EE/CprE/SE 491 REPORT 11

9/16/23 - 9/30/23

Group number: **16**

Project title: **Photovoltaic Feasibility in Puerto Rico**

Client &/Advisor: **Prof. Vikram Dalal**

Team Members/Role: **Isaac Buettner, Adam Curtis, Hannah Nelson, Manuel Perez-Colon, Larry Trinh**

- **Weekly Summary**

  We mainly continued our research and designs after getting specific information from an industry contact. Calculated qualitative information from this. We have a lot of solid pieces being put together, including the types/brand of panels to use, the inverter, and how to connect these. Our emphasis going forward will be finding what type of battery storage we would like to use and how to use the software to model our design.

- **Past week accomplishments**
  - Isaac: Made progress with acquiring software that we can use to simulate our design. Began learning how to use it and applying it to our design.
  - Adam: Created a new, detailed solar panel layout for the building we are planning to use. I also started on a wiring plan for connecting the panels, including calculations for voltage, current, output power, and began checking if our chosen inverter will be compatible with the current 176kW plan.
  - Hannah: Looked into specific inverters that could be used in our project. Evaluated one in particular that might end up being the one we use. Additionally, researched the requirements for connecting a microgrid solar installation such as ours to the main power grid of Puerto Rico.
  - Manuel: Conducted research on specific locations that will be viable for installations and variations such as ours. Began evaluating these locations for total potential generation if our design was able to be applied to them all (with slight variations).
  - Larry: Conducted research on solutions for cybersecurity for our design. We will need to secure all switchgear against both physical and cyber threats.

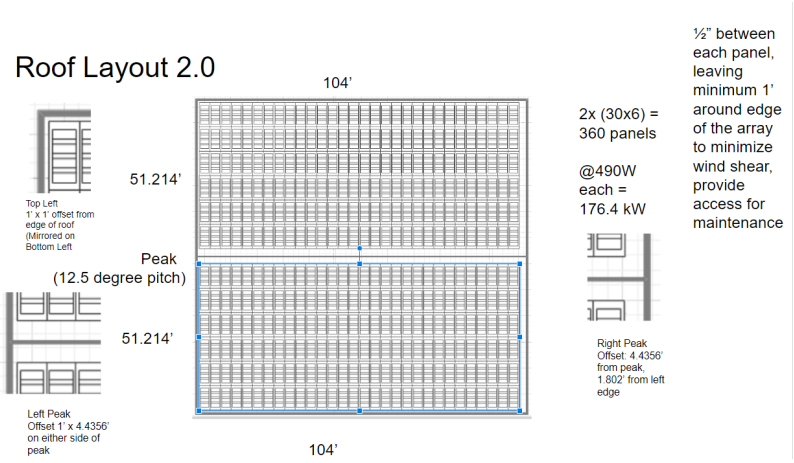
- **Individual contributions**

Name	Individual Contributions *(Quick list of contributions. This should be short.)*	Hours for (2) weeks	Hours cumulative
Adam Curtis	Rooftop layout design	10	74
Hannah Nelson	Research on inverters, microgrid connection	10	74
Isaac Buettner	Gained access to software, learning to use it.	10	57
Larry Trinh	Research on cybersecurity, safety for our design	10	58
Manuel Perez	Compiling list of potential locations, calculating potential output.	10	58

