Resilience Optimization Proceeding

JUNTA REGLAMENTADORA DE SERVICIO PÚBLICO

February 23, 2021

Optimization - Workshop #2

Agenda – Workshop #2

- Introduction (10 AM)
- Update: Cost Estimate – MiniGrid Transmission Projects (10:15/10:30)
  - Changes to overall cost estimates from IRP filing (PREPA responses to Appendix B questions)
  - Discussion of implications for increased costs
- San Juan / Bayamon area MiniGrid Transmission Projects (11 AM)
  - Detailed project listings from IRP – by voltage, by project type
  - Maps of projects by MG region from IRP
  - Critical/priority load cluster data
  - Discussion
    - Data availability for gauging clusters of critical/priority load
    - Methods to identify / prioritize each of 115 kV, 38 kV, and feeder hardening needs
    - Timeline for solutions
- Break – lunch (12:30)
- San Juan / Bayamon transmission discussion – cont'd. (1 PM)
- Preliminary list: categories and specific projects – "no regrets"
  - Wires and substation upgrades – 115 kV, 38 kV, specific feeders?
  - Timelines for rapid deployment across two types of resilience solutions: wires, and DER
- DER for Resilience –SJ/Bayamon transmission need impact, identifying DER solutions (3 PM)
  - Identifying best case Microgrid and other DER solutions within SJ/Bayamon region
  - Discussion: Microgrid, DER solutions including stakeholder input on specific locations, essential needs
  - Timelines for solutions
- Next Steps / Next Workshop Agenda Items (3:45 PM)

Discussion - Agenda

- Comments / Questions?
- Additional agenda items within scope of primary focus?

Introduction

Introduction: Purpose / Process

- Purpose
  - Explore ideas to implement near-optimal resiliency solutions
  - Determine/define metrics to use
  - Identify/verify uncertainties that make precise analysis difficult
  - Wires and DER solutions tradeoffs – SJ/Bayamon focus this workshop
  - Establish common ground for certain elements of solutions?
- Process
  - Comment round all stakeholders after Workshop #2
    - Response to questions posed during workshop
    - Provide suggestions/comment on preliminary “no regrets” options
    - Suggestions for future workshop structure and/or substantive matter
  - Workshop #3: address DER options in more detail

Further Objectives

- These workshops to Inform Near Term Decisions
  - Identify least regrets, low-hanging fruit – resiliency
    - Certain wires options (e.g., non-Minigrid solutions, selected MiniGrid candidate undergrounding) – blue sky and severe event
    - DERs – best candidate microgrids; other stand-alone DERs through VPP/PPOA, DR, self-funded, or other funding vehicle (FEMA resiliency programs?)
    - Allow / support / guide rapid deployment of near-term actions
- Longer-Term Decisions - ongoing
  - More complex circumstances
    - Increased stakeholder participation to vet specific locations for essential facility solutions, and procurement paths (e.g., public vs. private funding for DER solutions)
    - Public purpose microgrids, public purpose stand-alone DER?
    - DR/DER tariff – proportional to costs from VPP competitive procurement?
  - Other processes affect optimal choices: results of Procurement RFPs, DR initiatives, FEMA funding support
    - VPP decisions from procurement plan – resilience element?
    - Greater use of DOE/National Labs resiliency support

Workshops/Process Going Forward

- Comments after this workshop
- Workshop 3 March 23
- Workshop 4 April 22
- Workshop 5 May 7
- Workshop 6 May 28

Update: Cost Estimate – MiniGrid Transmission Projects

Update to MiniGrid Transmission Costs

- PREPA response to Appendix B, Q2. Note cost magnitude vs. Sandia microgrid cost estimate.
- Significant increase in costs over MG components from IRP filing ($5.9 Billion)

Revised Cost Estimates per 10 Yer Plan (Class 5 Estimates): Assets listed in IRP Exhibits 2-85 to 2-93

Minigrid Transmission System Required Investment			
Item	**Description**	**Cost ($M)**	**Notes**
1	**Controllers & SCADA: 8 Minigrids**	**$ 6.75**	***No change in estimate from IRP***
2	**115 kV Transmission system investment**	**$ 2,863.71**	**Class 5 Cost Estimates: Please refer to corresponding tab**
	2a. Existing Lines to Harden:	$ 447.44	List of 24 Projects ~198 miles from IRP Ex 2-11
	2b. New Lines (OH & UG):	$ 1,462.17	List of 16 Projects ~141 miles from IRP Ex 2-09
	2c. Existing Stations to Harden: 43 Projects	$ 954.10	List of Stations per IRP Ex 2-12
3	**38 kV Transmission system investment**	**$ 4,865.61**	**Class 5 Cost Estimates: Please refer to corresponding tab**
	3a. Existing Lines to Harden:	$ 476.97	List of ~241 miles per IRP Ex 24, 36 ,44 ,52, 62, 71, 84
	3b. New Lines (OH & UG):	$ 4,388.65	List of ~318 miles per IRP Ex 23, 35, 43, 51, 61, 69, 83
	3c. New Stations & Harden to Existing Stations:		List of Stations per IRP Ex 24, 36 ,44 ,52, 62, 71, 84
		$ 7,736.07	
	Total Peak Load at End User	~2,400 MW	(critical plus priority load = ~1,600 MW)
	Cost per MW Peak Load ($ Mill.)	$ 3.22	Sandia: $2 Million/MW for Microgrid
	Cost per MW critical + priority	$ 4.84	

Notes

1. A class 5 cost estimate is one that is prepared at an early stage in the project development process and is expected, based on industry standards, to range from 50% below to 100% above the actual final project cost. Leading industry practice is to revise estimates, so they become more accurate as engineering design progresses and project requirements are solidified.
2. PREPA will begin in Q1 2021 performing field assessment and A&E design on T&D assets. Once completed, PREPA can provide more accurate estimates

115 kV Existing Infrastructure Hardening

- $277 million in IRP filing, increase to $447 million

Per Exhibit 2-11: New Lines (OH & UG): 24 Projects ~ 198 miles				
ID	Project	Miles	Cost Estimate: 10 YR PLAN (M$)	M$/mi
21	Reconstruction Line 40300 Aguirre - Santa Isabel TC - Ponce TC @1192.5 kcmil ACSR Bunting	17.57	$ 56.18	$ 3.20
4	Reconstruction Line 36200 Monacillo TC - Juncos TC @1192.5 kcmil ACSR Bunting	20.11	$ 42.74	$ 2.13
18	Reconstruction Line 39800 Mayaguez Planta - Acacias TC@1192.5 kcmil ACSR Bunting	15	$ 29.09	$ 1.94
14	Reconstruction Line 37100 C.Sur - Guánica TC@1192.5 kcmil ACSR Bunting	11.5	$ 28.75	$ 2.50
3	Line 37800 Jobos TC - Cayey TC @1192.5 kcmil ACSR Bunting	15.32	$ 26.87	$ 1.75
6	Reconstruction Line 37400 Bayamon TC - Hogar Crea Sub. - H. Tejas TC - Candelaria Arena Sub. - Dorado TC @1192.5 kcmil ACSR Bunting	10.23	$ 25.58	$ 2.50
1	Reconstruction Line 37800 Cayey TC - Caguas TC @1192.5 kcmil ACSR Bunting	12.25	$ 25.13	$ 2.05
9	Reconstruction Line 36100 Bayamón TC - Caná Sect. - Bo. Piñas GIS @1192.5 kcmil ACSR Bunting	9.5	$ 23.75	$ 2.50
20	Reconstruction Line 37000 C.Sur - Ponce TC @1192.5 kcmil ACSR Bunting	11	$ 23.29	$ 2.12
19	Reconstruction Line 36900 C.Sur - Canas TC - Ponce TC @1192.5 kcmil ACSR Bunting	10.38	$ 21.96	$ 2.12
10	Reconstruction Line 36800 S. Llana TC to Canóvanas TC@1192.5 kcmil ACSR Bunting	7.76	$ 15.05	$ 1.94
13	Reconstruction Line 37900 Sabana Llana TC - Encantada Sub. - Conquistador Sub. @1192.5 kcmil ACSR Bunting	5.99	$ 14.98	$ 2.50
11	Reconstruction Line 41200 S. Llana TC to Canóvanas TC@1192.5 kcmil ACSR Bunting	7.76	$ 14.76	$ 1.90
8	Reconstruction Line 41500 Dorado TC - Bo. Piñas GIS @1192.5 kcmil ACSR Bunting	7.54	$ 14.22	$ 1.89
5	Reconstruction Line 39100 Cambalache TC - Hatillo TC @1192.5 kcmil ACSR Bunting	6.64	$ 14.05	$ 2.12
2	Reconstruction Line 36300 Maunabo TC - Juan Martin Sect. @1192.5 kcmil ACSR Bunting	4.86	$ 12.15	$ 2.50
12	Reconstruction Line 37800 Monacillo TC - Buen Pastor TC @1192.5 kcmil ACSR Bunting	4.27	$ 11.03	$ 2.58
17	Reconstruction Line 37200 Mayaguez TC - Añasco TC@1192.5 kcmil ACSR Bunting	4.04	$ 10.10	$ 2.50
22	Line 38900 M. Peña GIS - Berwind GIS Relocation/Hardening @1192.5 kcmil ACSR	4.36	$ 9.37	$ 2.15
15	Reconstruction Line 36700 Mayaguez Planta - Alturas de Mayaguez - Mayaguez TC@1192.5 kcmil ACSR Bunting	3.46	$ 8.65	$ 2.50
16	Reconstruction Line 37200 Mayaguez Planta - Mayaguez TC@1192.5 kcmil ACSR Bunting	3.46	$ 8.65	$ 2.50
7	Reconstruction Line 37500 Bayamón TC - Rio Bayamón Sect. - Grana Substations @ 1192.5 kcmil ACSR Bunting	2.36	$ 5.90	$ 2.50
23	Line 38900 Berwind GIS - Parque Escorial Relocation/Hardening @1192.5 kcmil ACSR	1.4	$ 3.25	$ 2.32
24	Line 38900 Parque Escorial - Sabana Llana Relocation/Hardening @1192.5 kcmil ACSR	1	$ 1.96	$ 1.96
		197.76	**$ 447.44**	
	Cost per mile ($M/mi) from 10 Yr Plan (Class 5) considers that a line will have both segments to be hardened & segments to be rebuilt. It also considers terrain adjustement: urban & rural routing			

