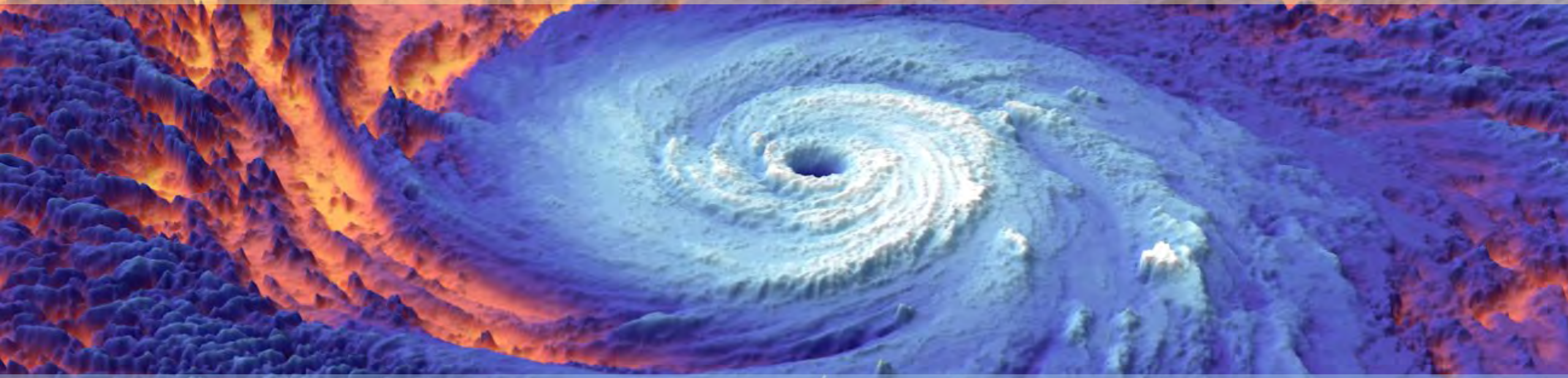
Boricua Energy Justice and Rural Community Microgrids

Small and Medium-sized Enterprises for Just Transitions and Sustainable Development Panel
Challenges and Opportunities towards a Just Transition and Sustainable Development Workshop
Roundtable on Science and Technology for Sustainability: National Academies
24 de julio de 2023



Marcel J. Castro Sitiriche
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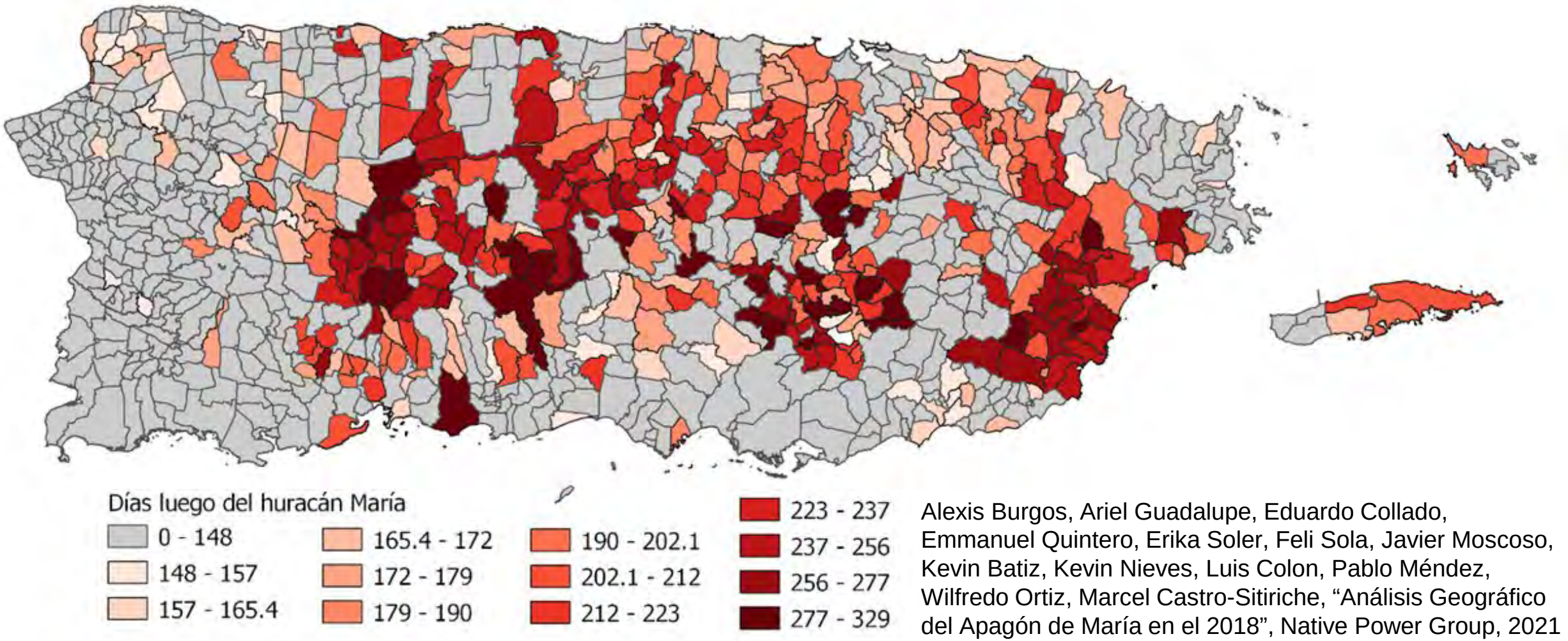
Recinto Universitario de Mayagüez, University of Puerto Rico in Mayagüez

Photo Credit: Thermal image captured by the MODIS on NASA's Terra satellite
https://eoimages.gsfc.nasa.gov/images/imagerecords/91000/91004/maria_tmo_2017263_lrg.png

Comunidades con hogares que se reconectaron a la AEE desde febrero hasta agosto 2018

