
EE/CprE/SE 491 WEEKLY REPORT 2

2/5/23 - 2/12/23

Group Number: 16

Project title: Feasibility of Solar PV Energy for Puerto Rico

Client &/Advisor: Vikram Dalal

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

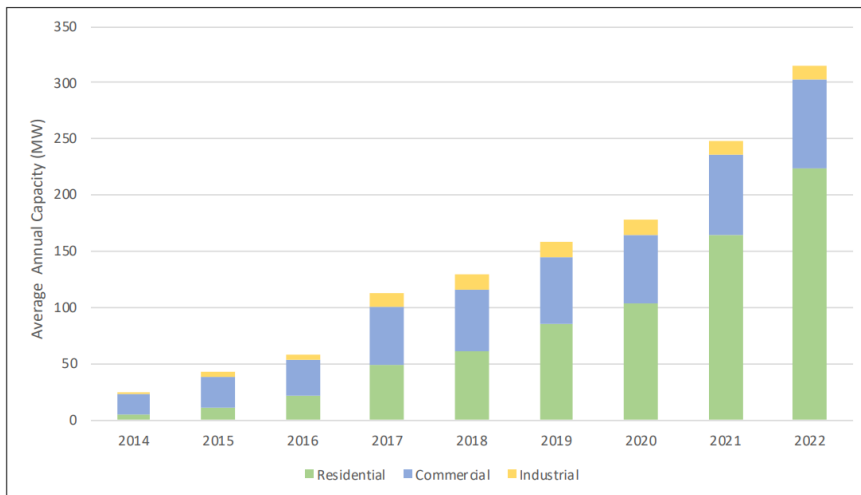
o Weekly Summary

We had a group meeting with Professor Dalal on Monday, and plan to have another meeting without him on Monday. In our meeting, we discussed our research findings and what steps we should take moving forward. He also suggested that we make a presentation of what we have accomplished each week— similar to this but with more detail. Then, the rest of the week we continued research into the areas we had been assigned, with more guidance from Dalal after the meeting.

