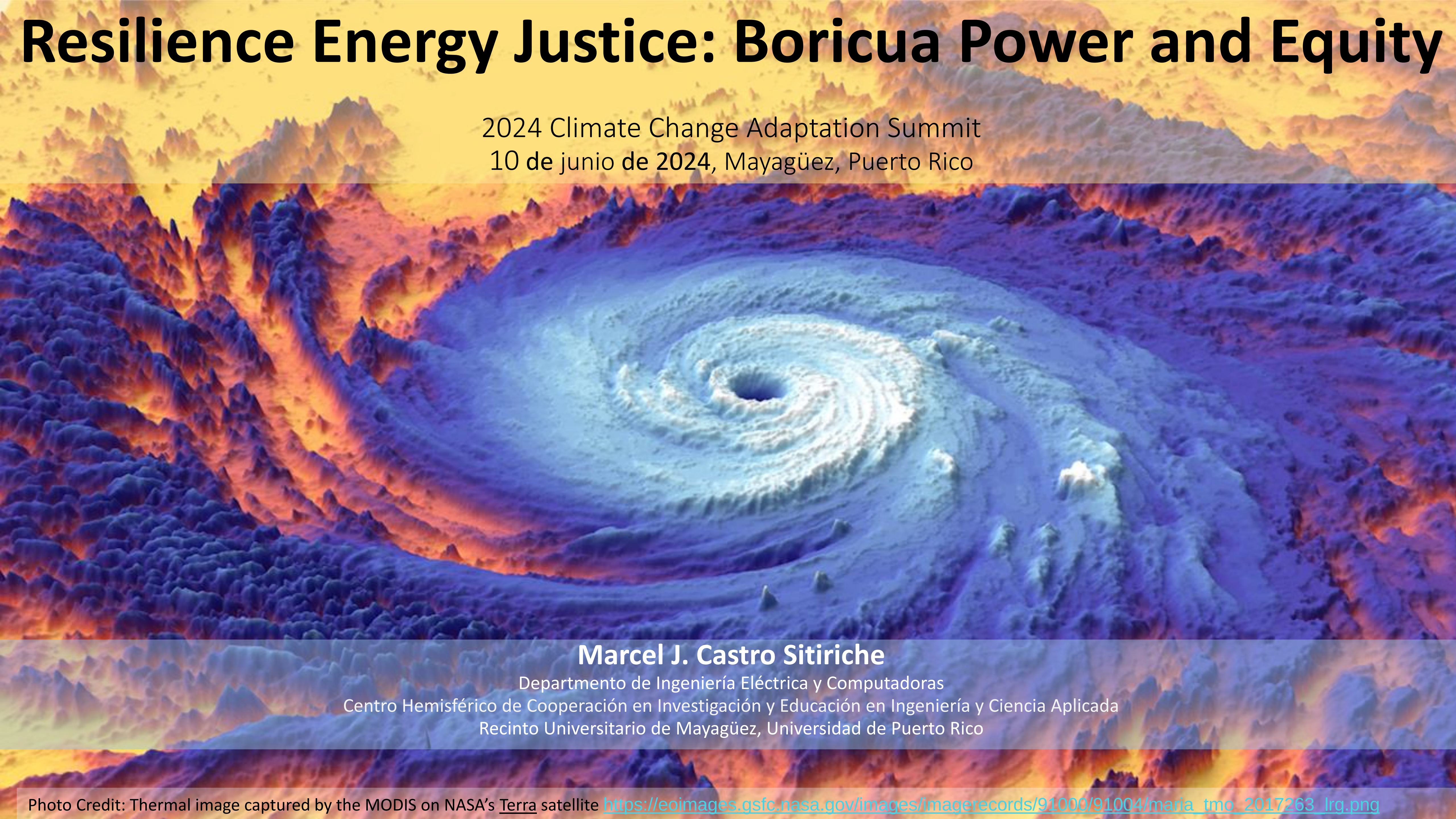
Resilience Energy Justice: Boricua Power and Equity

2024 Climate Change Adaptation Summit

10 de junio de 2024, Mayagüez, Puerto Rico



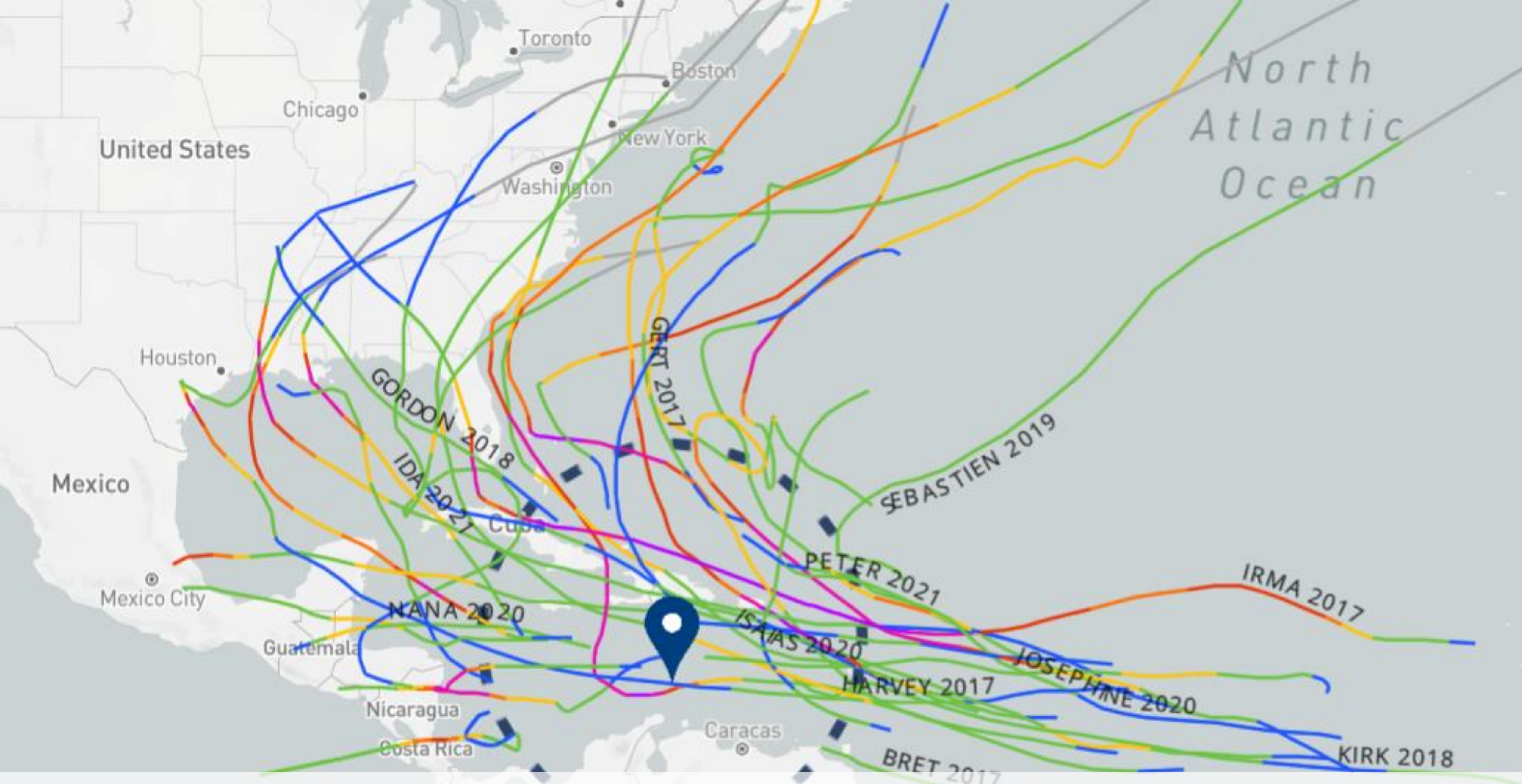
Marcel J. Castro Sitiriche

Departmento de Ingeniería Eléctrica y Computadoras

Centro Hemisférico de Cooperación en Investigación y Educación en Ingeniería y Ciencia Aplicada

Recinto Universitario de Mayagüez, Universidad de Puerto Rico

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



Marcel J. Castro-Sitiriche, Caribbean Region, Resilient Power and Energy Justice: The Case of Puerto Rico, Global Energy Access Innovation Workshop: IEEE Power Africa Conference, August 22, 2022, Kigali, Rwanda

CLEAN ENERGY

CLEAN ENERGY

Energy clean from carbon emissions, but also

Clean from Corruption

Clean from Colonialism

Clean from Oppression

Clean from Imperialism

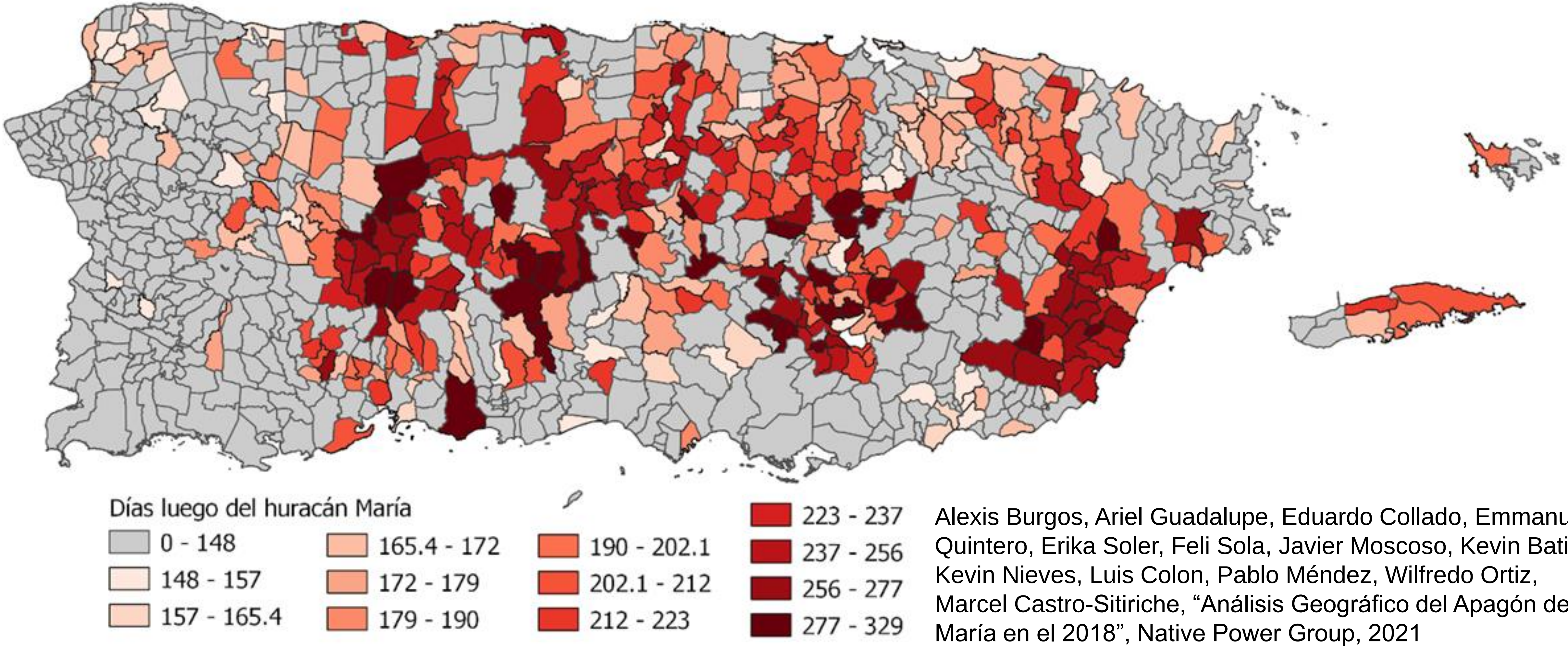

Rincón, Borikén
9/junio/2024
Foto: marcel

Veguita Zamas, Jayuya
Mayo, 2018
Foto: marcel

Justicia Energética Boricua

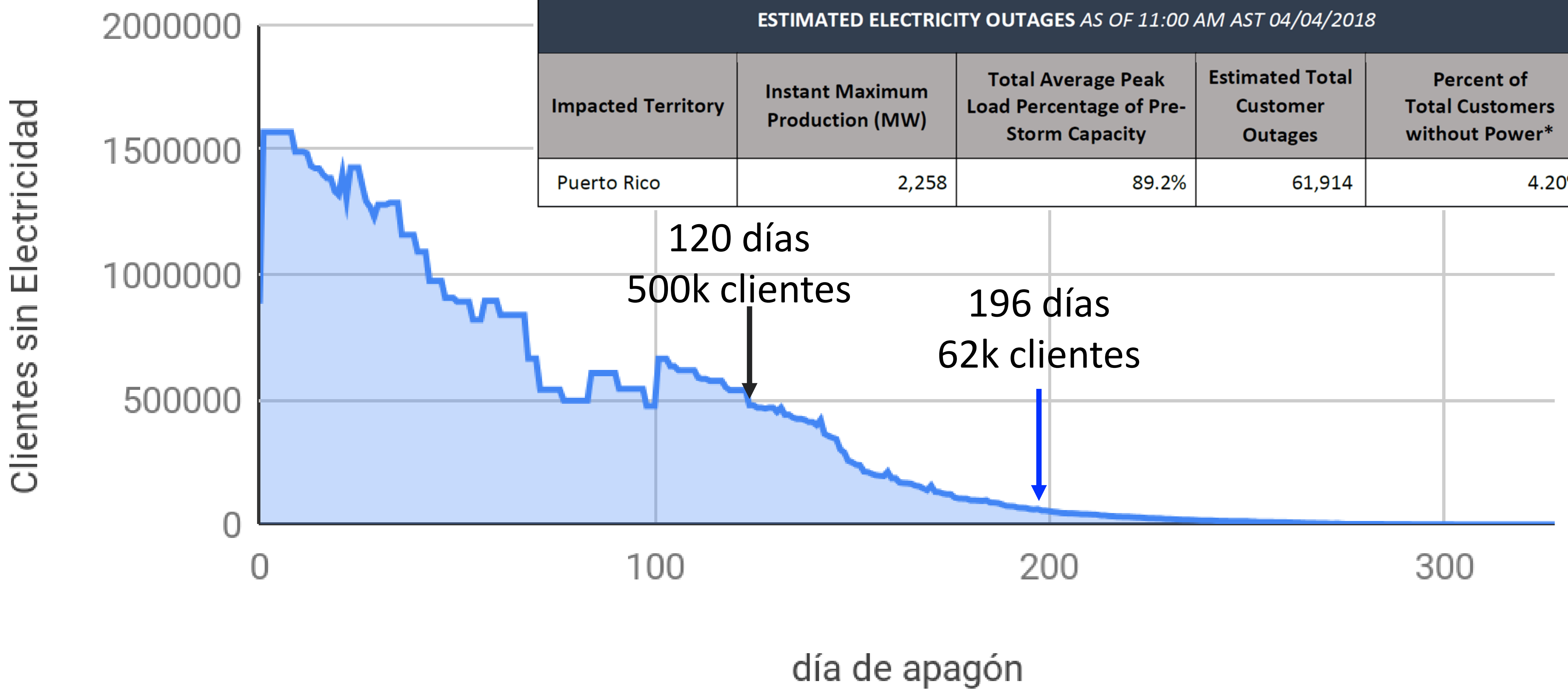
http://cohemisferico.uprm.edu/pr100/memos.html

Comunidades con hogares que se re-conectaron 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

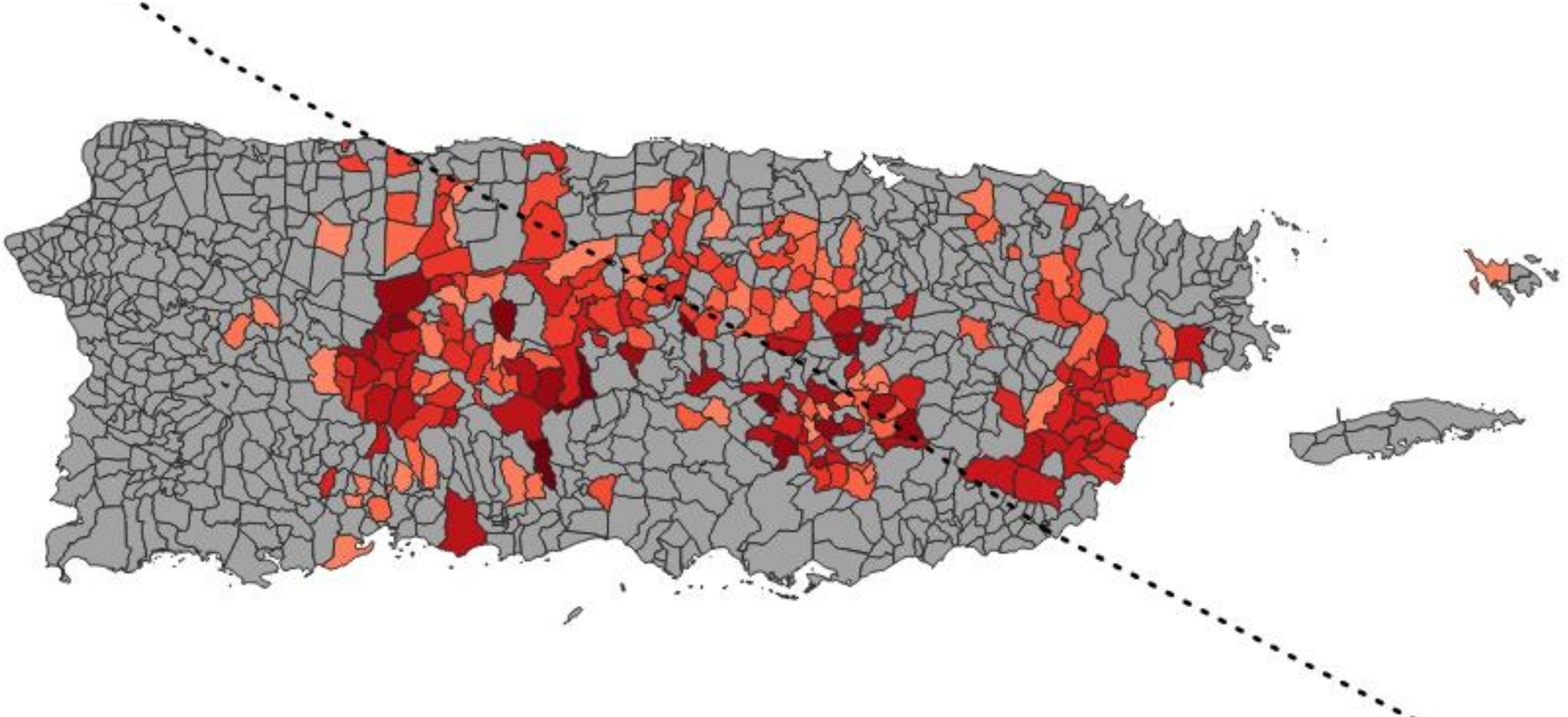
Clientes sin Electricidad: septiembre 2017 - agosto 2018