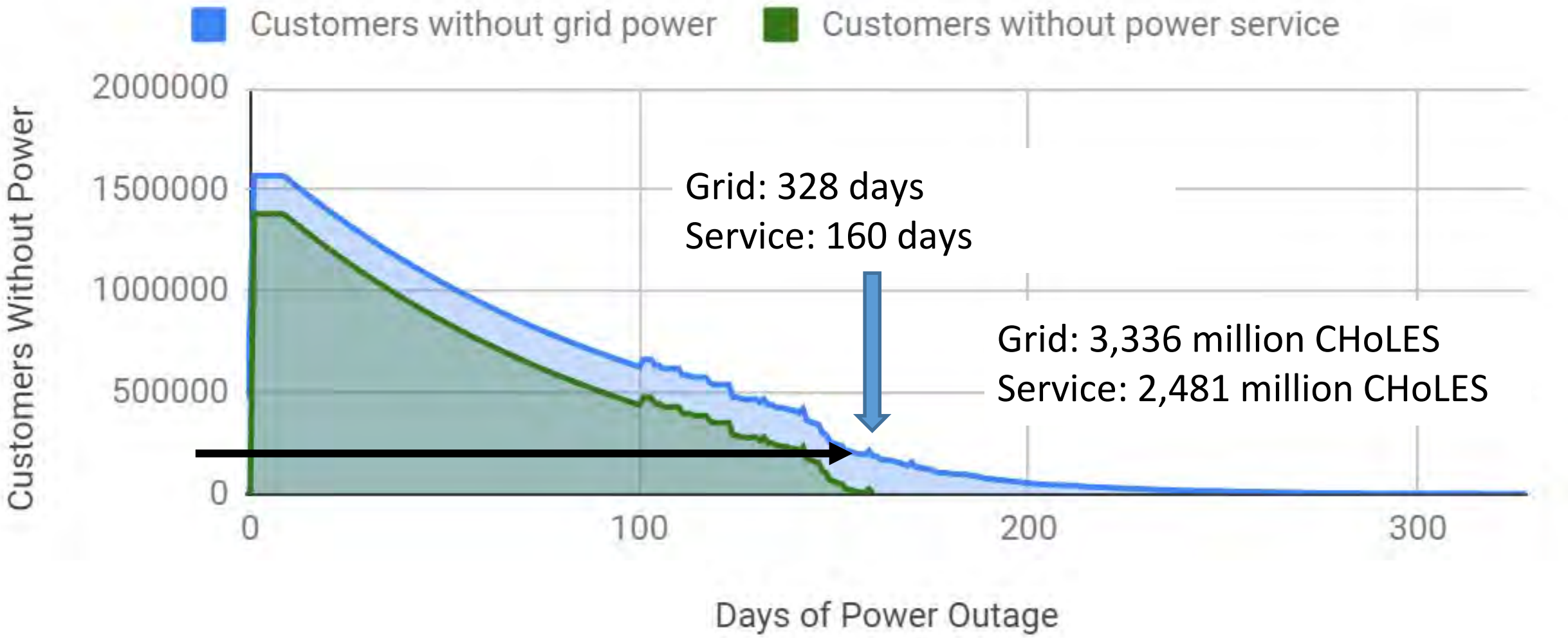


Alexis Burgos, Ariel Guadalupe, Eduardo Collado, Emmanuel Quintero, Erika Soler, Feli Sola, Javier Moscoso, Kevin Batiz, Kevin Nieves, Luis Colon, Pablo Méndez, Wilfredo Ortiz, Marcel Castro-Sitiriche, “Análisis Geográfico del Apagón de María en el 2018”, Native Power Group, 2021

M. Castro-Sitiriche, “Boricua Energy Justice”, **Infrastructure as Destiny: Resilience, Innovation and Equity**, AEG Thought Summit 2022, February 23, 2022.
Source: https://www.energy.gov/ceser/downloads/hurricanes-nate-maria-irma-and-harvey-situation-reports

Customers without power service and without grid power

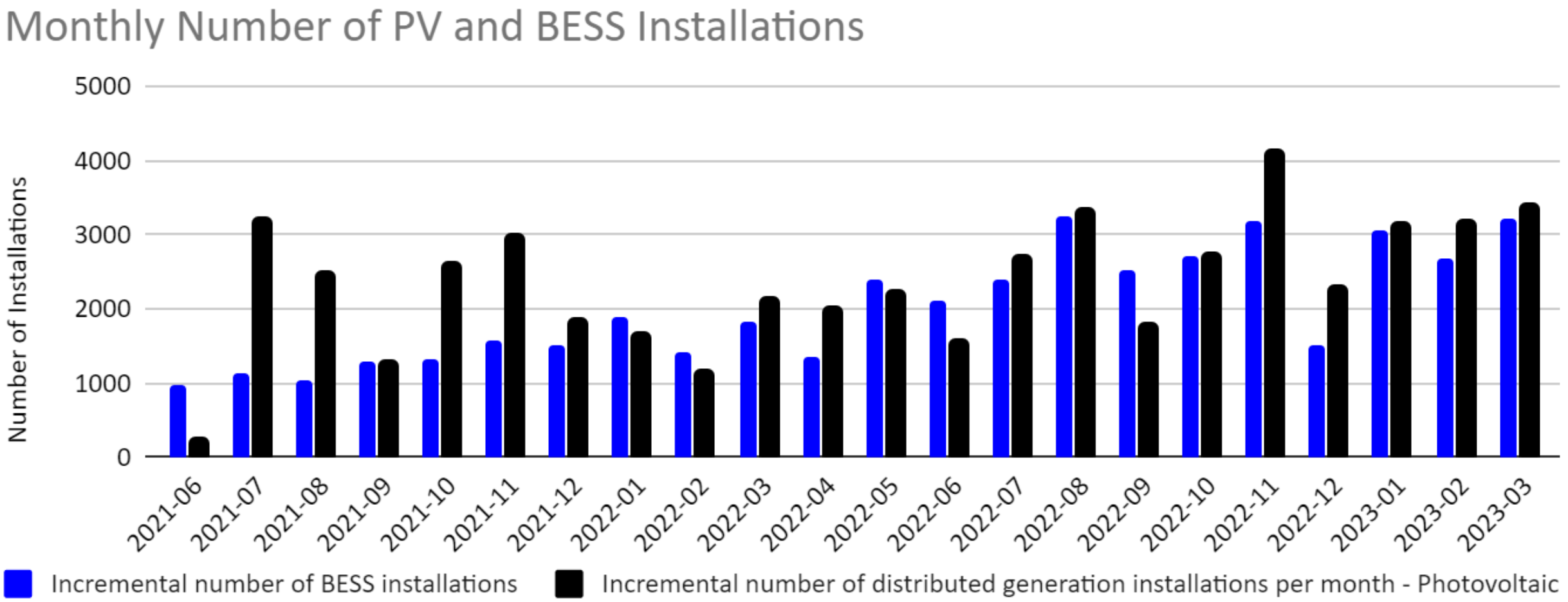
200,000 rooftop PV Hurricane María scenario



Marcel Castro-Sitiriche, Boricua Energy Justice, Native Power, June 2023.