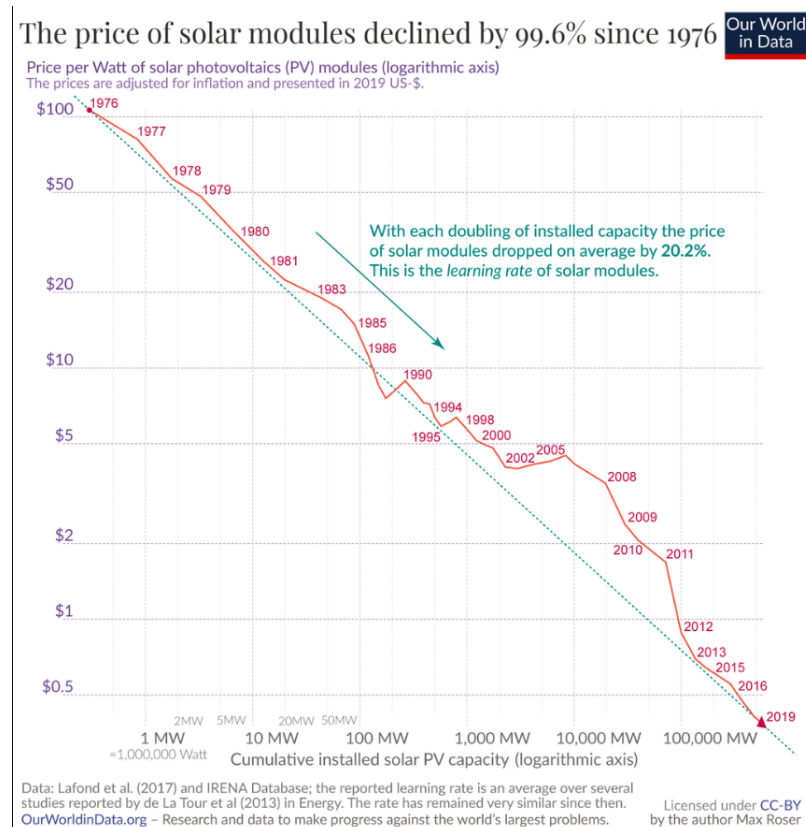
o Past week accomplishments

Hannah: Reviewed the PR 100 1-Year Report and did follow-up research for Dr. Dalal's questions: 1) How many PV systems have microgrid capacity and what is current power (kW) coming from those? 2) Do these systems have storage capacity and what are the options for the future? I found that within the 3% of renewable energy in PR's fleet, there are 42,000 PV rooftop systems connected to the grid (as of January). This meets around 5.5% of the residential sector's total electricity demand. That accounts for just under 225 MW from the residential sector. Additionally, the 2025 goal is to hit 3750 MW of renewable power and 1500 MW in battery capacity. Most people with PV systems are considered "prosumers"-- they both use grid electricity and sell it back.

FIGURE 1. **Average annual capacity of installed photovoltaics for net metering by sector in Puerto Rico (MW) [4].**



Adam: Conducted research on the price of photovoltaics over the years and how it has steadily decreased over time. Price has decreased 20% every time total PV installed has doubled. This supports the idea that it may be cheaper for the people of Puerto Rico to invest their money in PV now than it was 6 years ago. Also found information from the U.S. Energy Administration about the projected demand and costs per kWh of electricity in Puerto Rico, and found that the prices of electricity in Puerto Rico are 2 to 3 times higher than prices in Iowa for example, while overall demand and number of customers is much smaller in Puerto Rico. This highlights the mismanagement of the grid in Puerto Rico, as well as the extremely high cost of electricity due in part to the large portion of electricity generated by imported natural gas in Puerto Rico.



Manuel: I was unable to contribute this week due to having medical issues since Tuesday.

Larry: I am still working on researching the Puerto Rico economy, and trying to collect some data from various sources. According to Wikipedia, Puerto Rico is one of the high income economies in Latin America. The main income comes from manufacturing, pharmaceuticals, textile, electronics, but when we compare to all other states in the United States of America, Puerto Rico is the poorest area. The GDP was 116.8 billions in 2022 with the GDP per capita is around \$38000. I am also doing some research about the power resources in Puerto Rico to figure out what are the main power supplies for Puerto Rico, and how much Puerto Rico citizens spend for each kWh.

Data

Last Update: January 19, 2022 | Next Update: February 16, 2023

Economy

Population and Industry	Puerto Rico	United States	Period
Population	3.0 million	328.2 million	2019
Gross Domestic Product	\$ 66 billion	\$ 19,552 billion	2018

Prices

Electricity	Puerto Rico	United States	Period
Residential	33.47 cents/kWh	16.09 cents/kWh	Oct-22
Commercial	37.13 cents/kWh	13.04 cents/kWh	Oct-22
Industrial	34.49 cents/kWh	8.61 cents/kWh	Oct-22

Isaac: After our meeting this last week with Professor Dalal, I used this week to research more into energy storage systems for Puerto Rico. Specifically, I looked into what was being proposed and by who, but I made sure to look into more solid figures when it came to predictions for units and pricing. I wanted to make sure I was bringing accurate information to the table and that I wasn't just going to end up giving very loose approximations. Thankfully, in my research this week I found an IRP report from SIEMENS written in 2018, which outlined the paths available to Puerto Rico and what they suggested. While the report included other forms of energy such as wind farms and gas generators, a good portion was still focused on solar photovoltaics and energy storage and distribution systems. SIEMENS and AES both propose that Puerto Rico adopts a minigrid approach to their energy grid, with SIEMENS proposing 10 minigrids that can operate for months on end in "island mode" where they are self sufficient and cut off from the other grids. This would provide outstanding resilience and ensure that each grid would be able to help out any other minigrid if it were to be knocked offline. It was also looked into how prices can be reduced for energy storage systems and what impacts these prices. Right now, lithium ion batteries are the way to go and that's unlikely to change so it's important to know how they're priced and what the market looks like. It was estimated that to remake the grid would cost \$80-\$100/MWh with a LCOE of \$95.74/MWh while a minigrid in "island mode" would have an LCOE of \$152.49/MWh. The grid proposed by SIEMENS would have a total of 311MW in energy storage and would push Puerto Rico to become 35% renewable.