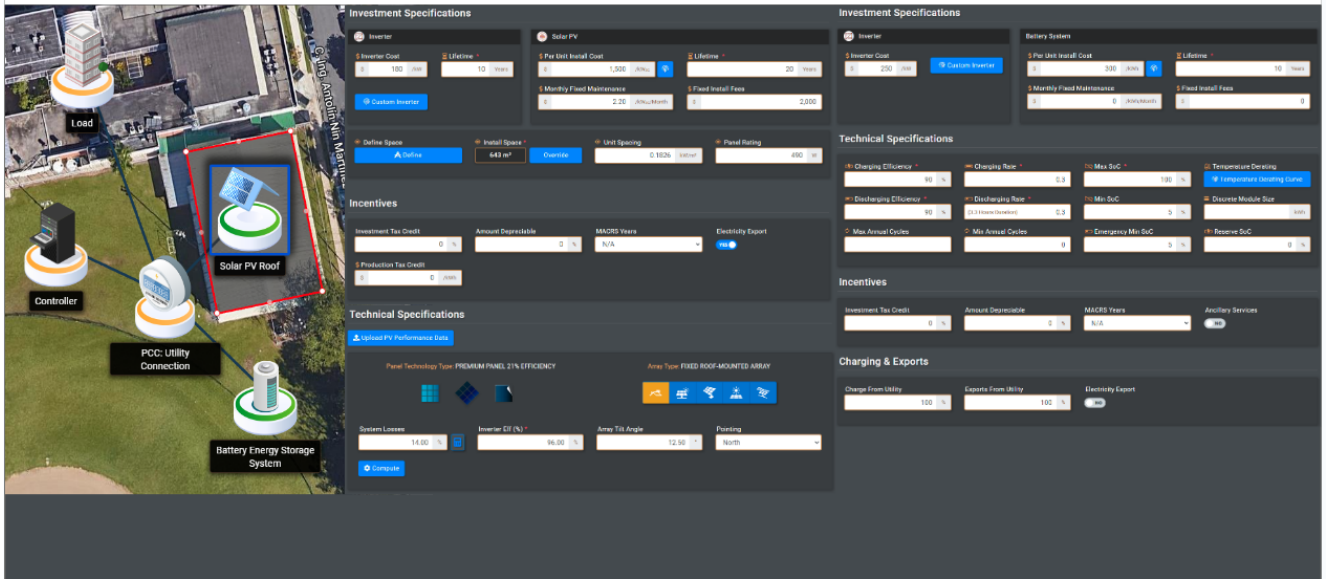
- **Plans for the upcoming week**
  - Isaac: Continue working with software, simulate our design.
  - Adam: Create wiring schematic for our design, verify inverters will work with our design, and find battery charging hardware that will also work.
  - Hannah: Work with Larry to find a cybersecurity solution that will be compatible with our design. Find information about potential battery backup suppliers.
  - Manuel: Complete list of potential locations that could work with our design and finalize calculations for total potential output and how much these installations could offset the fossil fuel powered grid that currently exists in PR.
  - Larry: Work with Hannah to find a cybersecurity solution that will be compatible with our design. Find standards related to safety of the switchgear.

Summary of biweekly advisor meeting

We meet with Professor Dalal every other Monday. This week we presented to Professor Dalal a Powerpoint including all of our progress laid out in this report in more detail, including our research, functions of the software we are using, calculations, and our rooftop layout design. Below are a few slides from our presentation.



Software Microgrid Modeling



Solar Panel Wiring Plan

Each Panel has a Positive and Negative terminal.

Connect in Series to increase voltage, Parallel to increase current

Max output voltage from 1 panel = 36.5V (Trinasolar TallMax 490W)

Max output current from 1 panel = 13.43A (Trinasolar Tallmax 490W)

36.5 x 13.43 = 490W

30 panels per row wired in series = 36.5 x 30 = 1095 V (Max input to Solectria Inverter: 1250 VDC)

12 rows wired in parallel = 13.43 x 12 = 161.16 A (Max input to Solectria Inverter: 237.3 A)

1095 x 161.16 = 176.47kW (Max in Solectria Inverter: 204kW)

Output voltage from Solectria Inverter: 480VAC 3 Phase

Inverters

- 2 options to choose from: XGI 1500-166 or XGI 1500-250
- Main differences are max. operating power range: model 166's max. is **170 kW** vs model 250's is **255 kW**, and size (more power = slightly larger)
- Temperature range up to 140 degrees F ✅
- Regarding security: firmware can be updated remotely, firewall included in gateway, secure IP address

How to protect solar inverters from Cyber attacks?

- Get a router and configure it with a proper firewall.
- Change the password for every configured user of the inverter
- Two factor authentication.
- Restrict what solar inverter has access to.

I have uploaded some papers about cyber security topics in the shared folder:

- Cyberphysical Security of Grid Battery Energy Storage Systems
- Roadmap for Photovoltaic Cyber Security.