

Strategic Placement of Microgrids using Nighttime Imagery and Hosting Capacity for RE Microgrids



PRESENTED BY

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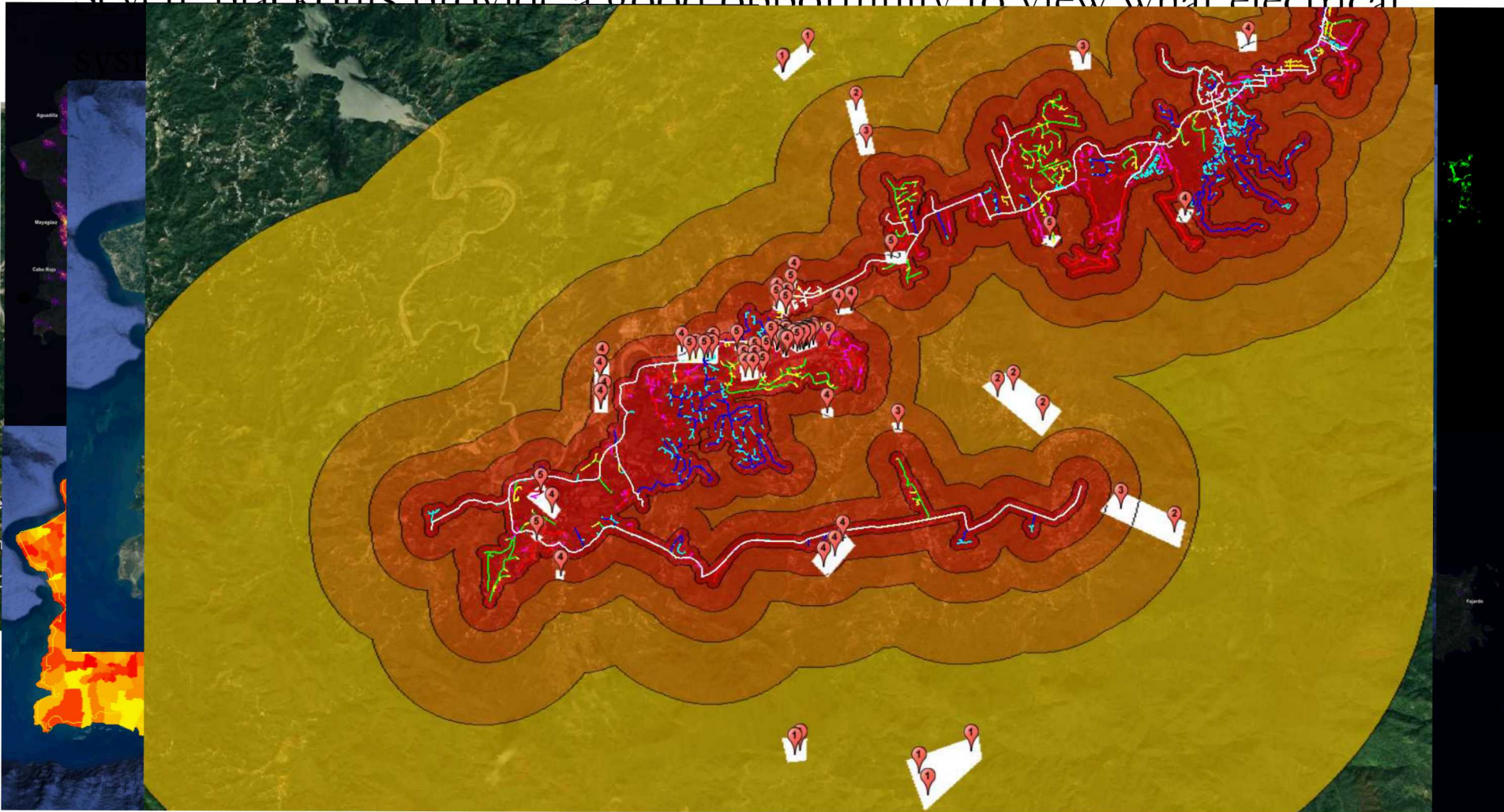
Melvin Lugo Alvarez-University of Puerto Rico at Mayaguez



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Strategic Placement of Microgrids using Nighttime Imagery

- Severe blackouts provide a good opportunity to view what electrical

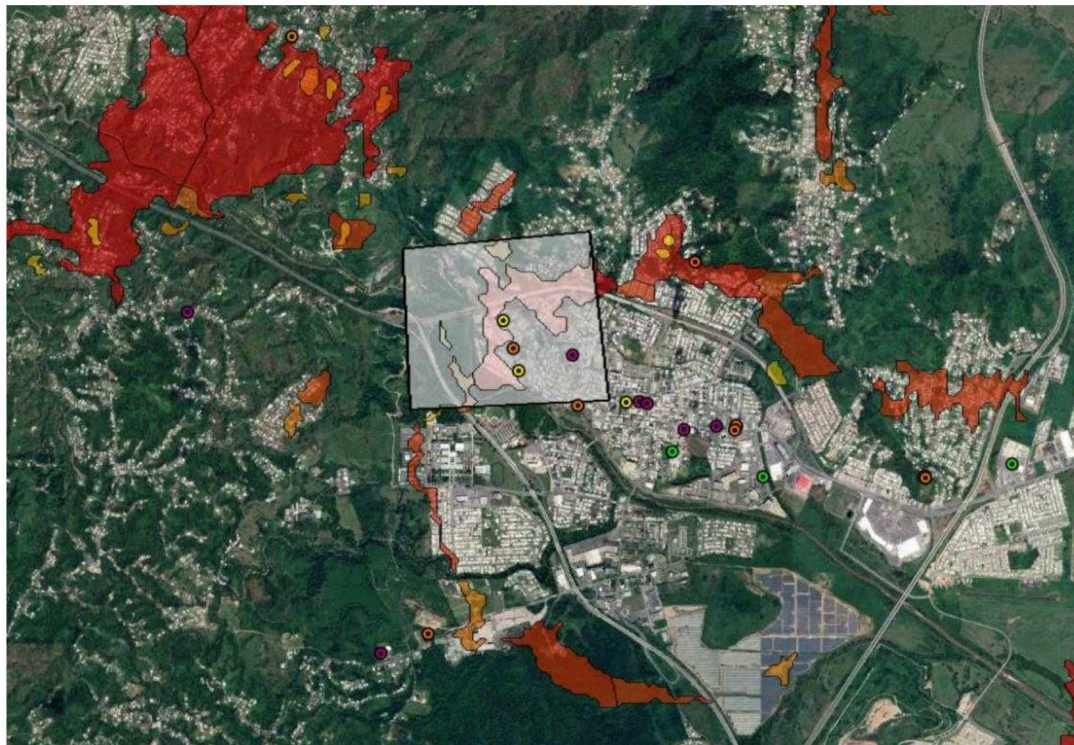


Identifying the most promising areas for microgrids

- Initial 42 locations selected based on the overlap of the blackout region and significant number of critical infrastructures weighted by importance on a 1-5 scale.
- The footprint (shape of the footprint) for each of the 42 locations was simply illustrative until we developed a better method



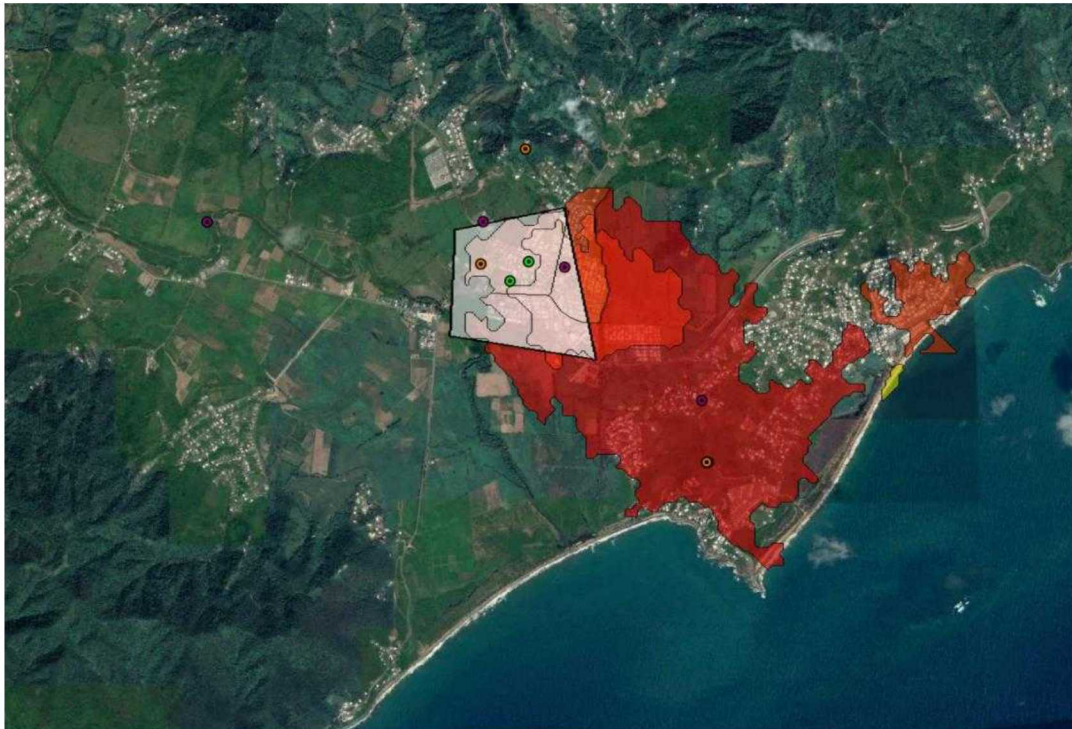
Location_1



-  Hospital/Urgent Care/ VA Facility
-  Primary Care Clinic/Dialysis Center/Community Health Center
-  Emergency Shelter
-  Telecom Tower