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%

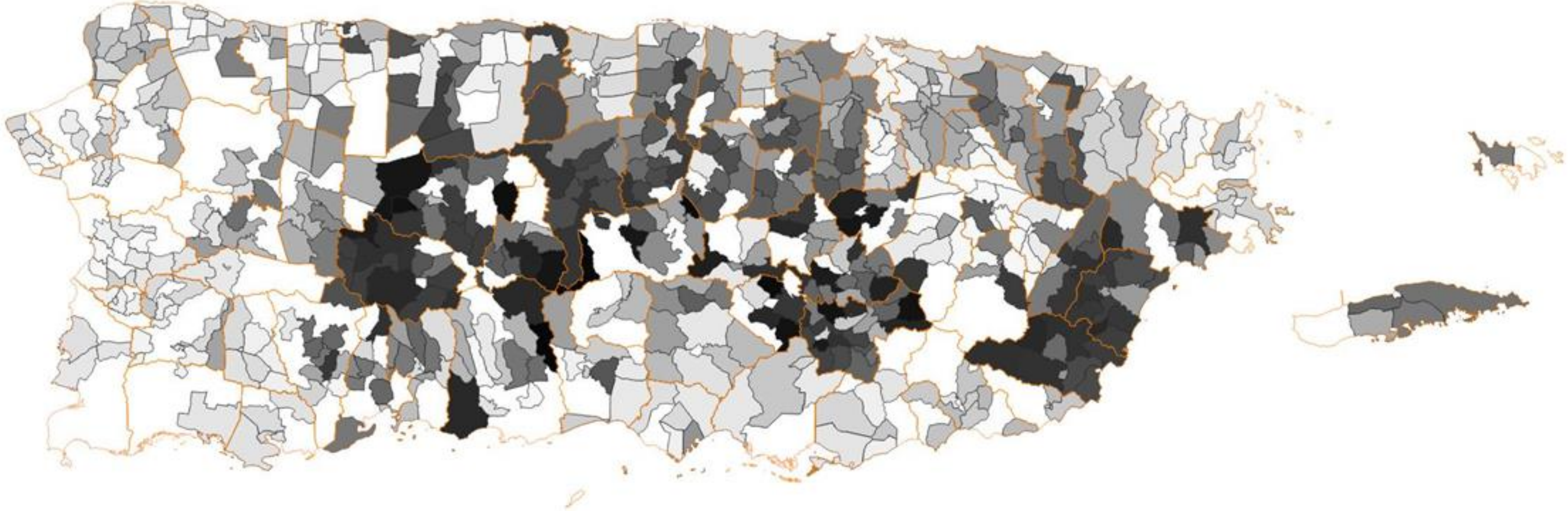
M. Castro-Sitiriche, "Boricua Energy Justice", **Infrastructure as Destiny: Resilience, Innovation and Equity**, AEG Thought Summit 2022, February 23, 2022.
Source: https://www.energy.gov/ceser/downloads/hurricanes-nate-maria-irma-and-harvey-situation-reports

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

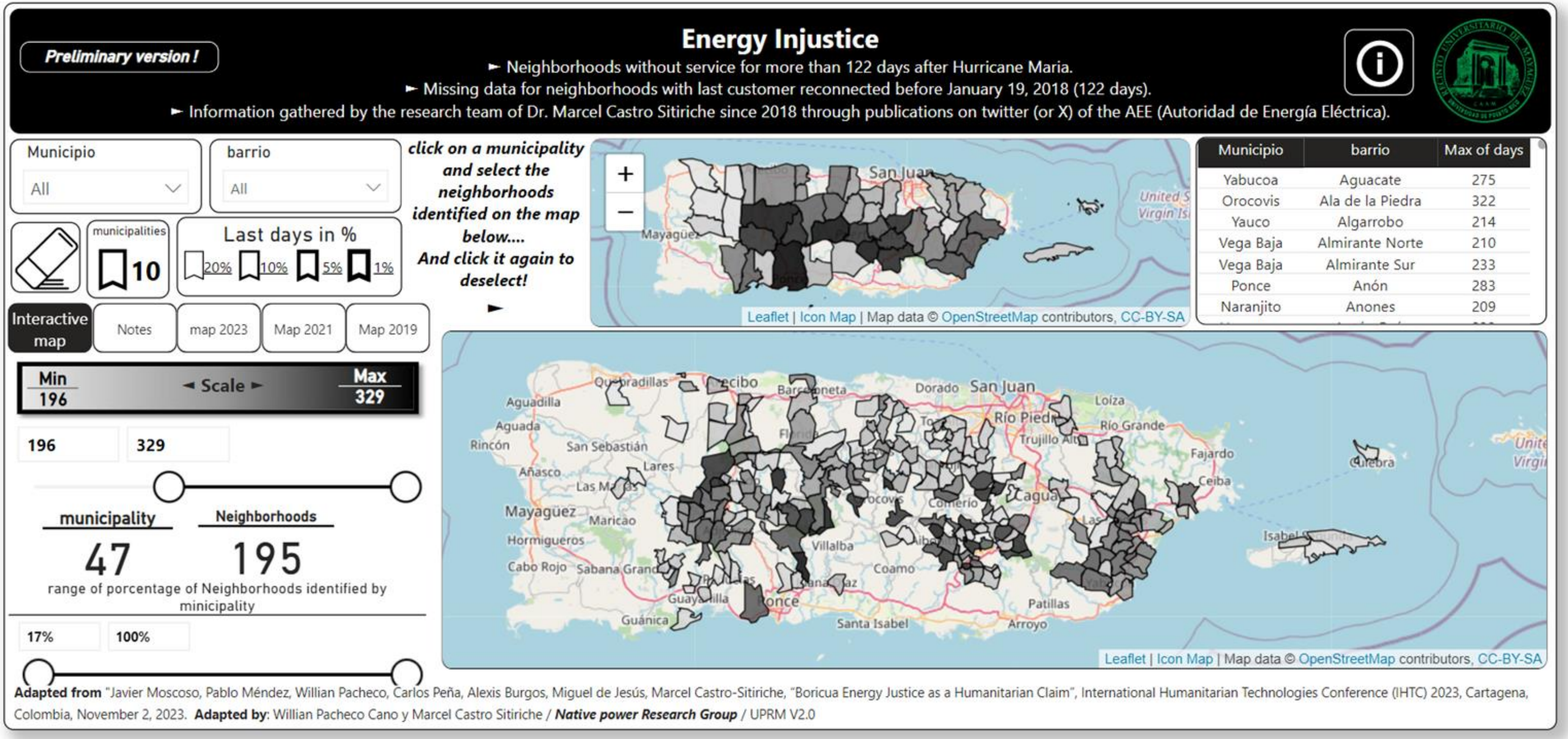


Adapted from: Alexis Burgos, Ariel Guadalupe, Eduardo Collado, Emmanuel Quintero, Erika Soler, Feli Sola, Javier Moscoso, Kevin Batiz, Kevin Nieves, Luis Colon, Pablo Méndez, Wilfredo Ortiz, Marcel Castro-Sitiriche, “Análisis Geográfico del Apagón de María en el 2018”, Native Power Group, 2021

Comunidades con hogares que se re-conectaron a la AEE desde enero hasta agosto 2018



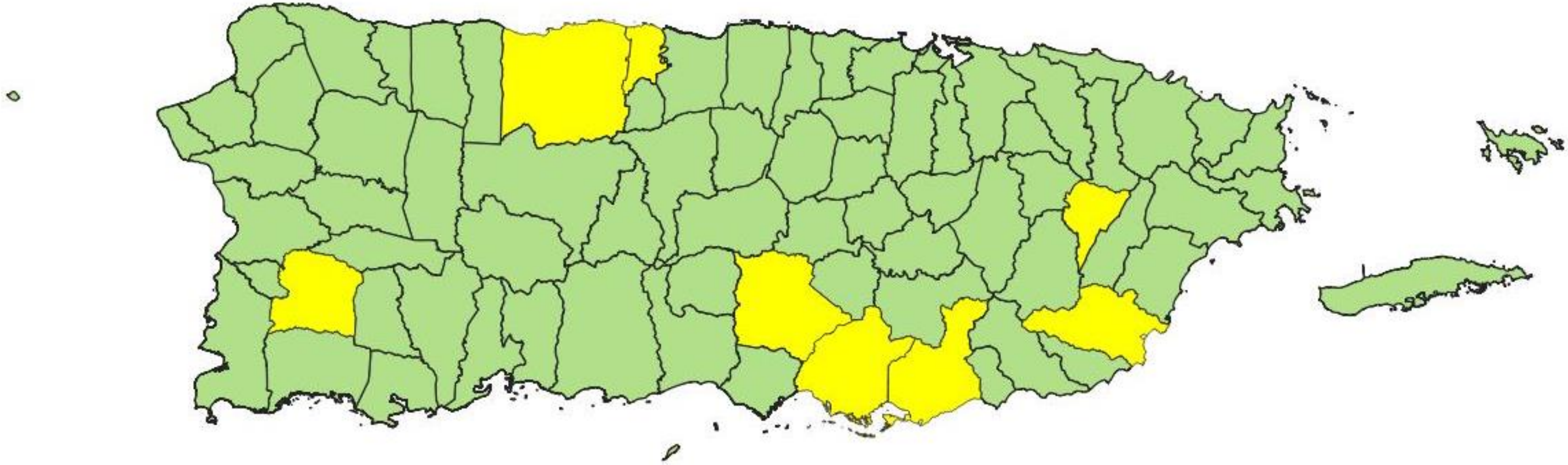
Adapted from: Javier Moscoso, Pablo Méndez, Willian Pacheco, Carlos Peña, Alexis Burgos, Miguel de Jesús, Marcel Castro-Sitiriche, “Boricua Energy Justice as a Humanitarian Claim”, *International Humanitarian Technologies Conference (IHTC) 2023*, Cartagena, Colombia, November 2, 2023.



https://bit.ly/boricuaENERGYinjustice

Fincas Solares

Tranche 1 Solar Farms: 11 sites in 8 municipalities



https://www.energiaestrategica.com/con-un-34-de-incremento-puerto-rico-aprueba-11-ppas-de-energias-renovables/

“Muchos arrancan en los diez centavos o hasta por debajo de los diez centavos, y según van pasando los años, aumentaría hasta 14 centavos y un poco más”, indicó.

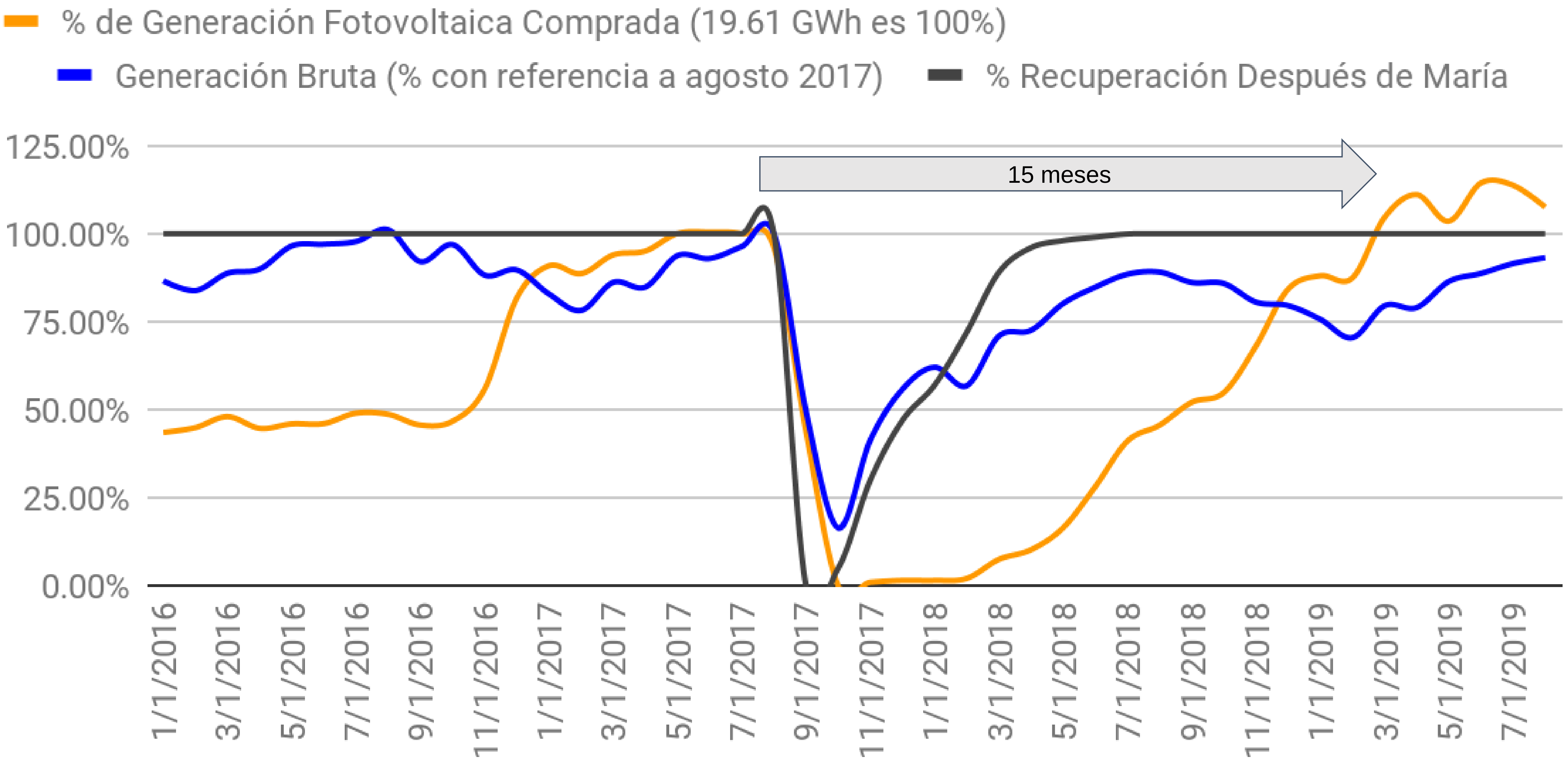
Francisco Berríos
Secretario auxiliar de Energía y presidente de la Junta de Gobierno de AEE
https://www.elvocero.com/exclusivo/exclusivo-defiende-ubicaci-n-de-proyectos-de-energ-a-renovable/article_ee710b46-4073-11ee-b3ff-8b33d4130a7f.html

Government Disinformation: Yesterday

- …el gobernador destacó que la producción de energía en la finca solar es menor de 10 centavos (0.0989) el kilovatio hora, cuando el costo de la energía para el abanado está en la actualidad a 23 centavos el kilovatio hora.
- “Los que piensan que aquí con sistemas solares en los techos ya sería suficiente, se olvidan que hay muchísimas estructuras en Puerto Rico que no están aptas para tener sistemas solares. … Pero, la única manera de tú sustituir las plantas, decomisar plantas, que es una de las funciones que tiene Genera en Puerto Rico, es sustituyéndolas con fincas solares como esta que tenemos aquí. Si no, nunca vamos a decomisar planta alguna”

https://www.primerahora.com/noticias/gobierno-politica/notas/pierluisi-inaugura-la-finca-solar-mas-grande-de-puerto-rico/

Recuperación después del Huracán María



Techos, estacionamientos, techos, microrredes… y más techos

Alternativas Solares

Techos, estacionamientos, techos, microrredes y más techos

techos residenciales: un millón

Veguita Zamas, Jayuya
Mayo, 2018
Foto: marcel

marcel.castro@upr.edu

ARET Study in 2009

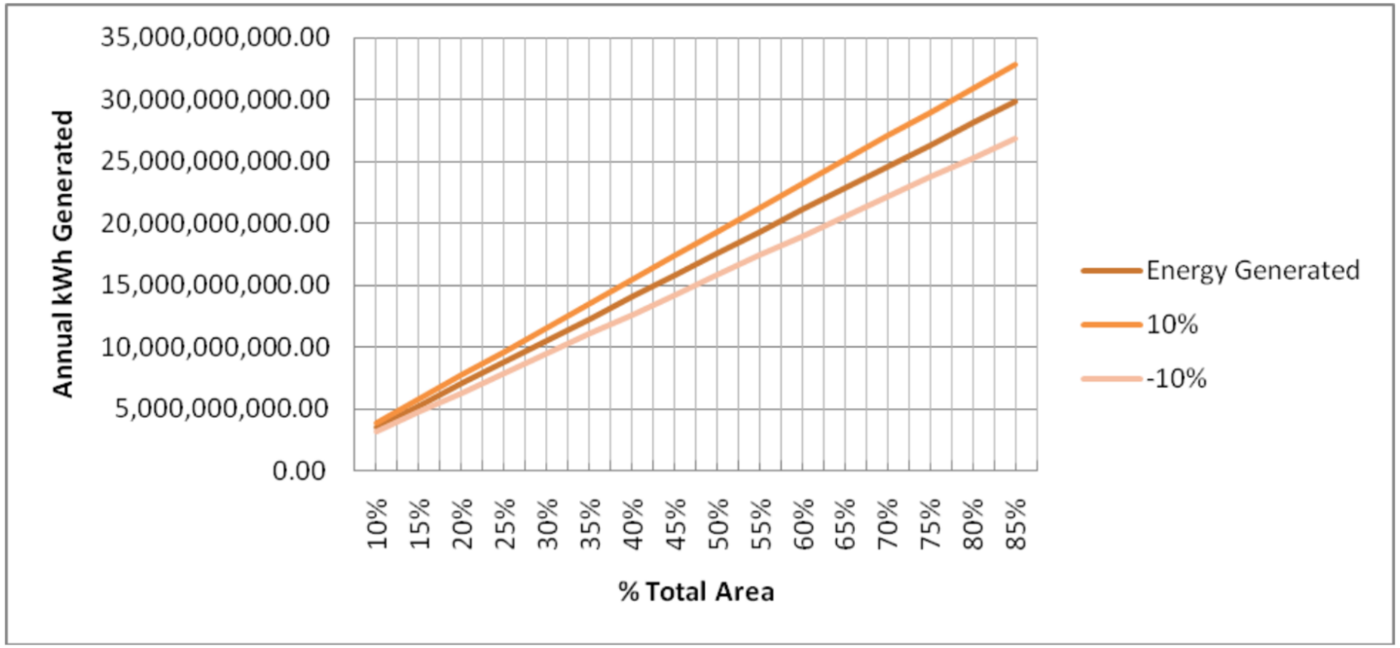


Figure 5.20 Annual Residential Generation Potential

The percentage of total rooftop space needed to displace the electric energy production (25Twh) reported for Puerto Rico on 2005 is 65%.