115 kV New Underground

- Bulk of 115 kV costs for new underground, across Island - $569 M in IRP

Per Exhibit 2-9: New Lines (OH & UG): 16 Projects ~ 141 miles				
ID	**Project**	**Miles**	**Cost Estimate: 10 YR PLAN (M$)**	**M$/mi**
1	New 115 kV Underground Circuit Vega Baja TC – Manati TC @2750 kcmil Cu XLPE	6.78	$ 98.95	$ 14.59
2	New 115 kV Underground Circuit Cambalache TC – Barceloneta TC @2750 kcmil Cu XLPE	8.46	$ 123.46	$ 14.59
3	New 115 kV Underground Circuit Palo Seco Steam Plant –Hato Tejas TC - Dorado TC @2750	10.88	$ 158.78	$ 14.59
4	New Underground Line 115 kV Yabucoa TC- Humacao TC @ 2750 kcmil Cu XLPE	2.50	$ 32.29	$ 12.92
5	Underground 115 kV Line Yabucoa TC - Sun Oil - Juan Martin Sect @ 2750 kcmil Cu	5.12	$ 74.72	$ 14.59
6	New 115 kV Underground Circuit Juncos TC – Caguas TC- Bairoa TC @2750 kcmil Cu XLPE	9.17	$ 118.43	$ 12.92
7	New 115 kV Underground Circuit Humacao TC - Juncos TC @ 2750 kcmil Cu XLPE	10.60	$ 136.90	$ 12.92
8	New 115 kV Underground Circuit Daguao TC – Fajardo TC@ 2750 kcmil Cu XLPE (manhole to	10.16	$ 148.32	$ 14.60
9	New 115 kV Underground Circuit Canóvanas TC – Palmer TC@2750 kcmilCu XLPE	11.00	$ 160.53	$ 14.59
10	Line 40500 extension to Interconnect Venezuela TC GIS @2750 kcmil Cu XLPE	0.68	$ 8.79	$ 12.92
11	New Underground 115 kV Line Martin Peña GIS - Berwind TC @ 2750 kcmil Cu XLPE	6.60	$ 85.24	$ 12.92
12	New Underground 115 kV Line Sabana Llana TC- Berwind TC @ 2750 kcmil Cu XLPE	2.70	$ 34.87	$ 12.92
13	New 115 kV Underground Circuit Caguas TC/Bairoa TC – Monacillo TC @2750 kcmil Cu XLPE	10.59	$ 154.55	$ 14.59
14	Construction of 115 kV Line 37800 for Bairoa TC @ 1192.5 kcmil ACSR	1.55	$ 4.29	$ 2.77
15	New 115 kV Line Hatillo TC - Mora TC @1192.5 kcmil ACSR Bunting	17.33	$ 47.93	$ 2.77
16	New 115 kV Line Costa Sur - Dos Bocas HP @1192.5 kcmil ACSR Bunting @ 230 kV	26.80	$ 74.11	$ 2.77
		140.92	**$ 1,462.17**	

Substation Hardening – Lower Cost than IRP

Per Exhibit 2-12: 115 kV Stations to Harden- 43 Projects					
Item No.	Project Description	Cost Estimate (Class 5- $M)	Item No.	Project Description	Cost Estimate (Class 5- $M)
1	Manati TC - 115 kV and 46 kV Switchyards	20	23	Switchyards (in addition to hardening should at least include protection and control systems modernization + remote	93.3
2	Cambalache - TC 115 kV and 46 kV Switchyards	23.5	24	Aguirre 230 kV, 115 kV and 46 kV Switchyards	42.2
3	Dos Bocas HP - 115 kV and 46 kV Switchyards	19.1	25	Maunabo TC Hardening/Reconstruction 115 kV and 46 kV Switchyards	4.5
4	Barceloneta TC - 115 kV and 46 kV Switchyards	20	26	Jobos TC 115 kV and 46 kV Gas Insulated Substation (includes new 230/115 kV Transformer conneceted to 230 kV line to AES)	27.6
5	Mora TC Gas Insulated Substation 115 kV and 46 kV Switchyards	11.5	27	Ponce TC 115 kV and 46 kV Switchyards GIS	17.1
6	Bayamon TC - 230 kV, 115 kV and 46 kV Switchyards	65.7	28	San Juan GIS 115 kV Switchyard	3.5
7	Vega Baja TC - 115 kV and 46 kV Switchyards	20.5	29	Isla Grande TC - Hardening GIS 115 kV and 46 kV Switchgear	3.5
8	Dorado TC - 115 kV and 46 kV Switchyards	27.1	30	Monacillo TC - 115 kV, 46 kV and 13.2 kV Switchyards	49
9	Juncos TC - 115 kV and 46 kV Switchyards	25.5	31	Hato Rey TC - 115 kV, 46 kV and 13.2 kV Switchyards	29.2
10	Caguas TC -115 kV and 46 kV Switchyards	29.4	32	Viaducto TC - 115 kV and 46 kV Swichyards	36.3
11	Rio Blanco HP - 115 kV and 46 kV Switchyards	35.8	33	Berwind TC - 115 kV, 46 kV and 13.2 kV Switchyards	14.8
12	Cayey TC - 115 kV and 46 kV Switchyards	16.2	34	New Venezuela TC Gas Insulated Substation for 115 kV, 46 kV and	4.4
13	Humacao TC - Hardening and Expansion 115 kV and 46 kV	23.9	35	Yabucoa TC - 115 kV extension includes provision for 115 kV underground circuits and future generation)	21.5
14	Canóvanas TC - 115 kV and 46 kV Switchyards (includes 46 kV bus	9.8	36	Mayaguez TC - Hardening/Reconstruction 230 kV and 115 kV Switchyards	14.2
15	Sabana Llana TC - 115 kV and 46 kV Switchyards	34.7	37	Comerio TC - Hardening/Extension 115 kV and 46 kV Switchyards (includes extension to interconnect new 46 kV line to new	12.4
16	Fajardo TC - 115 kV and 46 kV. Extension of 46 kV Bus for New UG to Fajardo	19.4	38	Palmer TC - Hardening/Reconstruction 115 kV and 46 kV Switchyards	15.5
17	Daguao TC - 115 kV and 46 kV Switchyards	18.4	39	Añasco TC - Hardening/Reconstruction 115 kV Switchyard	3
18	Victoria TC - 115 kV and 38 kV Switchyards	31.1	40	Rio Bayamon Sect - 115kv Hardening/Reconstruction	8.3
19	San Sebastián TC - 115 kV and 38 kV Switchyards	17.8	41	Crea (Hogar Crea) 115 kV Sect.	3.6
20	Mayaguez GP - 115 kV and 38 kV Switchyards	23.9	42	Candelaria Arenas 115 kV Sect.	2.8
21	Acacias TC - 115 kV and 38 kV Switchyards (includes extension for new	40	43	Juan Martin 115 kV Sect.	1.4
22	San Germán TC - 115 kV and 46 kV Switchyard Costa Sur Gas In ulated	12.7			**$ 954.1 million ($1.4 B in IRP)**

Existing 38 kV Hardening (Overhead)

- About 1/3 higher cost than IR

	Per Exhibits 2-24 to 2-84: Hardening OH ~ 241 miles			
ID	**Region**	**Miles (total)**	**Cost Estimate: 10 YR PLAN (M$)**	**NOTES**
1&2	Mayaguez	24.05	$ 47.48	IRP Exhibit 2-24
3&4	Caguas/Cayey	75.3	$ 148.66	IRP Exhibit 2-36
5	Carolina	4.48	$ 8.84	IRP Exhibit 2-44
6	Arecibo	63.81	$ 125.97	IRP Exhibit 2-52
7	San Juan	58.61	$ 115.71	IRP Exhibit 2-62
	Bayamon	12.91	$ 25.49	IRP Exhibit 2-71
8	Ponce	2.44	$ 4.82	IRP Exhibit 2-84
	Total c.miles:	**241.6**	**$ 476.97**	

Cost per mile ($M/mi) from 10 Yr Plan (Class 5) considers that a line will have both segments to be hardened & segments to be rebuilt. It also considers terrain adjustement: urban & rural routing

Hardening OH (M$/mi)	
$	1.97

New 38 kV Undergrounding

- Particularly higher cost than in IRP (~3.5x)

