EE/CprE/SE 491 REPORT 13

10/1/23 - 10/15/23

Group number: **16**

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

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

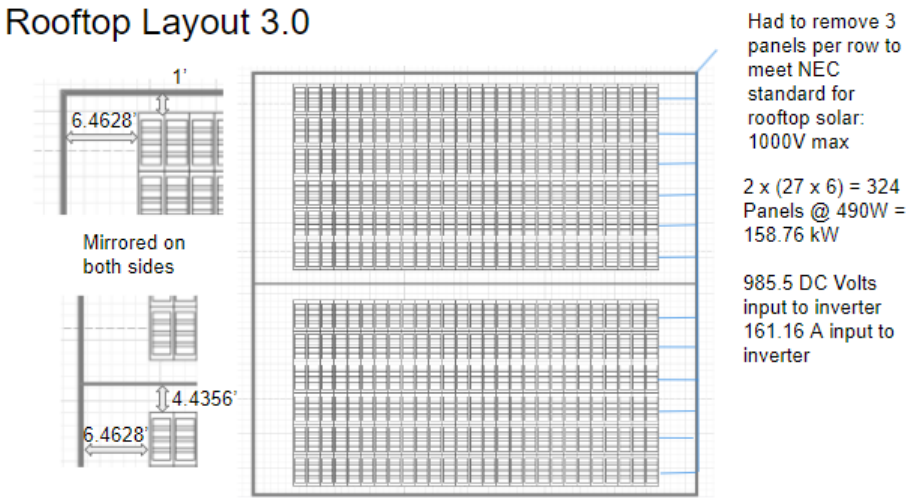
Team Members/Role: **Isaac Buettner, Adam Curtis, Hannah Nelson, Manuel Perez-Colon, Larry Trinh**

- **Weekly Summary**

Met with our advisor, Professor Dalal, and gave the second PIRM presentation. We've been getting lots of feedback lately, which has been helpful to determine goals going forward. Our team is splitting up work by "topic" – everyone has a different focus. Some of the main objectives include finalizing products used, cybersecurity, battery storage calculations, schematic, microgrid simulations, and location scouting. We are aiming to finalize our "models" that best show what we have been working on.

- **Past week accomplishments**
    - **Isaac**: Reformatted the website to more cleanly integrate/outline certain reports from both EE491 and EE492. Recalculated and updated my models to fit the specifications provided in Adam's roof layout schematic 3.0. Plugged in new data from selected batteries and inverters. Began running optimization reports focused on improved economic feasibility through the XENDEE software. I have decided for now that due to the sheer price of individual systems it may be better to focus on just lowering prices for now until we can collect and provide more accurate estimates. Used the PR-DRIFT NREL tool to forecast the residential power demand of 2025 so as to avoid complications from the 2024 leap year and scaled down to the population of the relevant neighborhood/district (Hato Rey Norte) with respect to the total population to get a more accurate representation of the residential power demand of the area.

- **Adam:** Redesigned the rooftop layout to make sure the voltage will be within NEC standards of 1000V DC max on a rooftop photovoltaic installation. As a consequence we had to decrease our peak output from 176 kW to 158 kW. This will allow us to have greater access to the panels for maintenance as well. Additionally, I started a bill of materials containing information concerning the specific components required for our plan, quantities of each component, and prices for each component, which when complete will provide us with a total cost of components for the project. Estimates for labor will be made in the coming weeks as I will contact a solar contractor to learn approximate time and costs for installing panels such as ours. Finally, I found a solution for a battery backup, which is essentially a shipping container with batteries containing 250kWh that could be installed near our rooftop solar installation. This solution is also much less expensive than our previous idea of using the Tesla powerwall batteries.



Battery Backup Options

Tesla Powerwall: designed for use in homes, only compatible with Tesla solar panels.

