Identifying Problems in Puerto Rico's Electrical System due to Distributed Generation

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Abstract

The rapid evolution of distributed generation (DG) technologies has revolutionized the landscape of power generation, distribution, and consumption. This is a comprehensive review of distributed generation cluster studies, aiming to provide insights into their input to the electric system, problems, and a clearer view on how to solve these issues due to these photovoltaic system projects. Several platforms were used to accomplish this methodology which had specific ratings and characteristics. As found in the studies, many feeders had electricity ratings violations regarding Puerto Rico's electrical standards. The proposed mitigations to solve these issues should improve the electrical service.

Introduction

Since Hurricane María hit Puerto Rico, the electrical system was down for nearly 11 months. This event made people choose a better and reliable source of backup power during outages. Based on finding the impact which distributed generation causes to Puerto Rico's electrical grid, distributed generation are renewable projects and, in this case, photovoltaics that once generate all the energy from the sun to its full capacity, start to flow backwards to the grid and there's when one of many problems arrives. Performing the studies will identify the problems to mitigate and further correct those violations while also determining who caused the violation.

Problem

1) Poor distributed generation planning leads to common issues with the electric grid like:

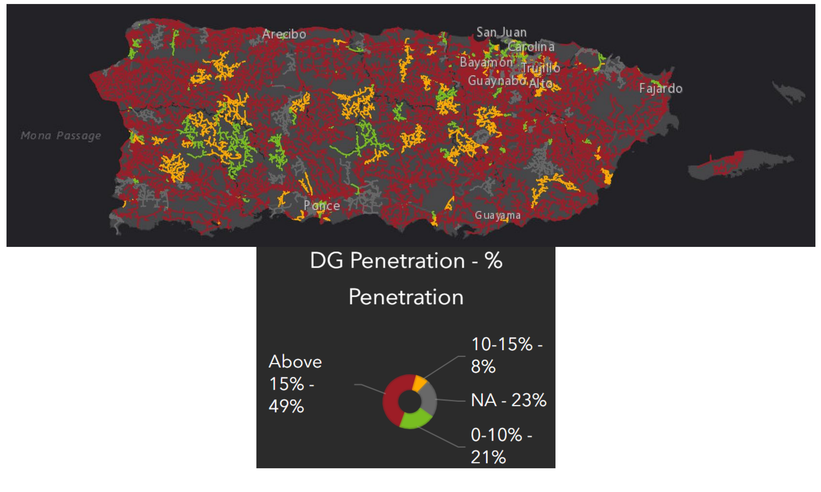
- Voltage Fluctuations
- Power Outage
- Power Quality and Reliability

2) Identify which feeder exceeded the 15% of DG penetration.

- Distribution transformer upgrade needed?
- Primary system upgrade triggered by a voltage violation?
- Primary system upgrade triggered by a thermal overload?

3) Determine which DG project caused the feeder to fall into violation.

- Locate the violation within the feeder sections
- Provide mitigations to solve the problems



Methodology

After determining which feeder will be studied taking into consideration its voltage, demand, ratings, DGs and its penetration percentage level a study was made.

Table 1
Distribution Transformer's Ratings

kVA	Rated Line-to-Line Voltage							
	208	220	240	380	400	416	480	600
3	8.33	7.87	7.22	4.56	4.33	4.16	3.61	2.89
6	16.7	15.7	14.4	9.12	8.66	8.33	7.22	5.78
9	25	23.6	21.7	13.7	13	12.5	10.8	8.66
15	41.6	39.4	36.1	22.8	21.7	20.8	18	14.4
30	83.3	78.7	72.2	45.6	43.3	41.6	36.1	28.9
45	125	118	108	68.3	65	62.5	54.1	43.3
75	208	197	180	114	108	104	90.2	72.2
112.5	312	295	271	171	162	156	135	108
150	416	394	361	228	217	208	180	144
225	625	590	541	342	325	312	271	217
300	833	787	722	455	433	416	361	289
500	1388	1312	1203	760	722	694	601	481
750	2082	1968	1804	1140	1083	1041	902	722
1000	2776	2624	2406	1519	1443	1388	1203	962

