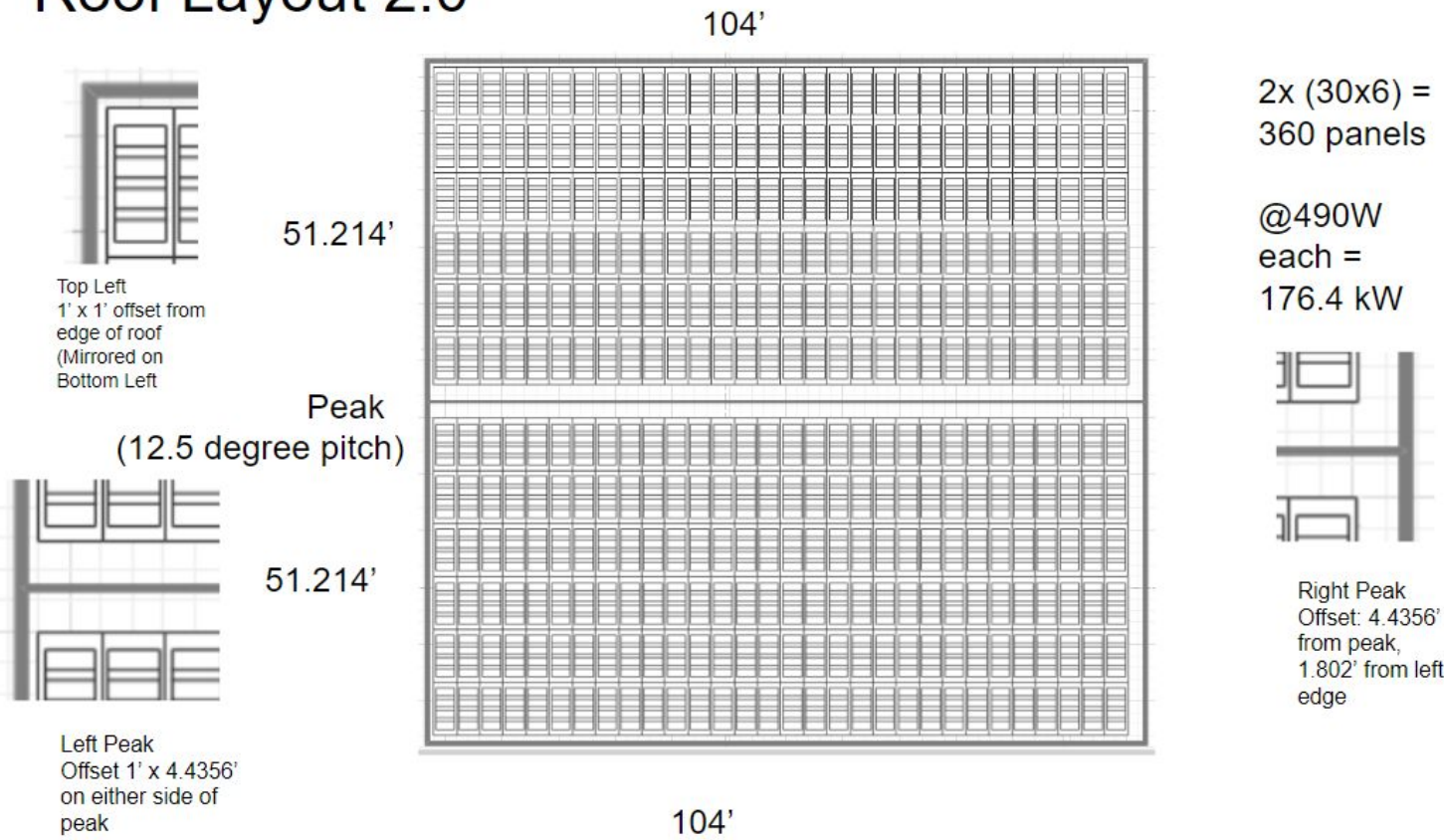# PIRM 2: PV Feasibility in Puerto Rico

SDDEC23-16: Isaac Buettner, Adam Curtis, Hannah Nelson, Manuel Perez-Colon, Larry Trinh

PV Design

## Roof Layout 2.0

Top Left
1' x 1' offset from edge of roof (Mirrored on Bottom Left

51.214'

Peak
(12.5 degree pitch)

51.214'

Left Peak
Offset 1' x 4.4356' on either side of peak

104'

104'

2x (30x6) = 360 panels

@490W each = 176.4 kW

½" between each panel, leaving minimum 1' around edge of the array to minimize wind shear, provide access for maintenance