Key Coordinate:
18.1542,-65.8344

Location_2



-  Hospital/Urgent Care/ VA Facility
-  Primary Care Clinic/Dialysis Center/Community Health Center
-  Emergency Shelter
-  Telecom Tower

Key Coordinate:
18.007439,-65.8993

Location_3



-  Hospital/Urgent Care/ VA Facility
-  Primary Care Clinic/Dialysis Center/Community Health Center
-  Emergency Shelter
-  Telecom Tower

Key Coordinate:
18.4088,-67.1518



Current Objective function parameters:

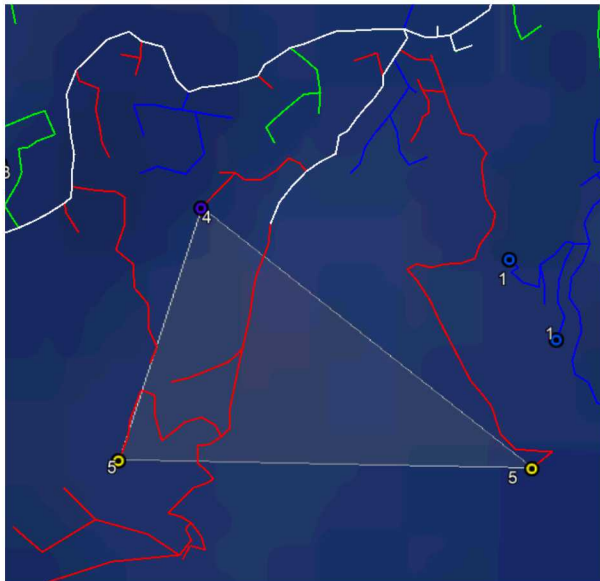
- Number of loads
- Number of switches required to isolate loads
- Sum of load ratings
- Average load rating
- Load per length
- Number of loads per area (load density)

Boundary conditions prior to normalization:

- Lower bound:
 - Average load rating must be greater than 2
- Upper bound:
 - Convex Hull area must be less than or equal to upper limit. This value can be adjusted for the cases being evaluated

