KMeans – Labeling

After performing a KMeans clustering methods, it is possible to identify the four clusters corresponding to the input data. The obtained results are shown next:

## 

# Cluster 1 – 49 states

Centroid @ [-22.099, 0.93002]

Cluster 1, with 49 states, corresponds to the one with minimum average values both for voltages and angles in the nine nodes. As higher voltage drops and angle differences occur due to increased power flows within the system, since more current in the lines causes more losses, this cluster equals to the **High load rate during peak hours**.

# Cluster 2 – 51 states

Centroid @ [12.320, 0.99982]

On the other hand, Cluster 2, with 49 states, corresponds to the one with maximum average values both for voltages and angles in the nine nodes. Reduced power flows within the system due to low load imply less current in the lines causing losses, hence voltage drops will be lower in such scenario. Considering this, Cluster 2 corresponds to the **Low load rate during night**.

# Cluster 3 – 47 states

Centroid @ [ 7.8550, 0.98069]

Cluster 3, with 47 states, has decreased average voltages and angle compared to Cluster 2. The disconnection of a line would have a similar effect, as the power flows in a different way through the system, increasing losses in the lines. Taking this into account, Cluster 3 corresponds to the **Disconnection of a line for maintenance.**

# Cluster 4 – 53 states

Centroid @ [ -6.0804, 0.98950]

Finally, Cluster 4, with 53 states, has measurements with small drops both in the average voltages and angles in the nine nodes. During the shut down of a generator, as there is no power flowing into the grid, it is expected that angles between generator buses and their connections are similar. Hence, inspecting the angle differences at each generation bus and their connection, it is possible to verify that Cluster 4 has the minimum difference, implying that in some cases the injected power equals to zero. Considering this, Cluster 4 corresponds to **Shut down of a generator for maintenance.**