Right Peak
Offset: 4.4356' from peak, 1.802' from left edge

Inverters and String Combiner

➔ 30 panels wired in series = 1095 V
➔ 12 rows wired in parallel with Solectria XGI 1500 PV Combiner = 161.16 A
➔ Solectria Inverter XGI 1500/200-480
 - Inverter is transformerless; however, PR code requires transformer connection (wye-grounded)

➔ Current work is focused on microgrid interconnection requirements and battery storage
  - Tesla Powerpacks are recommended with this combiner/inverter combo
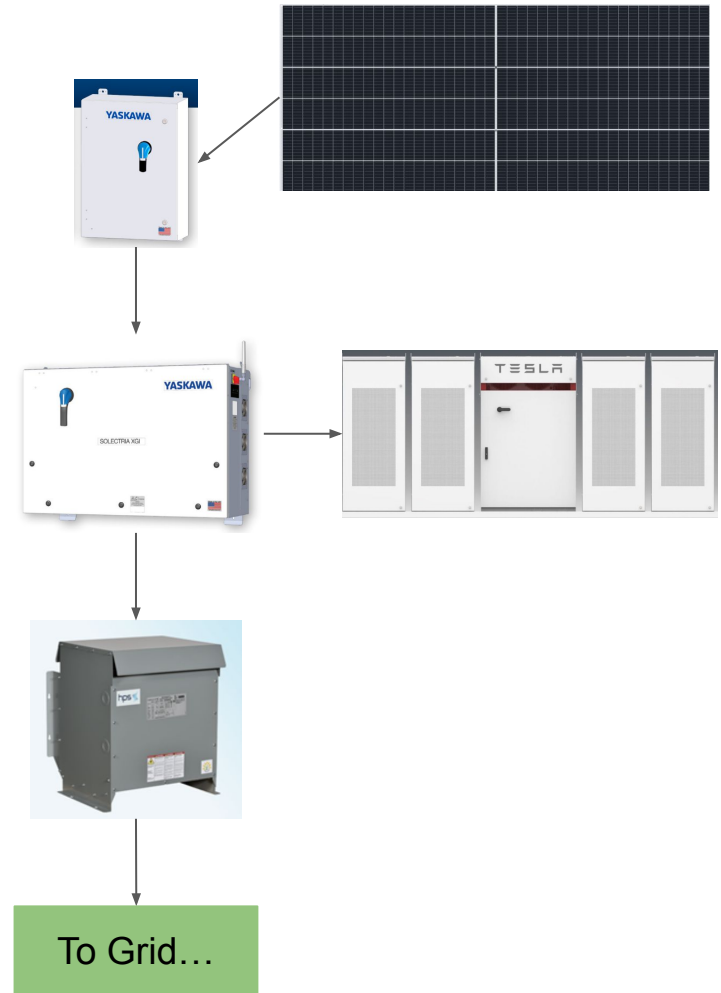
To Grid…

Microgrid Software & Models

Xendee Microgrid

Streamlines optimization for multiple cases (e.g. Economic, CO_2 Emissions, %Renewable)
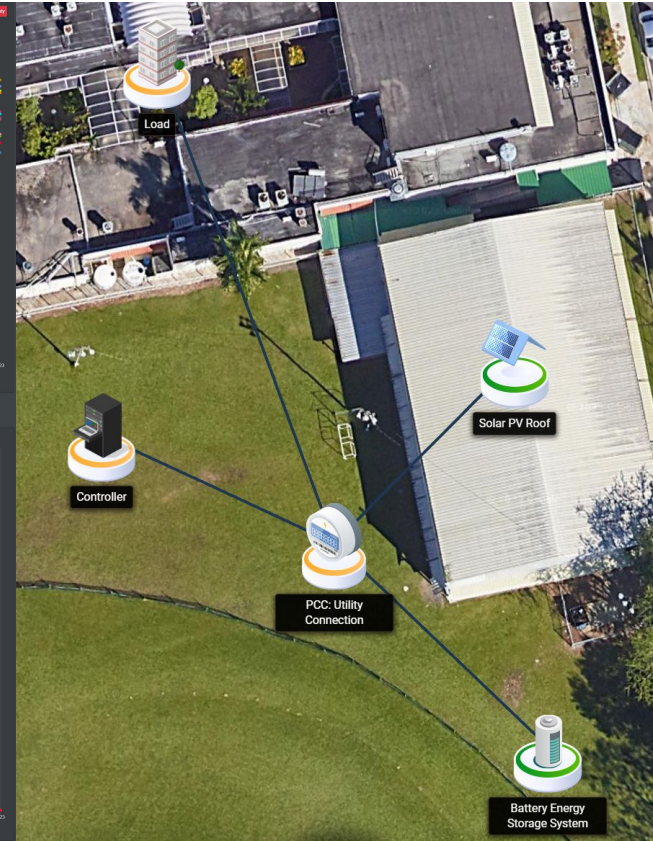
Possible Locations