Cluster Studies

Feeder Selection

- DG databases information
- Feeder voltage ratings
- Peak value
- Perform the DG penetration formula
- Determine if feeder needs to be studied

Feeder Package

- Prepare the list of DG projects located inside a feeder
- Prepare a digital model of the electric feeder's circuit for simulation
- Input the Minimum Noontime Load (MNL) value in the meter
- Validate the circuit model with multiple platforms

Execution & Results

- Perform the cluster studies by simulating the day case with the DGs OFF and then ON
- Gather the results in a report
- Analyze the data provided by the simulation
- Determine if the violations are due to DGs
- Provide mitigations to solve the violations

Results and Discussion

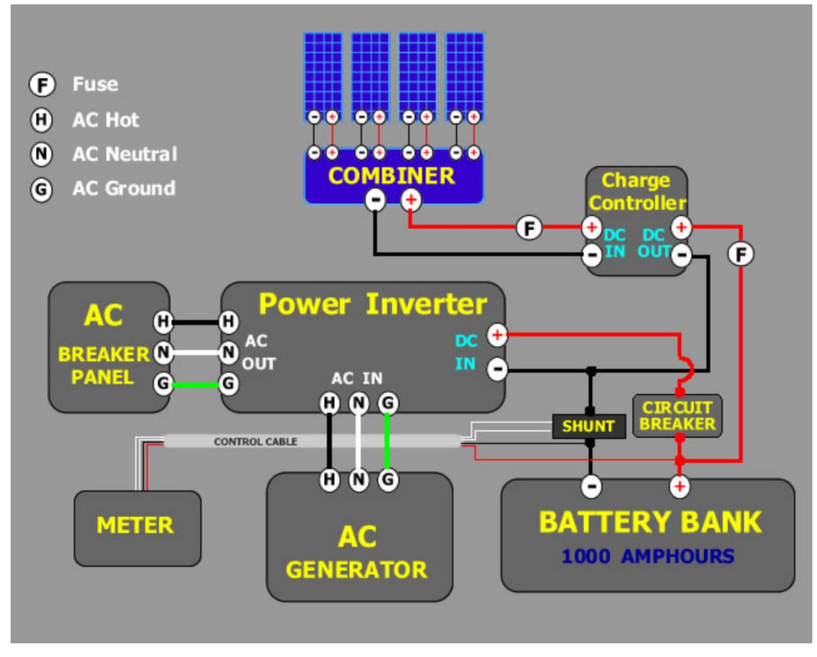
A total of 546 feeders were studied in all its parts in which only 226 had violations due to DGs. The boxes to check to determine if it had violations due to DGs was if it needed a distribution transformer upgrade, if the primary system needed an upgrade triggered by voltage violations, and if it was triggered by thermal overload. 206 of these feeders were identified to be violating the distribution transformer upgrade, 35 by voltage violations and 5 by overloads. These studies demonstrate that from the studied feeders that had violations due to DG projects, some of them had one or more violations at the same time.

Conclusions

Only 41% of these feeders have violations due to DGs, meaning that photovoltaic systems also contribute a negative impact to the reliability of the electrical system. Most of these violations were related to DG projects exceeding the maximum capacity of the distribution transformer in which are interconnected. Nonetheless, the violations found in every cluster study must be confirmed in the field by performing a validation assessment. With the completion of these studies, a better overview on the electrical system is shown. Every feeder, including the ones that didn't have any type of violations regarding DGs, are analyzed and recommendations are given about how much more generation is accepted between each of them to achieve the planned hosting capacity.

Future Work

- Implement an automated procedure to complete these studies quicker.
- Share the results of the studies to the respective platforms in a short period of time for the benefit of the customers.
- Provide insights as soon as a customer interconnects to the grid.
- Share a hosting capacity map to provide realistic feeder conditions to decide if the interconnection is feasible.



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