Battery Backup Power Container: 250kWh, $282,000

- Voltage/Connection: 277/480 Three Phase
  - Uses 150 Amp Three Pole Breaker Minimum
- Power Rating: 120 KVA Minimum
- Battery Capacity: 258 KWh (250 KWh)
  - Typically Runs A 120 KVA Load For ~2 Hours
  - Typically Runs A 60 KVA Load For ~4 Hours
  - Typically Runs A 30 KVA Load For ~ 8 Hours
  - Typically Runs A 10 KVA Load For ~ 24 Hours
- DC Bus Voltage: 358 Volts
- DC Amp Hours: 720 Ah
- Dimensions (D x W x H): 10' x 8' x 8'
- Weight: 5.5 tons
- Container: NEMA 3R / IP 54
- Compliance: CE, UL
  - Batteries Are UL 1973
  - Inverter Is UL 1741
- Standard Warranty: 10 Years
- Operation Mode: On Grid or Off Grid
- Part Number: BBP-EP-120KVA-258KWH-277480SP

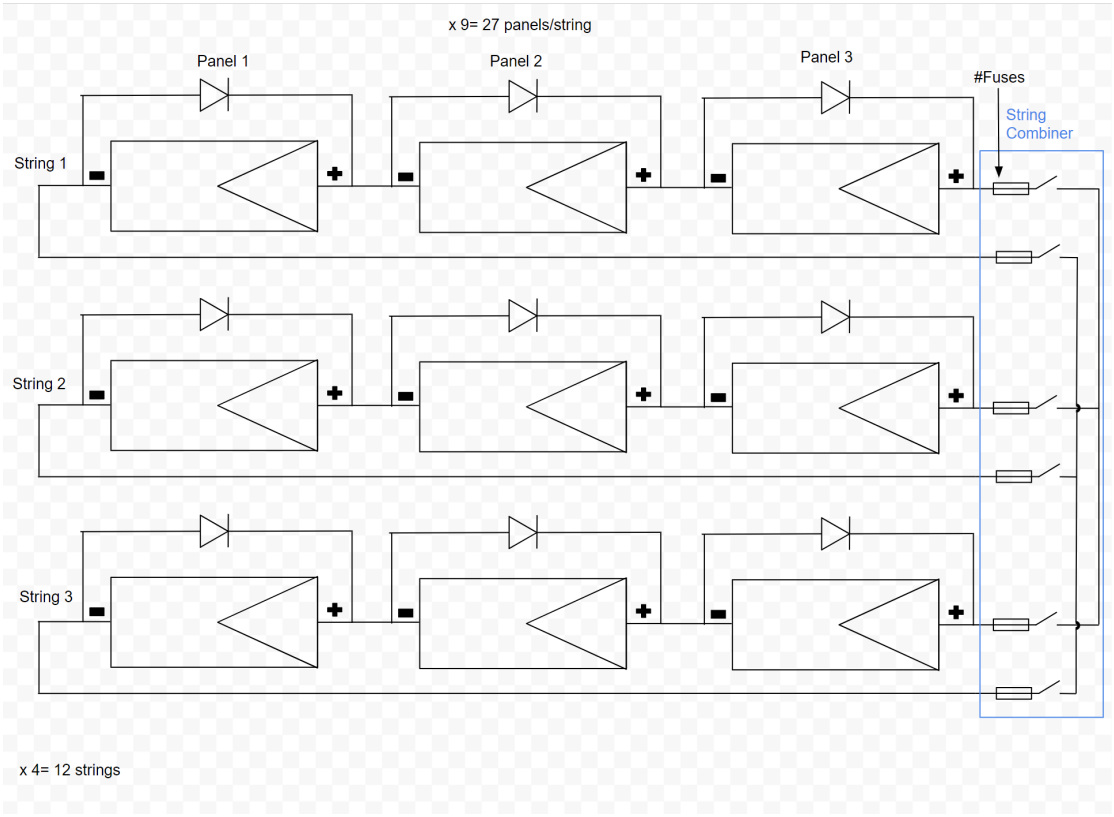
3938736/1377252 = 2.859 MWh/home/year = 2859 kWh/home/year on average (Data from EIA)
2859/365 = 7.832 kWh/day
7.832/24 = .326369 kWh/hour

Initial demand estimate for 100 homes, 8 hours = 100*8*.326369 = 258.952kWh demand