	Per Exhibits 2-23 to 2-83: New Lines (OH & UG): ~ 319 miles				
ID	Region	Miles (total)		Cost Estimate: 10 YR PLAN (M$)	NOTES
		OH	UG		
1&2	Mayaguez	71.67		$ 799.73	IRP Exhibit 2-23 ($240.6)
		21.33	50.34		
3&4	Caguas/Cayey	43.81		$ 532.11	IRP Exhibit 2-35 ($154.1)
		9.73	34.08		
5	Carolina	26.56		$ 399.73	IRP Exhibit 2-43 ($115.3)
		0	26.56		
6	Arecibo	23.05		$ 346.90	IRP Exhibit 2-51 ($64.4)
		0	23.05		
7	San Juan	31.11		$ 468.21	IRP Exhibit 2-61 ($130.3)
		0	31.11		
	Bayamon	27.7		$ 416.89	IRP Exhibit 2-69 ($121.9)
		0	27.7		
8	Ponce	94.69		$ 1,425.08	IRP Exhibit 2-83 ($412.8)
		0	94.69		
	Total c.miles:	**318.59**		**$ 4,388.65**	**vs. $1,239.40 in IRP**

New OH (M$/mi)	New UG (M$/mi)
$ 1.974	$ 15.05

Summary of Updated MiniGrid Costs by Type

Total Cost Estimate: 10 YR PLAN (M$)							
Region	**115 kV exist OH**	**115 kV new UG**	**115 kV new OH**	**Subst/ Switchyd**	**38 kV exist OH**	**38 kV new UG**	**Grand Total**
Arecibo	14	222	48	83	126	347	840
Bayamon	69	159		122	25	417	792
Caguas/Cayey	52	362	4	129	149	532	1,228
Carolina	30	309		134	9	400	881
Isla	110		74	101		-	285
Mayaguez	56			154	47	800	1,058
Ponce	101			91	5	1,425	1,623
San Juan	15	283		141	116	468	1,023
Grand Total	**447**	**1,336**	**126**	**954**	**477**	4,389	**7,729**
share by type	6%	17%	2%	12%	6%	57%	100%
Note: excludes all distribution hardening costs.							
SJ/Bayamon (M$)	84	442	-	262	141	885	1,815
Other Regions (M$)	363	894	126	692	336	3,504	5,914
share SJ/Bay	5%	24%	0%	14%	8%	49%	100%
share Other	6%	15%	2%	12%	6%	59%	100%

MG Costs by Type by Region - Differences

- Mayaguez and Ponce – largest share for new 38 kV UG
- All regions: 38 kV undergrounding is the largest cost category
- No 115 kV new undergrounding for Mayaguez and Ponce
- Rest of splits similar across regions

Cost Shares by Type by Region	115 kV exist OH	115 kV new UG	115 kV new OH	Subst/ Switchyd	38 kV exist OH	38 kV new UG	Grand Total
Arecibo	2%	26%	6%	10%	15%	41%	100%
Bayamon	9%	20%	0%	15%	3%	53%	100%
Caguas/Cayey	4%	29%	0%	10%	12%	43%	100%
Carolina	3%	35%	0%	15%	1%	45%	100%
Isla	38%	0%	26%	35%	0%	0%	100%
Mayaguez	5%	0%	0%	15%	4%	76%	100%
Ponce	6%	0%	0%	6%	0%	88%	100%
San Juan	1%	28%	0%	14%	11%	46%	100%

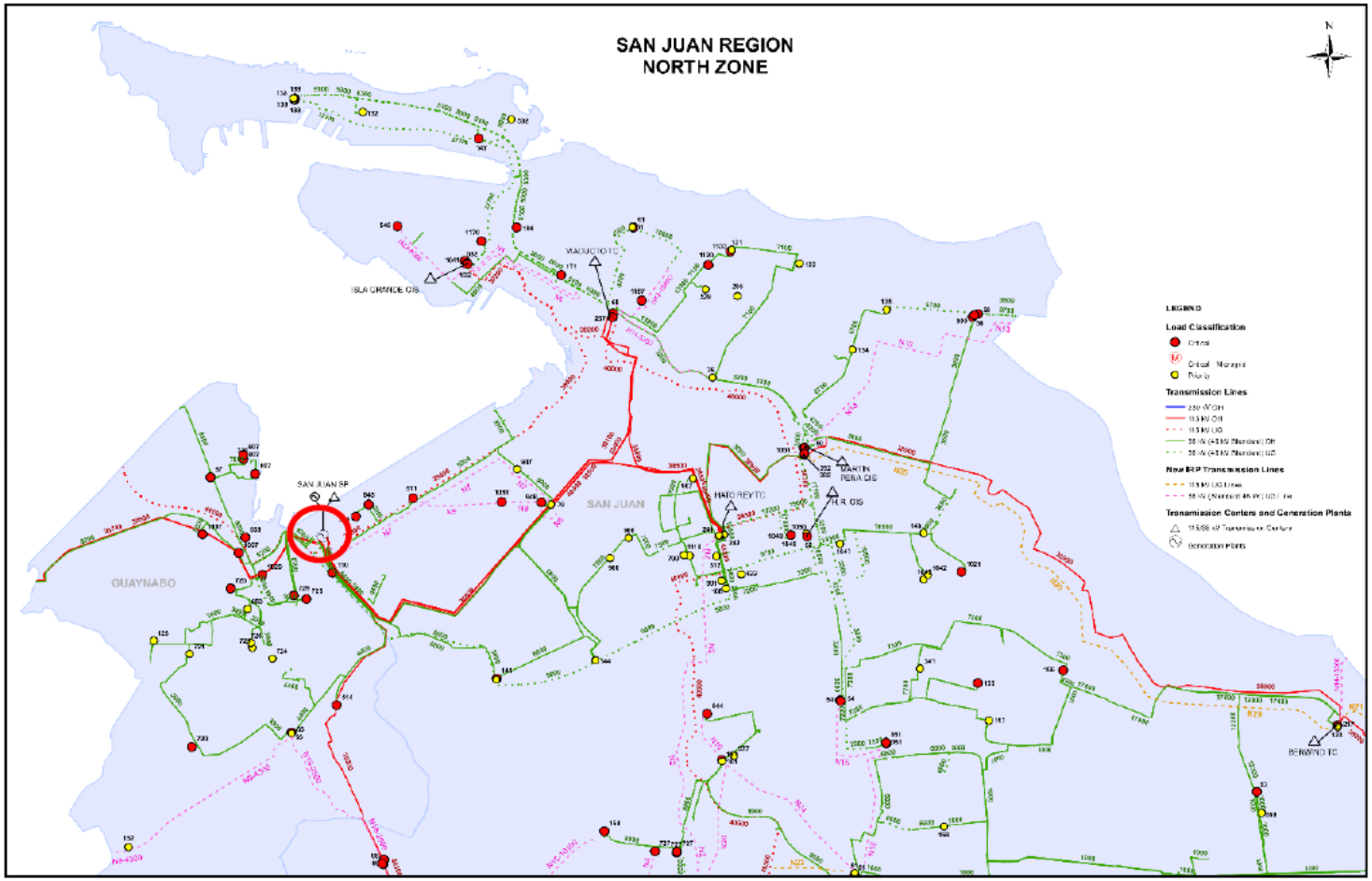
Observations / Discussion MG Costs

- Significant cost increase over MG components as presented in IRP
  - Especially for 38 kV undergrounding (3.5x cost in IRP), but also for 115 kV (1.5x – 2.5x)
  - Reduced costs / different specification (less GIS) for substation hardening
- Total costs greater than $3 million/MW of overall peak load, and almost $5 million / MW for critical + priority load
- Total costs illustrate the importance of using lower cost per MW DER options across the Island where those are identifiable and straightforward.
  - Microgrid options
  - Any critical or priority load at the furthest reaches of the system
  - ***This may be extensive across the island***
- 38 kV undergrounding is the bulk of costs (57%)
  - Ripe for optimization by assessing extent of load (critical or otherwise) on circuits
  - Ripe for improvements to Codes and Standards, + vegetation management to reduce costs of hardening 38 kV system