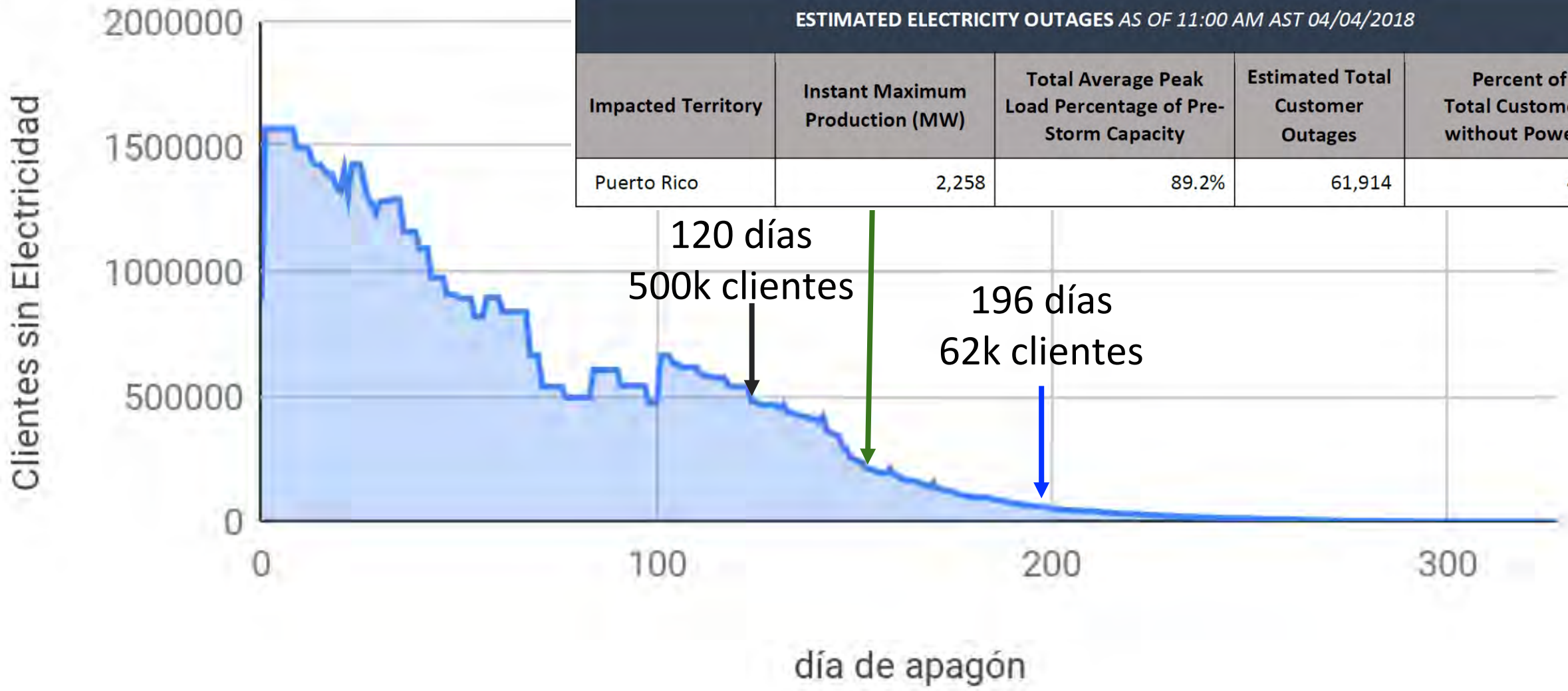
> 3,000 net-metering installations per month, total monthly estimate of 4,000
50,000 total approximate installations per year

200,000 installations in four years are possible (2018-2021)



Marcel Castro-Sitiriche, NEPR Data Analysis, Native Power Research Group. Source: Negociado de Energía de Puerto Rico (NEPR) https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/

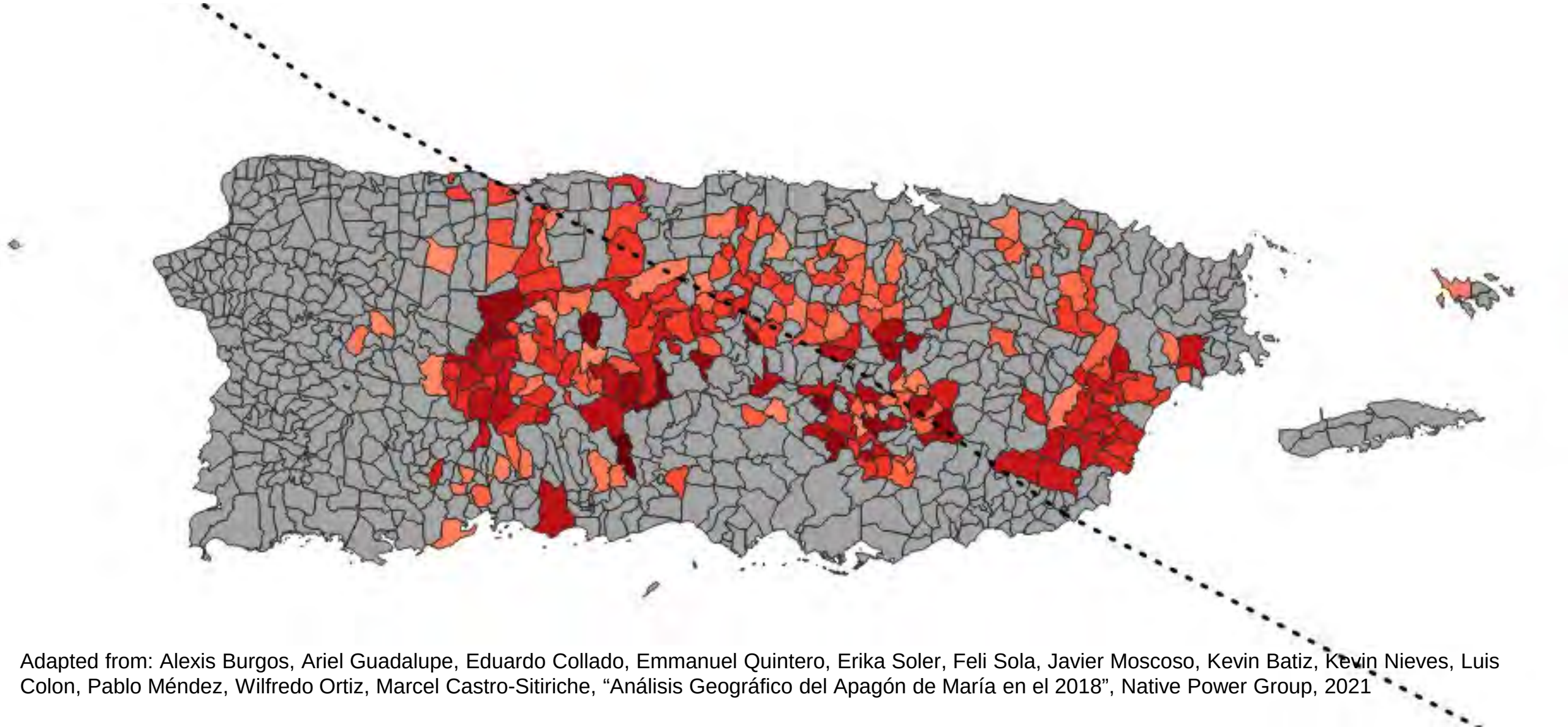
Clientes sin Electricidad: septiembre 2017 - agosto 2018



ESTIMATED ELECTRICITY OUTAGES *AS OF 11:00 AM AST 04/04/2018*				
Impacted Territory	**Instant Maximum Production (MW)**	**Total Average Peak Load Percentage of Pre-Storm Capacity**	**Estimated Total Customer Outages**	**Percent of Total Customers without Power***
Puerto Rico	2,258	89.2%	61,914	4.20%

M. Castro-Sitiriche, “Boricua Energy Justice”, **Infrastructure as Destiny: Resilience, Innovation and Equity**, AEG Thought Summit 2022, February 23, 2022.
Source: https://www.energy.gov/ceser/downloads/hurricanes-nate-maria-irma-and-harvey-situation-reports

Comunidades con hogares que se reconectaron a la AEE desde abril hasta agosto 2018: 62,000 familias



Adapted from: Alexis Burgos, Ariel Guadalupe, Eduardo Collado, Emmanuel Quintero, Erika Soler, Feli Sola, Javier Moscoso, Kevin Batiz, Kevin Nieves, Luis Colon, Pablo Méndez, Wilfredo Ortiz, Marcel Castro-Sitiriche, “Análisis Geográfico del Apagón de María en el 2018”, Native Power Group, 2021

Key Insights: Energy Justice

1. Access to Rooftop PV Systems with batteries can save lives.

2. Use of reconstruction funds to build Rooftop PV Systems can reduce energy cost.

Veguita Zamas, Jayuya
Mayo, 2018
Foto: marcel

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UPRM Power Group: 2018-2022 Peer-reviewed Publications related to Hurricane María