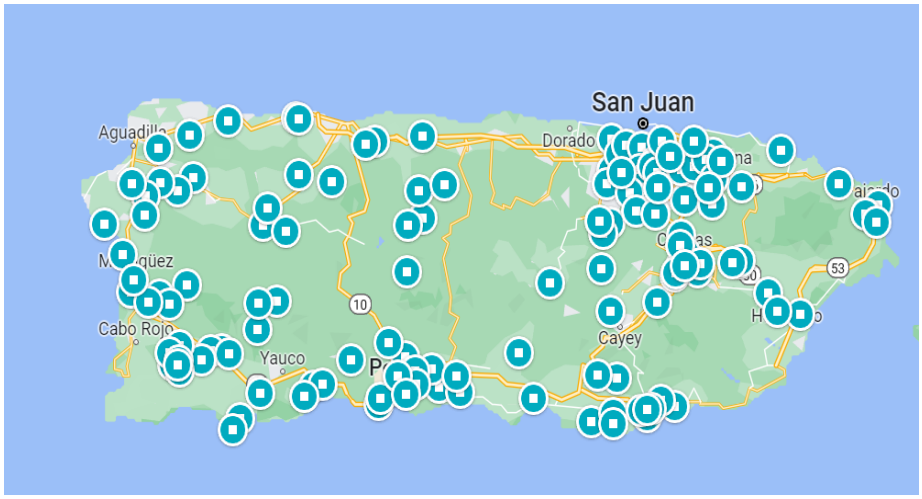
https://www.backupbatterypower.com/products/258-kwh-industrial-battery-backup-and-energy-storage-systems-ess-277-480-three-phase

- **Hannah:** Finalized models for string combiner, inverter, and specs needed for the transformer. I also got in contact with a sales representative from Solectria to estimate the cost of the string combiner and inverter. I have been reading through the Puerto Rico EPS manual for grid interconnection to determine what regulations we need to be aware

of, when choosing an inverter and transformer. In addition, I started a high-level schematic of our system, so far covering the panels and string combiner. Lastly, I contacted a professional in the cybersecurity field to get recommendations for how to protect our system and developed a plan of defense.



- **Manuel:** Completed map of potential locations for our project. This was done by using Google Maps search to find the roofed courts and then confirming that state and location through the satellite images to have a more accurate understanding of the condition of the court. Some were still not reconstructed from Hurricane Maria and thus were ruled out. Also calculated the amount of load one of our systems could produce for the system. This resulted in a yearly production of 696,000 kWh per system, with a total of 143 possible installations found.



- **Larry:** Finished up the cybersecurity portion. We suggest change from 5G cellular hotspot to wired ethernet cable. By using Solectria inverter, the solution will be testing implementation (5G hotspot and inverter) through Pratum, and asking Solectria to verify their web based monitoring. Also we need to isolate internal and external communication of the PV system, using authentication, antivirus software and some monitor tools such as intrusion detection and prevention that limit physical access from outside of the solar network. I am currently working on the schematic of the PV system, and trying to connect solar panels together into a grid.

- *o* **Individual contributions**

Name	**Individual Contributions** *(Quick list of contributions. This should be short.)*	**Hours for (2) weeks**	**Hours cumulative**
Adam Curtis	Rooftop redesign, standards verification, bill of materials, battery backup research	12	86
Hannah Nelson	Cybersecurity, schematic, grid interconnection	12	86
Isaac Buettner	Updating/Reformatting Website, Feasibility Reports, Model System Calculations	10	67
Larry Trinh		12	70
Manuel Perez	Locations, calculation on production	14	72

- *o* **Plans for the upcoming week**

**Advisor requested a tutorial from Isaac on XENDEE software, so that will be the topic of Monday's meeting.

- Isaac: Prepare a presentation for the advisor on how to use XENDEE modeling software, continue adjusting/updating relevant data as more specifications come in. Communicate with team members and go through the math to make sure I have the right data and numbers for every field to get accurate results when running optimization reports. Possibly look at other locations to run software simulations at to more closely model physical schematics outlined above.
- Adam: Continue filling in the BOM (Bill of Materials), expand the rooftop layout plan to show where we will be installing the inverter, string combiner, and battery backup. Look into security measures for these important electrical enclosures.
- Hannah: Continue drawing the schematic, connection to the inverter and secondary side of the transformer (will need to research more into how to do that). Further, I know the voltages needed for the transformer, but need to confirm some assumptions with our advisor in the next week. I also plan to update our design document.
- Manuel: Ask Dalal for guidance on what's next, is it enough to have the locations on google maps or should I have a database with geo locations attached? Should I focus on the example model we are planning on building?
- Larry: Continue working on the schematic of the PV systems, and doing some more research about components of the grid. At the same time. I will need to check with some of the professors from the department about how to put things together.