# Grid Strength Assessment for High Levels of Inverter-based Resources in the Puerto Rico Power System

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## BACKGROUND AND MOTIVATION

- Inverter-based resources (IBR) may soon become the dominant resource
- Fault current will decrease with higher IBR levels
- Conventional machines typically produce 5-10 times rated current while IBR produce 1-1.3 times
- This study discusses the change in short circuit capacity (SCMVA) due to high levels of IBR

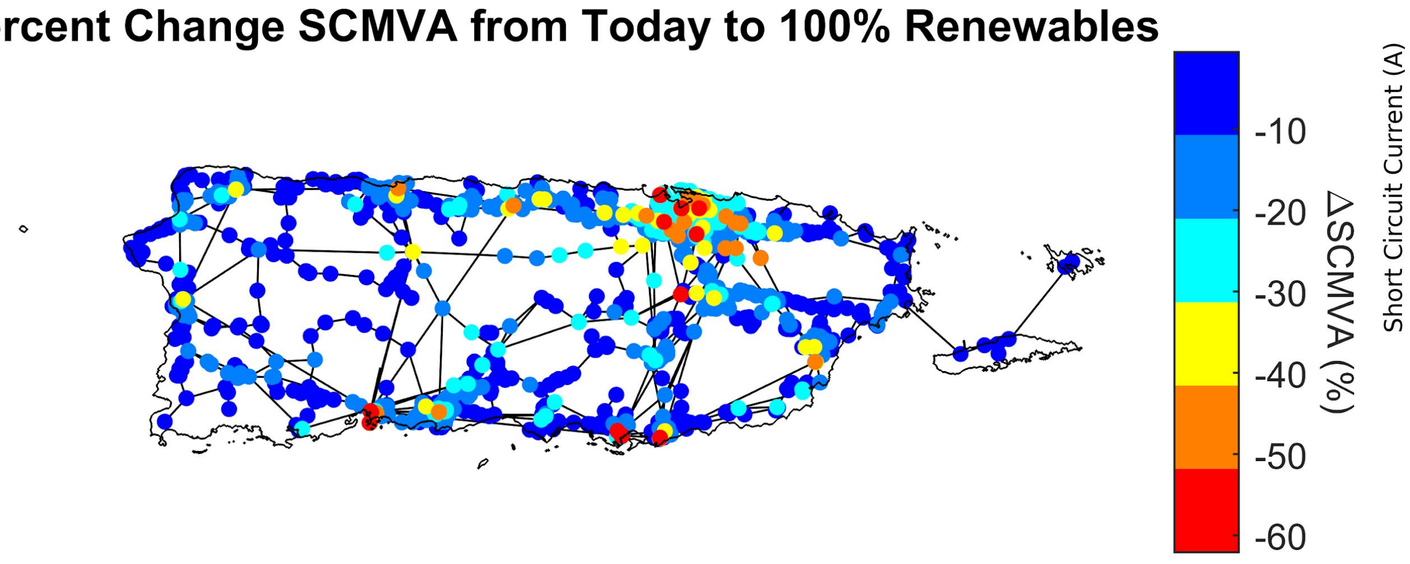
## CONCLUSION AND FUTURE WORK

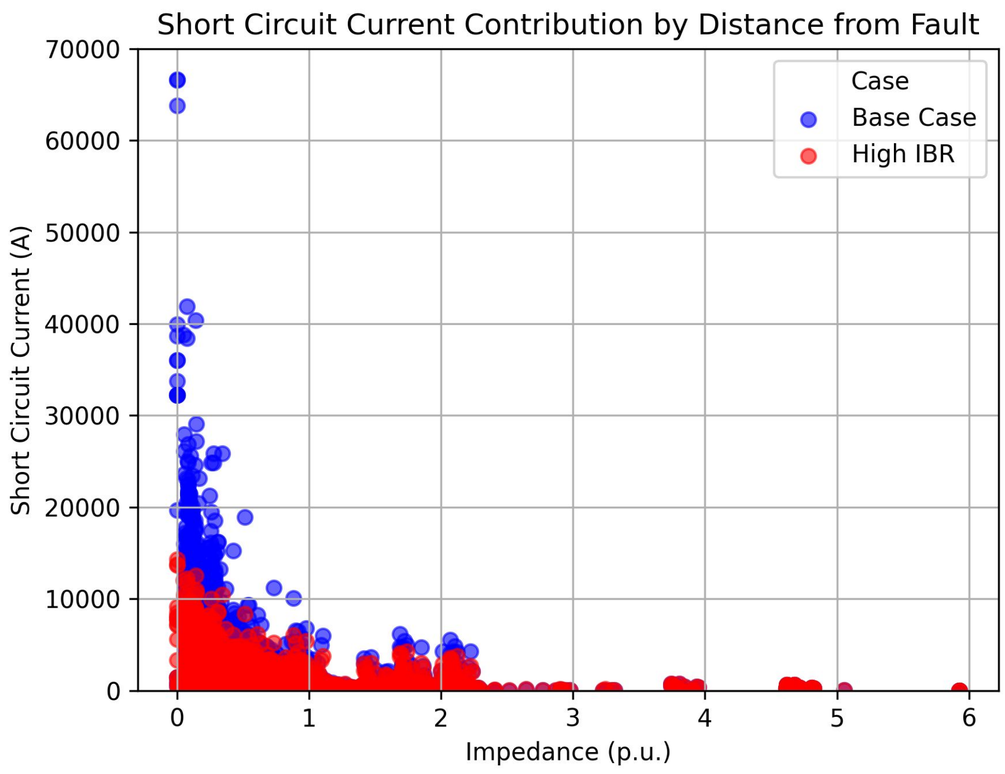
- Existing protection systems may not operate with the lower available fault current
- Detailed study is needed at weak locations to assess other factors of stability
- Future studies will assess the location and capacity of synchronous condensers for improving grid strength