1. **E. O'Neill-Carrillo**, Miguel A. Rivera-Quiñones. "Energy Policies in Puerto Rico and their Impact on the Likelihood of a Resilient and Sustainable Electric Power Infrastructure," *CENTRO*, Journal of the Center for Puerto Rican Studies, Hunter College, no. 3, vol. 30, 2018
2. **A. Irizarry-Rivera**, K. Montano-Martinez, S. I. Alzate-Drada and **F. Andrade,** "A case study of residential electric service resiliency through renewable energy following Hurricane Maria," *Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPOWER 2018)*, Dubrovnik, Croatia, 2018, pp. 1-6.
3. R. Darbali-Zamora, J. E. Quiroz, J. Hernández-Alvidrez, J. Johnson and **E. I. Ortiz-Rivera**, "Viability Assessment of a Real-Time Simulation Model for a Residential DC Microgrid Network to Compensate Electricity Disturbances in Puerto Rico," *2018 IEEE ANDESCON*, Santiago de Cali, Colombia, 2018, pp. 1-6.
4. G. Lopez-Cardalda, M. Lugo-Alvarez, S. Mendez-Santacruz, **E. O. Rivera and E. A. Bezares**, "Learnings of the Complete Power Grid Destruction in Puerto Rico by Hurricane Maria," *2018 IEEE International Symposium on Technologies for Homeland Security (HST)*, Woburn, MA, 2018, pp. 1-6.
5. **Castro-Sitiriche, M**., J. Gomez, Y. Cintrón, "The Longest Power Blackout in History and Energy Poverty", *International Conference on Appropriate Technology 2018*, Porto-Novo, Benin, November 2018.
6. E. O'Neill-Carrillo, I. Jordán, A. Irizarry-Rivera, R. A. Cintrón. "The Long Road to Community Microgrids," *IEEE Electrification Magazine*, vol. 6, no. 4, December 2018, pp. 6 – 17.
7. A. Kwasinski, **F. Andrade, M. J. Castro-Sitiriche and E. O'Neill-Carrillo**, "Hurricane Maria Effects on Puerto Rico Electric Power Infrastructure," in *IEEE Power and Energy Technology Systems Journal*, vol. 6, no. 1, pp. 85-94, March 2019.
8. **E. O'Neill-Carrillo,** J. McCalley, A. Kimber, R. Haug. "Stakeholder Perspectives on Increasing Electric Power Infrastructure Integrity." *ASEE Annual Conference*, June 2019, Tampa.
9. C. J. Newlun, A. L. Figueroa-Acevedo, J. D. McCalley, A. Kimber and **E. O'Neill - Carrillo**, "Co-Optimized Expansion Planning to Enhance Electrical System Resilience in Puerto Rico," *2019 North American Power Symposium (NAPS)*, Wichita, KS, USA, 2019, pp. 1-6.
10. **E. O'Neill-Carrillo**, E. Mercado, O. Luhring, I. Jordan and **A. Irizarry-Rivera**, "Community Energy Projects in the Caribbean: Advancing Socio-Economic Development and Energy Transitions," *IEEE Technology and Society Magazine*, vol. 38, no. 3, pp. 44-55, Sept. 2019.
11. Chen, S.E., Tang, W., **Irizarry, A.A.**, Baez-Rivera, Y., Pando, M.A., Majrekar, M., Young, D. and Ng, Y., "Posthurricane Investigation of a Critical Component toward Improved Grid Resiliency in Puerto Rico." *Journal of Performance of Constructed Facilities* 34.4 (2020): 02520001.
12. E. Parés-Atiles, **E. O'Neill-Carrillo and F. Andrade**, "Best Practices for Microgrids Applied to a Case Study in a Community," *2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*, Washington, DC, USA, 2020, pp. 1-5.
13. M. Lugo-Alvarez, R. Broderick and **E. I. Ortiz-Rivera**, "Strategic Placement and Design of Microgrids using Nighttime Imagery," *2020 47th IEEE Photovoltaic Specialists Conference (PVSC)*, Calgary, AB, Canada, 2020, pp. 1730-1734.
14. C. J. Newlun, F. M. Currie, **E. O'Neill-Carrillo, E. A. Bezares** and R. H. Byrne, "Energy Resource Planning for Puerto Rico's Future Electrical System," *2020 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)*, Chicago, IL, USA, 2020, pp. 1-5.
15. G. Lopez-Cardalda, **E. Ortiz-Rivera** and M. Lugaro-Alvarez, "Evaluation and Load Selection using Energy Storage System Priority Index (ESSPI)," *2020 IEEE International Symposium on Technology and Society (ISTAS)*, Tempe, AZ, USA, 2020, pp. 225-229.
16. F. Saker, G. Lopez, J. Pacheco, **E. Ortiz-Rivera and E. Aponte**, "Design of a Microgrid for Rural Community in Puerto Rico," *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, Fort Lauderdale, FL, USA, 2021, pp. 1758-1761.
17. G. Lopez-Cardalda and **E. I. Ortiz-Rivera**, "Proposed Methodology Using the Energy Storage System Prioritization Index," *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, Fort Lauderdale, FL, USA, 2021, pp. 2529-2533.
18. Chen, S. E., Pando, M. A., **Irizarry, A. A.**, Baez-Rivera, Y., Tang, W., & Ng, Y., "Resiliency of Power Grid Infrastructure Under Extreme Hazards-Observations and Lessons Learned from Hurricane Maria in Puerto Rico." *Advanced Geotechnical and Structural Engineering in the Design and Performance of Sustainable Civil Infrastructures: Proceedings of the 6th GeoChina International Conference on Civil & Transportation Infrastructures: From Engineering to Smart & Green Life Cycle Solutions--Nanchang, China, 2021 6*. Springer International Publishing, 2021.
19. M. Vázquez Nieves, J. A. Moscoso Cabrera, F. Lozano-I, **E. I. Ortiz-Rivera**, R. Darbali-Zamora and C. Birk Jones, "Analysis of PV Microgrids with Storage to Improve the Resiliency of the Island of Culebra, Puerto Rico," *2022 Resilience Week (RWS)*, National Harbor, MD, USA, 2022, pp. 1-8.
20. M. F. Sandoval, J. Hernández, S. Grijalva, R. J. Broderick, **E. O'Neill-Carrillo.** *Optimal Portfolio Design of Distributed Energy Resources on Puerto Rico Distribution Feeders with Long Outages after Hurricane Maria*. SAND2022-11264. Sandia National Laboratories, Albuquerque, NM, August 2022.
21. Echevarria, Angel, Rivera-Matos, Yiamar, Irshad, Nafeesa, Gregory, Christopher, **Castro-Sitiriche, Marce**l, King, Richard R., and Miller, Clark A. "Unleashing Sociotechnical Imaginaries to Advance Just and Sustainable Energy Transitions: The Case of Solar Energy in Puerto Rico," in IEEE Transactions on Technology and Society, 2022, doi: 10.1109/TTS.2022.3191542.