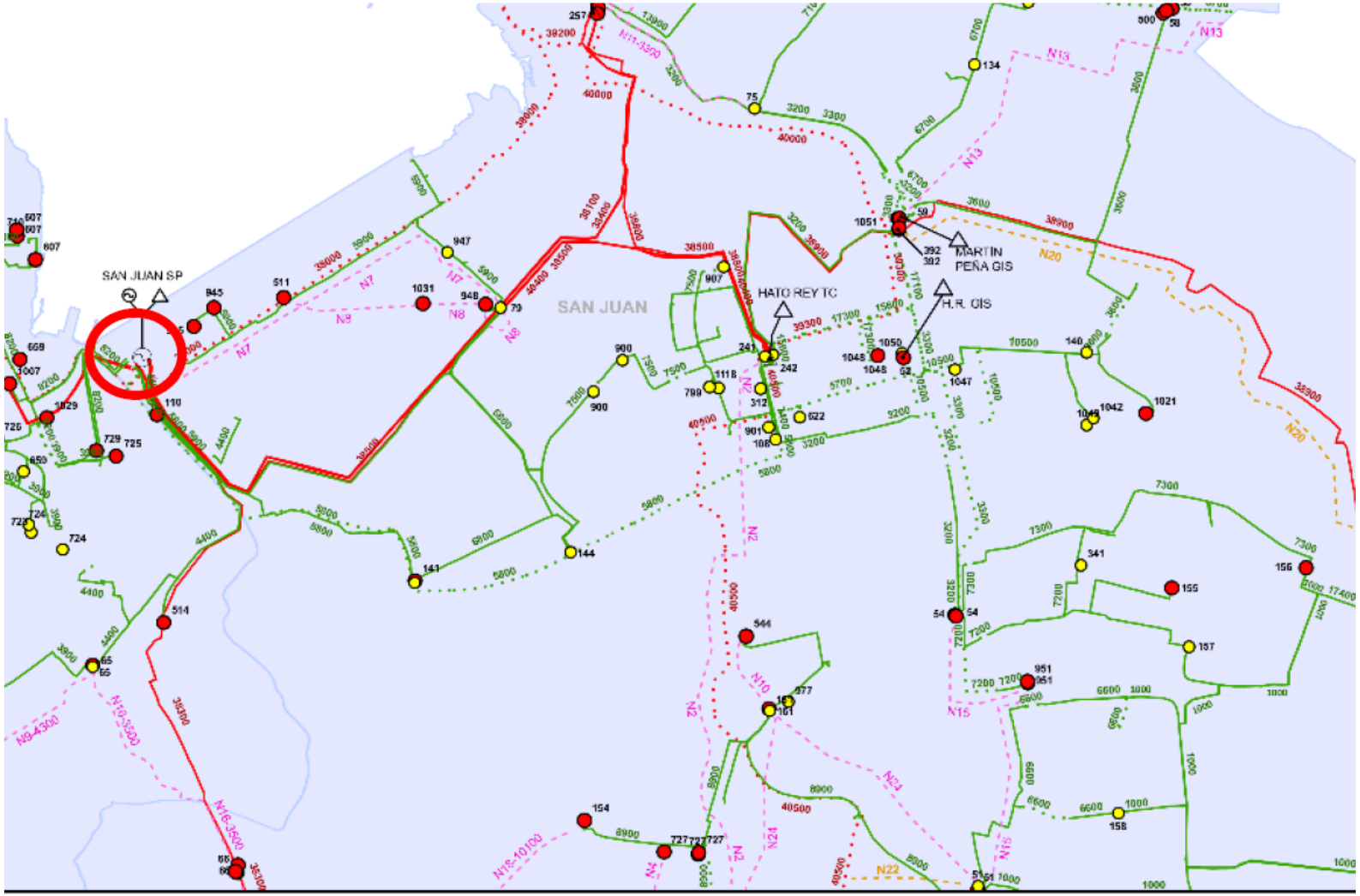
San Juan / Bayamon area MiniGrid Transmission Projects

San Juan Region MiniGrid - North

Exhibit 2-59: San Juan MiniGrid and Generation Injection Points (1)



San Juan Region MiniGrid – North – Close Up



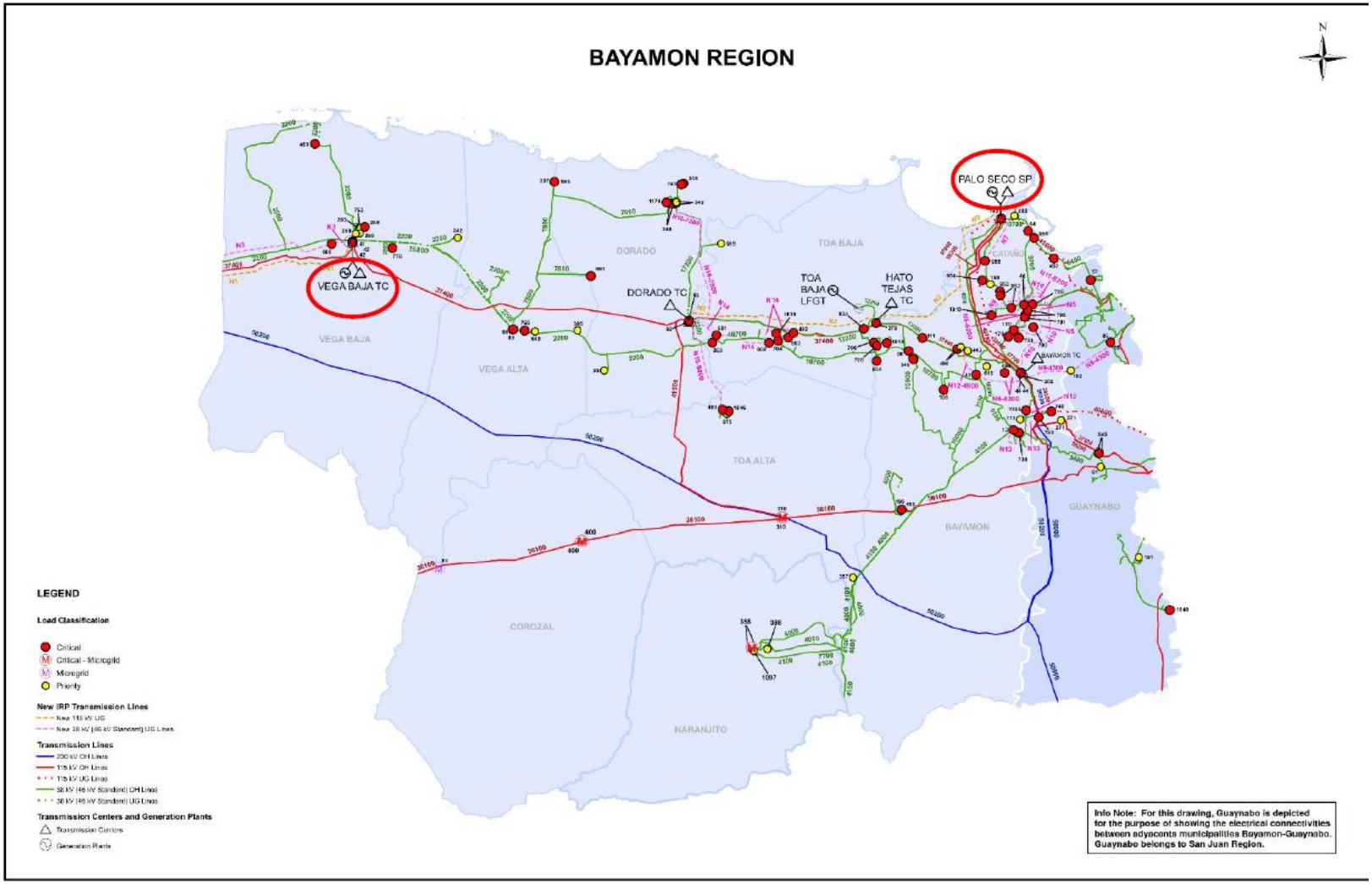
San Juan Region Investments Legend

Project Number	Project Description
N1	New Underground Line 46 kV Monacillo TC - San Juan Medical Center Sect. @ 2000 kcmil Cu
N2	New Underground Line Segment 46 kV Hato Rey TC - San Juan Medical Center Sect. @ 2000 kcmil Cu
N3	New 115 kV Underground Circuit Caguas TC/Bairoa TC – Monacillo TC @2750 kcmil Cu XLPE
N4	New Underground 46 kV Line San Juan Medical Center Sect. - 8900 Tap Americo Miranda @ 2-800 kcmil Cu (includes integration of critical loads to new loop)
N5	Underground subtransmission system and circuits for internal facilities at San Juan Medical Center @ 2-800 kcmil Cu (includes integration of critical loads to new loop)
N6	Interconnection/Sectionalizing Underground 46 kV Line 6300 to Isla Grande TC GIS @ 1-800 kcmil Cu
N7	New Underground 46 kV Line Planta San Juan - New Crematorio 46 kV Sect. @ 2-800 kcmil Cu (línea expreso)
N8	New Underground 46 kV Line New Crematorio 46 kV Sect. - AAA (subs 1572) - SAM's (sub 1581) - Puertos (sub 1571) @ 2-800 kcmil Cu
N9	Underground 46 kV Line 4300 Caparra Sect - Juan Domingo Sect. - Bayamón TC @ 2-800 kcmil Cu
N10	New Underground 46 kV Line Fonalledas Sect. GIS - Hosp. El Maestro 2-800 kcmil (ACB 8929B)
N11	Underground Line 3300 Viaducto TC - Egozcue Sect. @ 2-800 kcmil Cu
N12	Underground Line 10600 Viaducto TC - Villamil Sub. @ 2-800 kcmil Cu
N13	New Underground Line 46 kV M. Peña GIS - Villamar Sect. @ 2000 kcmil Cu
N14	Underground 46 kV Line 15300 Berwind TC – Los Angeles Sect. @ 2-800 kcmil Cu
N15	New Underground 46 kV Line Venezuela TC – Auxilio Mutuo – Baldrich Sect. @ 2-800 kcmil Cu
N16	Underground Line 3500 46 kV Circuit Caparra Sect. – Cachete Sect. – Las Lomas Sect. – Monacillo TC @ 2-800 kcmil Cu
N17	Underground 46 kV Circuit Las Lomas Sect. GIS – Hospital Metropolitano (ACB 10101) @ 2-800 kcmil Cu
N18	Underground Line 10100 Las Lomas Sect - ACB10133/10131 (Suiza Dairy) - Reparto Metropolitano TO @ 2-800 kcmil Cu (includes underground of line tap to Suiza Dairy @ 1-800 kcmil Cu)
N19	New Underground 46 kV Line New Trujillo Alto 46 kV Sect. - Sergio Cuevas Substations @ 1-800 kcmil Cu
N20	New Underground 115 kV Line Martin Peña GIS - Berwind TC @ 2750 kcmil Cu XLPE
N21	New Underground 115 kV Line Sabana Llana TC- Berwind TC @ 2750 kcmil Cu XLPE
N22	Line 40500 extension to Interconnect Venezuela TC GIS @2750 kcmil Cu XLPE
N23	Hardening 46 kV Line 8000 Isla Grande TC GIS - Crowley (extension of underground line if possible) @ 1-800 kcmil Cu
N24	New Underground Line 46 kV Venezuela TC - Fonalledas - San Juan Medical Center Sect. @ 2000 kcmil Cu