Old vs New Clustering Geometry

Old Cluster 8

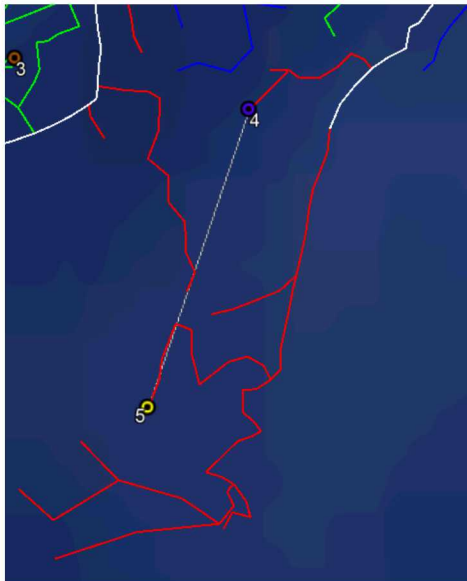


New Cluster 8 with Upstream Switch Location



Old vs New Clustering Geometry

Old Cluster 7

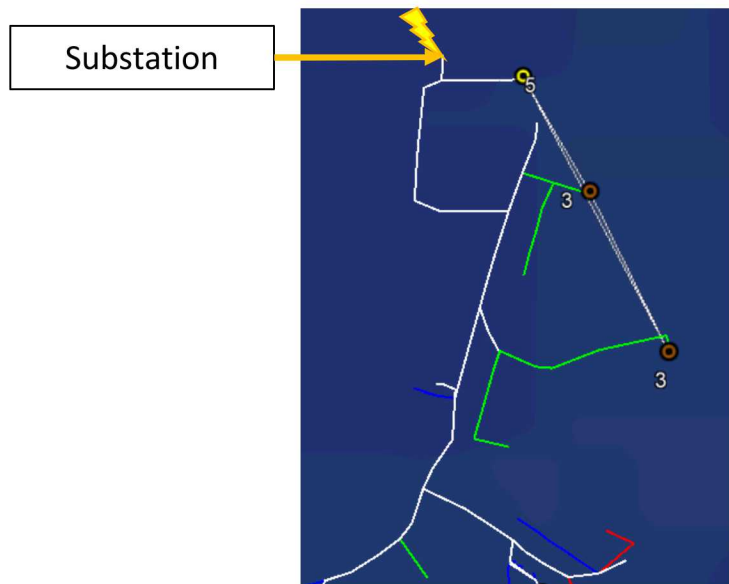


New Cluster 7 with Upstream Switch Location



Old vs New Clustering Geometry

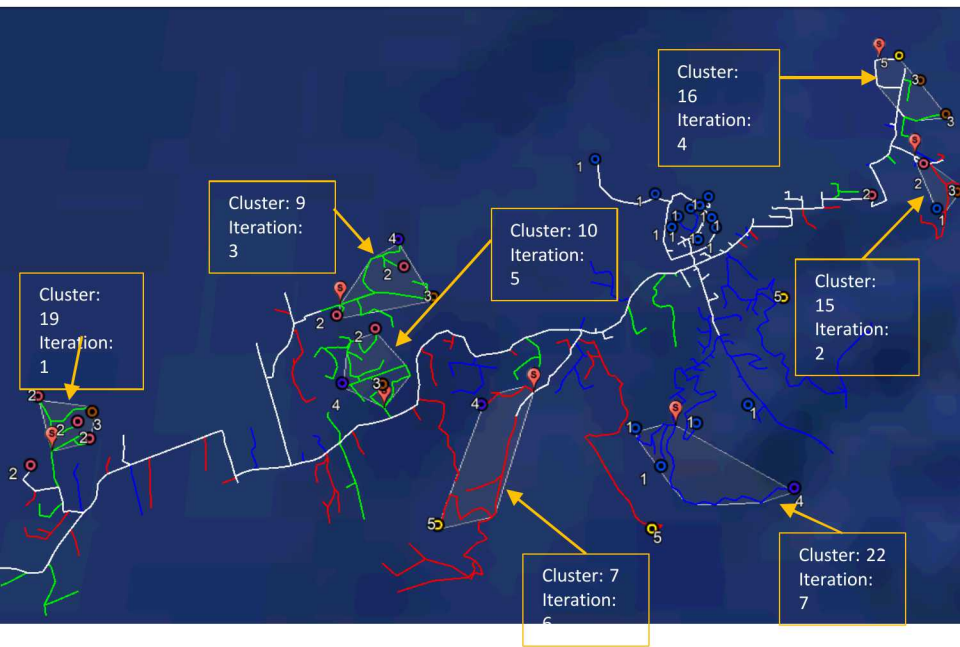
Old Cluster 16



New Cluster 16 with Upstream Switch Location



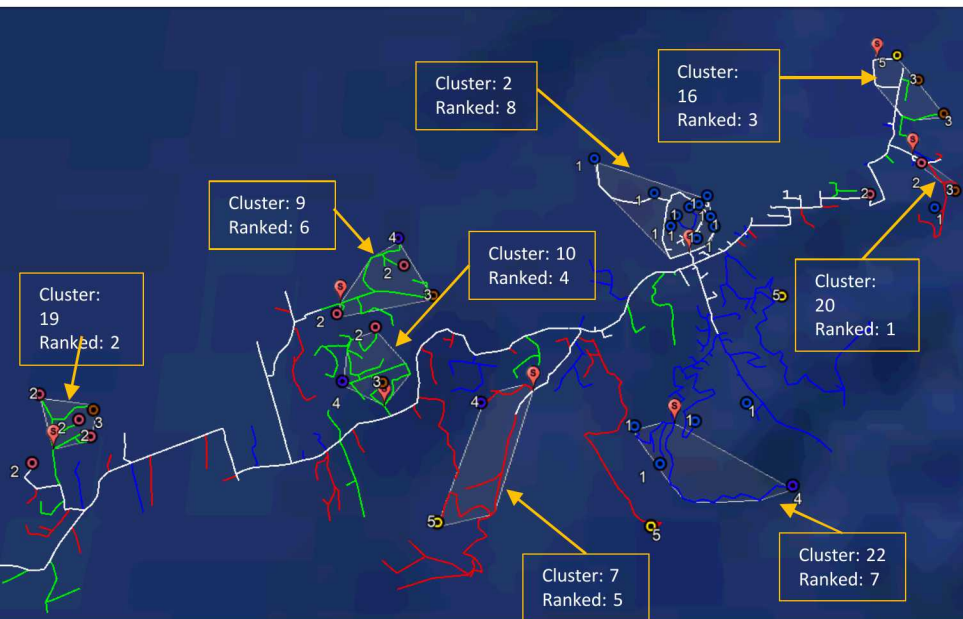
Iterative Process



Cluster	# Loads	Number of Switches	Sum of Ratings	Line Length (m)	Hull Area m ²	Average Load Rating	Load Per Length (Load/m)	Load Per Area (Load/m ²)	Result of Iteration #
19	4	1	9	1387.835	111786.8	2.25	0.0029	3.58E-05	1
15	3	1	6	1012.48	84038.82	2.00	0.0030	3.57E-05	2
9	4	1	11	1726.764	243019.2	2.75	0.0023	1.65E-05	3
16	3	1	11	1577.572	192858.6	3.67	0.0019	1.56E-05	4
10	3	1	9	1938.502	186769	3.00	0.0015	1.61E-05	5
7	2	1	9	2223.888	336434.3	4.50	0.0009	5.94E-06	6
22	3	1	6	2326.511	338382.4	2.00	0.0013	8.87E-06	7

- Maximum Area and Minimum Average rating constraints imposed prior to iteration

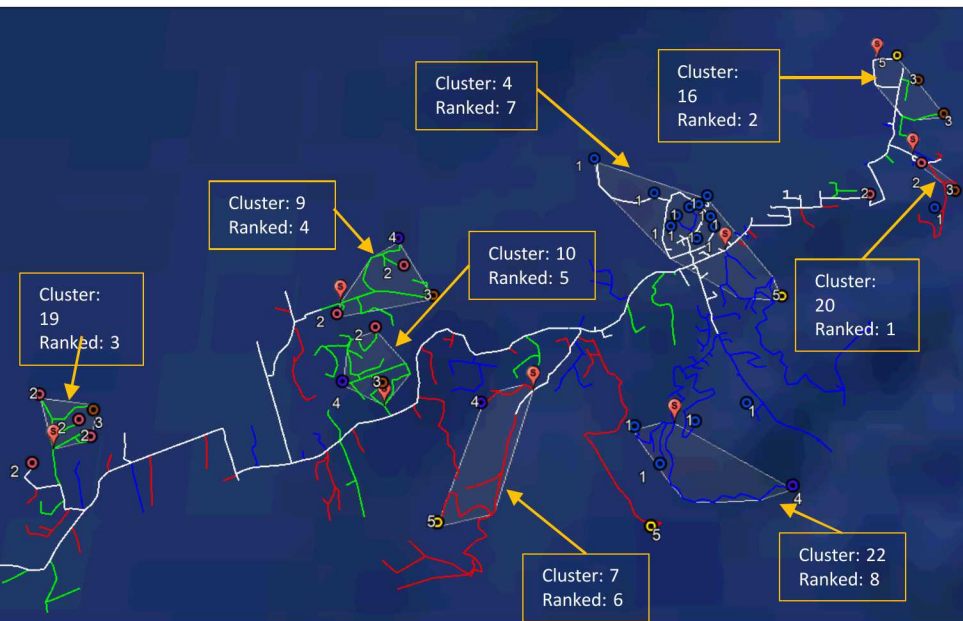
Ranked by Average rating per area



Cluster	# Loads	Number of Switches	Sum of Ratings	Line Length (m)	Hull Area m ²	Average Load Rating	Load Per Length (Load/m)	Load Per Area (Load/m ²)	Average Rating per Area	sorted by Average rating per area
20	2	2	5	697	28272	2.50	0.0029	7.074E-05	8.843E-05	1
19	4	1	9	1388	111787	2.25	0.0029	3.578E-05	2.013E-05	2
16	3	1	11	1578	192859	3.67	0.0019	1.556E-05	1.901E-05	3
10	3	1	9	1939	186769	3.00	0.0015	1.606E-05	1.606E-05	4
7	2	1	9	2224	336434	4.50	0.0009	5.945E-06	1.338E-05	5
9	4	1	11	1727	243019	2.75	0.0023	1.646E-05	1.132E-05	6
22	3	1	6	2327	338382	2.00	0.0013	8.866E-06	5.910E-06	7
2	10	1	10	3340	404811	1.00	0.0030	2.470E-05	2.470E-06	8

- Unconstrained
- Highlighted cell shows cluster that would fail average rating constraint

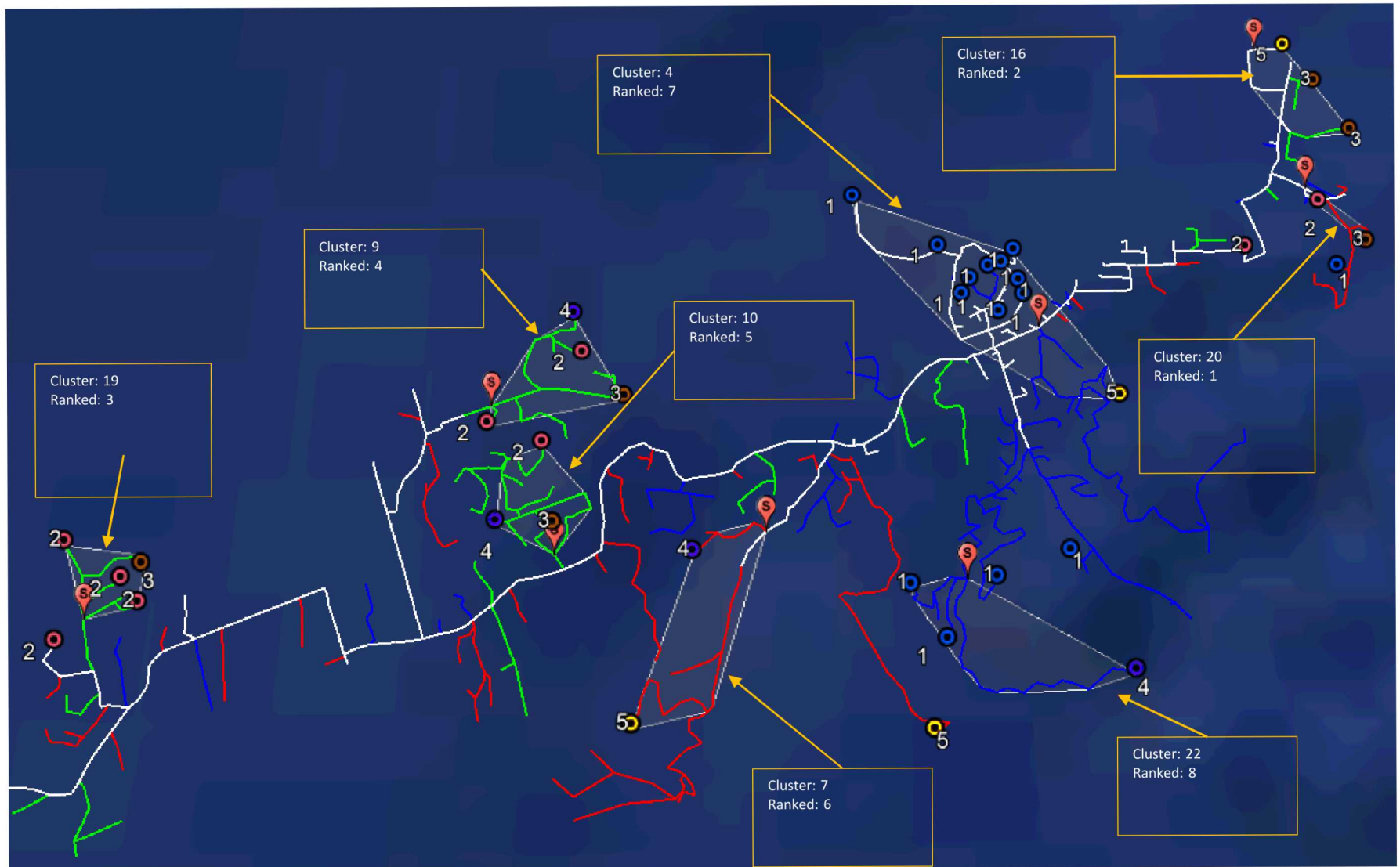
Ranked by Load per length times average rating