…new national "culture of disaster resilience" that includes components of:

"Building local, community capacity because decisions and the ultimate resilience of a community are driven from the bottom up"

National Research Council. 2012. *Disaster Resilience: A National Imperative*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13457

Veguita Zamas, Jayuya

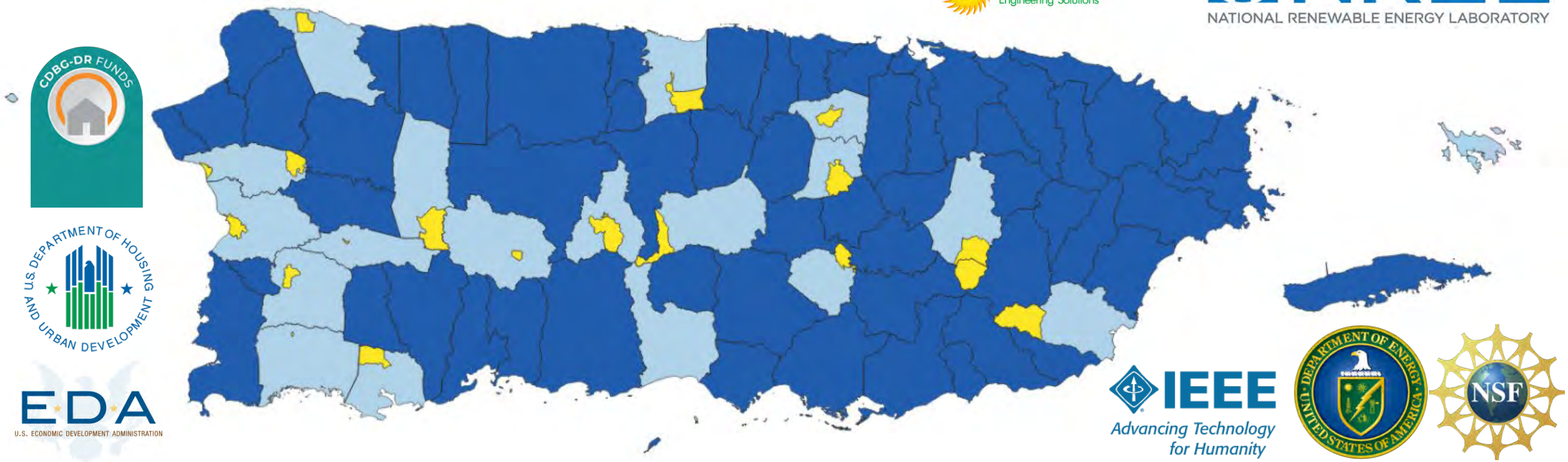
Veguita Zamas, Jayuya
Foto: Willian Pacheco, 2022

Villa Esperanza, Toa Alta

Villa Esperanza, Toa Alta
Mayo, 2016
Foto: marcel

UPRM Power Community Engagement:

Communities in 19 Municipalities



UPRM Team: Luisa Seijo from Social Sciences, Ricardo Fuentes from Economics, Lizzette González from Agricultural Science, Reinaldo Rosado from Social Sciences, Ingrid Rodríguez from Social Sciences, Francisco Maldonado from Civil Engineering, Marcel Castro-Sitiriche, Agustín Irizarry, Fabio Andrade, Gerson Beauchamp from Electrical and Computer Engineering, Arturo Massol from Biology, Christopher Papadopoulos from Engineering Sciences, William Frey from Business Administration, 2019-2024.

Jayuya
Febrero, 2018
Foto: marcel

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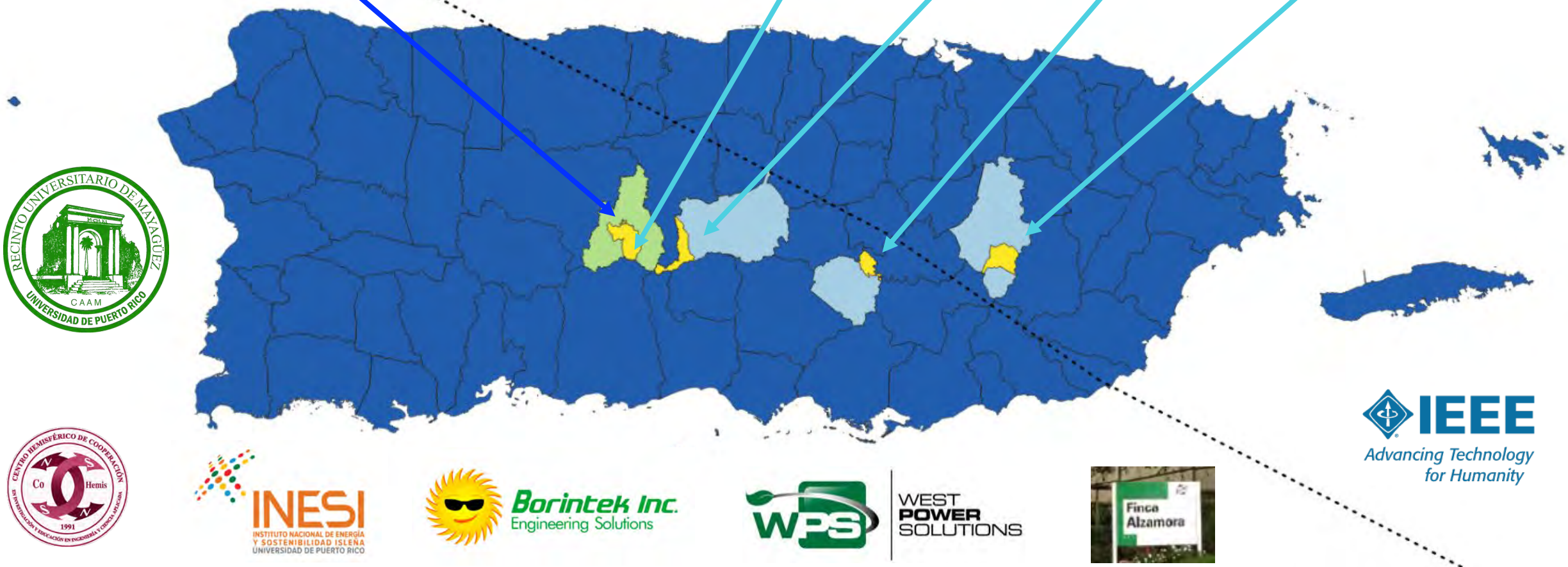
Oasis de Luz para La Montaña

November 2017: Jayuya Pueblo

2018:

Jayuya, Orocovis, Aibonito, Caguas



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Engineering Solutions

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IEEE
Advancing Technology for Humanity

Agustín Irizarry, Sergio Alzate
Sector Amoldadero, Barrio La Plata, Aibonito
Marzo, 2018

Efraín O'Neill y estudiantes de UPRM
Barrio Borinquen, Caguas
Marzo, 2018

Veguita Zamas, Jayuya
Mayo, 2018
Foto: marcel

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Oasis de Luz:
Bottom-up Microgrids for Puerto Rico

UPRM Power Community Engagement:

Community Microgrid Projects

UPRM Team: Marcel Castro-Sitiriche, Agustín Irizarry, Fabio Andrade, Gerson Beauchamp from Electrical and Computer Engineering, Arturo Massol from Biology, Solar Business Accelerator Project, EDA Funds, 2019-2023 and Resilient Operation of Networked Community Microgrids with High Solar Penetration Project, DOE Funds, 2021-2024.