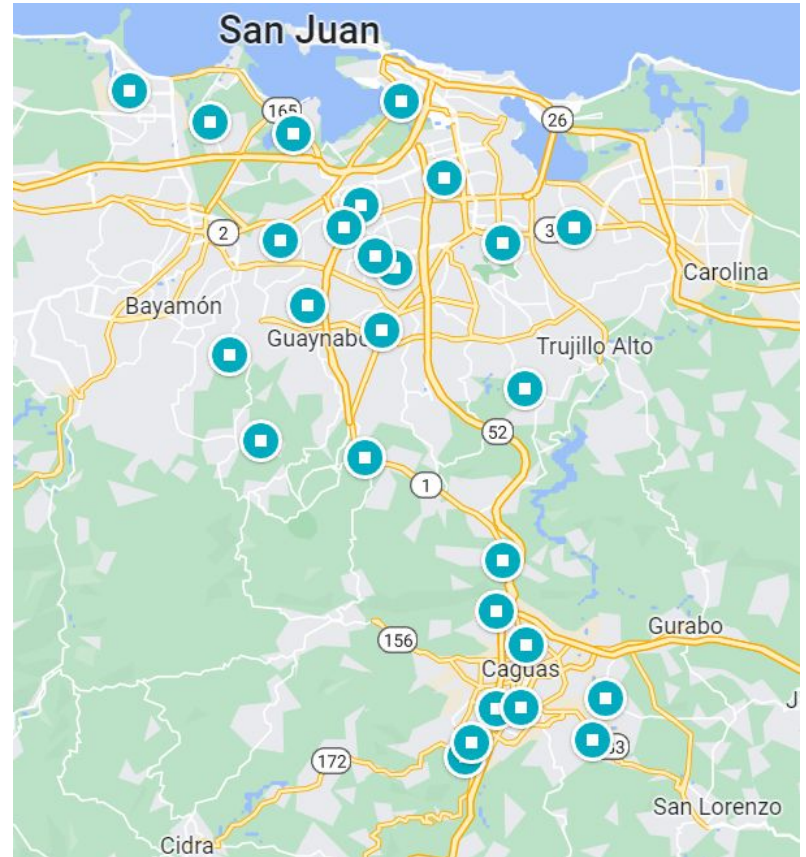Discovered 28 possible locations in the three states of San Juan, Guaynabo and Caguas.

By applying our estimate as an average per location, and comparing that to the yearly usage of Puerto Rico. This would be a 2.2% increase of the total renewable energy production in 2021. This would generate enough energy to offset around 10,000 household.

Yearly Production of all locations = 176.4*12*365*28 = 21,633,696 kWh

Yearly Renewable Production (2021) = 1,000,000,000 kWh

https://www.eia.gov/state/print.php?sid=RQ
https://ieefa.org/wp-content/uploads/2019/12/PREPA-RSA-Cordero-Guzman-UTIER-REPORT-9-10-19-FIN-ENGLISH.pdf

Cybersecurity

5G cellular hotspot → wired ethernet cable

- Testing implementation (5G hotspot and inverter) through Pratum, and asking Solectria to verify their web-based monitoring
    - Inverter includes firewall
    - Principle of Least Privilege: only allowing required traffic inbound AND outbound
- Limits (outside) access to inverter, software, controls by physical connection through ethernet cable, secured by fencing & camera
- $5000 penetration testing

Cybersecurity

- Isolating internal and external communication of PV systems.
- Using authentication.
- Using antivirus software.
- Using monitor tools such as intrusion detection and prevention that could monitor and examine network traffic flows.

Cost of Cybersecurity.

- Cost of cybersecurity insurance.
- Cost of Cybersecurity awareness training.
- Cost of Antivirus software.
- Cost of monitoring of website, servers, and domains
- Cost of data protection and back up.

Remaining work

- Proof of concept model
- Energy production calculations
  - Production for one install, estimate for multiple installations
- Estimate of total cost for install
  - Including all components and labor
  - Payback period
- Detailed Schematic
  - Wiring diagram, showing connection of panels, inverter, charger, grid connection
- Battery Storage/charging
  - Tesla Powerpack
- Connection with the grid
  - Step up/step down
  - Isolation from grid when generators go down