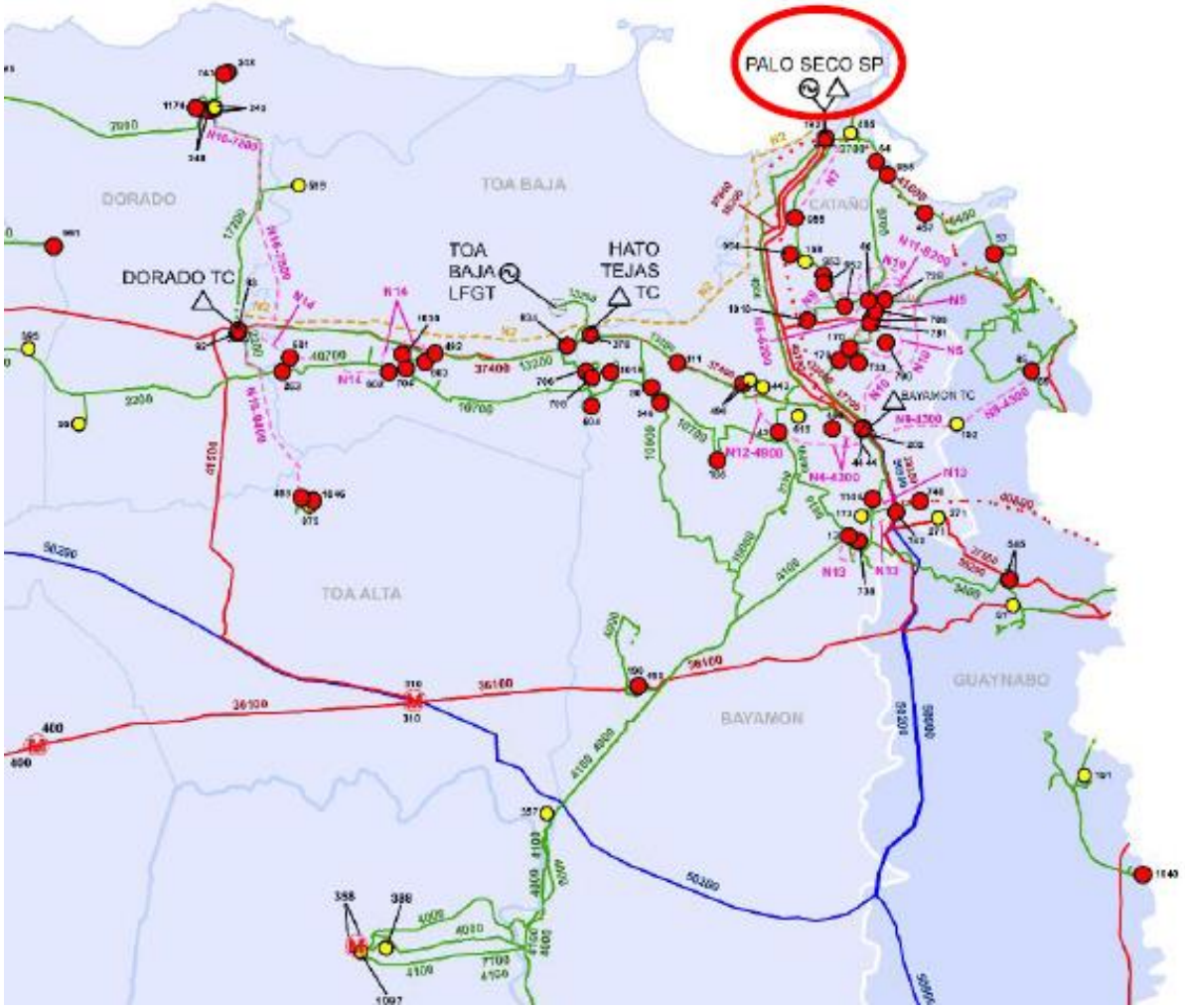
San Juan Projects, 115, 38 kV

Bayamon

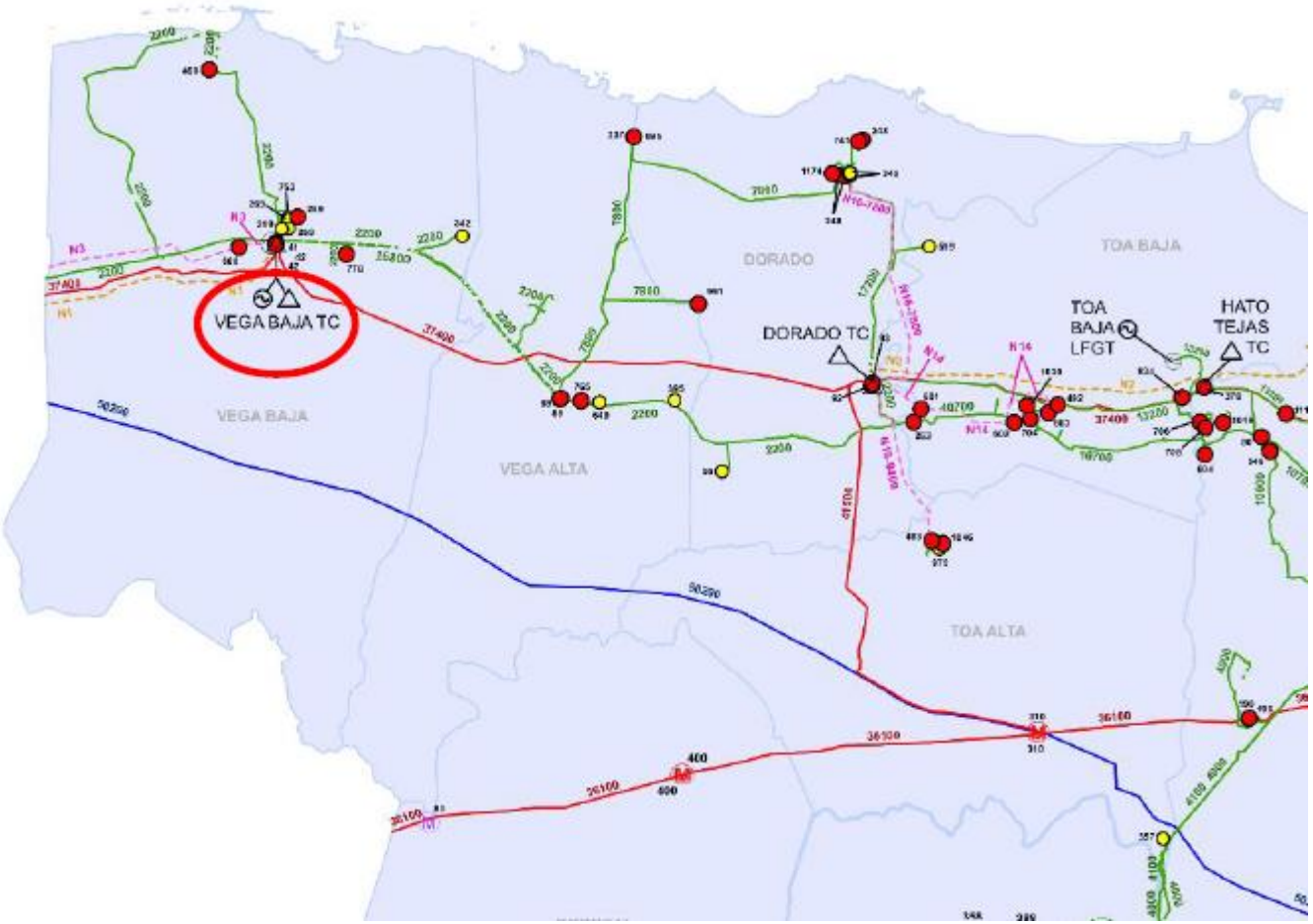
Exhibit 2-70: Bayamon MiniGrid Investments and Generation Injection Points