Castañer, Lares
Noviembre, 2020
Foto: marcel

Castañer Microgrid: 2021
Pilot Project Analysis

Image: Google Earth

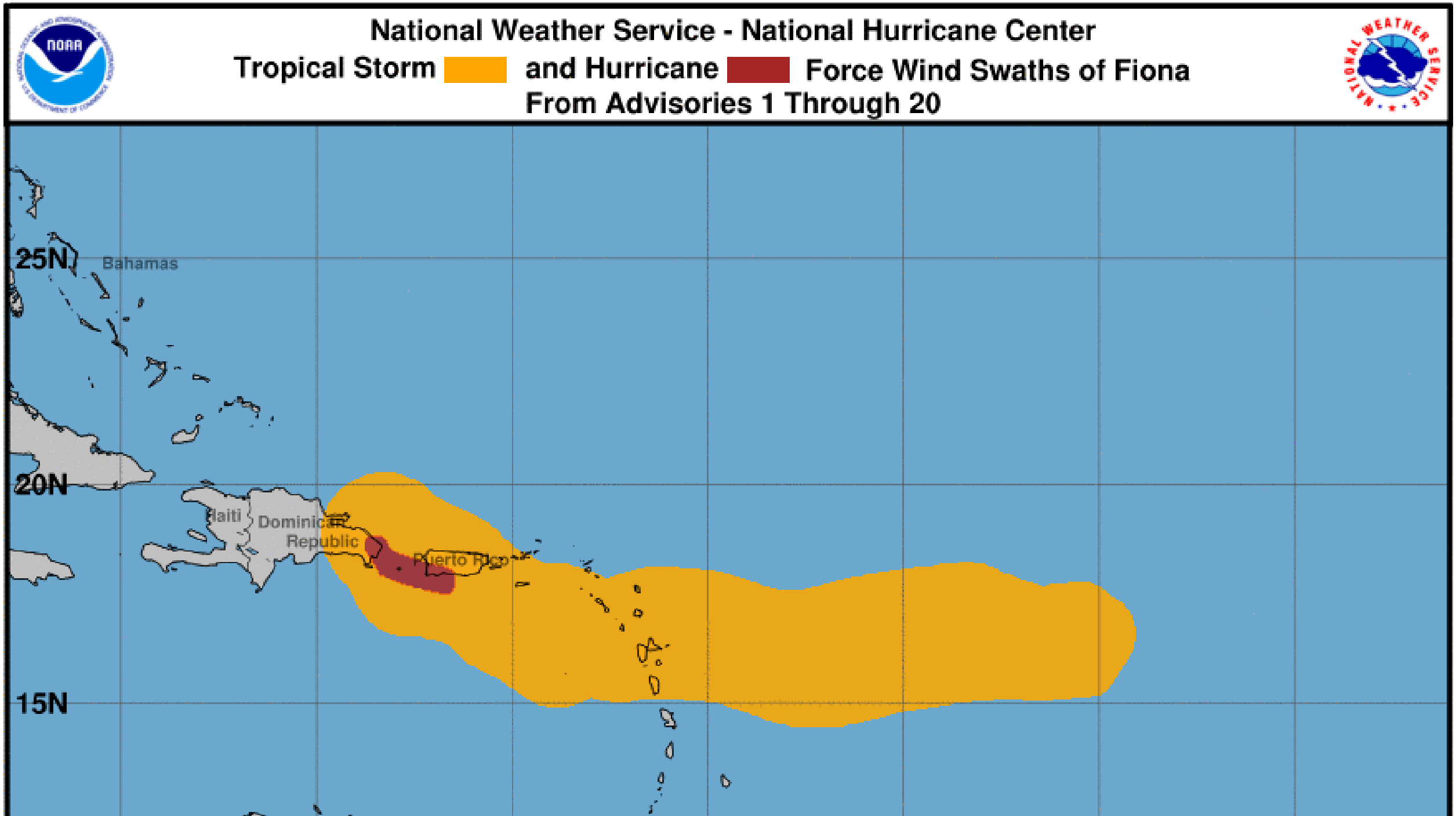

Castañer, Lares
Noviembre, 2020
Foto: marcel

Adjuntas - Microgrid

Adjuntas, Puerto Rico
Foto: Fabio Andrade, director, Microgrid Laboratory at UPRM

Maricao Microgrid: In Progress

Maricao, Puerto Rico
Foto: Andrés Peña, Microgrid Laboratory at UPRM


National Weather Service - National Hurricane Center
Tropical Storm and Hurricane Force Wind Swaths of Fiona
From Advisories 1 Through 20
25N
20N
15N
Bahamas
Haiti
Dominican Republic
Puerto Rico


public

VIGILANCIA

DE FATALIDADES ASOCIADAS AL HURACÁN FIONA

44 deaths:

Category 1 Hurricane Impact in Southwest.

Conteo de casos	Sexo	Edad (años)	Región de Salud	Fecha de la muerte (mm/dd/aaaa)	Clasificación	Tipo de muerte relacionada con el desastre	Causas de muerte
43	F	93	PONCE	11/22/2022	BAJO INVESTIGACION	BAJO INVESTIGACION	HYPERCAPNIC RESPIRATORY FAILURE, CARDIO RESPIRATORY ARREST, CHRONIC OBSTRUCTIVE PULMONARY DISEASE, HYPERTENSION, DIABETES MELLITUS, ASTHMA, ATRIAL FIBRILLATION
44	M	88	PONCE	12/07/2022	BAJO INVESTIGACION	BAJO INVESTIGACION	ACUTE RESPIRATORY FAILURE, UREMIC SYNDROME, ACUTE RENAL FAILURE

Nota: Esta información es preliminar; fue obtenida de los documentos compartidos por los Epidemiólogos Regionales y/o el Registro Demográfico y/o el Instituto de Ciencias Forenses. Causas de muerte según reportadas. En total se han registrado 44 casos fatales, los cuales se desglosan de la siguiente forma:

- Confirmados = 23 (2 muertes directas y 21 muertes indirectas con el desastre)
- Bajo investigación = 21.

https://www.salud.gov.pr/CMS/494

Valores de procesamiento de BESS instalados y capacidad de BESS reportados a NEPR por LUMA Energy