Irizarry, A., B. Colucci, and E. O'neil. "Achievable Renewable Energy Targets for Puerto Rico's Renewable Energy Portfolio Standard." *Puerto Rico Energy Affairs* (2009). https://www.uprm.edu/aret/

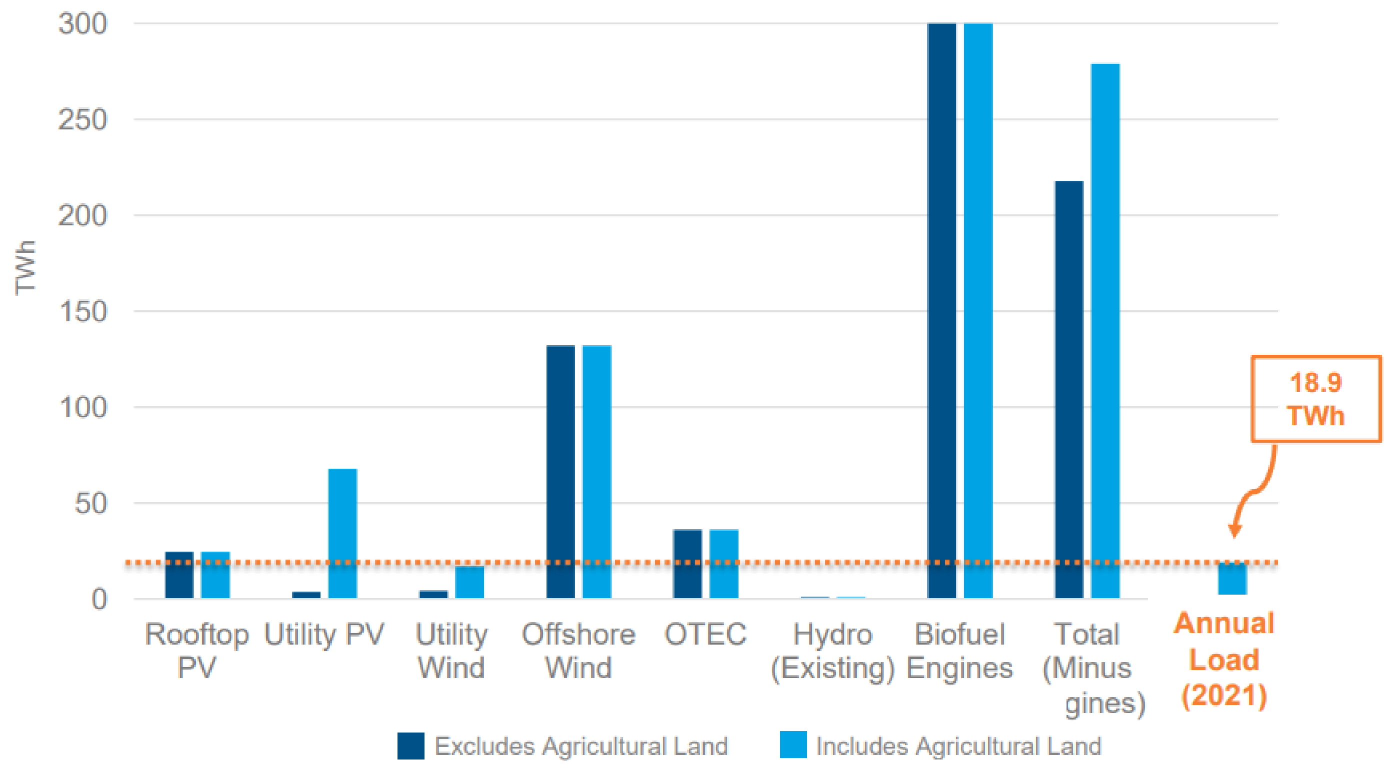
Preliminary Findings From *Renewable Energy Potential and Distributed Energy Resource Adoption*

Answer:

- Resource is more than ten times the demand.

Preliminary Findings:

- The **renewable energy technical resource in Puerto Rico significantly exceeds** the current and projected total annual loads through 2050.
- Adoption of **distributed solar and storage is projected to increase** considerably in all scenarios.



Potential annual generation in TWh of various renewable technologies compared to load (in 2021). *Graphic by NREL.*

https://www.nrel.gov/docs/fy23osti/85126.pdf

Small Solar Rooftop: **200,000 houses** (by 2020)

- Cost per household: $7,000: (Solar PV: 2 kWp, Battery: 10 kWh)
- 200,000 residential clients with houses (20%)
  - Capital Investment Need: $1,400 million
  - Solar PV Capacity: 400 MW
  - Energy Storage Capacity: 2 GWh
  - Annual Energy Production (4 SPH): 584 million of kWh
    - 9% of residential energy consumption (Sept. 2016 – Aug. 2017)
    - 3% of total energy consumption (Sept. 2016 – Aug. 2017)

Source: M. Castro-Sitiriche, J. Gomez, Y. Cintron, “The Longest Power Outage, María and Energy Poverty”, International Conference on Appropriate Technology, November, 2018.

500,000 houses by 2025

- Cost per household: $7,000: (Solar PV: 2 kWp, Battery : 10 kWh)
- 500,000 residential clients with houses (50%)
  - Capital Investment Need: $3,500 million
  - Solar PV Capacity: 1 GW
  - Energy Storage Capacity: 5 GWh
  - Annual Energy Production (4 SPH): 1,460 million of kWh
    - 22% of residential energy consumption (Sept. 2016 – Aug. 2017)
    - 8% of total energy consumption (Sept. 2016 – Aug. 2017)

Source: M. Castro-Sitiriche, J. Gomez, Y. Cintron, “The Longest Power Outage, María and Energy Poverty”, International Conference on Appropriate Technology, November, 2018.

1,000,000 houses by 2035

- Cost per household: $7,000: (Solar PV: 2 kWp, Battery : 10 kWh)
- 1,000,000 residential clients with houses (100%)
  - Capital Investment Need: $7,000 million
  - Solar PV Capacity: 2 GW
  - Energy Storage Capacity: 10 GWh
  - Annual Energy Production (4 SPH): 2,920 million of kWh
    - 45% of residential energy consumption (Sept. 2016 – Aug. 2017)
    - 17% of total energy consumption (Sept. 2016 – Aug. 2017)
    - **One third contribution for the 50% target for 2035**

Source: M. Castro-Sitiriche, J. Gomez, Y. Cintron, "The Longest Power Outage, María and Energy Poverty", International Conference on Appropriate Technology, November, 2018.

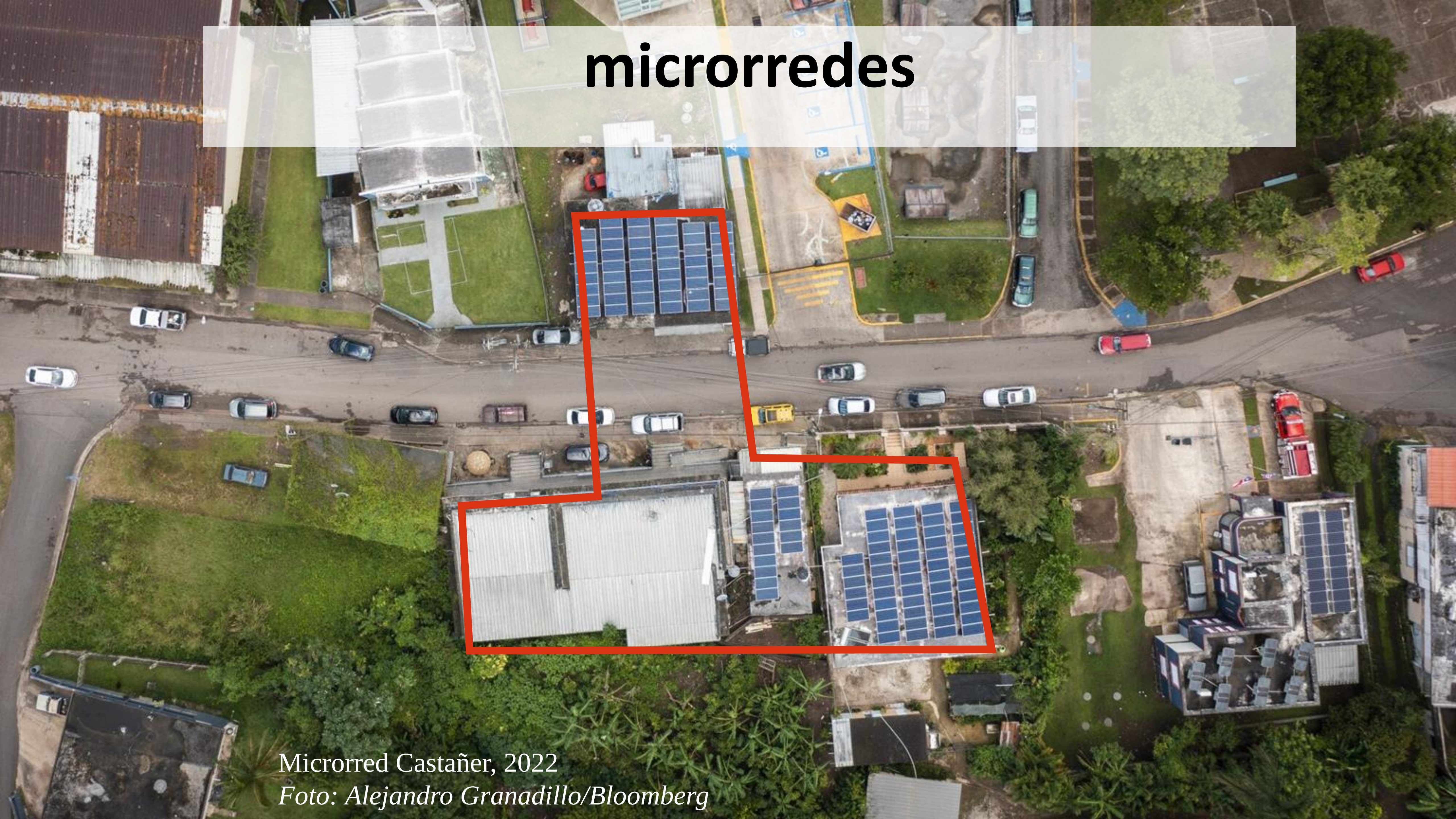
estacionamientos

Foto de - https://azeng.net/portfolio-item/centro-de-convenciones-de-puerto-rico/

techos comeriales

Foto de - https://azeng.net/portfolio-item/centro-de-convenciones-de-puerto-rico/

microrredes



Microrred Castañer, 2022
Foto: Alejandro Granadillo/Bloomberg

más (paneles) en techos residenciales

Puerto Rico Residential PV Solar Rooftop Potential

- Annual residential solar potential is 24.6 TWh (roughly 2x of residential electricity consumption)
- LMI opportunity is 11.9 TWh, nearly half (48%) of total annual residential solar potential
- Average household potential is 19,883 kWh nationally
  - Potential is slightly greater for higher incomes but still considerable for even very low income group (17,924 kWh/household)

National residential PV rooftop technical potential by income group

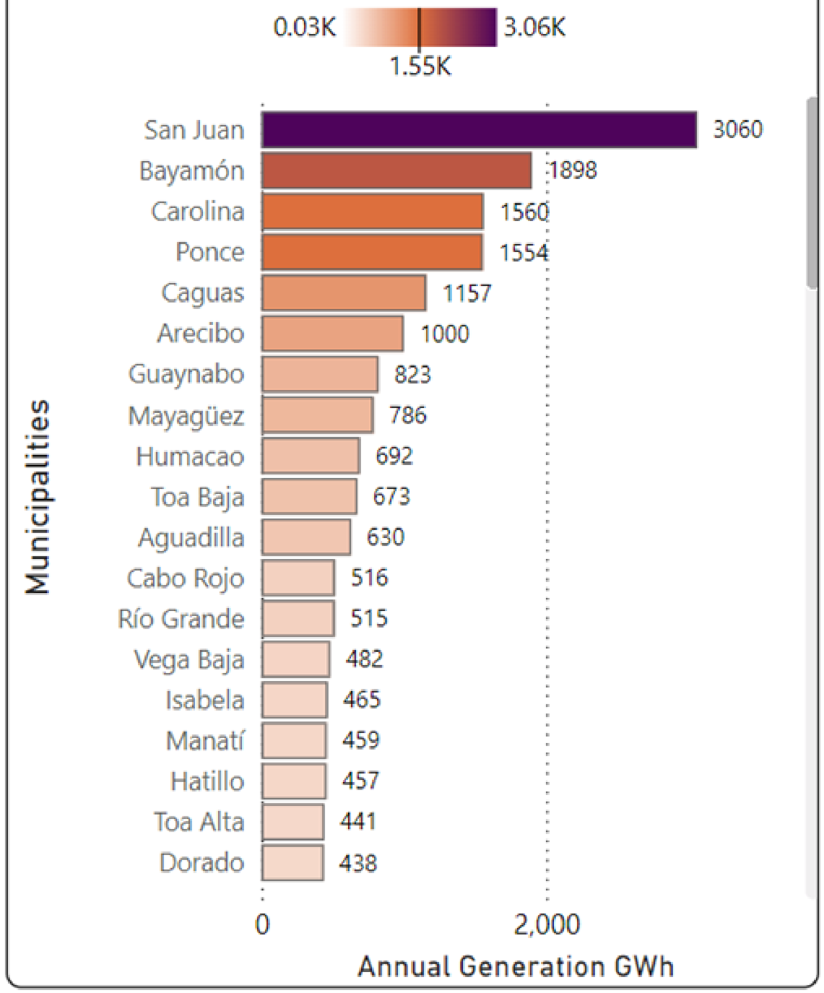
Income Group	Households (thousands)	Suitable Buildings (thousands)	Suitable Module Area (millions of m2)	Capacity Potential (GW_{DC})	Annual Generation Potential (TWh/year)
Very Low (0-30% AMI)	267.8	203.6	21.9	4.0	4.8
Low (30-50% AMI)	151.2	129.1	13.5	2.5	3.0
Moderate (50-80% AMI)	203.3	177.4	18.6	3.4	4.1
Middle (80-120% AMI)	297.8	267.7	28.2	5.1	6.2
High (>120% AMI)	317.1	279.5	29.6	5.4	6.5
All LMI Buildings	622.3	510.1	54.0	9.8	11.9
All Residential Buildings	1,237.2	1,057.3	111.8	20.4	24.6

Meghan Mooney (NREL), Data Review – PR LMI Rooftop PV Technical Potential and Solar Savings Potential, 2020.

PV Potential Annual Generation Solar Rooftop (data NREL) by municipality

Total PV, BESS and Wind | BESS VS PVs for System | BESS map | PV map | BESS VS PVs for Mun. and Dist. Comm. | **NREL - Generation** | NREL - Capacity | Installed / Potential (Capacity)

Potential Annual Generation Solar Rooftop by Municipality



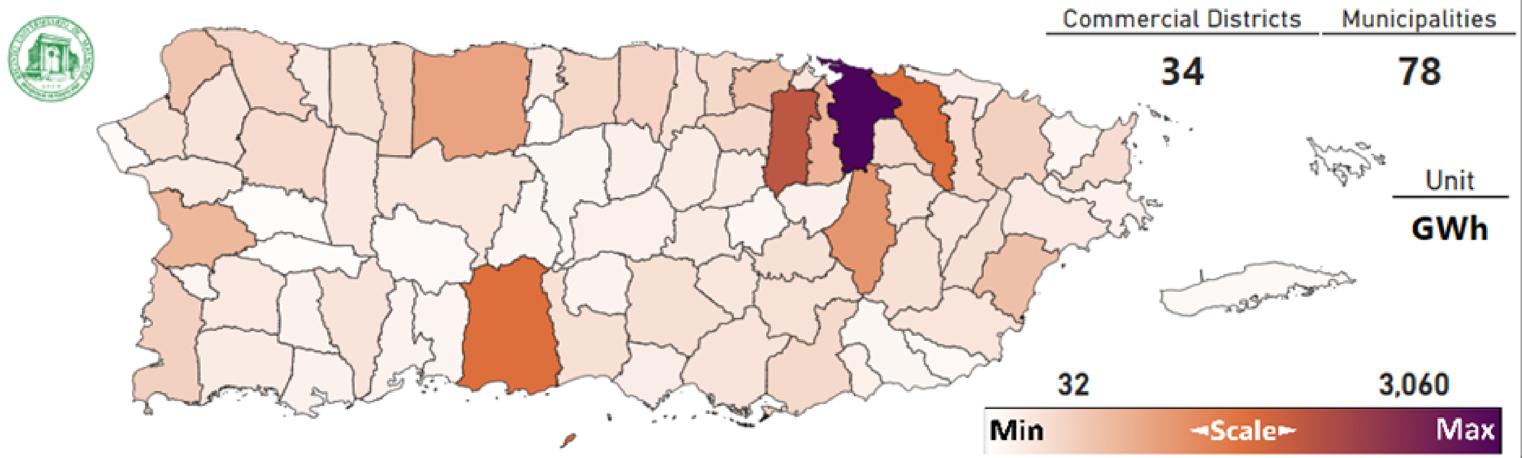
Ejemplo San Juan, generación mensual:

3,060 / 12 = **255 GWh**

Unit	Total Potential annual generation	Potential annual generation (Partial)	Percentage of total annual Generation
GWh	**31,763.06**	**31,763.06**	**100.00%**