Cluster	# Loads	Number of Switches	Sum of Ratings	Line Length (m)	Hull Area m ²	Average Load Rating	Load Per Length (Load/m)	Load Per Area (Load/m ²)	Load per length times average rating	sorted by load per length times average
20	2	2	5	697	28272	2.50	0.0029	7.074E-05	7.171E-03	1
16	3	1	11	1578	192859	3.67	0.0019	1.556E-05	6.973E-03	2
19	4	1	9	1388	111787	2.25	0.0029	3.578E-05	6.485E-03	3
9	4	1	11	1727	243019	2.75	0.0023	1.646E-05	6.370E-03	4
10	3	1	9	1939	186769	3.00	0.0015	1.606E-05	4.643E-03	5
7	2	1	9	2224	336434	4.50	0.0009	5.945E-06	4.047E-03	6
4	11	3	15	4815	681535	1.36	0.0023	1.614E-05	3.115E-03	7
22	3	1	6	2327	338382	2.00	0.0013	8.866E-06	2.579E-03	8

- Unconstrained
- Highlighted cell shows cluster that would fail average rating constraint

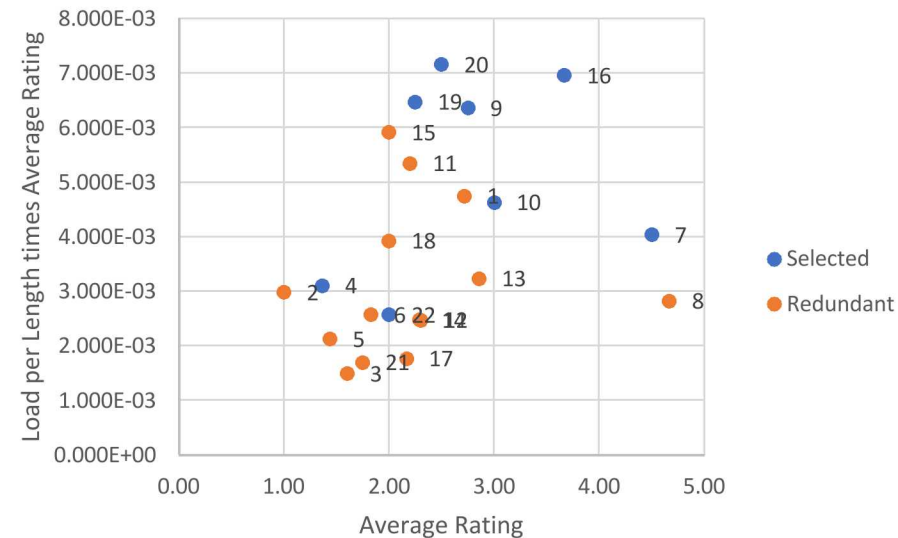
Ranked by Load per length times average rating



Ranked by Load per length times average rating

Cluster	# Loads	Number of Switches	Sum of Ratings	Line Length (m)	Hull Area m^2	Average Load Rating	Load Per Length (Load/m)	Load Per Area (Load/m^2)	Load per length times average rating	sorted by load per length times average
20	2	2	5	697	28272	2.50	0.0029	7.074E-05	7.171E-03	1
16	3	1	11	1578	192859	3.67	0.0019	1.556E-05	6.973E-03	2
19	4	1	9	1388	111787	2.25	0.0029	3.578E-05	6.485E-03	3
9	4	1	11	1727	243019	2.75	0.0023	1.646E-05	6.370E-03	4
15	3	1	6	1012	84039	2.00	0.0030	3.570E-05	5.926E-03	redundant
11	5	1	11	2053	238289	2.20	0.0024	2.098E-05	5.359E-03	redundant
1	7	1	19	3991	792185	2.71	0.0018	8.836E-06	4.760E-03	redundant
10	3	1	9	1939	186769	3.00	0.0015	1.606E-05	4.643E-03	5
7	2	1	9	2224	336434	4.50	0.0009	5.945E-06	4.047E-03	6
18	4	2	8	2032	301350	2.00	0.0020	1.327E-05	3.937E-03	redundant
13	7	2	20	6161	1277962	2.86	0.0011	5.477E-06	3.246E-03	redundant
4	11	3	15	4815	681535	1.36	0.0023	1.614E-05	3.115E-03	7
2	10	1	10	3340	404811	1.00	0.0030	2.470E-05	2.994E-03	redundant
8	3	1	14	4938	1512800	4.67	0.0006	1.983E-06	2.835E-03	redundant
6	23	1	42	16244	7017189	1.83	0.0014	3.278E-06	2.586E-03	redundant
22	3	1	6	2327	338382	2.00	0.0013	8.866E-06	2.579E-03	8
14	38	1	87	34921	15388472	2.29	0.0011	2.469E-06	2.491E-03	redundant
12	33	1	76	30618	12810543	2.30	0.0011	2.576E-06	2.482E-03	redundant
5	16	2	23	10763	2794636	1.44	0.0015	5.725E-06	2.137E-03	redundant
17	6	3	13	7312	1677018	2.17	0.0008	3.578E-06	1.778E-03	redundant
21	4	1	7	4103	642122	1.75	0.0010	6.229E-06	1.706E-03	redundant
3	5	1	8	5336	889077	1.60	0.0009	5.624E-06	1.499E-03	redundant

Load per Length times Average Rating Density Parameter



Four System Comparison

- Iterative process returns 7 clusters.
- Unconstrained density ranking systems return 8 clusters each.
- Minimum average rating constrained density ranking systems would return 7 clusters each.
- All methods remove overly large clusters.
- All methods require the removal of redundant clusters to be removed before proceeding to next iteration or assigning a cluster to the next rank.

	Iterative Process	sorted by Average rating per area	sorted by Average rating per length	sorted by load per length times average
Ranking	Cluster	Cluster	Cluster	Cluster
1	19	20	20	20
2	15	19	16	16
3	9	16	7	19
4	16	10	19	9
5	10	7	9	10
6	7	9	10	7
7	22	22	22	4
8	X	2	2	22

Four System Comparison

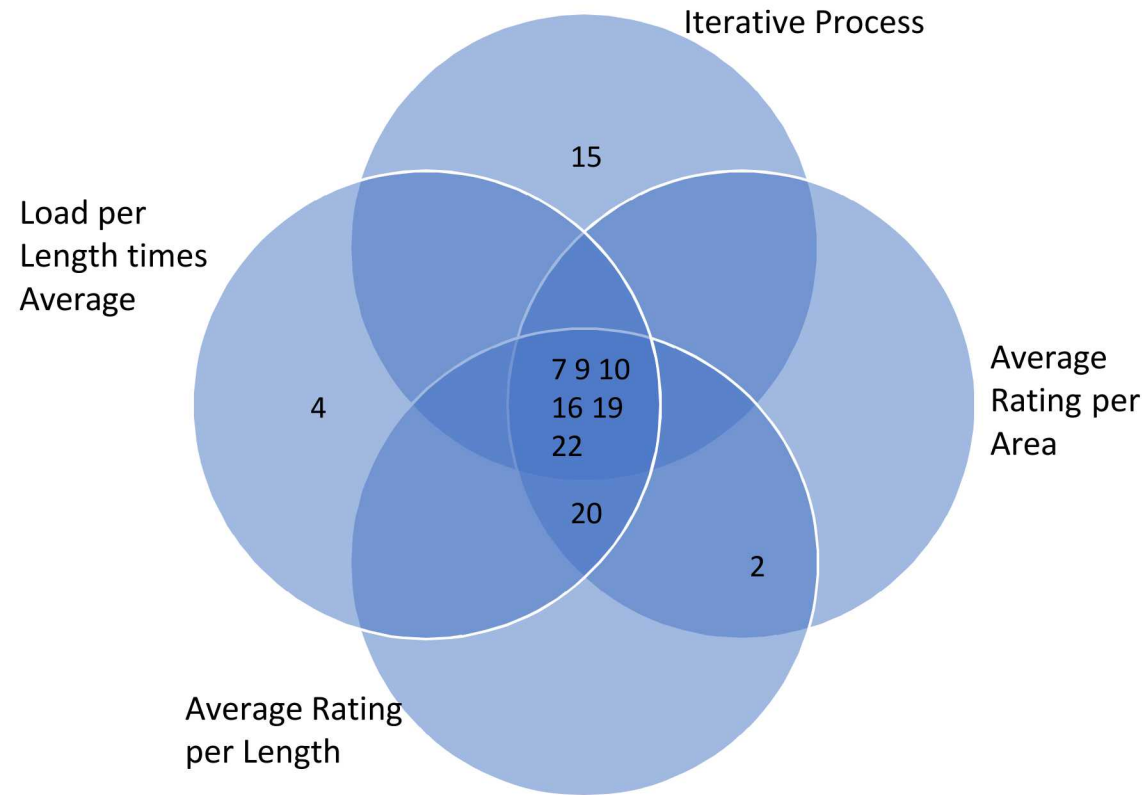


Table Representation of Venn Diagram

Iterative Process	sorted by Average rating per area	sorted by Average rating per length	sorted by load per length times average
19	20	20	20
15	19	16	16
9	16	7	19
16	10	19	9
10	7	9	10
7	9	10	7
22	22	22	4
	2	2	22