Periodo Junio de 2021 a Diciembre de 2022

Región

Arecibo | Bayamon | Caguas | Carolina | Mayaguez | Ponce | San Juan

Grafica por

Consumo | Clientes | Consumo/Clientes

Consumo % | Clientes % | Consumo/Clientes %

Distritos Técnicos

Todas

Municipios

Todas

Filtro Fechas

6/1/2021 — 12/1/2022

Tipo Cliente

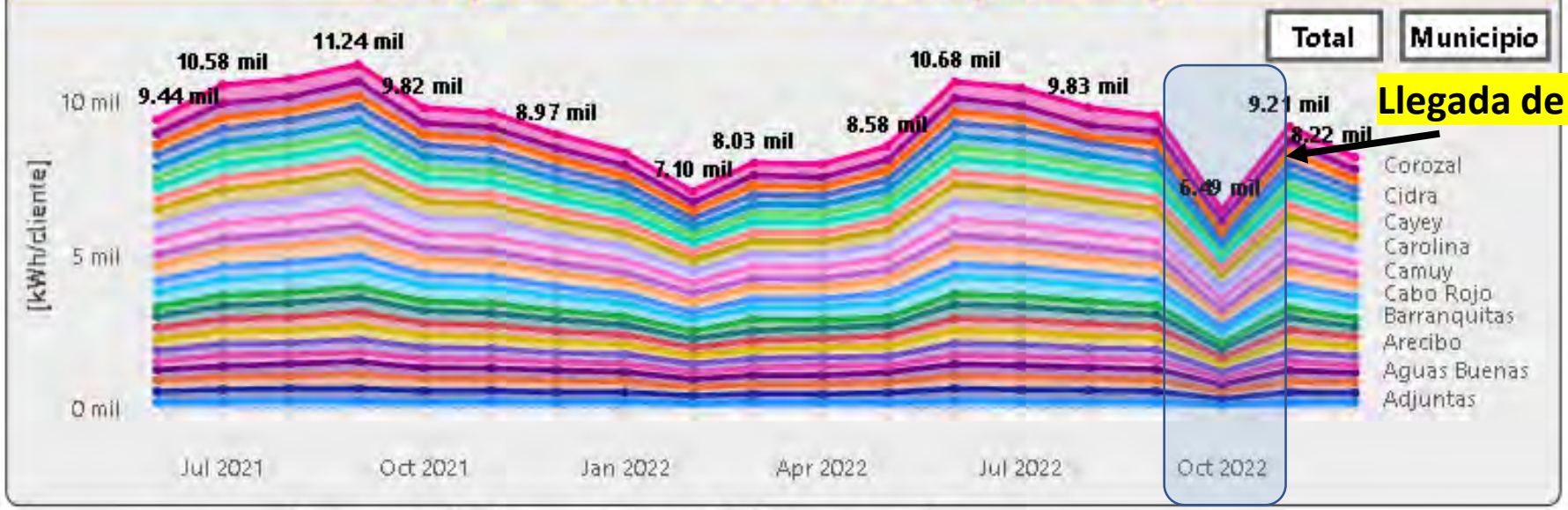
AGRÍCOLA | ALUMBRADO PÚBLICO | COMERCIAL | INDUSTRIAL | OTRAS AUTORIDADES | RESIDENCIAL | TOTAL