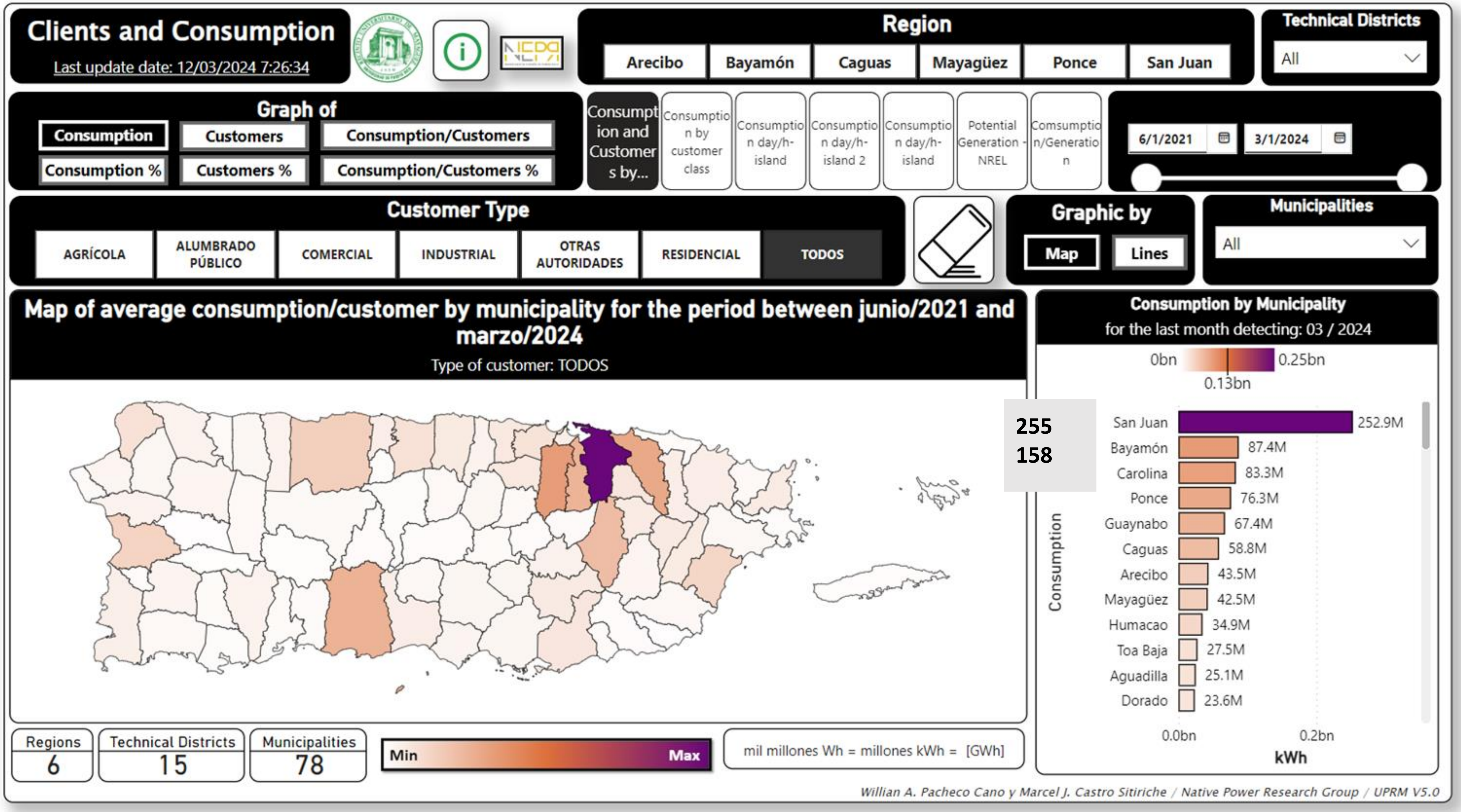
Potential Annual Generation PV Solar Rooftop

by Municipality



Units ► mil millones Wh = millones kWh = [GWh] ◄

Willian A. Pacheco Cano, Carlos Peña Becerra y Marcel J. Castro Sitiriche / Native Power Research Group / UPRM V2.0


Clients and Consumption
Last update date: 12/03/2024 7:26:34
Region
Arecibo
Bayamón
Caguas
Mayagüez
Ponce
San Juan
Technical Districts
All
Graph of
Consumption
Customers
Consumption/Customers
Consumption %
Customers %
Consumption/Customers %
Consumption and Customers by...
Consumption by customer class
Consumption day/h-island
Consumption day/h-island 2
Consumption day/h-island
Potential Generation - NREL
Comsumption/Generation
6/1/2021
3/1/2024
Customer Type
AGRÍCOLA
ALUMBRADO PÚBLICO
COMERCIAL
INDUSTRIAL
OTRAS AUTORIDADES
RESIDENCIAL
TODOS
Graphic by
Map
Lines
Municipalities
All
Map of average consumption/customer by municipality for the period between junio/2021 and marzo/2024
Type of customer: TODOS
255
158
Consumption by Municipality
for the last month detecting: 03 / 2024
0bn
0.13bn
0.25bn
San Juan 252.9M
Bayamón 87.4M
Carolina 83.3M
Ponce 76.3M
Guaynabo 67.4M
Caguas 58.8M
Arecibo 43.5M
Mayagüez 42.5M
Humacao 34.9M
Toa Baja 27.5M
Aguadilla 25.1M
Dorado 23.6M
Consumption
0.0bn
0.2bn
kWh
Regions 6
Technical Districts 15
Municipalities 78
Min
Max
mil millones Wh = millones kWh = [GWh]
Willian A. Pacheco Cano y Marcel J. Castro Sitiriche / Native Power Research Group / UPRM V5.0

SUMMARY: residencial rooftop PV

Average Potential for each rooftop 20 kW:

1. 3 kW for 1 million homes
2. 2 kW for consumption 380,000 apartments.
3. 5 kW for commercial sector consumption.
4. 1 kW for industrial sector consumption
5. 3 kW for electric vehicle

TOTAL: 14 kW in one million houses

NOTE: decentralized energy storage also needed

Rooftop PV Potential for each rooftop 20 kW

PV	PV	PV	PV
PV	PV	PV	PV
PV	PV	PV	PV
PV	PV	PV	PV
PV	PV	PV	PV

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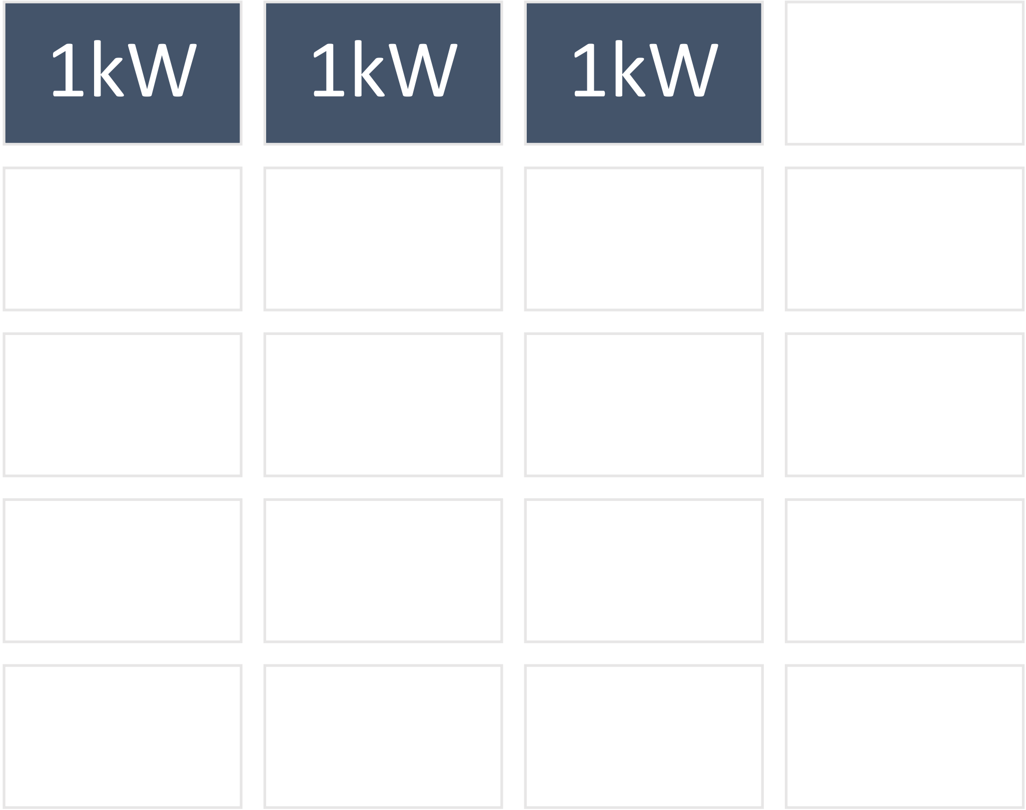

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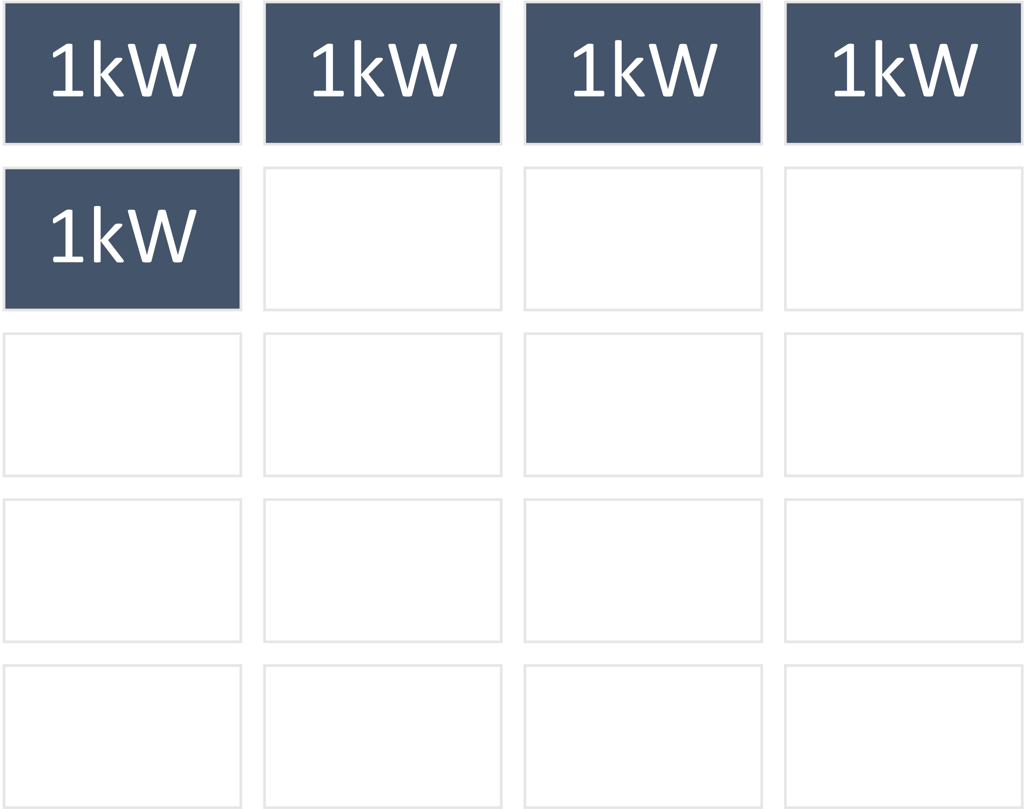

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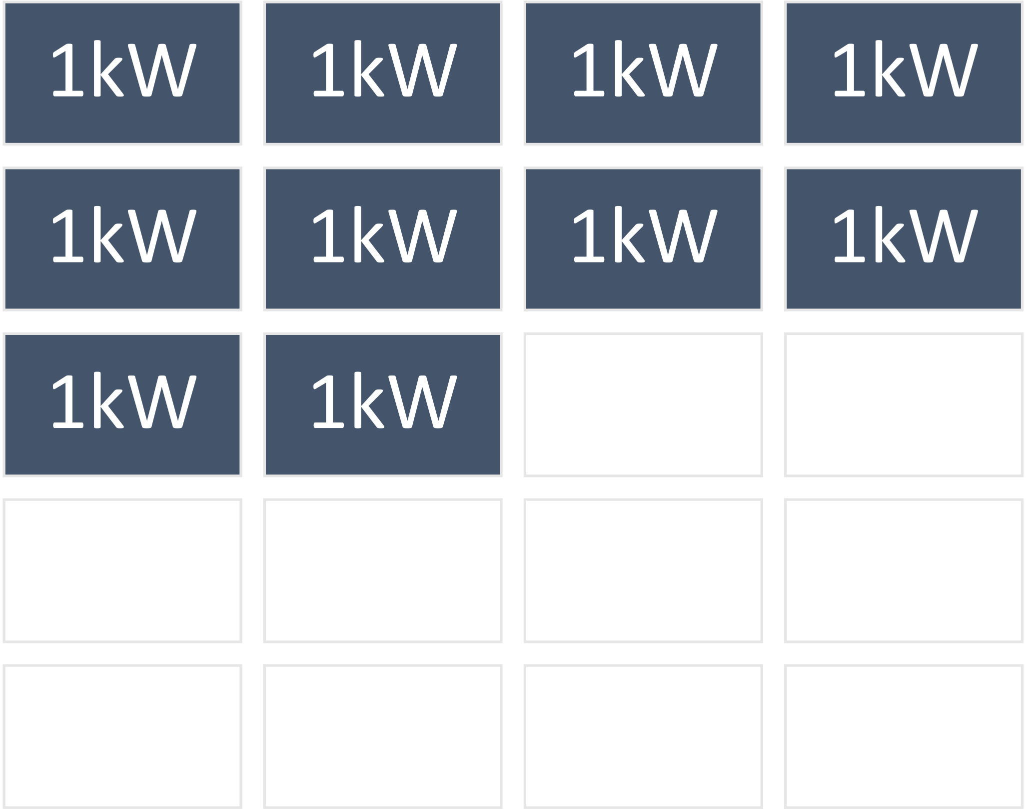

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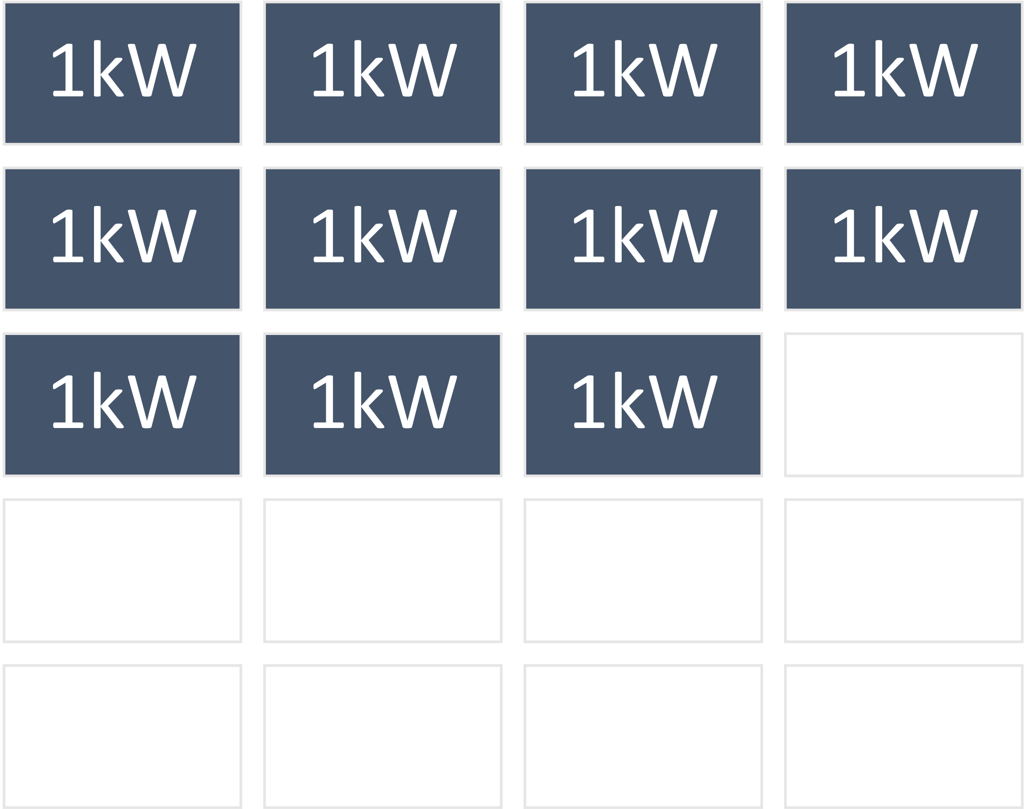