Bayamon – East – Cluster of Critical Loads



Bayamon - West



Bayamon – Projects 115, 38 kV

Bayamon Region Investments Legend

Project Number	Project Description
N1	New 115 kV Underground Circuit Vega Baja TC – Manati TC @2750 kcmil Cu XLPE
N2	New 115 kV Underground Circuit Palo Seco Steam Plant –Hato Tejas TC - Dorado TC @2750 kcmil Cu XLPE
N3	New Underground 46 kV Line Vega Baja TC - Hospital Wilma Vazquez - Walmart - Ortho - Manati TC @ 2-800 kcmil Cu
N4	Underground of 46 kV Line 4300 Bayamón TC – Hosp. San Pablo (ACB 4301) – Bayamón Pueblo Sect. @ 2-800 kcmil Cu
N5	New Underground 46 kV Circuit Cataño Sect. - Zona Industrial Goya (New 3 Way GOABs between 9623A and 9607B) @ 2-800 kcmil Cu
N6	Underground Line 6200 Cataño Sect - Puma Energy (Sub. 1771) @ 2-800 kcmil Cu
N7	New Underground 46 kV Circuit P. Seco - AAA (New ACB between 9501C and Sub. 1883)@ 2-800 kcmil Cu
N8	New Underground 46 kV Circuit Cataño Sect. - Centro Medico Carcel/Carcel Regional (New ACB between 9503C and 9503D) @ 2-800 kcmil Cu
N9	Underground 46 kV Line 4300 Bayamón TC - Juan Domingo Sect. - Caparra Sect. @ 2-800 kcmil Cu
N10	New Underground 46 kV Circuit Bayamón TC – Cataño Sect. @ 2-800 kcmil Cu
N11	Underground 46 kV Line 8200 Cataño Sect - ACB 8215A (Sub. 1882, Claro) @ 2-800 kcmil Cu
N12	Complete Underground 46 kV Line 4900 Bayamón Pueblo Sect. – ACB 4905B (Plaza del Sol, H. Depot, Walmart) @ 2-800 kcmil Cu (extender el soterrado existente)
N13	New Underground 46 kV Line Guaraguao Sect. - Pan Pepin - AAA Superacueductos - COSTCO @ 2-800 kcmil Cu
N14	New Underground 46 kV Line Dorado TC - ACB 10729 (Walmart) - Holsum - AAA Sub. 9384 - Sub. 9368 (Pepsi) @ 2-800 kcmil Cu
N15	Underground 46 kV Line 9400 Dorado TC - Toa Alta Sub. 9401 @ 2-800 kcmil Cu (backup shall be provided by hardened tap from hardened line 2200 Dorado TC - Vega Alta)
N16	Underground 46 kV Line 7800 Dorado TC - New Dorado Pueblo Sect. @ 2-800 kcmil Cu

Specific SJ / Bayamon 115 kV Projects

Row Labels	Sum of Cost Estimate: 10 YR PLAN (M$)
115 kV exist OH	**194**
Line 38900 Berwind GIS - Parque Escorial Relocation/Hardening @1192.5 kcmil ACSR	3
Line 38900 M. Peña GIS - Berwind GIS Relocation/Hardening @1192.5 kcmil ACSR	9
Line 38900 Parque Escorial - Sabana Llana Relocation/Hardening @1192.5 kcmil ACSR	2
Reconstruction Line 36100 Bayamón TC - Caná Sect. - Bo. Piñas GIS @1192.5 kcmil ACSR Bu	24
Reconstruction Line 36200 Monacillo TC - Juncos TC @1192.5 kcmil ACSR Bunting	43
Reconstruction Line 36300 Maunabo TC - Juan Martin Sect. @1192.5 kcmil ACSR Bunting	12
Reconstruction Line 37100 C.Sur - Guánica TC@1192.5 kcmil ACSR Bunting	29
Reconstruction Line 37400 Bayamon TC - Hogar Crea Sub. - H. Tejas TC - Candelaria Arena S	26
Reconstruction Line 37500 Bayamón TC - Rio Bayamón Sect. - Grana Substations @ 1192.5	6
Reconstruction Line 37800 Monacillo TC - Buen Pastor TC @1192.5 kcmil ACSR Bunting	11
Reconstruction Line 37900 Sabana Llana TC - Encantada Sub. - Conquistador Sub. @1192.5	15
Reconstruction Line 41500 Dorado TC - Bo. Piñas GIS @1192.5 kcmil ACSR Bunting	14
115 kV new OH	**74**
New 115 kV Line Costa Sur - Dos Bocas HP @1192.5 kcmil ACSR Bunting @ 230 kV	74
115 kV new UG	**442**
Line 40500 extension to Interconnect Venezuela TC GIS @2750 kcmil Cu XLPE	9
New 115 kV Underground Circuit Caguas TC/Bairoa TC – Monacillo TC @2750 kcmil Cu XLPE	155
New 115 kV Underground Circuit Palo Seco Steam Plant –Hato Tejas TC - Dorado TC @2750	159
New Underground 115 kV Line Martin Peña GIS - Berwind TC @ 2750 kcmil Cu XLPE	85
New Underground 115 kV Line Sabana Llana TC- Berwind TC @ 2750 kcmil Cu XLPE	35

Critical Load – by MiniGrid Region and SubArea

- ~400 MW critical load (feeder + 38 kV total) – SJ/Bayamon
- Distributed across feeders and some direct 38 kV station load

Location of Critical Load - Dist. Feeders vs. 38 kV (typ. cust owned)				
Row Labels	Sum of Total Critical	Sum of Distribution Sub Critical	Sum of Transmission Sub Critical	% distr feeder critical vs. 38 kV
Arecibo	**117**	**102**	**15**	87%
Caguas	**128**	**107**	**21**	84%
Carolina	**133**	**107**	**26**	81%
Cayey	**60**	**56**	**3**	95%
Mayaguez North	**85**	**66**	**19**	78%
Mayaguez South	**110**	**94**	**16**	85%
Ponce	**144**	**131**	**13**	91%
San Juan	**399**	**315**	**84**	79%
BAYAMON	159	132	27	83%
CAGUAS	7	7	-	100%
S.JUAN	234	176	57	75%
Grand Total	**1,177**	**980**	**197**	83%

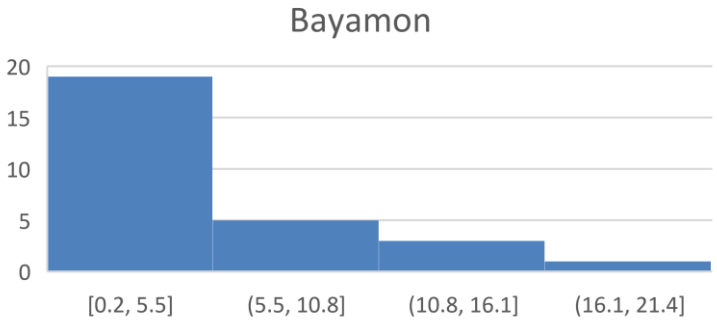
Priority Load – by MiniGrid Region and SubArea

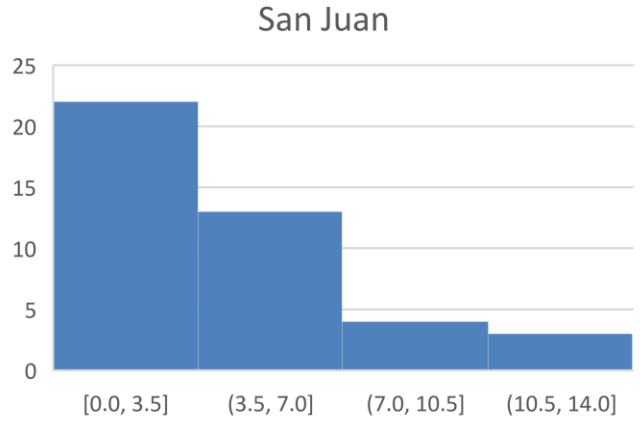
- ~480 MW priority load, much greater % not on distribution feeders

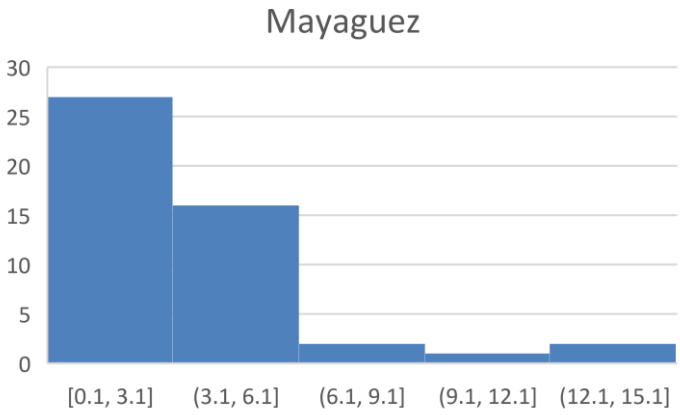
Location of Priority Load - Dist. Feeders vs. 38 kV (typ. cust owned)				
Row Labels	Sum of Total Priority	Sum of Distribution Sub Priority	Sum of Transmission Sub Priority	% distr feeder priority vs. 38 kV
Arecibo	**61**	**6**	**54**	11%
Caguas	**74**	**21**	**54**	28%
Carolina	**34**	**20**	**13**	61%
Cayey	**30**	**12**	**18**	41%
Mayaguez North	**8**	**6**	**1**	86%
Mayaguez South	**10**	**4**	**6**	39%
Ponce	**79**	**16**	**64**	20%
San Juan	**185**	**130**	**55**	70%
ARECIBO	0	-	0	
BAYAMON	78	54	24	69%
CAGUAS	0	-	0	0%
S.JUAN	107	76	31	71%
Grand Total	**480**	**215**	**265**	45%

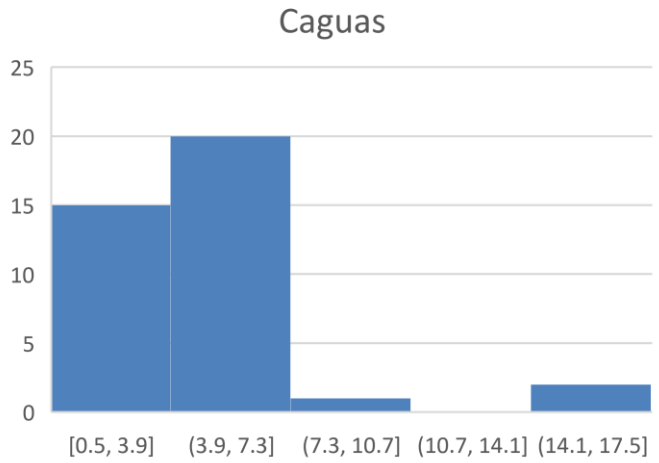
Sample Histograms of Critical Load Density on Feeders

- Further analysis required to determine which critical load is clustered on which feeders. [histograms show #s of feeders & peak load, for feeders with critical load)









How to Measure Intensity of Spending per Critical Load?

