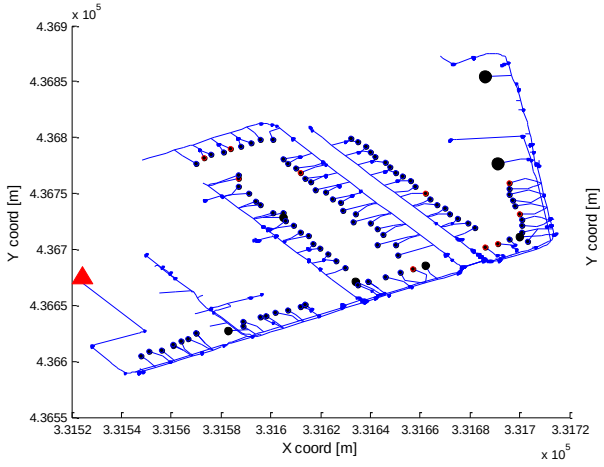

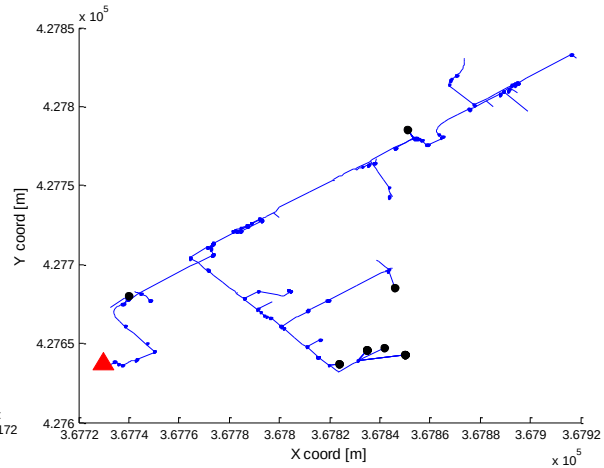

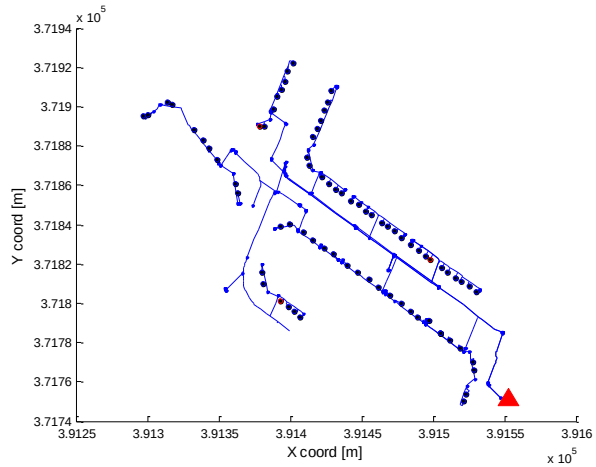

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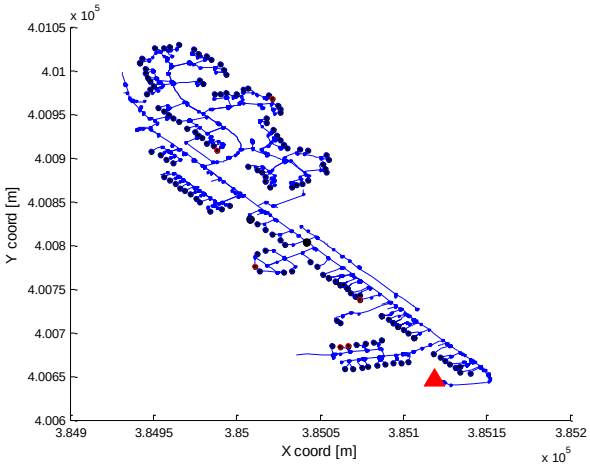

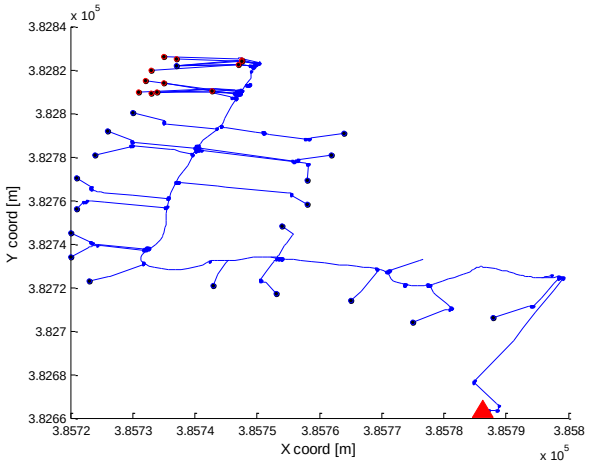

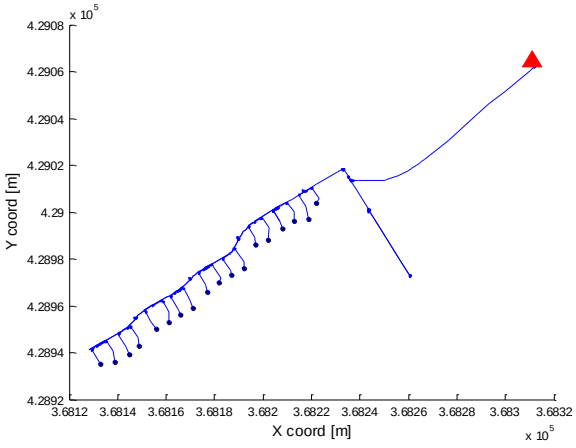

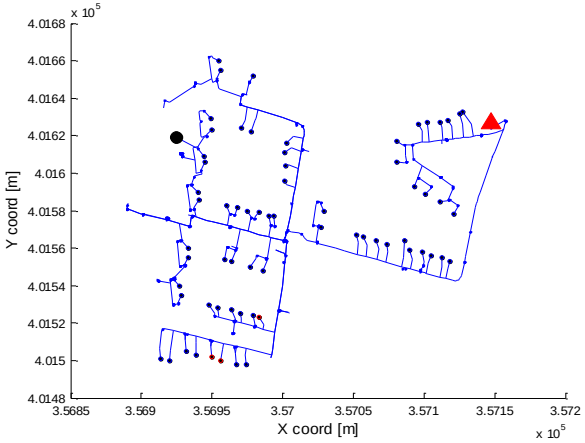

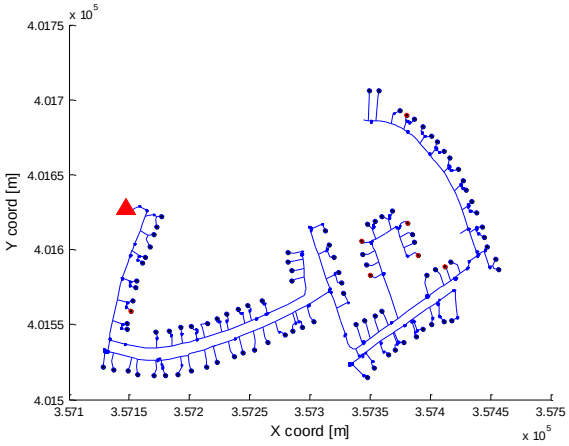

Key Remarks

- 11 representative feeders were obtained (3 with PV).
- Three representative feeders (1, 6 and 7) correspond to pure domestic feeders of different lengths without PV penetration (or insignificant). They represent >70% of the whole population.
- The proposed methodology is scalable and generic. It can be applied to a larger set of feeders as well as other DNOs.
- Analysis can be carry out on the representative feeders and the results can then be extrapolated to the corresponding populations.

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