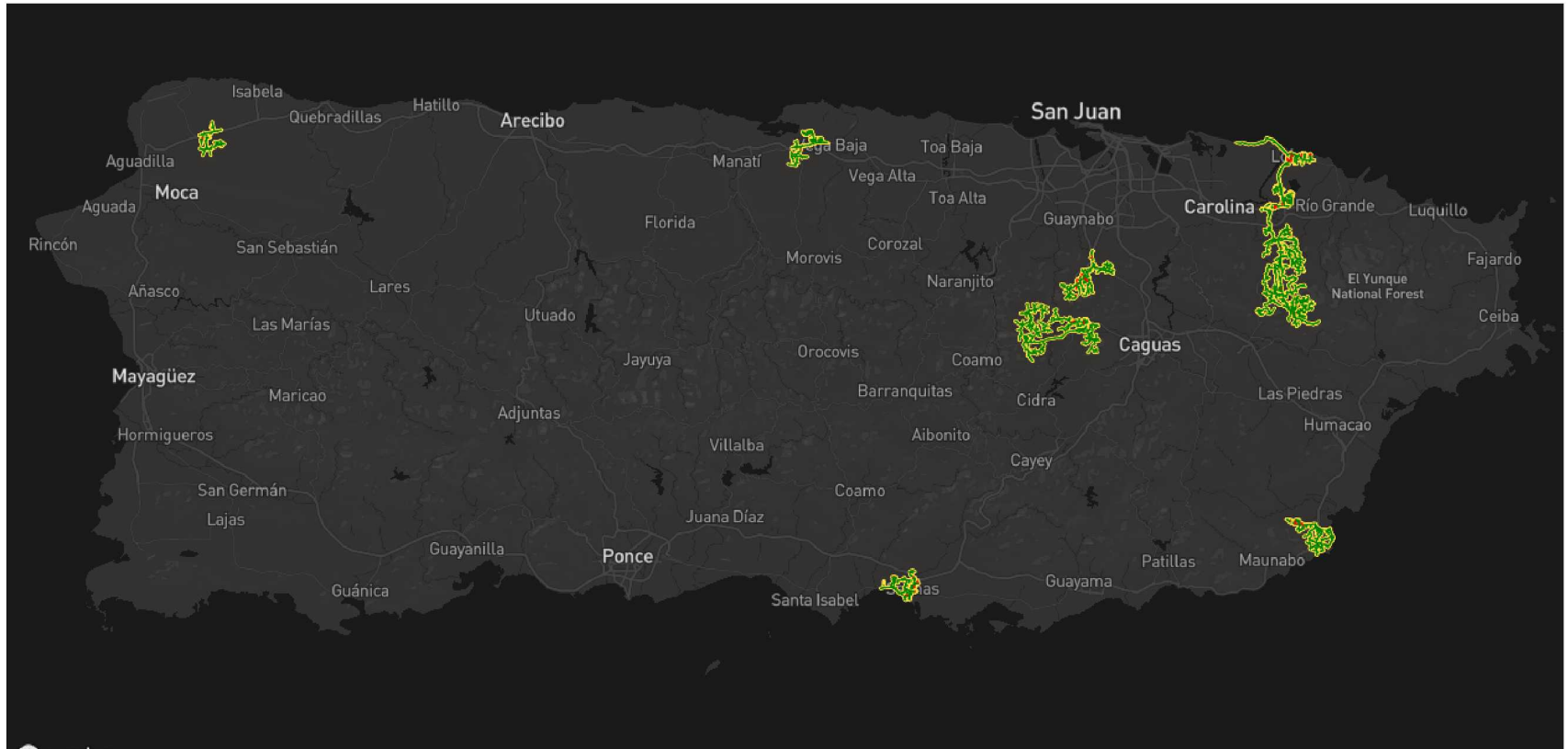
Note: Clusters 2 and 4 would be dropped out if a minimum average rating constraint is imposed.

Current Selection of Feeders and Microgrids

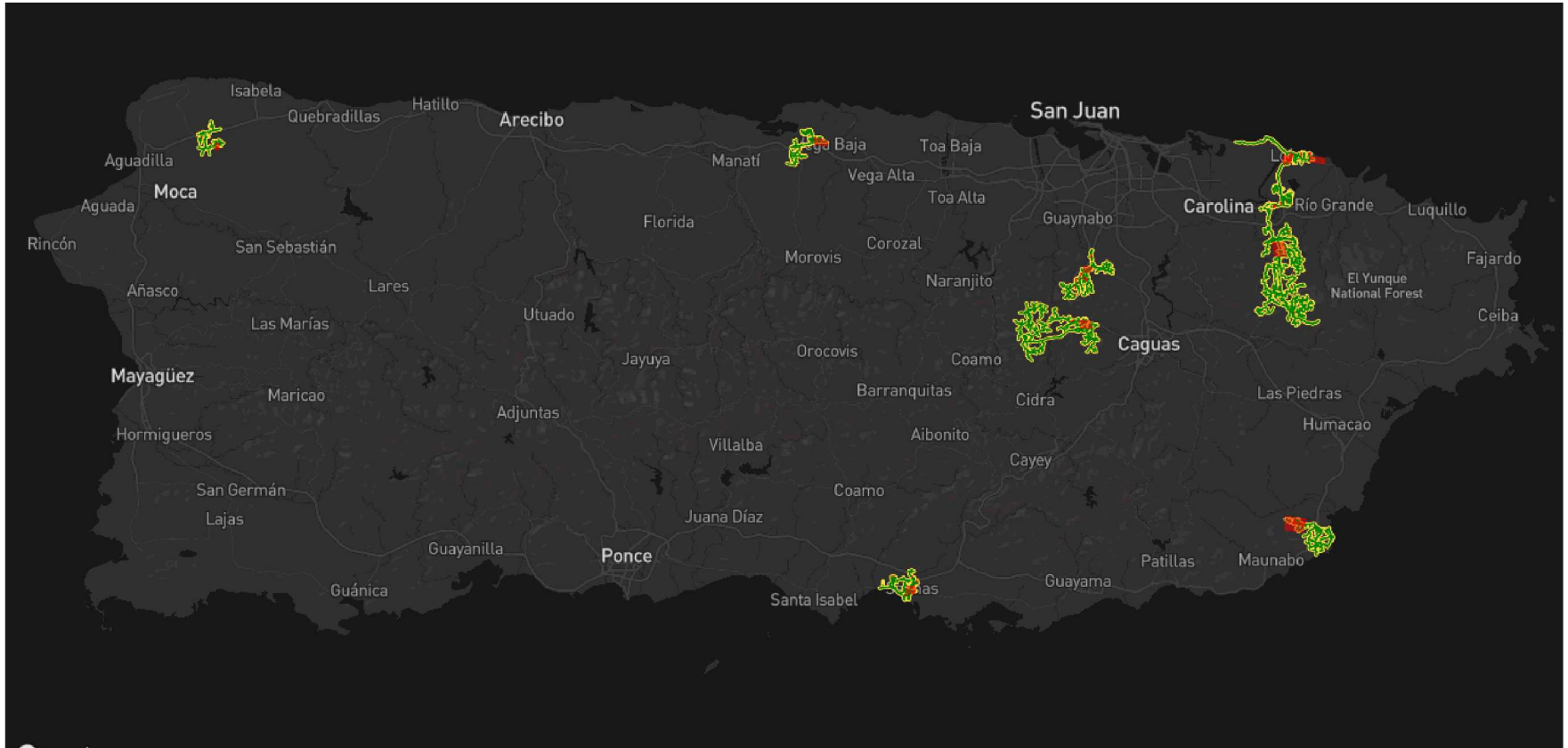
Sr. No	Selected Feeder Name	Corresponding Microgrid Name (Sandia JSON)
1	1343-05	Location_13
2	2401-01	Location_37
3	2402-02	Location 36 + Location 11
4	2901-03	Location 17
5	3701-03	Location 12
6	3701-04	Location 12
7	4501-01	Location 33
8	4501-02	Location 33
9	7012-01	Location 30
10	9003-05	Location 8

- Notice that currently selected 10 feeders overlap with 9 microgrid locations.