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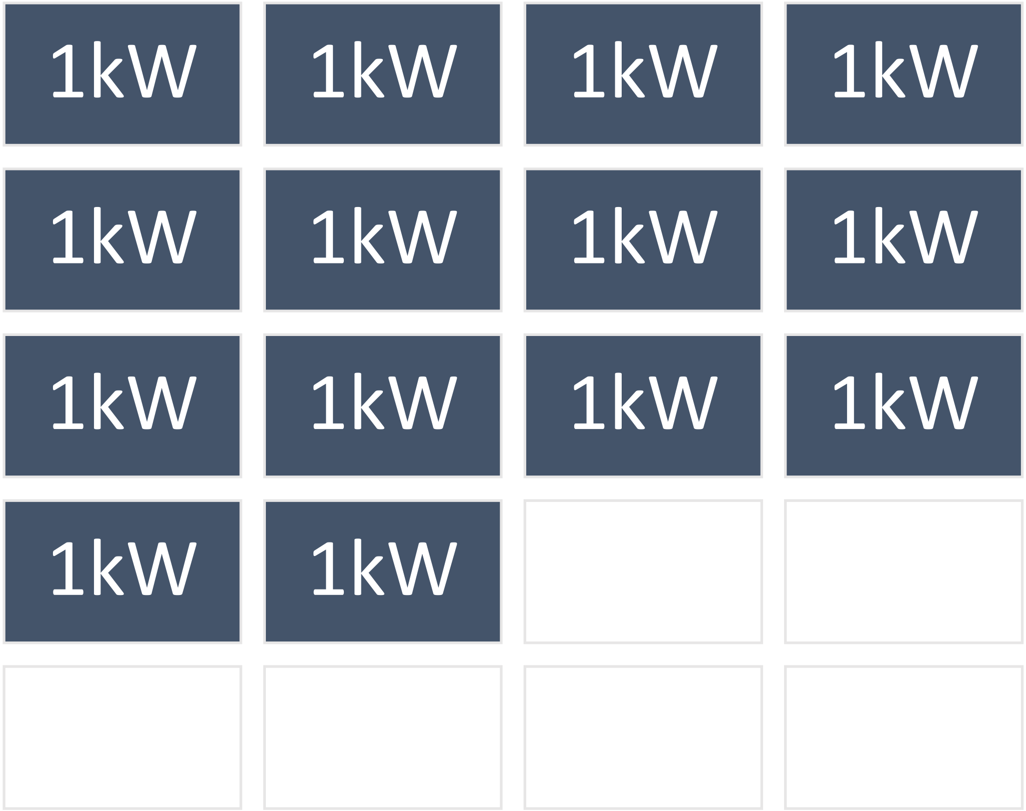
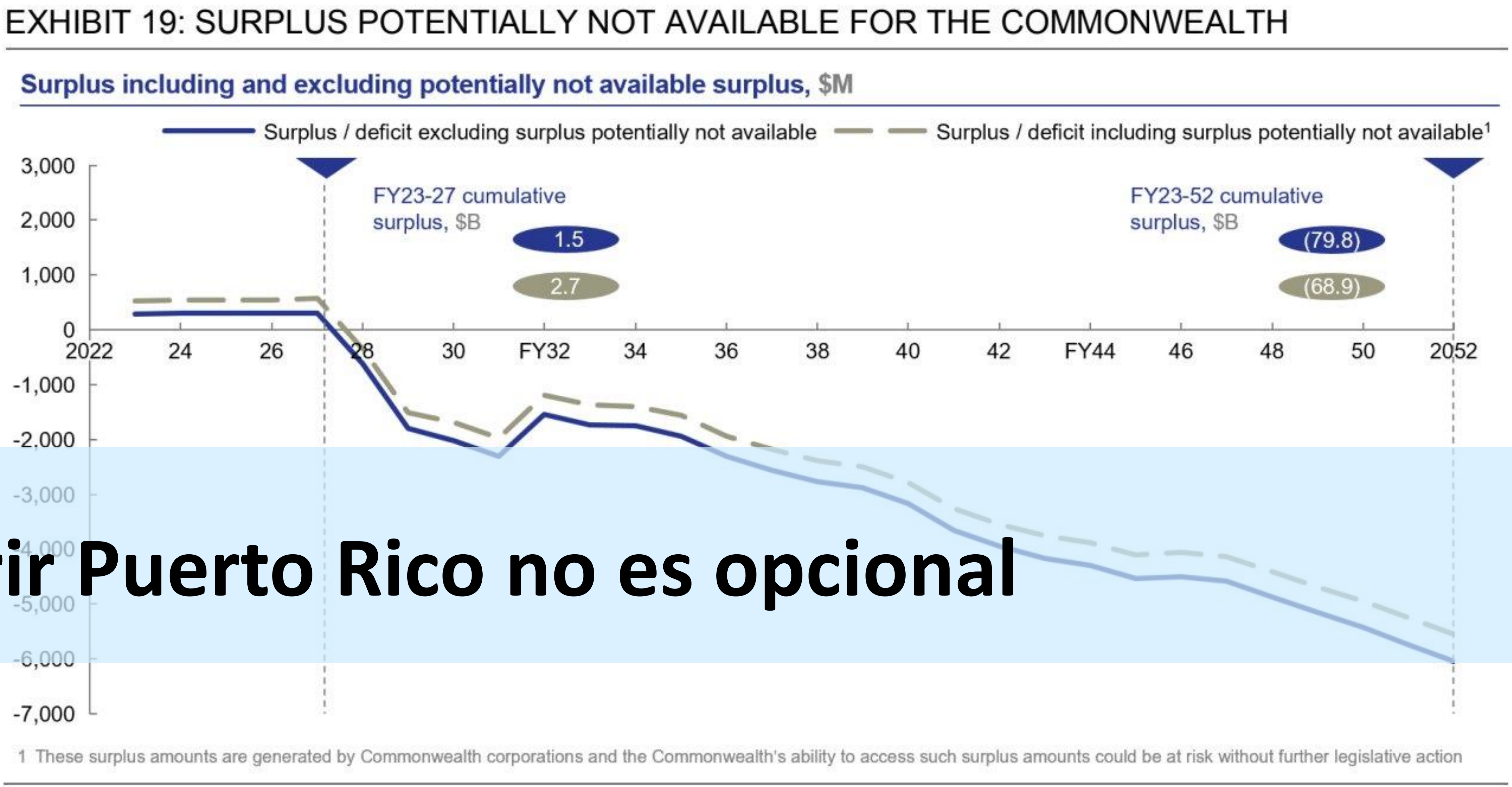
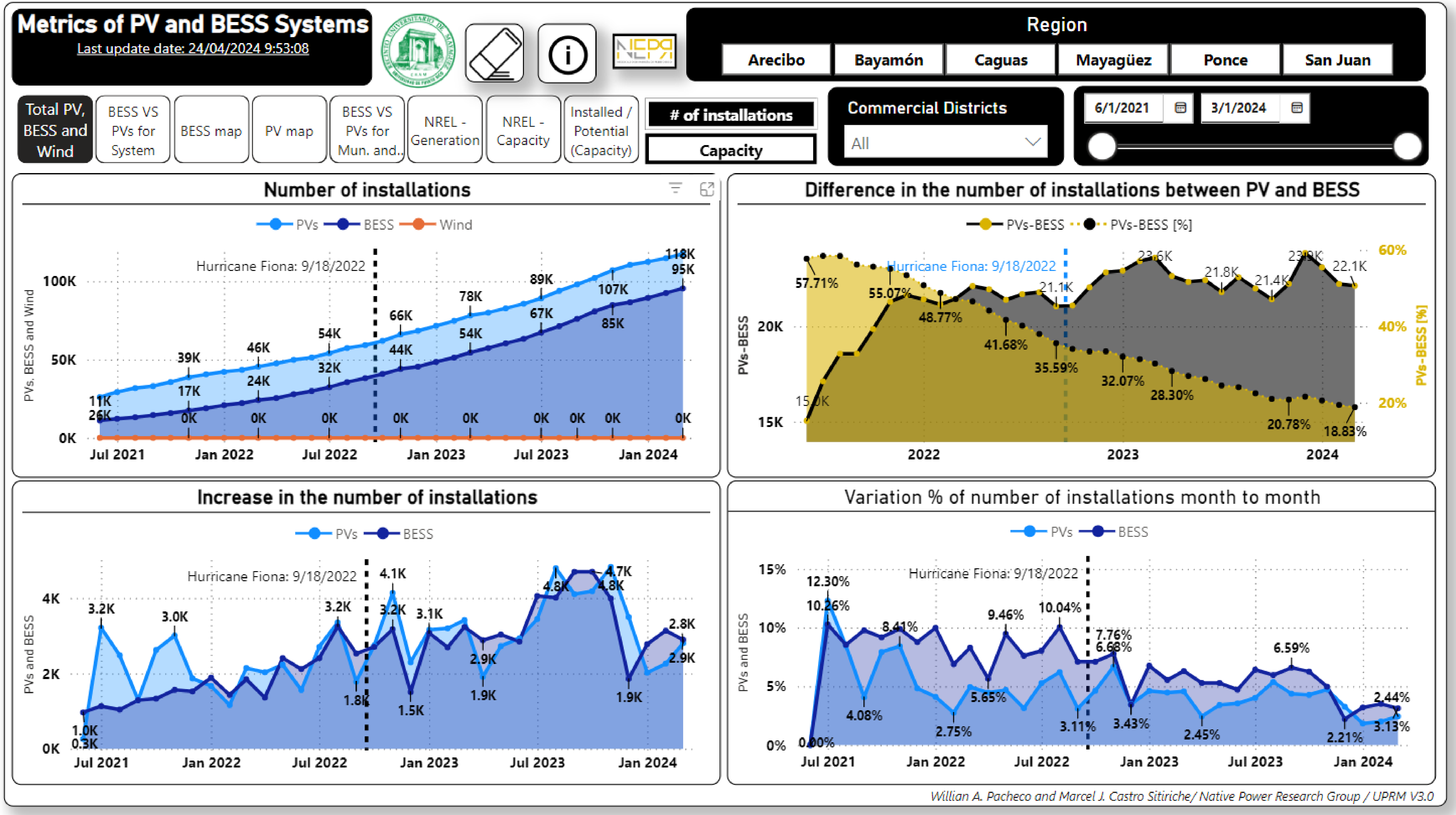


Plan Fiscal 2023

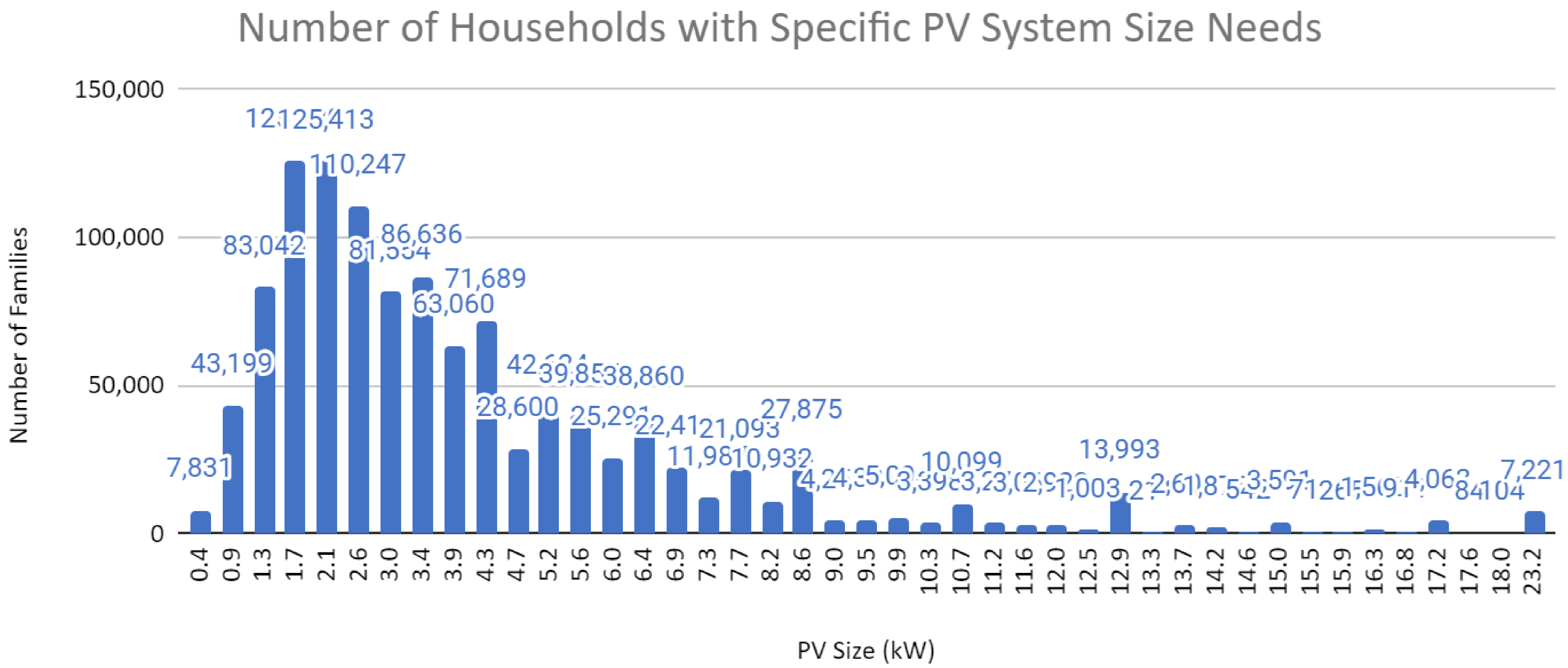


Sufrir Puerto Rico no es opcional


… pero disfrutar Puerto Rico es una desición.
Rincón, Borikén
9/junio/2024
Foto: marcel

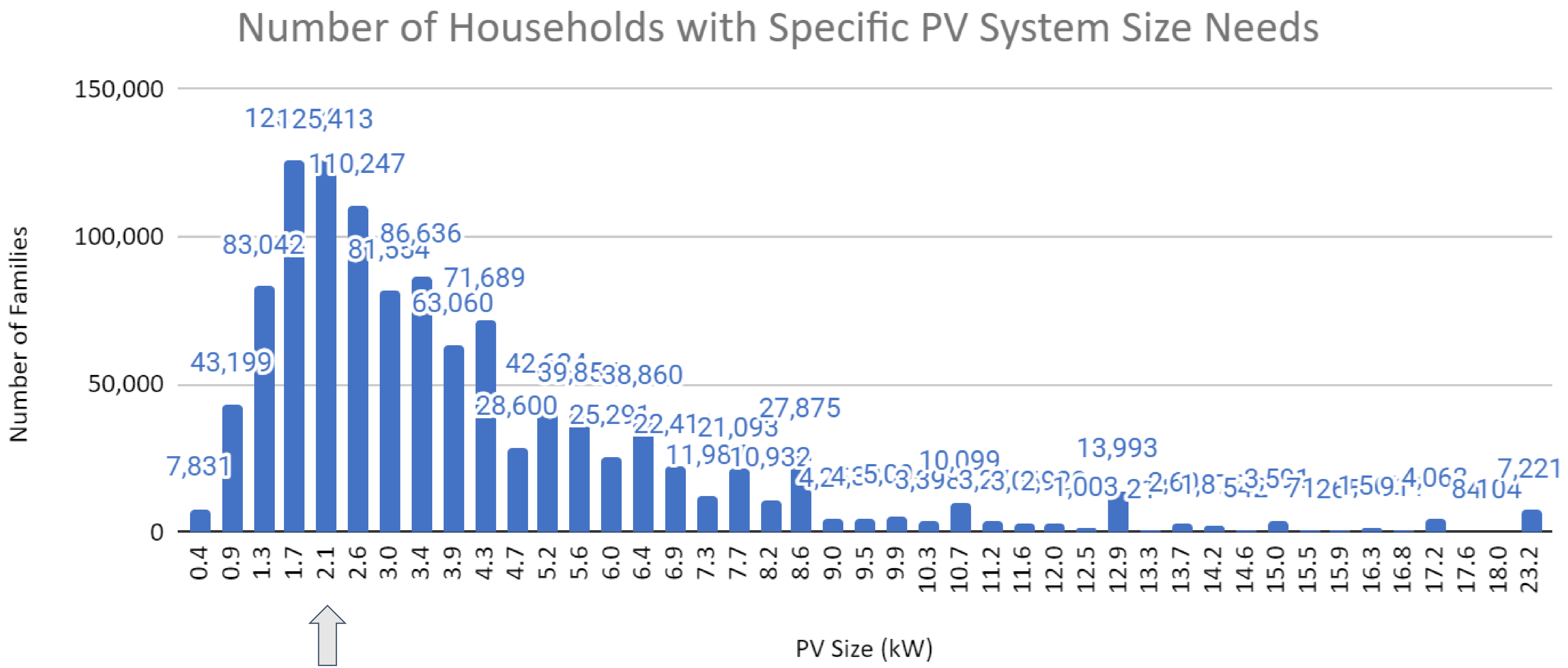


Enlace – https://app.powerbi.com/view?r=eyJrIjoiMjQwYmZmOGMtN2E2Ni00MTUyLWJmNWItMzkzYTAwZGRhOTg5IiwidCI6IjBkZmE1ZGMwLTAzNmYtNDYxNS05OWU0LTk0YWY4MjJmMmI4NCIsImMiOjF9



M. Castro-Sitiriche, “Bottom-up Grid for a Resilient Puerto Rico”, Panel on Alternative Energy: Disasters as Windows of Opportunity for Alternative Energy Pathways, RISE Conference 2019.
Acknowledgement: Census ACS data management was done by Hector Cordero from CUNY Baruch-MSPIA.

2.1 kW	**385,405**	**24.68%**



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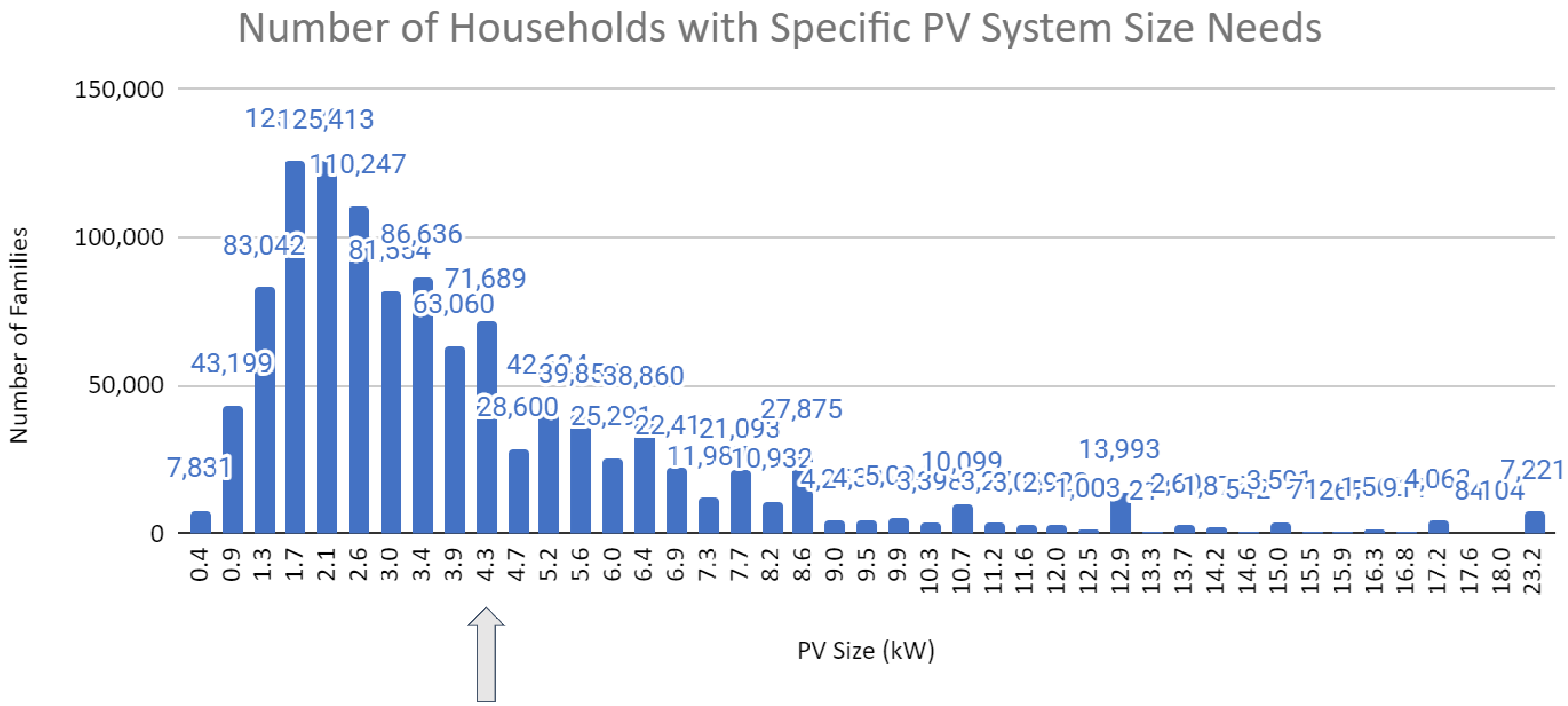
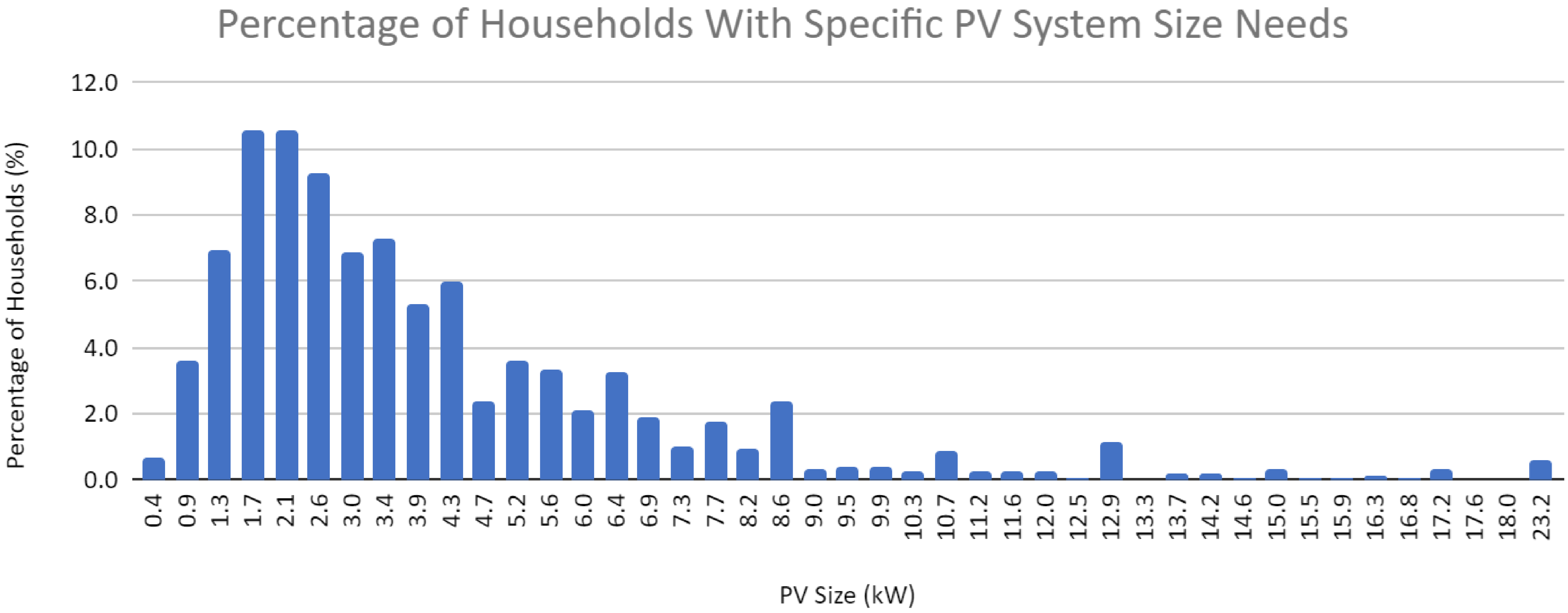
4.3 kW	798,591	51.13%





