
EE 492 Bi-Weekly Report 3 - sddec18-03

Design of a More Reliable Power Grid for Puerto Rico

9/24/18 - 10/8/18

Faculty Advisor: Vikram Dalal

Team Members

Logan Lillis - *Communications and Reports Lead*

Ricardo Rodriguez-Menas - *Webmaster and Project Plan Lead*

Heiqal Zamri - *Test Engineer Lead*

Pinjia Zhang - *Design Lead*

Weekly Summary

During this two-week period, we divided research areas among the group and dug much deeper into costs, reliability, and feasibility of 4 areas. Using reports researched from the Department of Energy and various other cited sources from the main study, we were able to gain a very deep understanding of what our plan is for each researched topic. Individual presentations were made on each topic to present to professor Dalal. Individual research took up the majority of hours this bi-weekly period, and specifics for each member's topics can be found in the "Past Week Accomplishments" section.

Past Week Accomplishments

Logan:

- ❖ Extensive research on Generation, Transmission, and Distribution in Puerto Rico. With this background, I believe the research segment is almost complete for these topics. The implementation of natural gas will be further researched further.
 - Main source: NYPA "Build Back Better" Report, EIA Puerto Rico analysis, Department of Energy Puerto Rico grid resilience publication.
 - Existing statistics as well as proposed plans
- ❖ Existing Transmission:
 - Existing: 2,478 miles of transmission lines and 334 substations
 - 230kV backbone with 115kV supporting
 - Make 3 transmission "loops" on the island
 - North/South Corridor(s) sustained most damage due to lack of access and narrow right-of-ways.
- ❖ Transmission Redesign:

- “Build Back Better” NYPA Report estimates \$13.9 billion for T&D Rebuild
- Design for category 4 storm rating and associated flooding with high category 5 survivability rate in high-priority areas and crucial north-south corridors
 - Currently, 85% of transmission infrastructure is not built to withstand a category 4 storm.
- Monopoles withstood natural disasters better than lattice towers.
 - Galvanized Steel
- Propose environmental regulation changes that allow for maintenance on inland transmission and distribution infrastructure.
 - Microgrids may also play a role in powering these rural areas.
- NYPA suggested adding new lines designed for 345kV (but initially operated at 230kV) to allow for flexible future planning and adding a fourth transmission loop.
- Substation: Allow for flood hardening, maintenance, and some storm repair.
- ❖ Existing Distribution:
 - 1,200 circuits, 30,000 miles of overhead and underground lines.
 - 75% Distribution circuits damaged, consisting of both overhead and underground lines.
 - Galvanized steel poles withstood the natural disasters significantly better than wood or concrete.
- ❖ Distribution Redesign:
 - Galvanized Steel Monopoles
 - Install a larger conductor with total insulation.
 - Install underground distribution in high-wind prone areas
 - South of island where most hurricanes make contact
 - Convert 4kV circuits to 15kV for added efficiency
- ❖ Existing Generation:
 - Generating capability: 5,839MW
 - Peak demand: 3,060MW (recorded in 8/2017)
 - Prepa’s self-proclaimed goal is to move towards natural gas fired and renewable energy generation.
 - 20% Renewable by 2035
- ❖ Generation Redesign:
 - NYPA Study estimates \$3.1 billion for generation rebuild
 - Storm Hardening
 - Most generation plants on north or south of island and prone to flooding
 - NYPA study recommended doing a study for a new generation reserve margin of 50% (i.e. 4,350MW of generating capability)
 - Closing some older diesel plants / transitioning to natural gas or natural gas co-fire
- ❖ Generation Redesign - Natural Gas:
 - Only two main generating facilities are equipped to be fired (or partially fired) by natural gas
 - NYPA suggests F and H class generating units for the redesign to allow for dual-fire or solely natural gas-fired plants.

- “The estimated investment required to rebuild the plants to operating condition consistent with future needs is approximately **\$3.1 billion**, including an estimated \$2.8 billion for replacing the Palo Seco plant with an F-class machine, replacing the steam units at Aguirre with an H-class machine, and the installation of storm hardening for the sites.”
- Aguirre Off-Shore Port, Roosevelt Roads Brown-Field
- ❖ Natural Gas Deliquification Port:
 - Currently, import 55 billion cubic feet of LNG each year
 - Main imports from Trinidad and Tobago
 - Some industrial customers receive LNG from the US
 - Jones Act
 - Floating deliquification port proposed and approved by FERC in 2015
 - Off coast of Aguirre, where current LNG imports come through.
 - Originally planned a pipeline from south coast to north, but nixed due to environmental and load concerns
 - North coast has 2 natural gas-fired generation plants. Currently use trucks to transport LNG
 - Possible brownfield location at retired naval base

Ricardo:

- ❖ NODES. (Research applications and technical descriptions of NODES functioning)
- ❖ DC Microgrid (Read studies about proposals of grids using DC current in rural zones since this would allow us to have smaller energy storage implementations)
- ❖ Combination of Circuits for small storage grids (small batteries)
- ❖ EIA studies of ratings for small vs large energy battery storage, including cost and rates

Heiqal:

- ❖ Research on Microgrids based on the NYPA document that was discovered. Learned about the different microgrids that we can use to implement our design for Puerto Rico such as the microgrids that can work on its own and connect to the main grid and also a microgrid that can function on its own for places in mountainous areas. I also researched about the distribution of microgrids based on the infrastructure. For example, the implementation of the microgrids to focus more on places that contains fire department and hospitals. It was also understood that there are microgrids out there that are being created such as the Berkeley lab Microgrids. The cost of the microgrids are also coming into light with this project.