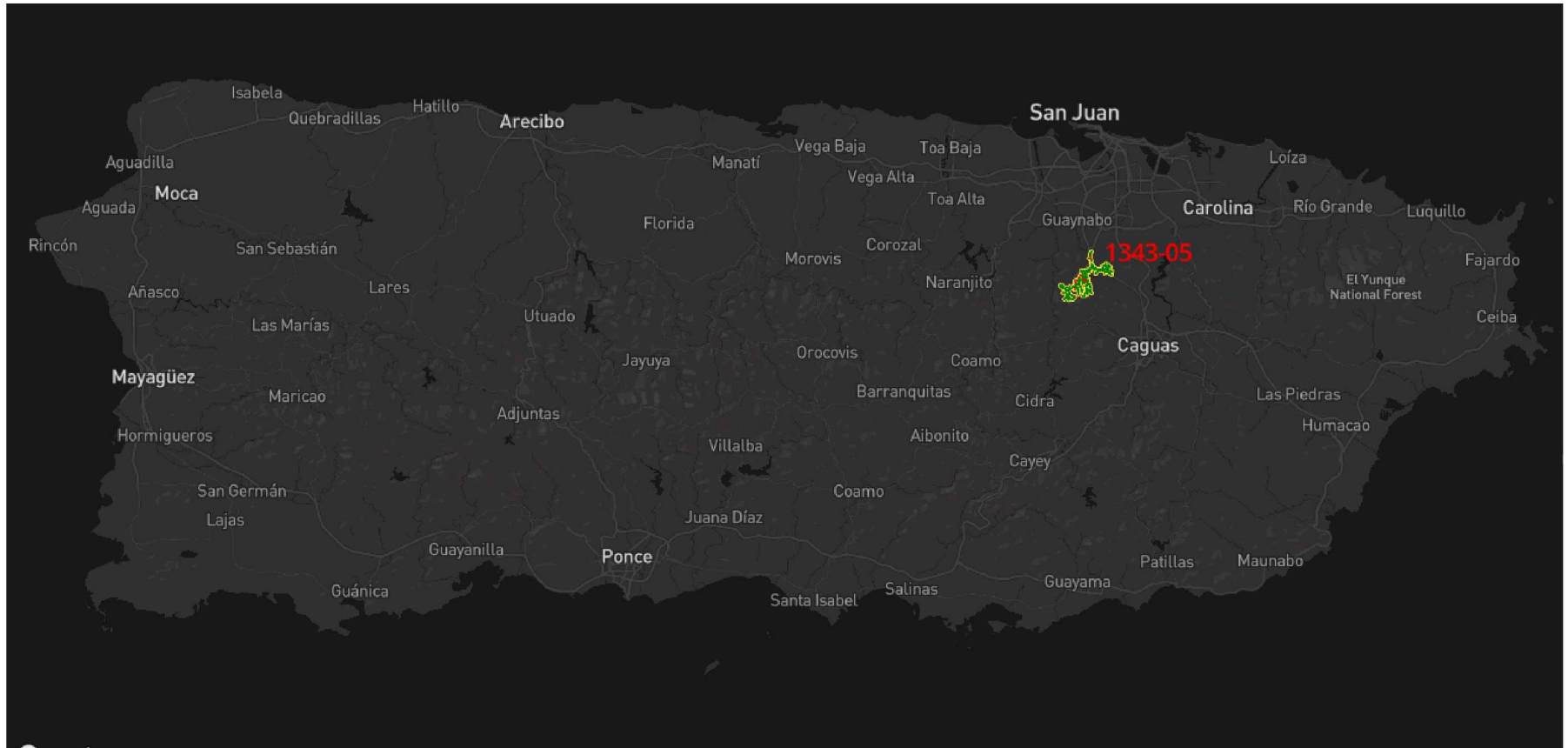
Geographical Distribution of Selected Feeders (without Microgrid Polygons)



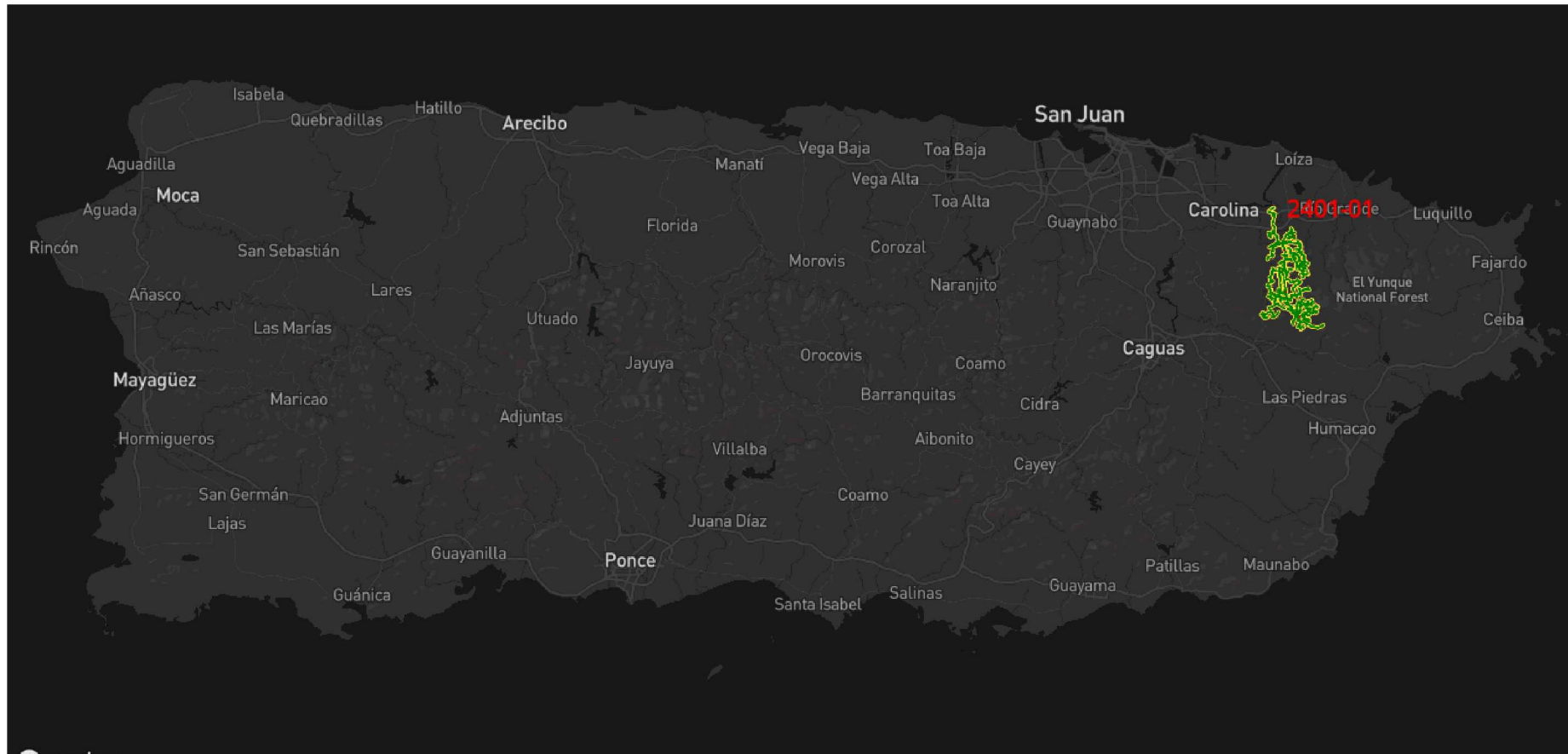
Geographical Distribution of Selected Feeders (with Microgrid Polygons)



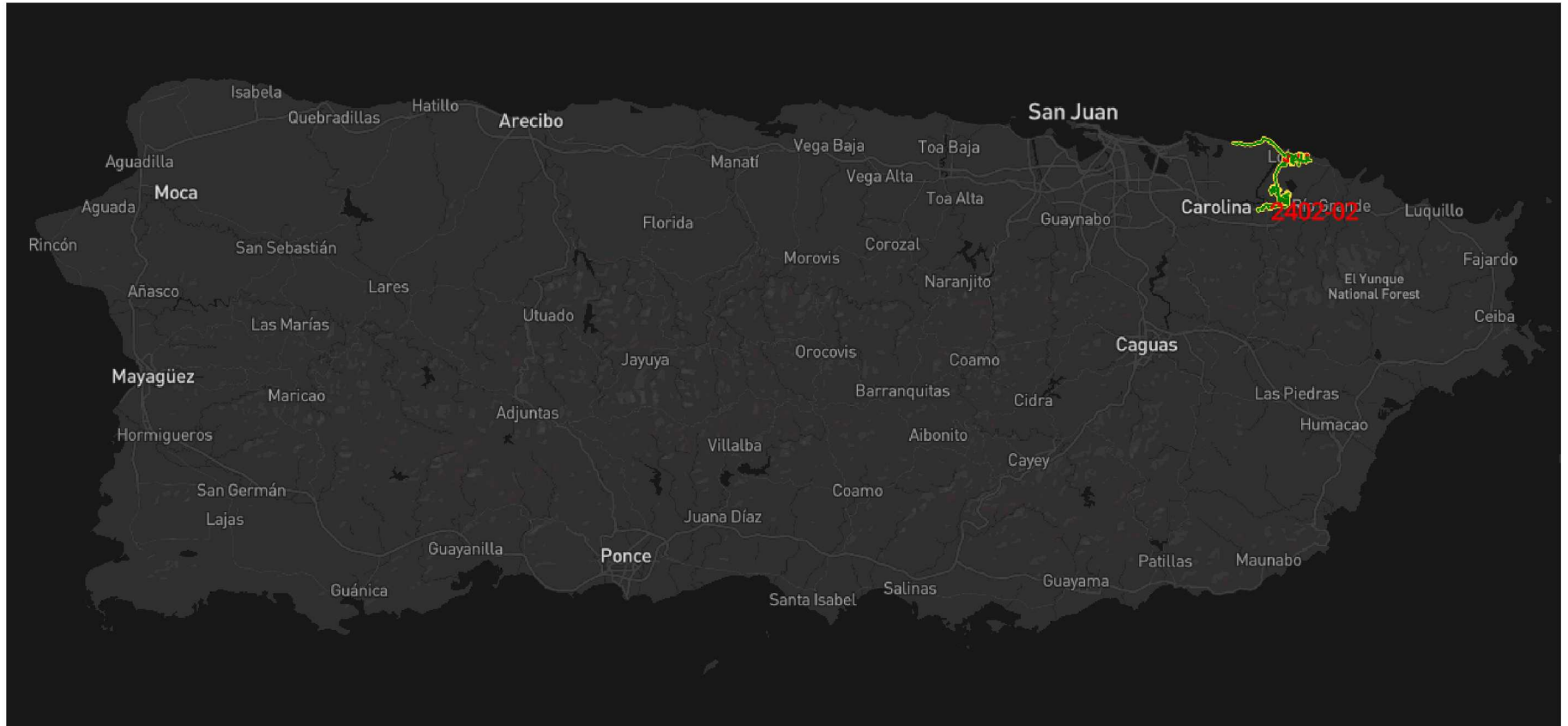
Geographical Distribution of Selected Feeders (Feeder: 1343-05)