Grafica por

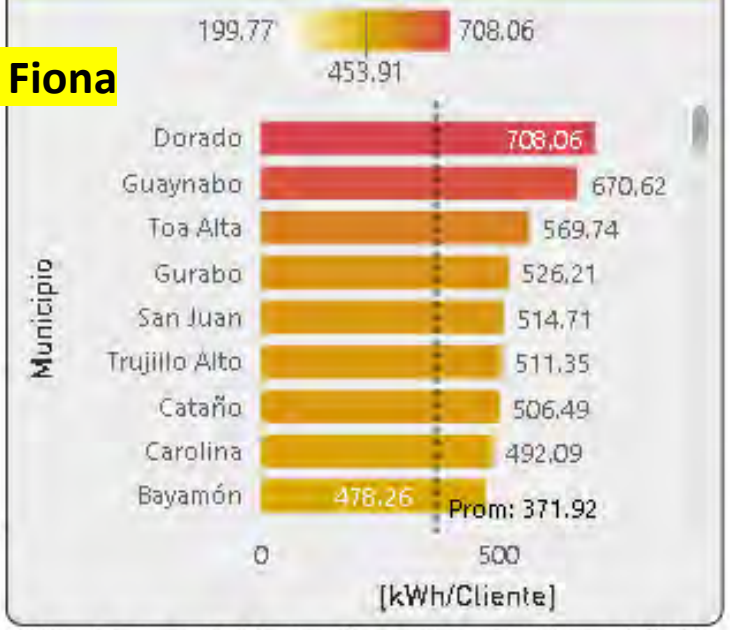
Mapa | Lineas

Fecha Inicial	Fecha Final
2021-06	2022-12

Valor promedio de consumo/cliente por municipio

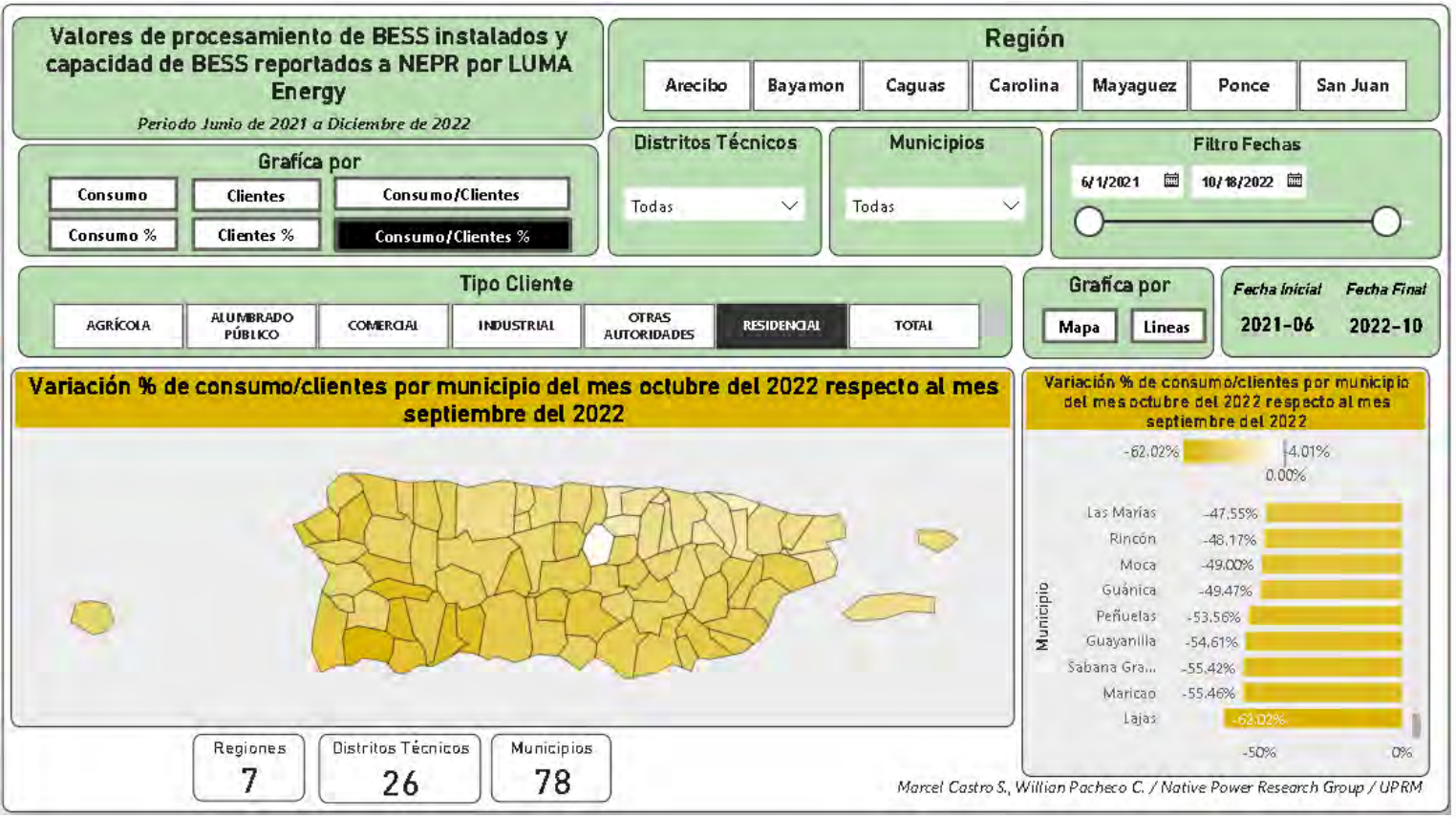


Promedio de consumo/cliente para cada municipio



Regiones	Distritos Técnicos	Municipios
7	26	78

Marcel Castro S., Willian Pacheco C. / Native Power Research Group / UPRM



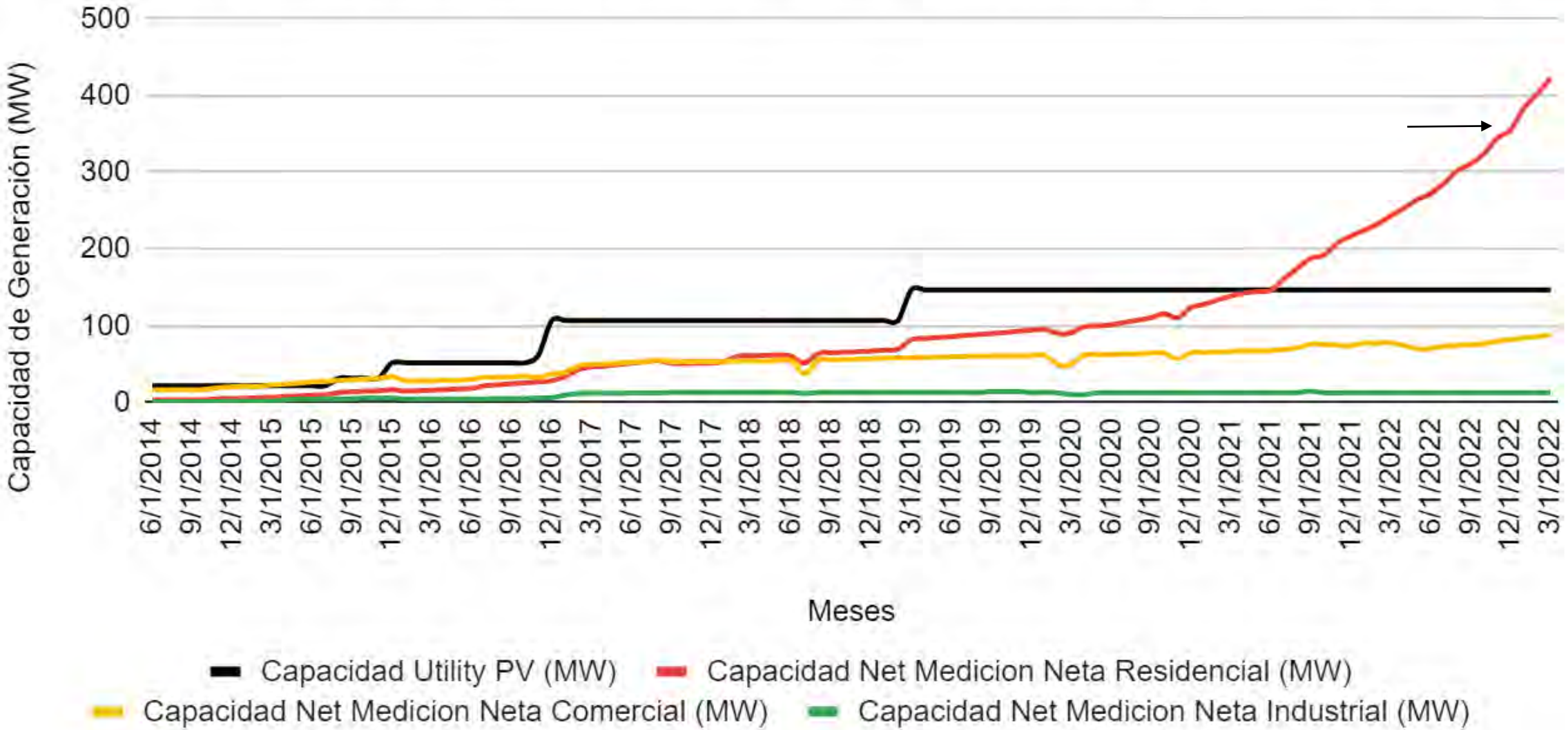
Numero	Municipio	Variacion % consumo/clientes
1	Corozal	-4.01%
2	Loíza	-15.07%
3	Dorado	-16.51%
4	Cataño	-17.15%
5	Toa Alta	-19.30%
6	Trujillo Alto	-21.06%
7	Carolina	-21.57%
8	Ceiba	-21.83%
9	Canóvanas	-23.25%
10	Toa Baja	-25.36%
11	Vieques	-26.91%
12	San Juan	-27.19%
13	Guaynabo	-27.26%
14	Bayamón	-27.44%
15	Río Grande	-27.52%
16	Fajardo	-27.77%
17	Luquillo	-29.12%
18	Culebra	-29.34%
19	Arecibo	-29.76%
20	Barceloneta	-30.12%
21	Caguas	-31.06%
22	Manatí	-31.11%
23	Florida	-31.36%
24	Gurabo	-31.69%
25	Vega Baja	-32.49%
26	Mayagüez	-34.06%
27	Aguas Buenas	-34.09%
28	San Germán	-34.26%
29	Ciales	-34.45%
30	Vega Alta	-35.02%
31	Aibonito	-35.15%
32	Hormigueros	-35.70%
33	Quebradillas	-36.01%
34	Naranjito	-36.12%
35	Utuado	-36.32%

Numero	Municipio	Variacion % consumo/clientes
36	Cayey	-36.76%
37	San Sebastián	-37.14%
38	Humacao	-37.23%
39	Barranquitas	-37.56%
40	Aguadilla	-38.19%
41	Añasco	-38.49%
42	Santa Isabel	-38.60%
43	Lares	-38.74%
44	Hatillo	-38.97%
45	Guayama	-39.20%
46	Adjuntas	-39.90%
47	Cidra	-39.94%
48	Comerío	-40.15%
49	Juncos	-40.32%
50	Las Piedras	-40.39%
51	San Lorenzo	-40.39%
52	Morovis	-40.50%
53	Camuy	-40.86%
54	Arroyo	-41.07%
55	Salinas	-41.16%
56	Juana Díaz	-41.56%
57	Yabucoa	-41.72%
58	Orocovis	-42.00%
59	Aguada	-42.51%
60	Naguabo	-42.68%
61	Maunabo	-42.73%
62	Ponce	-43.05%
63	Isabela	-43.26%
64	Patillas	-43.99%
65	Jayuya	-45.03%
66	Yauco	-45.42%
67	Cabo Rojo	-45.90%
68	Villalba	-45.97%
69	Coamo	-46.42%
70	Las Marías	-47.55%
71	Rincón	-48.17%
72	Moca	-49.00%
73	Guánica	-49.47%
74	Peñuelas	-53.56%
75	Guayanilla	-54.61%
76	Sabana Grande	-55.42%
77	Maricao	-55.46%
78	Lajas	-62.02%

La variación de consumo por cliente entre los meses de octubre a septiembre de 2022 se encuentra entre el -15% y -62% para el 99% de los municipios.

Willian Pacheco-Cano, Marcel Castro-Sitiriche, NEPR Data Analysis, Native Power Research Group. Source: Negociado de Energía de Puerto Rico (NEPR)
https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/

Capacidad Instalada: Generación Solar Fotovoltaica Boricua (MW)



Marcel Castro-Sitiriche, NEPR Data Analysis, Native Power Research Group 2023. Source: Negociado de Energía de Puerto Rico (NEPR) https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/

CAN DISTRIBUTED SOLAR ADVANCE A JUST AND SUSTAINABLE ENERGY TRANSITION FOR COMMUNITIES IN PUERTO RICO?

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marcel.castro@upr.edu **@marceljcastro**

http://cohemis.uprm.edu/solar2020/

Veguita Zamas, Jayuya