- Differences across regions – 38 kV UG costs
- Differentiating between 115 kV and 38 kV undergrounding value, when comparing to DER options?
- Mayaguez and Ponce $/per unit of critical load >> SJ and Bayamon per unit of critical load, for 38 kV undergrounding

Total Cost Estimate: 10 YR PLAN (M$)											
Region	115 kV exist OH	115 kV new UG	115 kV new OH	Subst/ Switchyd	38 kV exist OH	38 kV new UG	Grand Total	Critical Load Dist	Critical Load 38 kV	Total Crit Ld	$ M/MW Crit 38 kV UG
Arecibo	14	222	48	83	126	347	840	102	15	117	3.0
Bayamon	69	159		122	25	417	792	132	27	159	2.6
Caguas/Cayey	52	362	4	129	149	532	1,228	164	24	188	2.8
Carolina	30	309		134	9	400	881	107	26	133	3.0
Isla	110		74	101		-	285				
Mayaguez	56			154	47	800	1,058	161	35	196	4.1
Ponce	101			91	5	1,425	1,623	131	13	144	9.9
San Juan	15	283		141	116	468	1,023	176	57	234	2.0
Grand Total	**447**	**1,336**	**126**	**954**	**477**	4,389	**7,729**				
share by type	6%	17%	2%	12%	6%	57%	100%				

Questions for Discussion and Eventual Resolution

- How to recognize/acknowledge which 115 kV undergrounding is critical for system-wide integrity, and access to supply?
- How to determine which 115 kV undergrounding projects, currently for MG, might be marginal when considering overall load and DER options?
- How to determine cutoffs for 38 kV undergrounding? Which 38 kV projects easily identifiable for serving clusters of critical / priority load?
- What is the importance of "weighting" critical load for essential facilities – do data reveal particular substations with downstream service to highly critical load?
- Do data reveal clear linkages of 115 kV and 38 kV projects to serve clusters of critical / priority load in densest load areas in SJ/Bayamon?
  - If so: what next? If not: how to determine this?
- How to identify highest ranking Microgrid sites AND what to do about it?
  - PREPA IRP
  - Sandia study
- How do selections align with restoration plans?
- How do selections align with vegetation management plans?

Preliminary No Regrets Options – Wires – Criteria/Attributes

- 230 kV
  - Hardening of existing OH lines.
  - Not MiniGrid specific, but has broad impact on resiliency by enhancing island-wide grid cohesion.
- 115 kV
  - Existing infrastructure OH hardening
  - SJ “Underground Loop” – which projects?
  - Other “between minigrid” connections?
- 38 kV
  - Initially limited to specific SJ and Bayamon load clusters?
- Substations (GIS)

Preliminary No Regrets – SJ Region Transmission

- No regrets transmission already approved:
  - 230 kV not part of MG solutions, for Island-wide grid reliability.
  - 115 kV existing hardening
- MiniGrid components:
  - Some key substation hardening?
  - Key 115 kV undergrounding?
  - Selective 38 kV undergrounding to dense clusters of critical load
- Questions for PREPA/Stakeholders:
  - Provide a list ranking the MiniGrid projects. And,
  - Provide a list of San Juan / Bayamon / Adjacent? regions:
    - Top 5-10 115 kV undergrounding projects currently categorized as MiniGrid project
    - Top 5-10 38 kV undergrounding projects
    - Specific substation and feeders requiring hardening to create more limited SJ/Bayamon region MiniGrid for earlier / initial deployment

DER Options for San Juan / Baymon Region

No Regrets Options – DERs – Questions for Discussion and Comment

- What are the best microgrid candidates?
  - Which public purpose microgrid should be pursued? How?
  - Which private purpose microgrids? How?
  - How is resiliency value considered?
- Stand Alone DER – larger scale
  - Public purpose – how to determine, and how to deploy?
  - Private – full prosumer deployment?
  - How is resiliency value considered?
- DER – Small Scale
  - Via VPP procurements
  - Via DR tariff
  - Via alternative resiliency programs
  - How are any of these best deployed, rapidly, in best locations?

E.g.: PREPA and Sandia Microgrid Options – SJ / Bayamon

- PREPA: 7 locations for microgrid

MiniGrid	Microgrid Name	Critical	Priority	Balance	Total
San Juan	CARRAIZO	1.8	0.0	10.7	12.5
	NARANJITO	6.6	0.2	6.1	12.8
	PINAS	4.4	0.0	11.6	16.0
	UNIBON	0.0	3.2	5.3	8.5
	VILLA BETINA	3.9	7.0	15.2	26.1
	QUEBRADA NEGRITO	0.0	0.0	4.5	4.5
	COROZAL	6.0	2.7	0.0	8.7
San Juan/Bayamon Total		22.8	13.0	53.3	89.1

- Sandia: dozens of locations

What is PREPA's Role in Facilitating DERs for Resiliency?

- Analysis of Options?
  - MiniGrid proposal did not simultaneously analyze in detail DER complements.
  - Does PREPA have such an analysis? Do stakeholders?
  - Response to Appendix B questions: method to look at clusters of critical load?
- Facilitates the development and integration of distributed generation?
  - Through VPP PPOAs
  - Through DR programs
  - Through additional specific programs?
    - FEMA-funded resiliency programs?
    - Role in public purpose microgrids?
- Participates in the installation and maintenance of these distributed photovoltaic systems with storage?
  - Not considered – third party entities do this
  - Act 17: prosumer focus
- Manages the interaction and relationship of the various distributed generators and microgrids? Is this what LUMA will do?
- Participates in the development of large-scale renewable energy and storage and promotes the optimization of the existing hydroelectric system?

Wrap Up – Next Steps

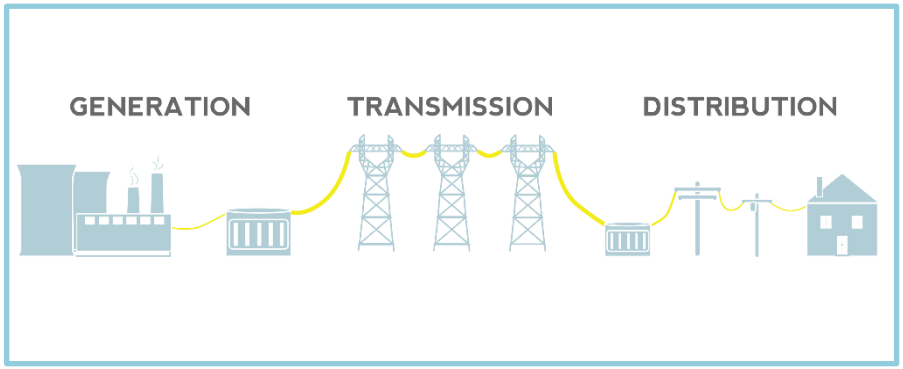
- Next workshop March 23
  - Focus on DER Solutions – broadly across Island
  - Create / expand metrics to determine and compare costs for DER options
  - Answer: How to Provide / Rapidly Deploy DER?
- Other
  - Comments and responses to questions – Before March workshop

Backup Slides

Two Types of Resiliency Solutions

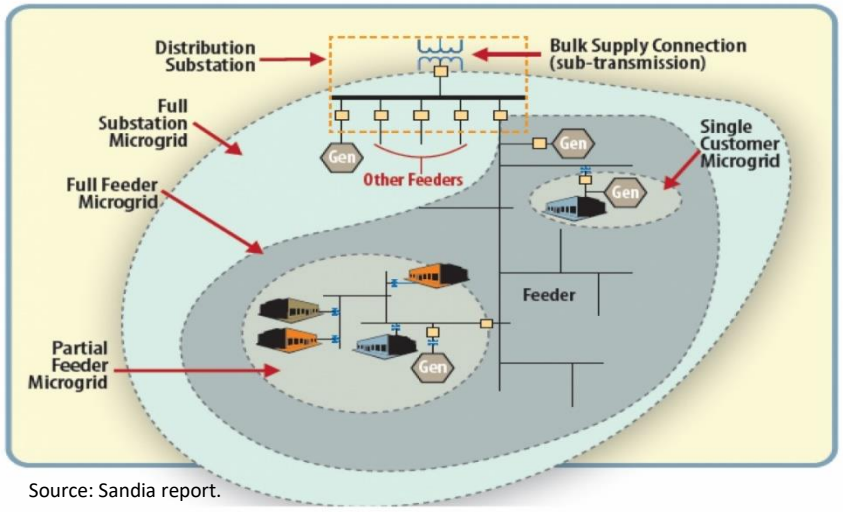
Not Mutually Exclusive

T&D System Hardening Approach



VS.

Distributed Resource Approach



Source: Sandia report.