Geographical Distribution of Selected Feeders (Feeder: 2401-01)



Geographical Distribution of Selected Feeders (Feeder: 2402-02)



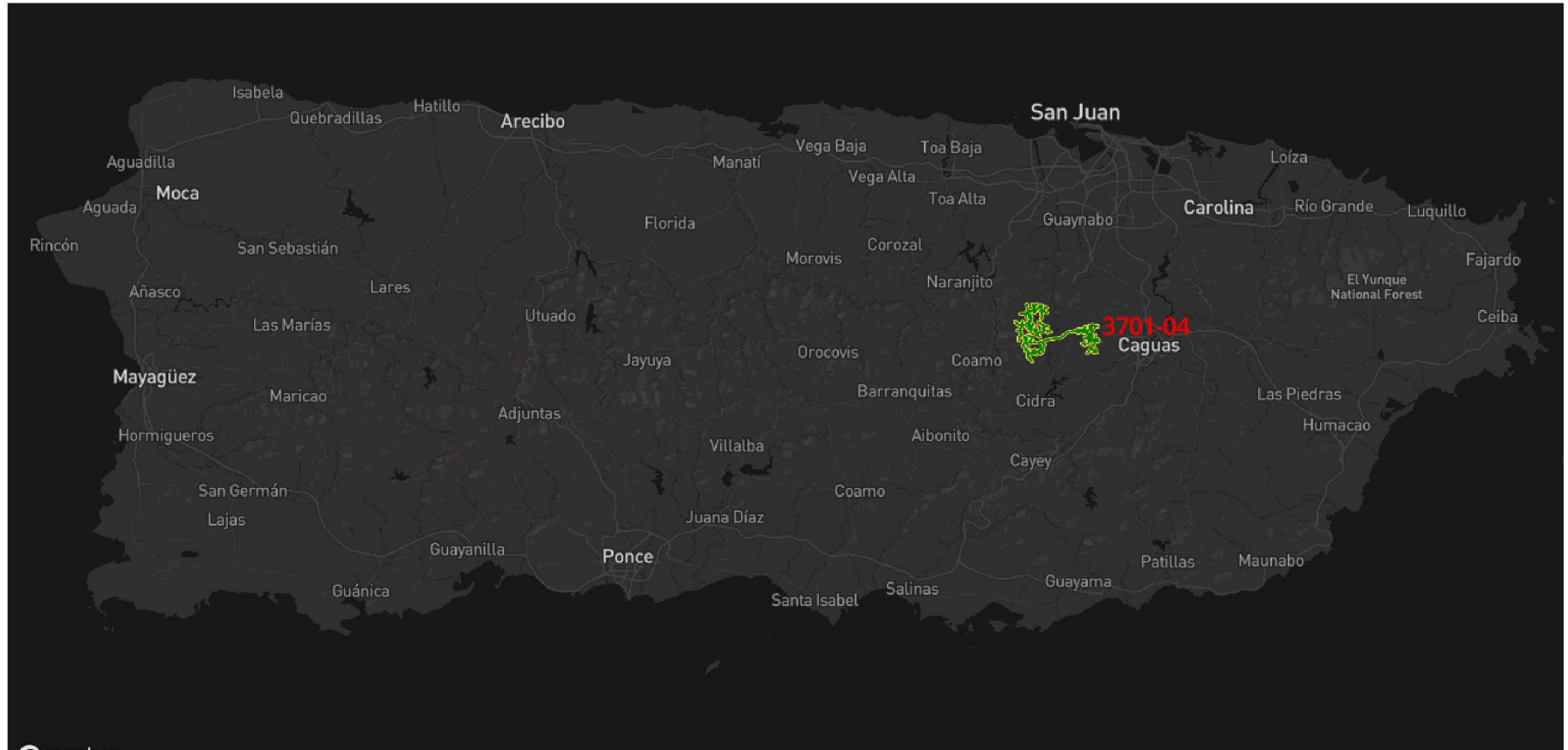
Geographical Distribution of Selected Feeders (Feeder: 2901-03)



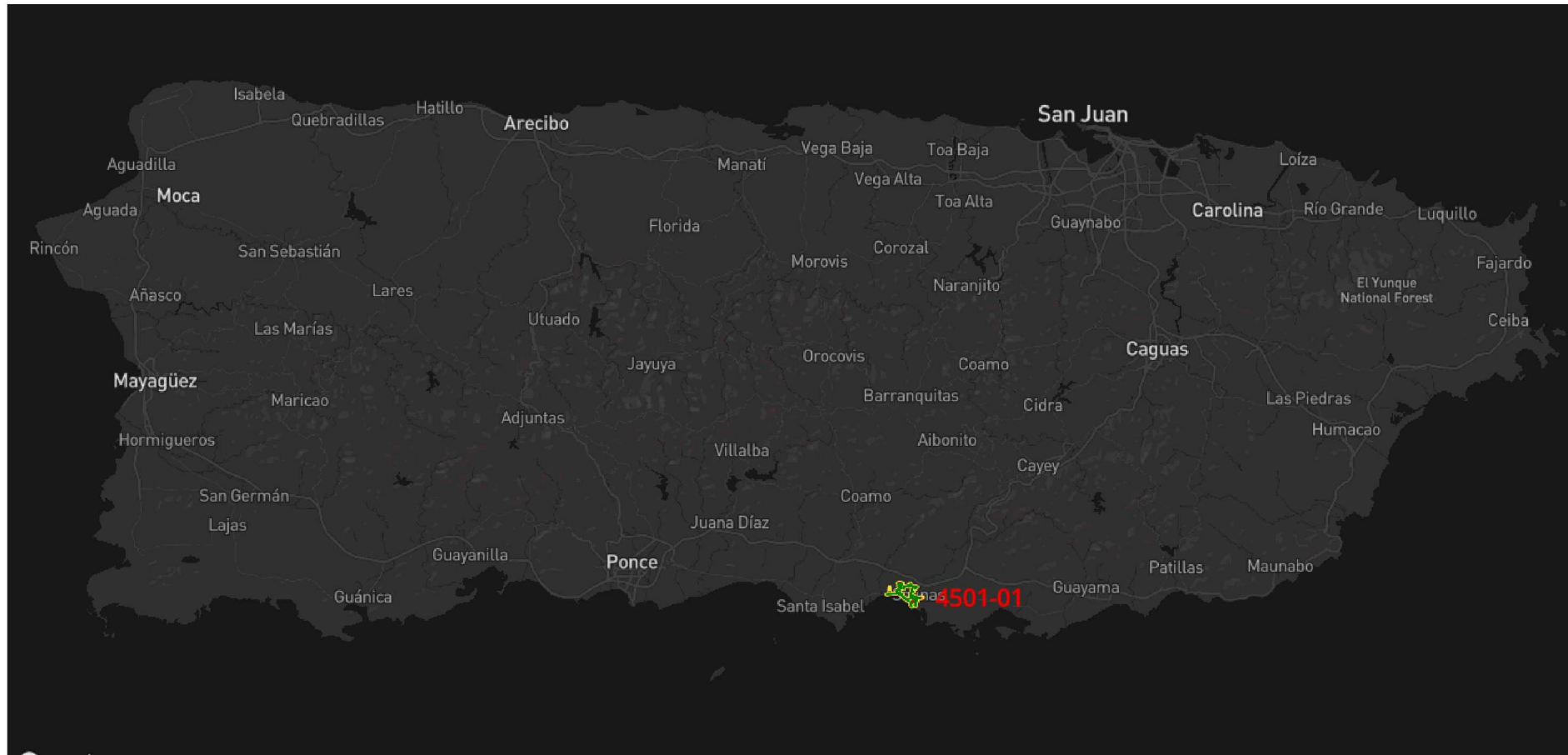
Geographical Distribution of Selected Feeders (Feeder: 3701-03)