Exhibit 6-38. Li-Ion Battery System Capital Cost and Operating Cost Assumptions – Base Case

Construction Year	All-in Capital Costs			Operating Costs	
	4-hour Li-ion Battery Storage 2018\$/KW	2-hour Li-ion Battery Storage 2018\$/KW	6-hour Li-ion Battery Storage 2018\$/KW	Fixed Operating Costs 2018\$/kW-year	Variable Operating Costs 2018\$/MWh
2018	1,392	832	1,953	9.09	2.67
2019	1,218	734	1,703	8.96	2.60
2020	1,110	674	1,546	8.95	2.58
2021	1,041	635	1,447	8.81	2.51
2022	972	596	1,349	8.67	2.43
2023	936	576	1,296	8.54	2.36
2024	899	556	1,243	8.41	2.29
2025	861	534	1,188	8.40	2.28
2026	843	523	1,163	8.26	2.20
2027	825	512	1,138	8.12	2.13
2028	800	496	1,104	7.99	2.06
2029	782	485	1,079	7.86	1.99
2030	764	474	1,054	7.85	1.97
2031	746	462	1,031	7.71	1.90
2032	728	450	1,007	7.57	1.82
2033	717	443	992	7.44	1.75
2034	700	431	969	7.31	1.69
2035	682	419	945	7.30	1.67
2036	664	407	922	7.19	1.64
2037	647	395	898	7.08	1.62
2038	629	383	875	6.97	1.59

Source: Siemens, NREL

Individual contributions

<u>NAME</u>	<u>Individual Contributions</u> <i>(Quick list of contributions. This should be short.)</i>	<u>Hours this week</u>	<u>HOURS cumulative</u>
Adam Curtis		5	9
Hannah Nelson		4	7
Isaac Buettner		3	6
Larry Trinh		4.5	8.5
Manuel Perez		3	4

- o **Plans for the upcoming week** *(Please describe duties for the upcoming week for each member. What is(are) the task(s)?, Who will contribute to it? Be as concise as possible.)*

Team meeting Monday at 3:15 PM

Hannah: Continue the microgrid research and read government sources for microgrid requirements and how interconnection is achieved. Also look into the overall infrastructure in terms of transmission and distribution lines, and current battery storage. I found a desire for an overall “decentralized” system for greater stability and resilience—see if I can find the research behind that. Also to start on PowerPoint for Dalal.

Adam: Look deeper into the cost of installing PV on an average home. Contact family in the electrical contracting business for information on costs of labor/time to install solar on an average home for comparison. Continue looking through the old Senior Design Project for sources/info. Finalize report Powerpoint for next week's meeting.

Manuel: Meet with the team on Monday and identify where I need to be moving forward. Discussing my findings from last week. Construct PowerPoint presentation for the next meeting with Dalal.

Larry: Continue doing some more research with reliable sources about the economy, income and expenses of Puerto Rico, and also try to figure out how many percent of their expenses use for electricity. From the data we see that the electricity price in Puerto Rico is much higher than average in the United States, what are the reasons?. Working on the power point for next week’s meeting

Isaac: Continue to look into energy storage systems, look more into the market and see if forecasts for pricing have changed since 2018 and if any real progress has been made. I would also like to discuss with the team on Monday when we think we’ll have enough base research done and when we’ll be ready to look into moving onto the next step and what that will look like, though I feel like we should still be good with researching for a while.