MiniGrid Approach

- Undergrounding of existing/new transmission infrastructure
- Selective substation hardening
- $5.9B in MG Tx expenditures, + additional distribution $
- Ensure sufficient capacity to meet critical/other load

DER Deployment

- Site-specific DG or microgrids serving critical (& other?) load during grid outage
- Distributed resiliency
- Avoids some level of T&D expenditure

Issues and Remaining Workshops

- Issues – How does optimization address:
  - "Blue sky" and resiliency needs – all DER resources service both normal and weather event circumstances
  - Consideration of the avoided costs of T, D for DER solutions
  - Uncertainty of costs for both forms of solutions
  - Transmission grid is integrated – MiniGrid and "Non-MiniGrid" infrastructure
    - How does optimization address "other" transmission?
- Remaining Workshops
  - Review transmission projects/categories; determine which are reasonable to proceed
  - San Juan / Bayamon projects first
  - Distributed resources for balance of resiliency need

Analytical Objective

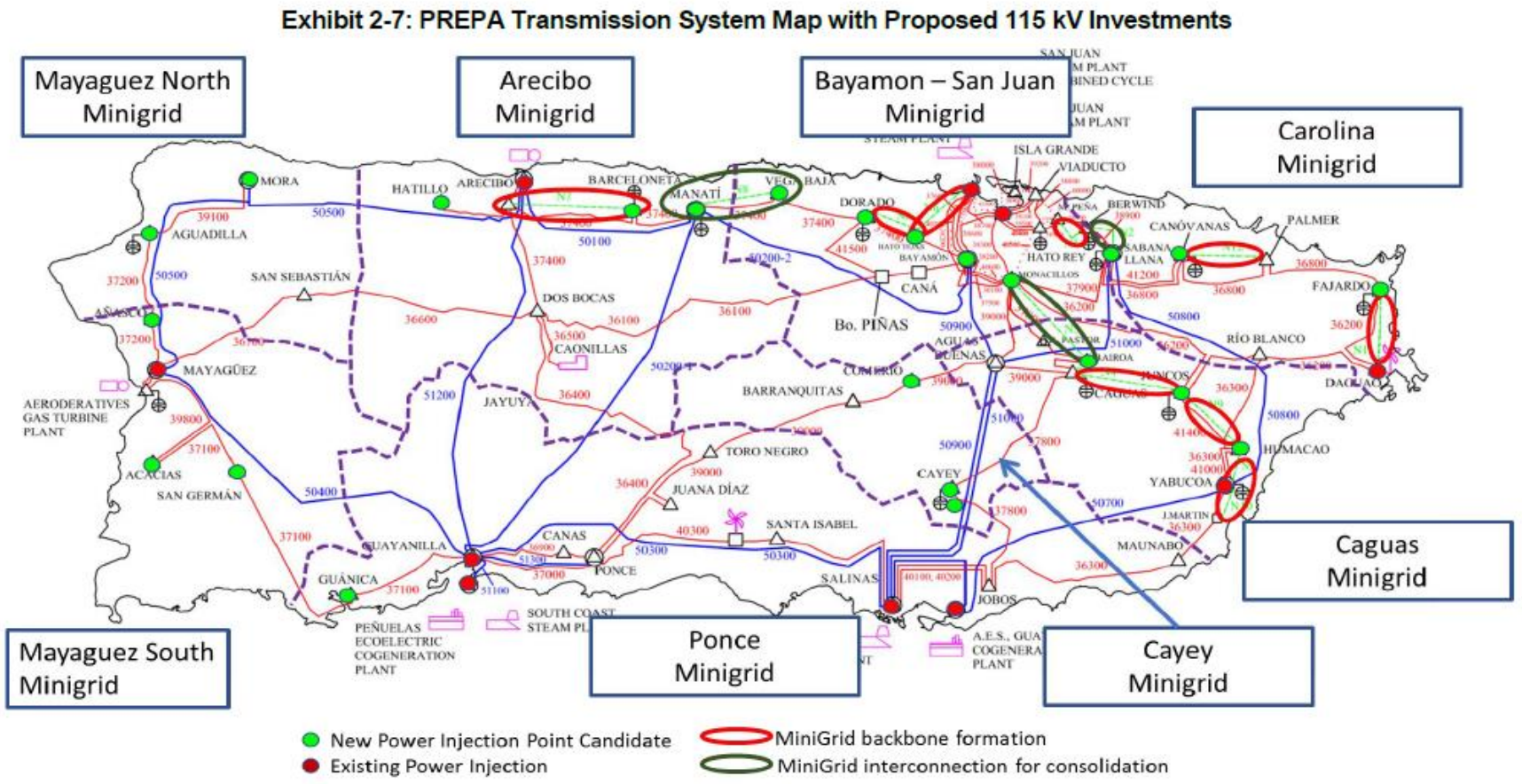
- Determine reasonably lowest cost mix of MiniGrid transmission assets and DERs to enhance grid resiliency
- Identify "no regrets" solutions for:
  - Transmission infrastructure hardening
  - Microgrid or stand-alone distributed generation
- Refine analysis for more difficult transmission vs DG cases

- Recognize that DER resources for grid resiliency are also available for "blue sky" days; conversely, DERs that support capacity and energy needs can be doubly-purposed to also provide resiliency.
- Transmission reinforcement needed for "blue sky" operation in addition to serving as "MiniGrid" resource in severe weather/islanded mode.

Analytical Framework for Resilient Grid

1. Identify and define classes of customers regarding the criticality of electricity service and associated expected levels of resiliency.
2. Identify and describe the customers' roles in providing capacity and energy supply for resiliency.
3. Provide microgrid and related single-site (individually, or in the aggregate as VPPs) local capacity and energy solutions for both resiliency and normal energy/capacity needs.
4. Determine transmission costs, avoided transmission costs.
5. Optimize transmission and distribution (T&D) system expenditures for resiliency, including aspects of PREPA's MiniGrid concept.

PREPA Transmission System



Source: IRP Appendix 1, Redacted Exhibit

Sandia Distributed Resiliency Approach

- Sandia identified 159 candidate microgrids, supplemented with backup generation to critical assets in locations that may not warrant a microgrid.
- System costs $1.2B if only critical loads served by microgrids and $2B to serve both critical and non-critical load.
- A large cluster of portfolios achieves performance benefits close to the do-everything scenario at cost on the order of $300-$400M.
  - Estimate total microgrid cost on the order of $1.3-$2M per MW of peak load required for the microgrid
  - Appendix A: Microgrid Cost Methodology pgs. 55-60
  - Latitudes and longitudes of buildings suggested under each of the 159 candidate microgrids

Snapshot from Sandia Report

Table 7. Microgrid Cost Estimates for each Microgrid Area

Microgrid #	Microgrid Name	Critical Demand (kW)	Non-Critical Demand (kW)	Option A1 ($M)	Option A2 ($M)	Option B1 ($M)	Option B2 ($M)
1	San Juan City Hall	1079	4630	15.42	20.90	4.56	5.60
2	Hospital Complex	70049	9323	203.99	280.19	181.13	248.37
3	International Airport	122315	12805	346.71	476.42	314.93	432.35
4	Muelle De Viejo Ferry and Cruise Terminals	4202	4069	21.97	29.91	12.56	16.59
5	Calle Cuervillas	1201	4250	14.75	19.99	4.87	6.03
6	Doctors Hospital Center	2164	2097	11.71	15.80	7.34	9.42
7	Centro Comunal El Gandel	456	1100	4.78	6.28	2.97	3.41
8	Conservatoria de Musica de Puerto Rico	2655	886	9.86	13.26	8.60	11.15
9	Pavia Hospital Complex	2032	14882	44.10	60.34	7.00	8.95
10	Avenida Wilson	1579	10464	31.63	43.19	5.84	7.36
11	Avenida Doctor Ashford	2902	14966	46.54	63.70	9.23	12.02
12	University Sacred Heart	1332	3019	11.94	16.12	5.21	6.49
13	FRD Airport and Convention Center	7774	21268	75.15	103.03	21.70	29.16
14	Sagrado Corazon	1377	3848	14.18	19.19	5.33	6.65

Source: Sandia report, page 56.

- "There is a great range in size with the microgrids, so the costs for given microgrids vary widely. It may be possible to further reduce the size of larger microgrids like microgrid 2, the Hospital Complex, or microgrid 3, the International Airport, by splitting them into smaller microgrids or serve a smaller subset of critical loads. In any case the results presented show load and cost comparative information which can be further analyzed to determine which ones are the most important and critical for service to Puerto Rico during major events." (Sandia report, page 55)

Other Reference Materials / Resiliency

- DOE / National Labs work
- NARUC
- Other jurisdictions - Hawaii

Storage for Resiliency

- DERs for resiliency: storage as key

  "The real value of storage is as a means to provide a key characteristic missing from power grids: the ability to absorb stresses with little or no loss of performance – the essence of resilience. Storage applied systematically throughout the grid can provide the missing "shock absorber" springiness that the grid is missing. To provide this value, storage must be incorporated into the grid as core infrastructure and must be deeply integrated into grid operations. Doing so will provide far-reaching benefits to users of electricity at all levels, including vastly increased system resilience, expanded system operational flexibility, support for critical lifeline functions during critical events, and even improved cyber security"

  PNNL, Taft, et al., The Use of Embedded Electric Grid Storage for Resilience, Operational Flexibility, and CyberSecurity October 2019

  https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-29414.pdf

- Storage at utility-scale also brings resilience
- How do we trade off distributed storage and utility-scale storage?

Para más información:

http://energia.pr.gov

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