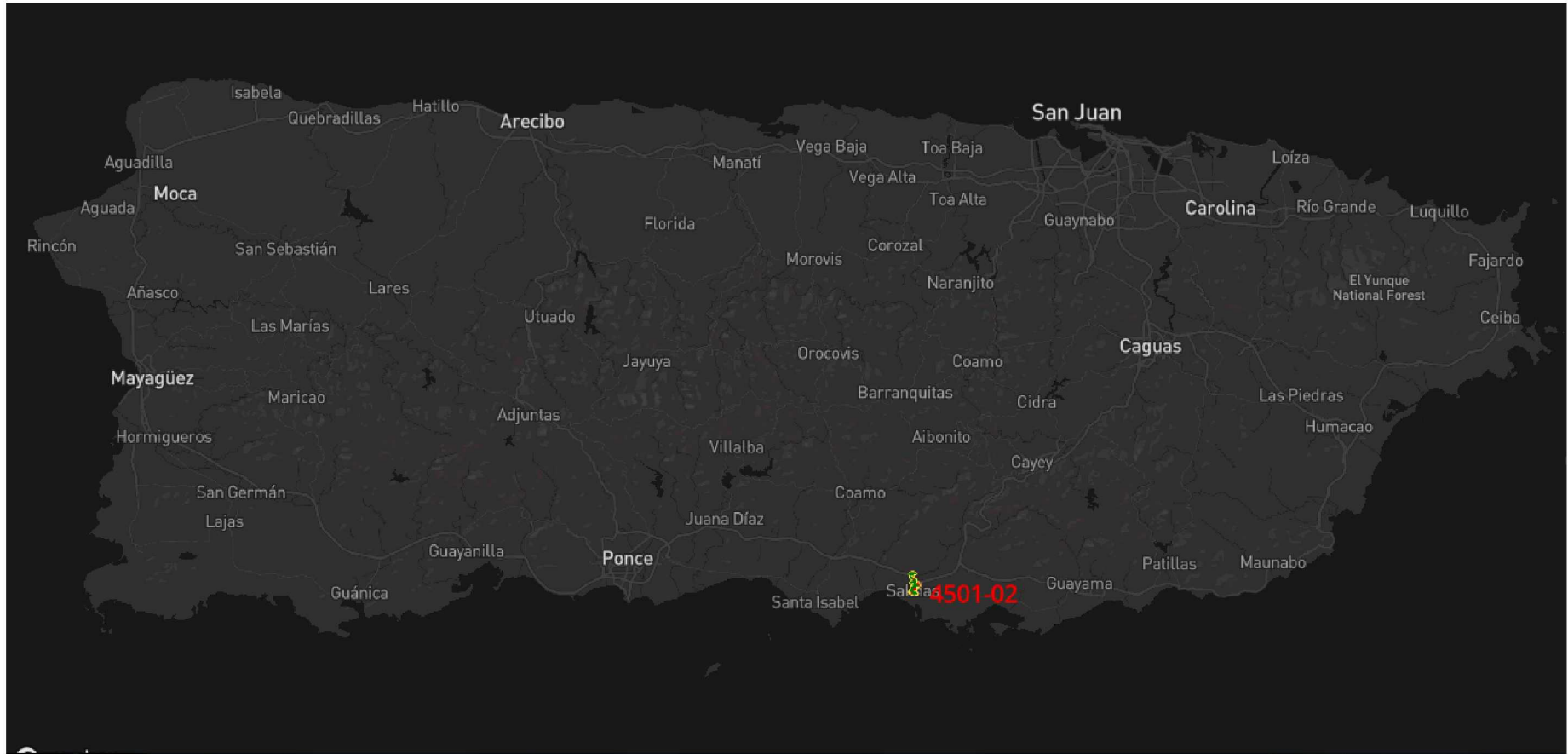
Geographical Distribution of Selected Feeders (Feeder: 3701-04)



Geographical Distribution of Selected Feeders (Feeder: 4501-01)



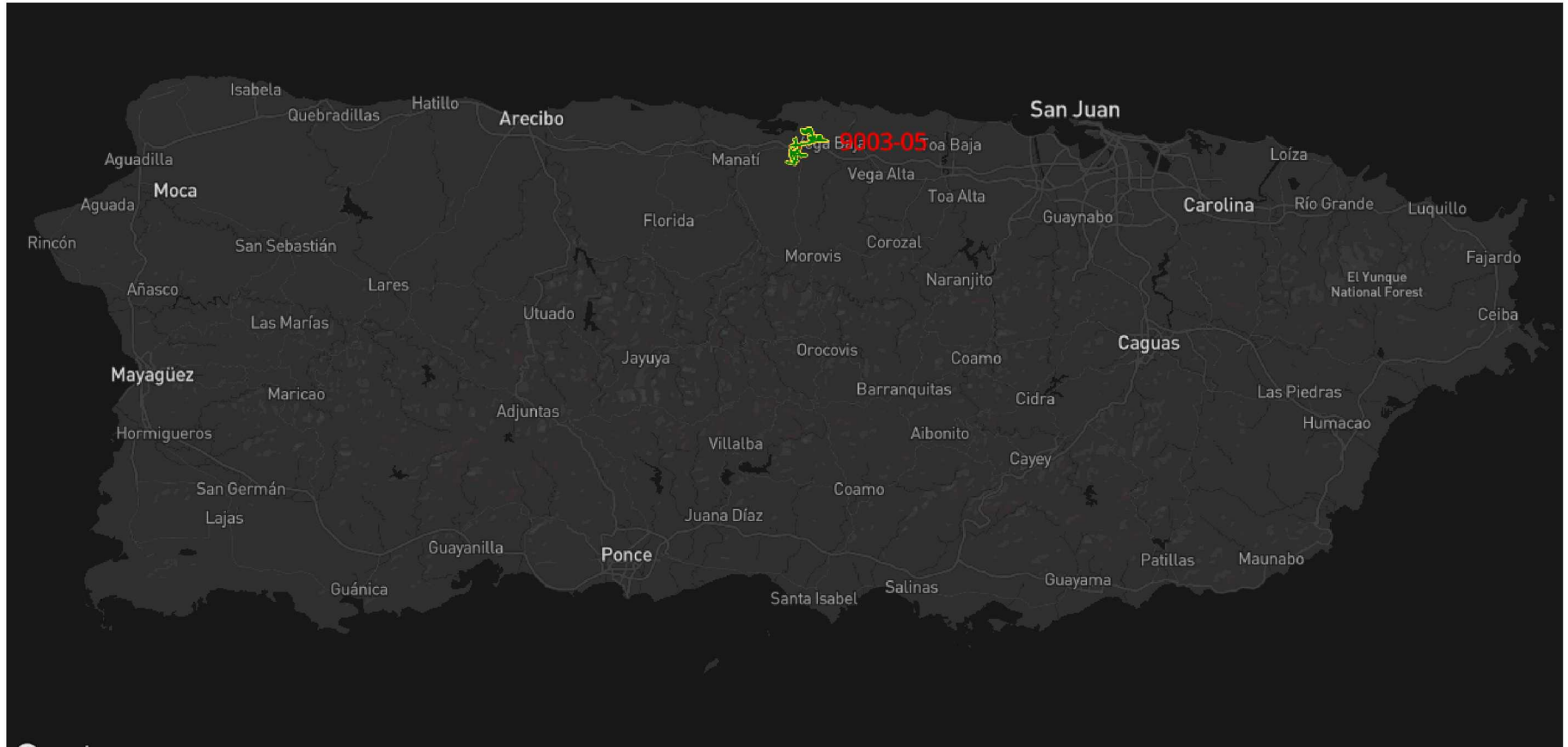
Geographical Distribution of Selected Feeders (Feeder: 4501-02)



Geographical Distribution of Selected Feeders (Feeder: 7012-01)



Geographical Distribution of Selected Feeders (Feeder: 9003-05)



- ❑ Run power flow analysis of each of the 10 feeders to identify microgrid system constraints.
- ❑ Perform a an optimal switch location analysis to create the highest critical load pocket that is also the smallest possible load to be served.
- ❑ Do I slope analysis in the area of the microgrid feeder to determine the viability of a renewable dominated microgrid.
- ❑ Run an optimization with Prosumer grid to determine optimal generation assets, configuration and costs.