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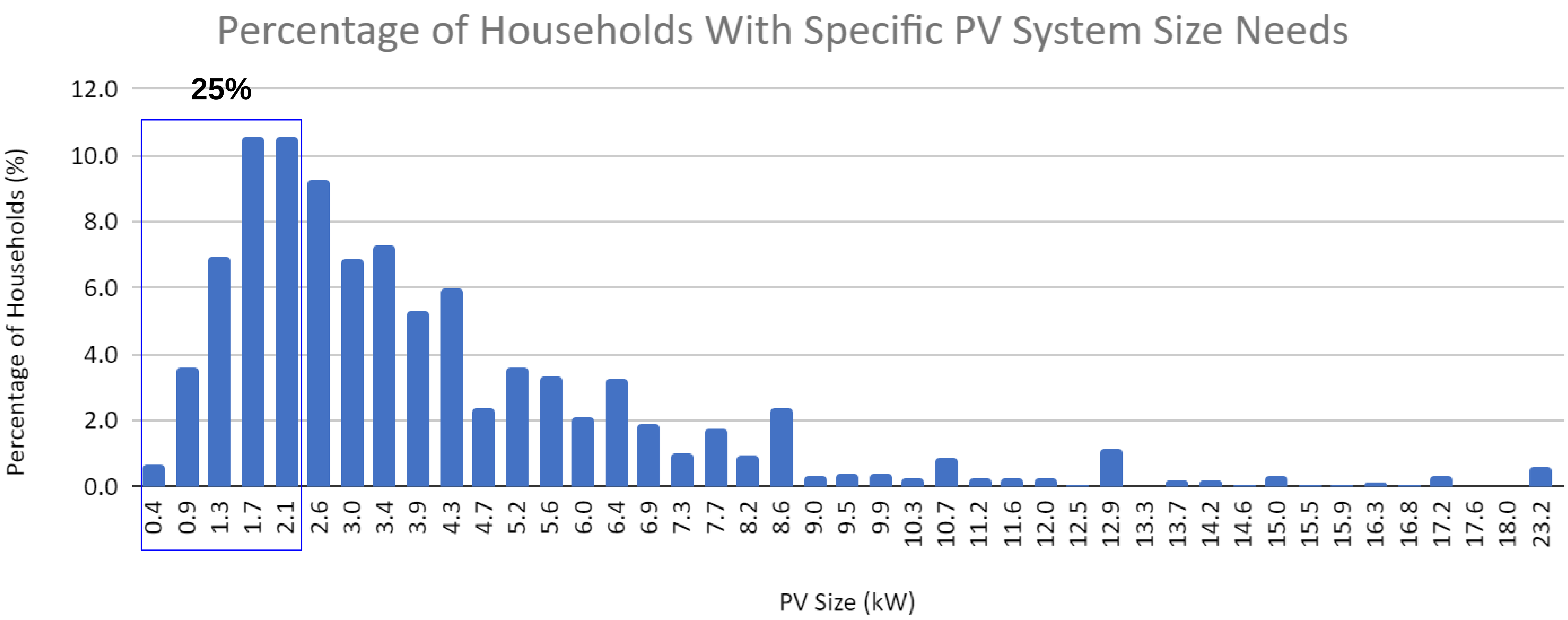

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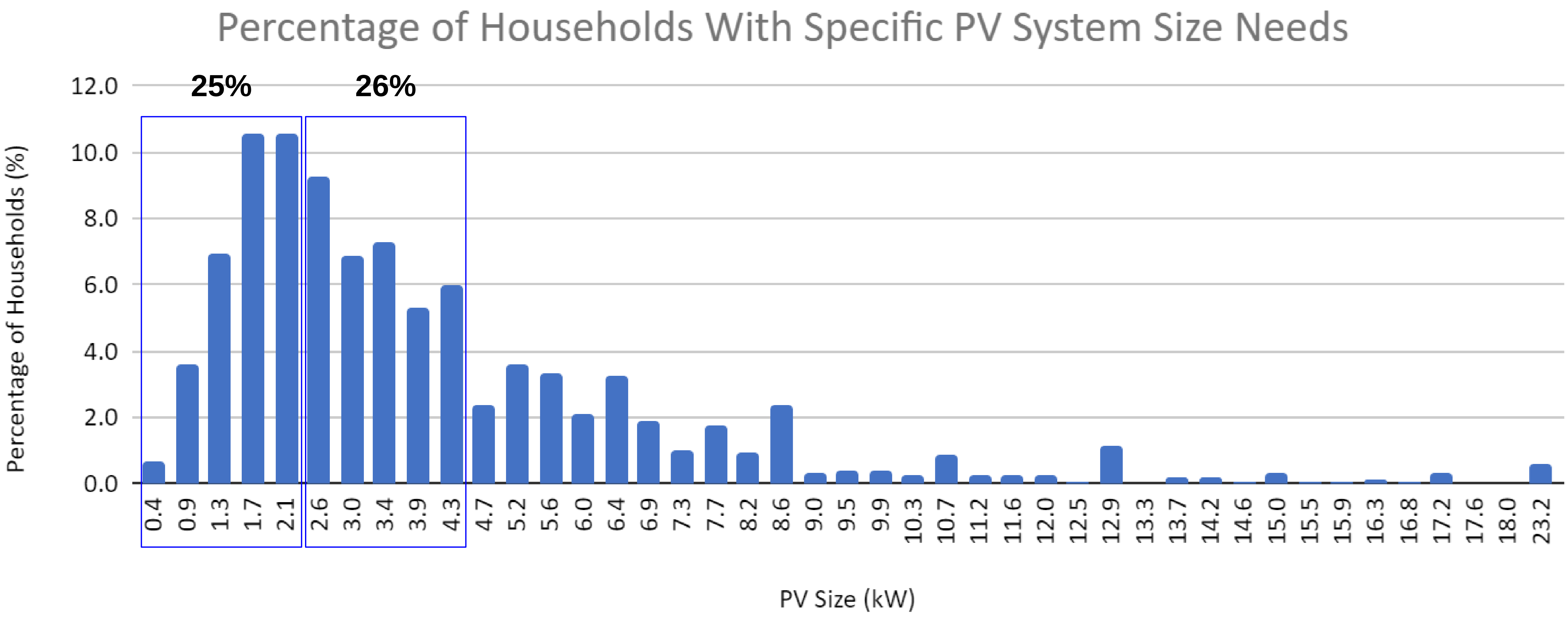

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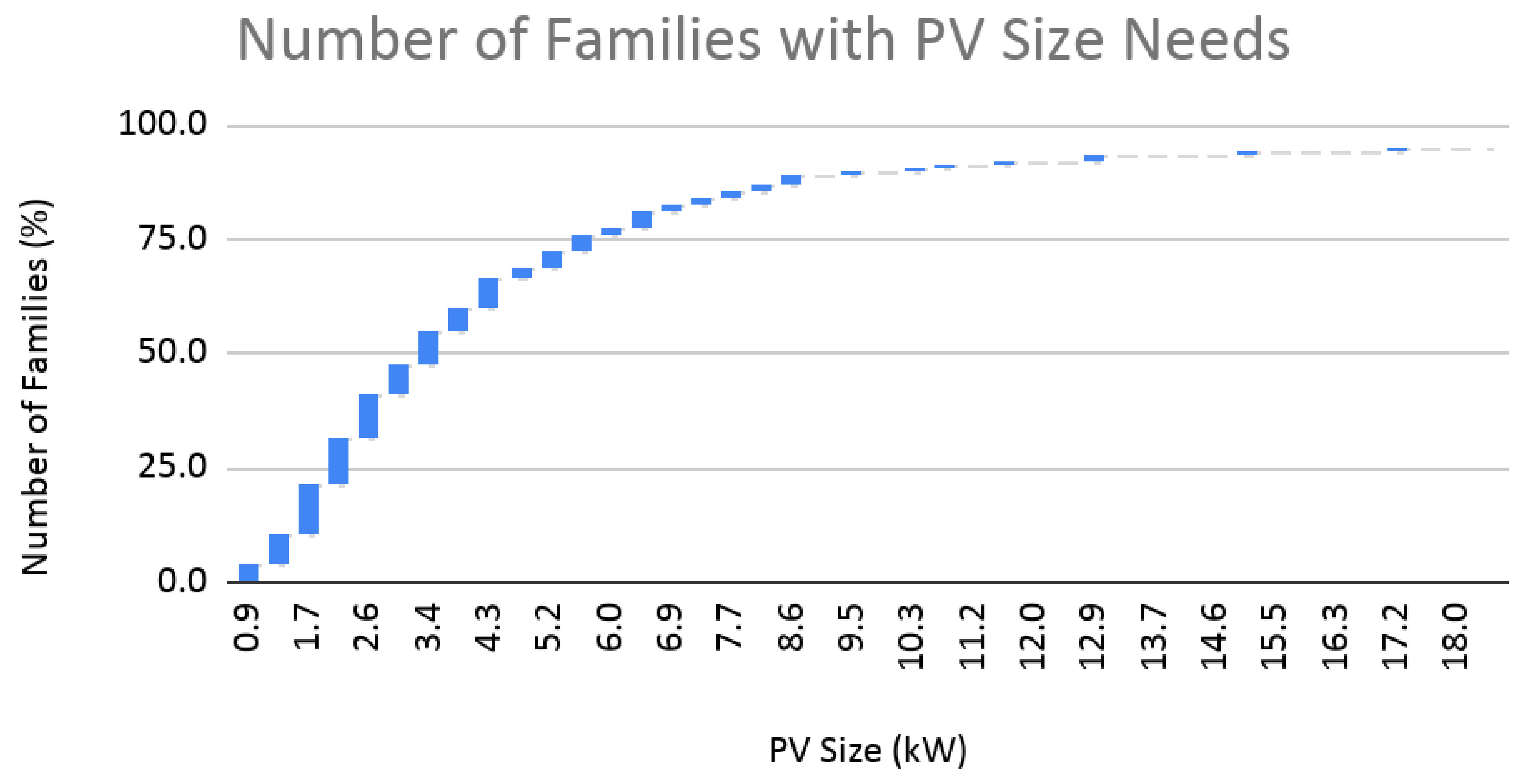
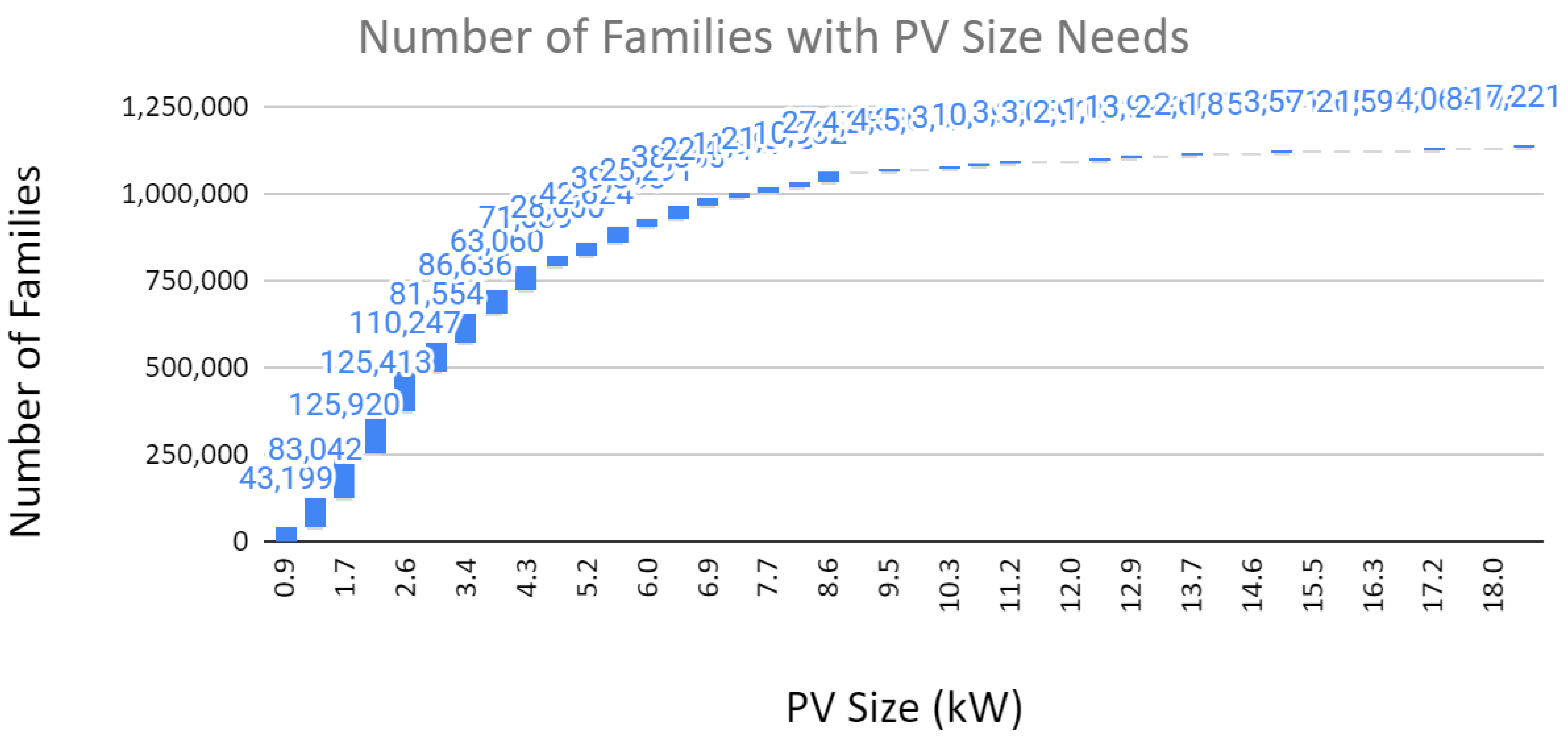


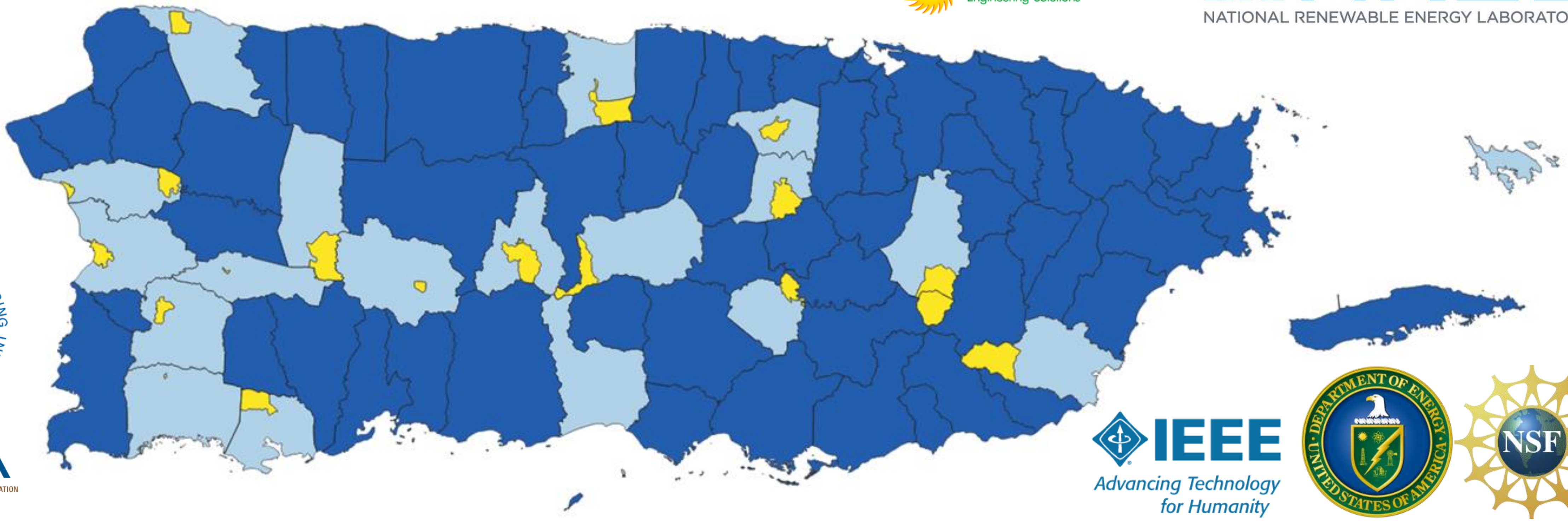
Number of Families with PV Size Needs
100.0
75.0
50.0
25.0
0.0
Number of Families (%)
0.9
1.7
2.6
3.4
4.3
5.2
6.0
6.9
7.7
8.6
9.5
10.3
11.2
12.0
12.9
13.7
14.6
15.5
16.3
17.2
18.0
PV Size (kW)