Pinjia:

- ❖ Research on the peripheral issue with the solar construction. The new tariff that stroked recently on the solar panel. With the high demanding in PR, panel will still go up to a higher price, approximate to be 30%. People should find another way like replacing their public lightning system with solar power and take out a portion of this electricity generation to resident electricity usage. This is an alternate way of lowering cost considered with the local

financial crisis. It cannot be neglected that the global price of coal and oil is rising, there is not much choice for residents on island to choose. Local government should take immediate action to make sure the lasting of electricity such as bringing more energy storage for temporary time. And find the stable resource after the trend passed away.

- ❖ Research on the combination of power grid layout after introduced the solar part and other renewable energy. Have the renewable energy system introduced should let the power grid has a more robust dispatching system and a strong load balancing system. Just like the solar, it should include solar connector to input the electricity balance signal to the grid and send it over back to the feedback port. Then when there is a power drop somewhere, the solar grid can quickly make up this loss. Also distributed system inside building is also preferred but not may be the first choice and it depends on different family. If NYPA can provide a better solution with a more effective electricity generation, the implementation can bring out a flexible and low cost system. Then people may not necessary to consider how to reduce their normal electricity usage and it can make the cost to get lower down.

Pending Issues

- ❖ Need to determine a software capable of modeling load flows and microgrids
 - Pinjia will work with power professors
- ❖ Need to begin writing paper/deliverables

Individual Contributions

Team Member	Contribution	Weekly Hours	Total Hours
Logan Lillis	<ul style="list-style-type: none"> ● Generation Research <ul style="list-style-type: none"> ○ Existing generation and fuel. ○ Transition to natural gas ○ Expected decrease in maximum generation capability needed ○ Cost estimates ● Transmission and Distribution Research <ul style="list-style-type: none"> ○ Adding a fourth transmission loop for added reliability ○ Upgrading hardware to monopoles ○ Possibly upgrading voltage class ○ Cost Estimates ● Gather hours and write bi-weekly report ● Attended Weekly Meetings 	11	20.5

Ricardo Rodriguez-Menas	<ul style="list-style-type: none"> ● Energy Storage Research <ul style="list-style-type: none"> ○ Battery companies, energy farms vs. small, distributed banks ● Research on DC Microgrids ● Research on NODES ● Attended Weekly Meetings 	8	23.5
Heiqal Zamri	<ul style="list-style-type: none"> ● Microgrid research <ul style="list-style-type: none"> ○ NYPA, Fiscal Plan of Puerto Rico, Berkeley Lab Microgrids ○ Different types of microgrids for main grid use and rural use ○ Targeting important loads like hospitals ● Attended Weekly Meetings 	10	17
Pinjia Zhang	<ul style="list-style-type: none"> ● Renewable Energy Research <ul style="list-style-type: none"> ○ Solar construction. Tariffs raising cost, but global cost of fossil fuels is also rising ○ Local government's role ○ How adding distributed energy resources will affect the grid redesign. 	5	10.25

Plan for Upcoming Week

All:

- ❖ Continue to read and research further reading on Puerto Rico redesign proposals.
 - NYPA
 - CRS
 - RMI
 - FEMA
 - PROMESA
 - PREPA

Logan:

- ❖ Continue researching generation implementation, amounts, and needs.
- ❖ Based on load requirements and locations, begin deciding where/what power plants should be converted to natural gas or dual-fired generation.
- ❖ Further research on brownfield for natural gas terminal at retired naval base
- ❖ Research feasibility on cost comparison of money lost using existing, low-efficiency heavy oil fuel generating machines versus the cost of installing new, efficient natural gas machines.
 - Look into other cost flows to compare current plan with building back better
- ❖ Research how to introduce resilience and efficiency
 - LEED/RELi certifications may be a good place to start

Ricardo:

- ❖ Renew research on big storage battery companies supplies
- ❖ Research on ABB company ratings and cost of implementation
- ❖ Work on proposal not to implement big storage energy farms for rural parts of the country

Heiqal:

- ❖ Look more into how the Microgrids are being implemented by Berkeley Lab
- ❖ Focus more on the cost of the Microgrids to have a better understanding
- ❖ Connect all information we got from our parts of the project together and try to make it slightly better

Pinjia:

- ❖ Go over with the Fiscal Plan of the Puerto Rico to better realize the financial situation. Talk more about the economy and government that can affect the layout of power grid.