## CASE STUDY 1: LOSS OF SHORT CIRCUIT CAPACITY IN 100% RENEWABLE SCENARIO

- Base case is 2% renewable; 100% renewable case replaces all conventional machines in base case with IBR
- 3-phase faults applied at every bus and fault current calculated per IEC 60909 standard
- Highest change in SCMVA concentrated along the high voltage transmission system
- Locations far from generators have low SCMVA and experience almost no change in SCMVA in a high IBR scenario

**Percent Change SCMVA from Today to 100% Renewables**



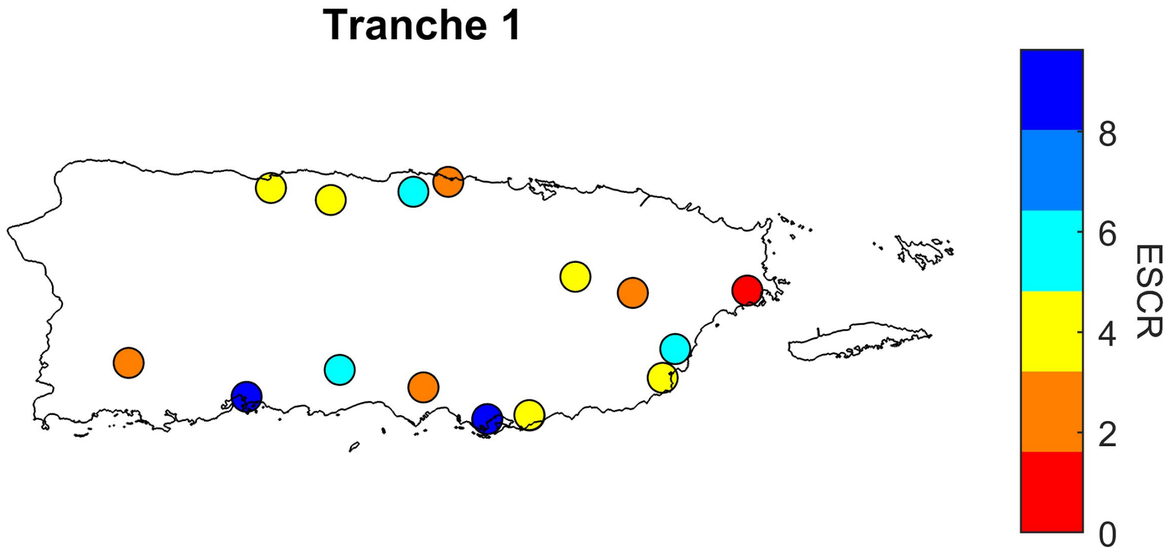




## CASE STUDY 2: SHORT CIRCUIT RATIO IN BASE CASE WITH TRANCHE 1 PLANNED IBR

- Short circuit ratio study using 2021 validated base case with tranche 1 planned IBR without considering generation retirements
- Tranche 1 includes ~25 sites averaging 70 MW of capacity
- **SCR** considers local IBR impacts without contributions from other IBR
- **ESCR** considers other nearby IBR impacts to voltage
- **WSCR** considers regional IBR capacity impacts

| SCR | ESCR | | WSCR |
|---|---|---|---|
| $SCR_i = \frac{SCMVA_i}{MW_i}$ | $ESCR_i = \frac{SCMVA_i}{MW_i + \sum IF_{ij} \times MW_j}$ | $IF_{ij} = \frac{\Delta V_i}{\Delta V_j}$ | $WSCR = \frac{\sum_i^N SCMVA_i \times MW_i}{(\sum_i^N MW_i)^2}$ |

**Equivalent circuit-based Short Circuit Ratio**
**Tranche 1**




| Location | SCR | ESCR |
|---|---|---|
| Santa Isabel | 8.19 | 2.43 |
| Breñas | 12.30 | 1.74 |
| Aguirre | 12.71 | 8.10 |
| Juncos | 15.61 | 3.08 |
| Jobos | 16.66 | 3.96 |
| Barceloneta | 16.90 | 3.71 |
| Cambalache | 20.41 | 4.55 |
| Jobos | 23.33 | 3.74 |
| Yabucoa | 26.19 | 5.41 |
| San German | 29.75 | 2.58 |
| Bairoa | 34.23 | 4.31 |
| Juana Diaz | 39.18 | 5.13 |
| Costa Sur | 39.79 | 9.63 |
| Vega Baja | 40.62 | 5.79 |
| Daguao | 46.77 | 1.49 |
| Yabucoa | 63.94 | 3.22 |
| **Regional Metric** | **WSCR** | |
| All Locations | | 1.947 |