Number of Families with PV Size Needs
1,250,000
1,000,000
750,000
500,000
250,000
0
43,199
83,042
125,920
125,413
110,247
81,554
86,636
63,060
Number of Families
0.9
1.7
2.6
3.4
4.3
5.2
6.0
6.9
7.7
8.6
9.5
10.3
11.2
12.0
12.9
13.7
14.6
15.5
16.3
17.2
18.0
PV Size (kW)

UPRM Power Community Engagement:

Communities in 19 Municipalities

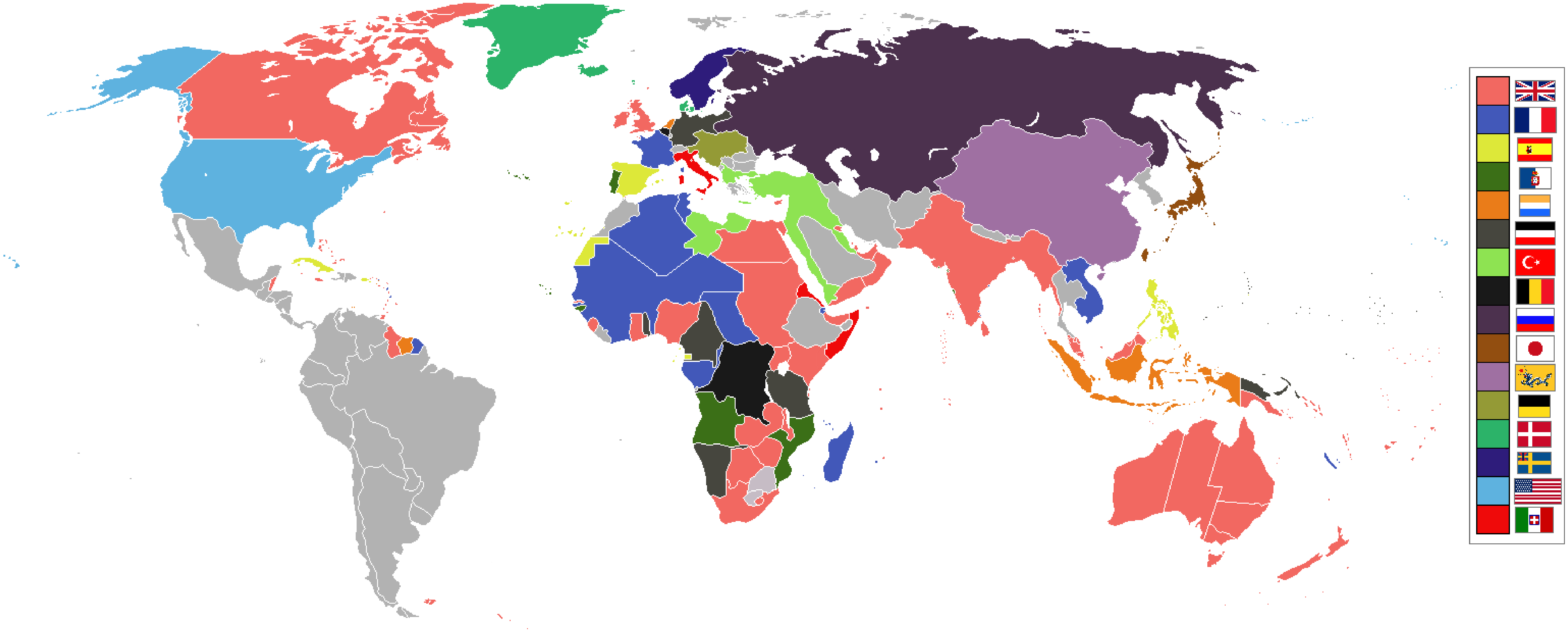


UPRM Team: Luisa Seijo from Social Sciences, Ricardo Fuentes from Economics, Lizzette González from Agricultural Science, Reinaldo Rosado from Social Sciences, Ingrid Rodríguez from Social Sciences, Francisco Maldonado from Civil Engineering, Marcel Castro-Sitiriche, Agustín Irizarry, Fabio Andrade,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

Sociopolitical Context:
Electrification from 1881 to 1960s

- Historical context of the electrification of Europe and colonial extraction in the Caribbean.
- The problem with the Development Narrative
- The concept of Responsible Wellbeing

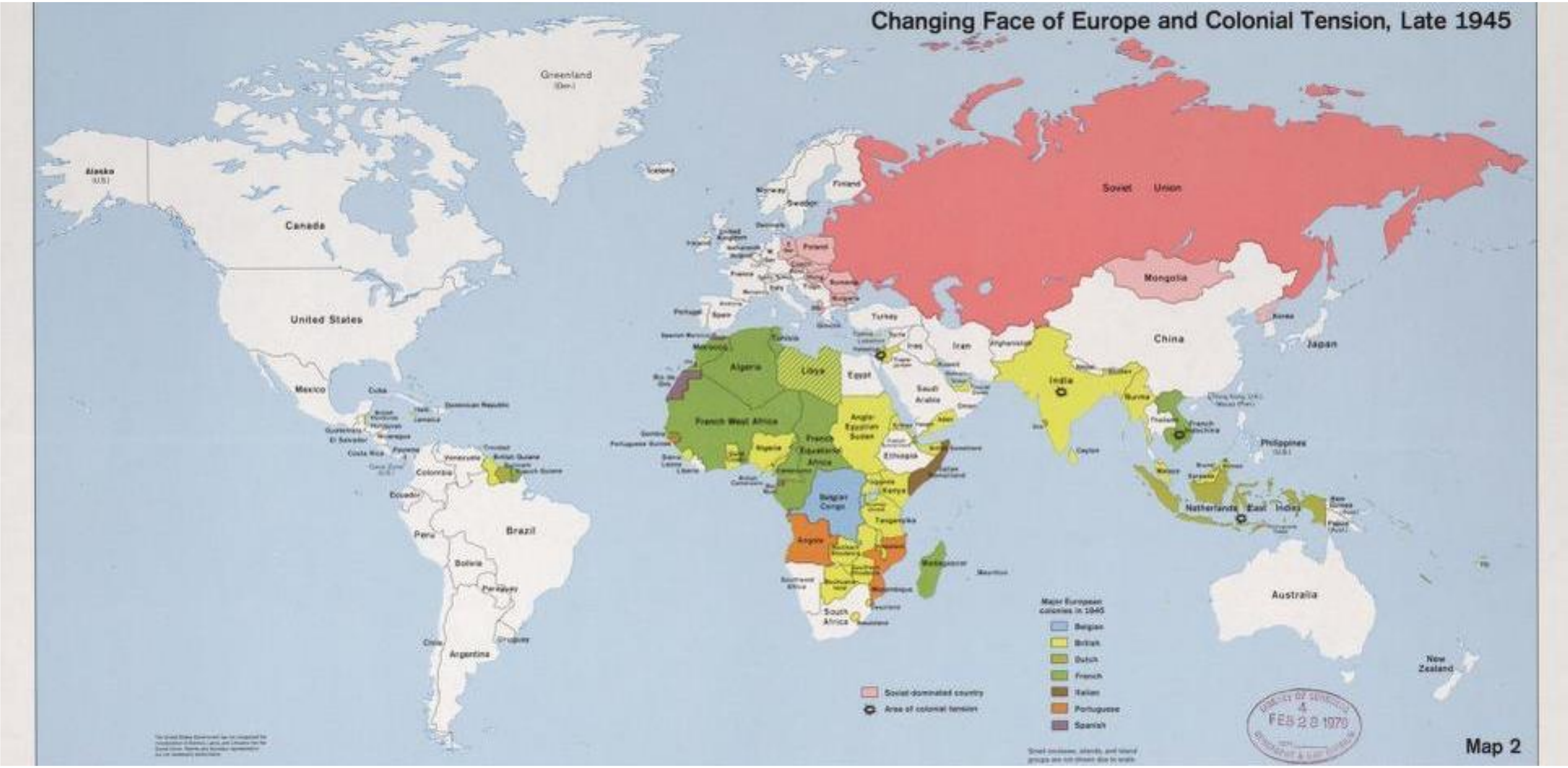
Colonies in 1898: Electrification from 1881 to 1960s



https://upload.wikimedia.org/wikipedia/commons/2/24/World_1898_empires_colonies_territory.png

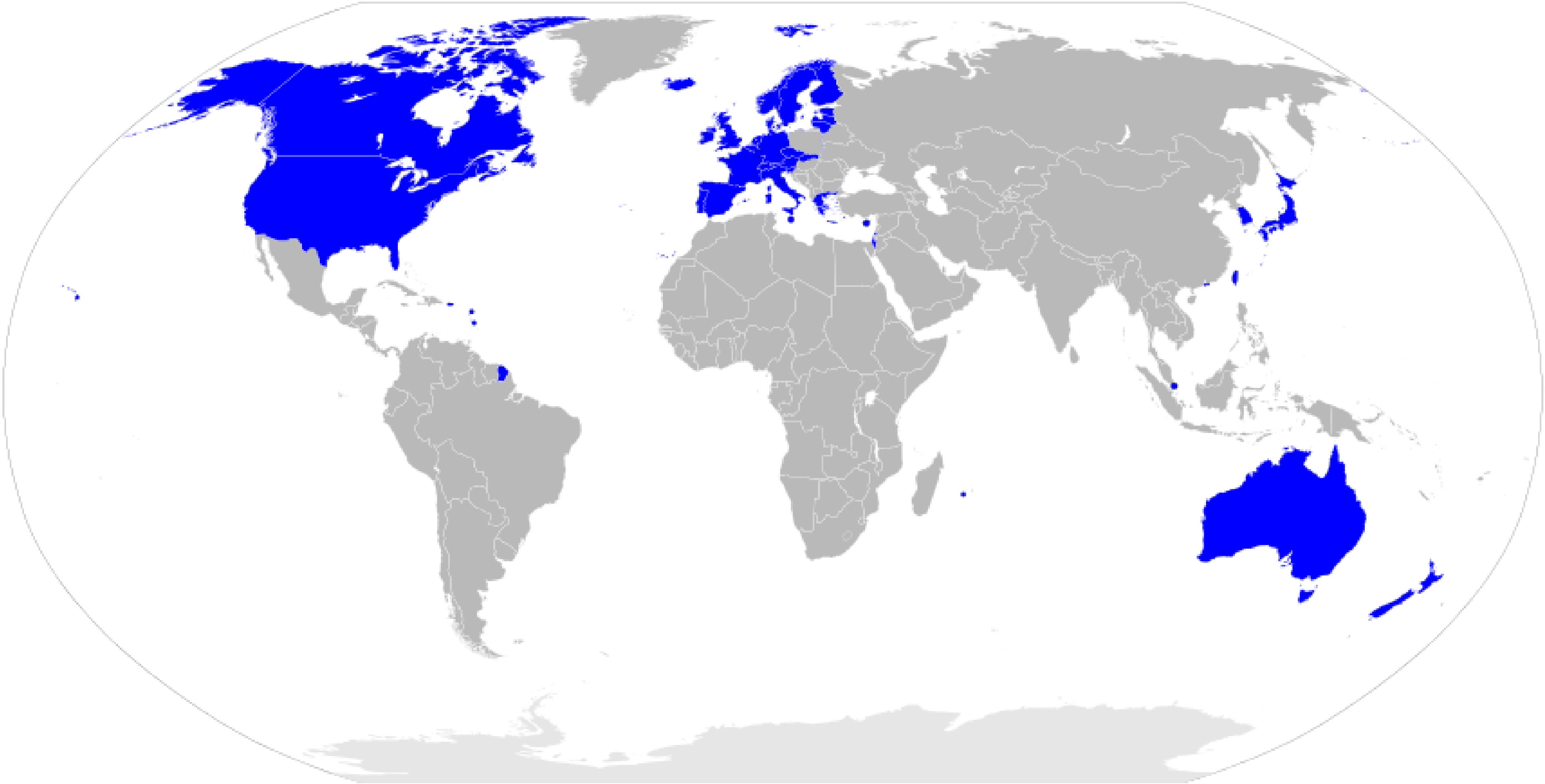
Marcel J. Castro-Sitiriche, Caribbean Region, Resilient Power and Energy Justice: The Case of Puerto Rico, Global Energy Access Innovation Workshop: IEEE Power Africa Conference, August 22, 2022, Kigali, Rwanda

Colonies in 1945: Electrification from 1881 to 1960s



https://www.loc.gov/resource/g5701f.ct002763/?r=-0.143,-0.035,1.305,0.595,0

Advanced Economies



THE GOOD LIFE

Write down:

- What is a good life?
- What makes life good?

P

sumak kawsay   *suma qamaña*

The Good Life: Alternative to the Development Narrative

- **Quechua - Ecuador**: sumak kawsay
  - Human Rights
- **Aymara - Bolivia**: suma qamaña
  - Ethic and Moral Principles
- Alternative Development -> an Alternative to Development

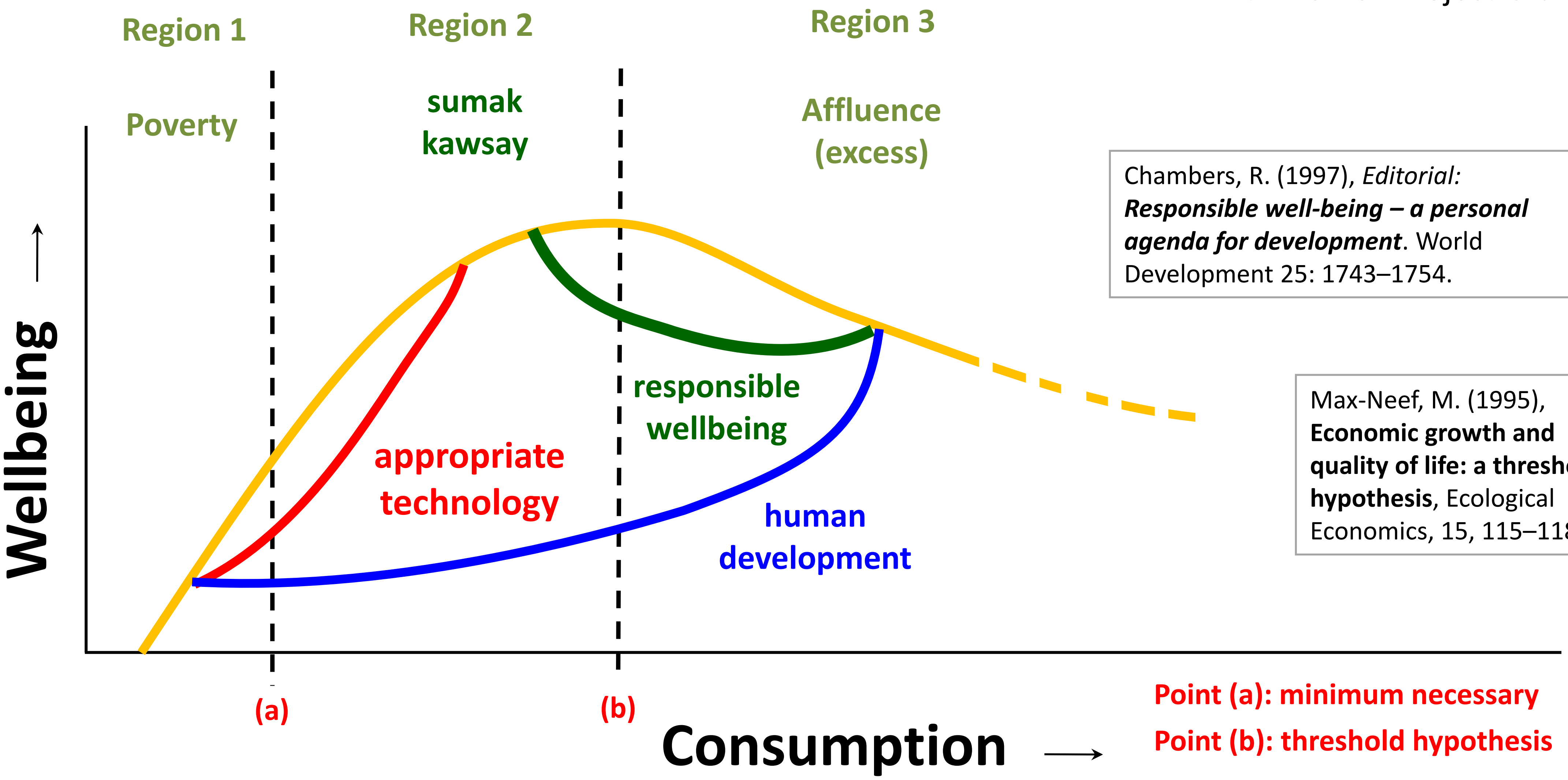
Gudynas and Acosta 2011; La renovación de la crítica al desarrollo y el buen vivir como alternativa

anaaakuaipa

- Quechua: Sumak Kawsay
- Aymara: Suma Qamaña (Barefoot College: Boricua Solar Mamas)
- Wayuunaiki: anaaakuaipa
- Taino: ana guakia...
  - Flor + lo que nos une

Responsible Wellbeing and Threshold Hypothesis:
Wellbeing vs Consumption

CRWS NSF Project Grant #1449489



Chambers, R. (1997), *Editorial:* ***Responsible well-being – a personal agenda for development***. World Development 25: 1743–1754.

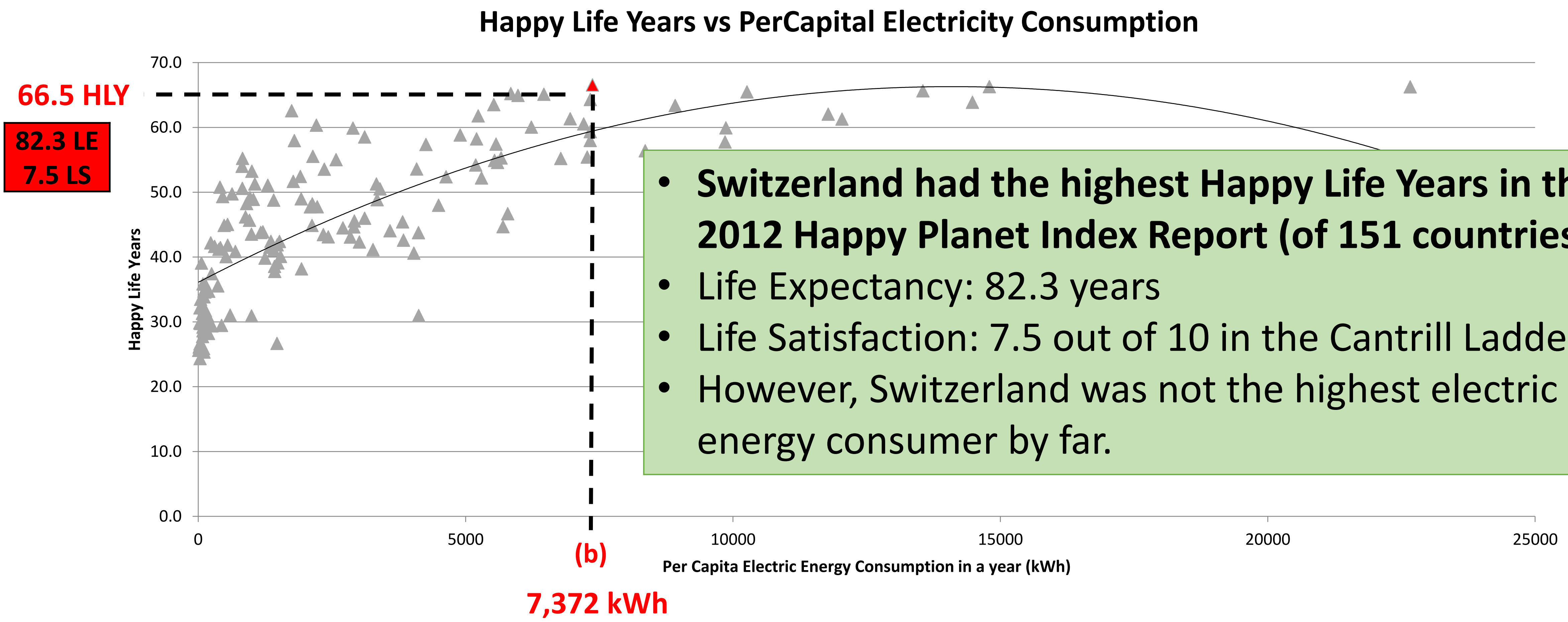
Max-Neef, M. (1995), **Economic growth and quality of life: a threshold hypothesis**, Ecological Economics, 15, 115–118.

Point (a): minimum necessary

Point (b): threshold hypothesis

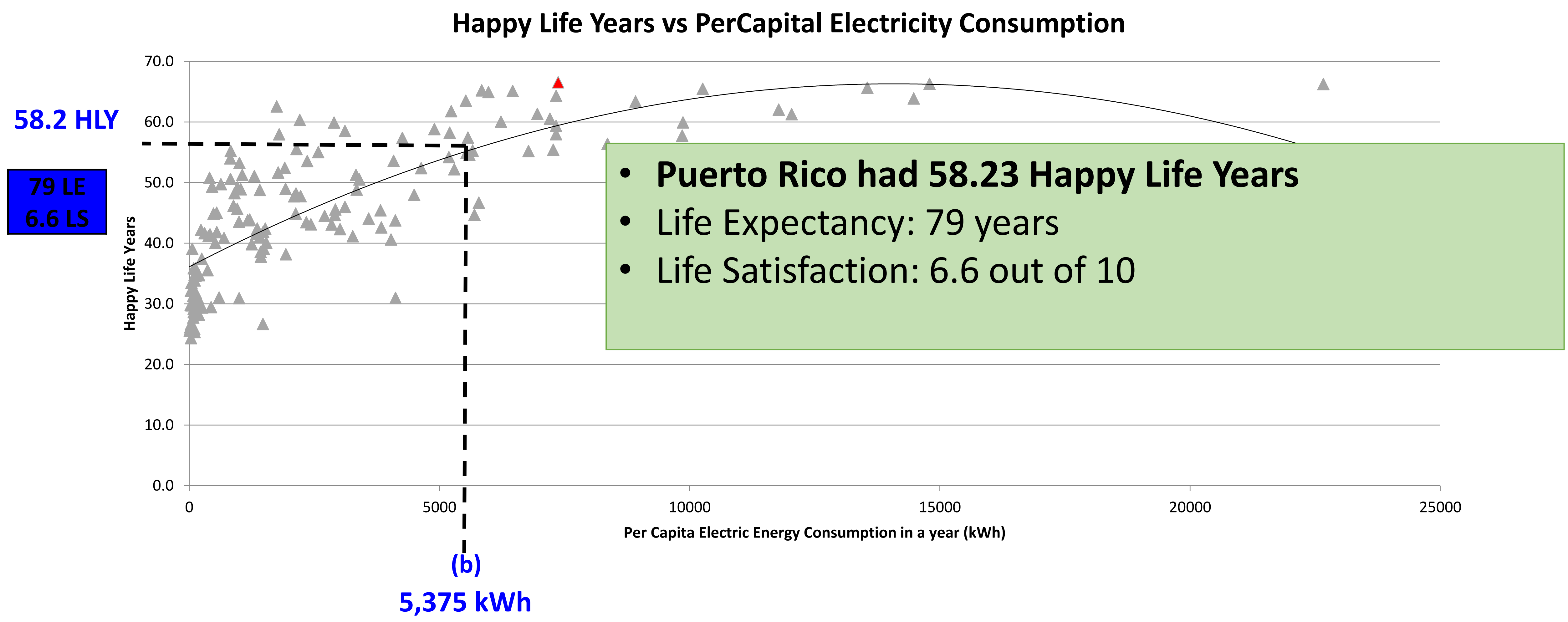
Adapted from: Castro-Sitiriche, Marcel J., Jonathan Ozik; "Rural Electrification Pathways to Wellbeing", *Proceedings of the 6th International Conference of Appropriate Technology: Knowledge and Technology Transfer Session*, Nairobi, Kenya, pages 54-63, November 2014

Energy Threshold Hypothesis: Switzerland



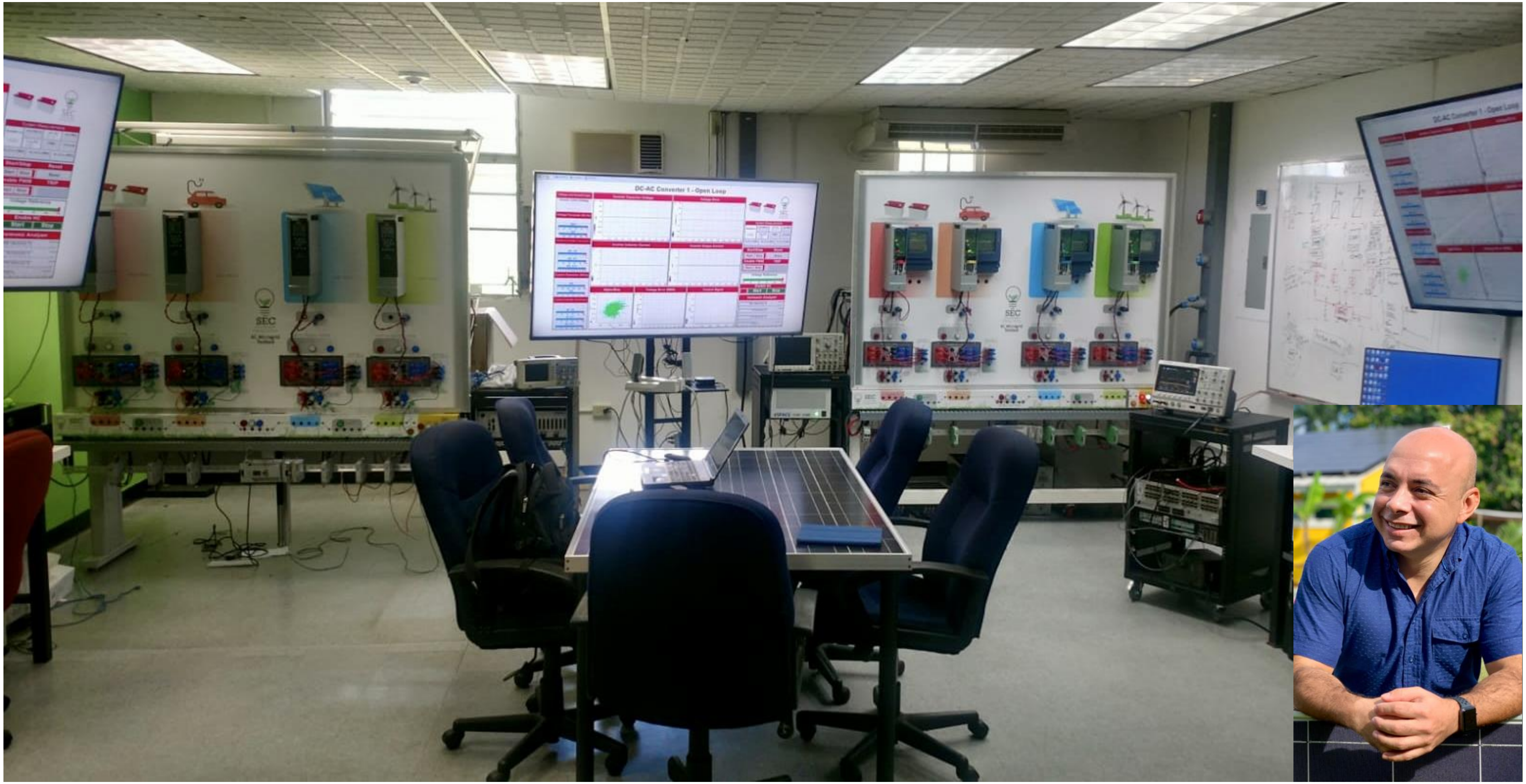
- **Switzerland had the highest Happy Life Years in the 2012 Happy Planet Index Report (of 151 countries)**
- Life Expectancy: 82.3 years
- Life Satisfaction: 7.5 out of 10 in the Cantrill Ladder
- However, Switzerland was not the highest electric energy consumer by far.

Energy Threshold Hypothesis: Puerto Rico



- **Puerto Rico had 58.23 Happy Life Years**
- Life Expectancy: 79 years
- Life Satisfaction: 6.6 out of 10

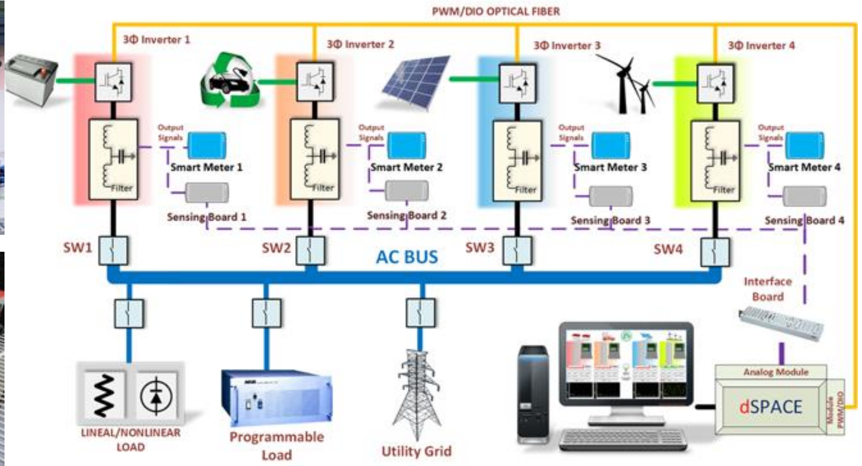
Microgrid Laboratory



Fabio Andrade

UPRM Power Collaborations

Microgrid Laboratory



Lawrence Livermore National Laboratory

University of Alaska Fairbanks

Arizona State University

University of South Florida

Universidad del Valle

Universidad de Jaén

NREL National Renewable Energy Laboratory

Sandia National Laboratories

Oak Ridge National Laboratory

U.S. Department of Energy Office of Science

NSF

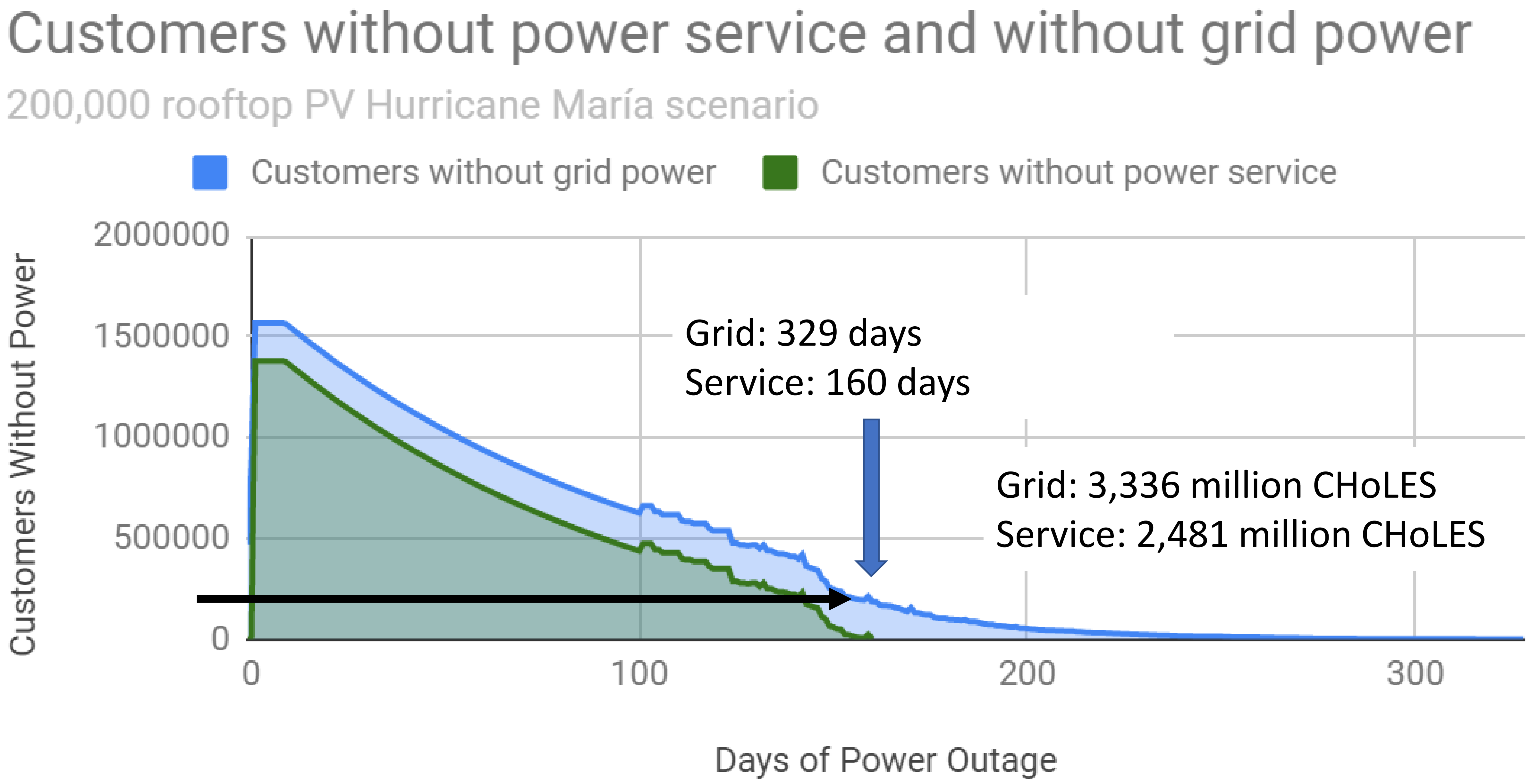
windmar

Casa Pueblo Adjuntas Puerto Rico


Solar House


Community Initiatives

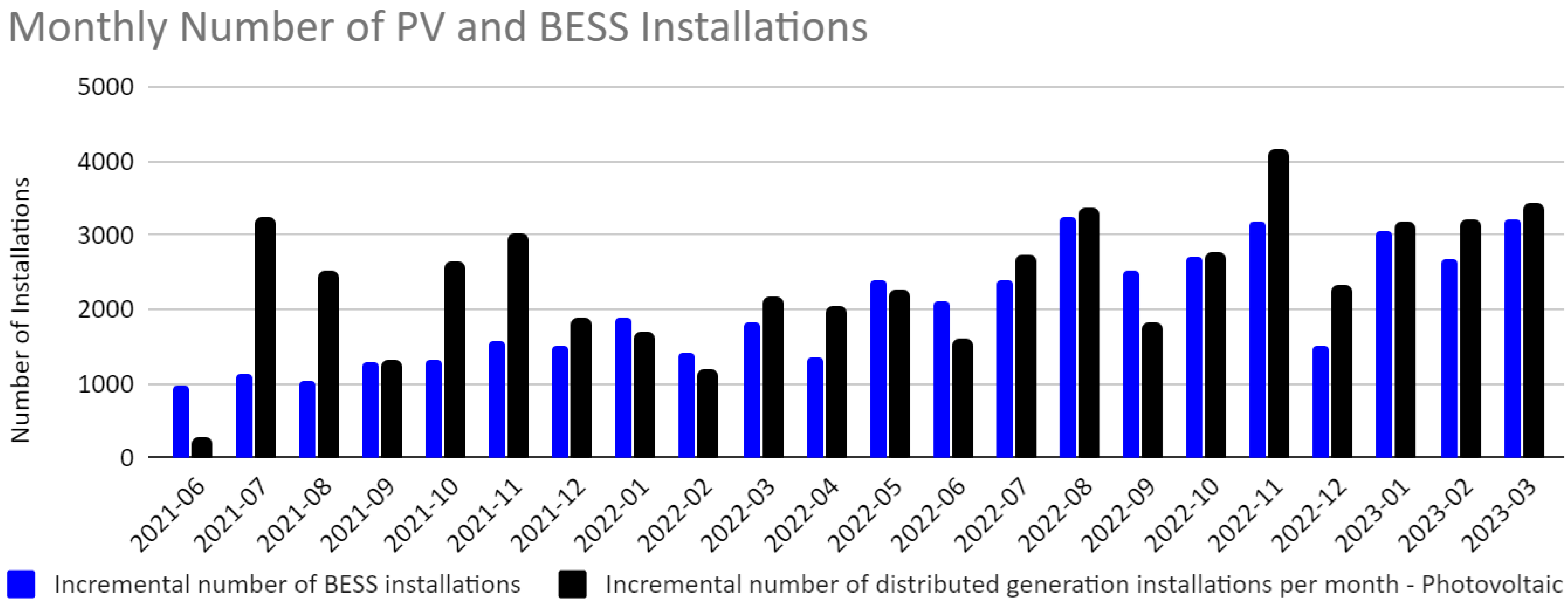
Community Initiatives



Marcel Castro-Sitiriche, “Resilience Energy Justice: Boricua Power and Equity”, Plenary Session, *IEEE-WEA*, Cartagena, Colombia, November 2, 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)

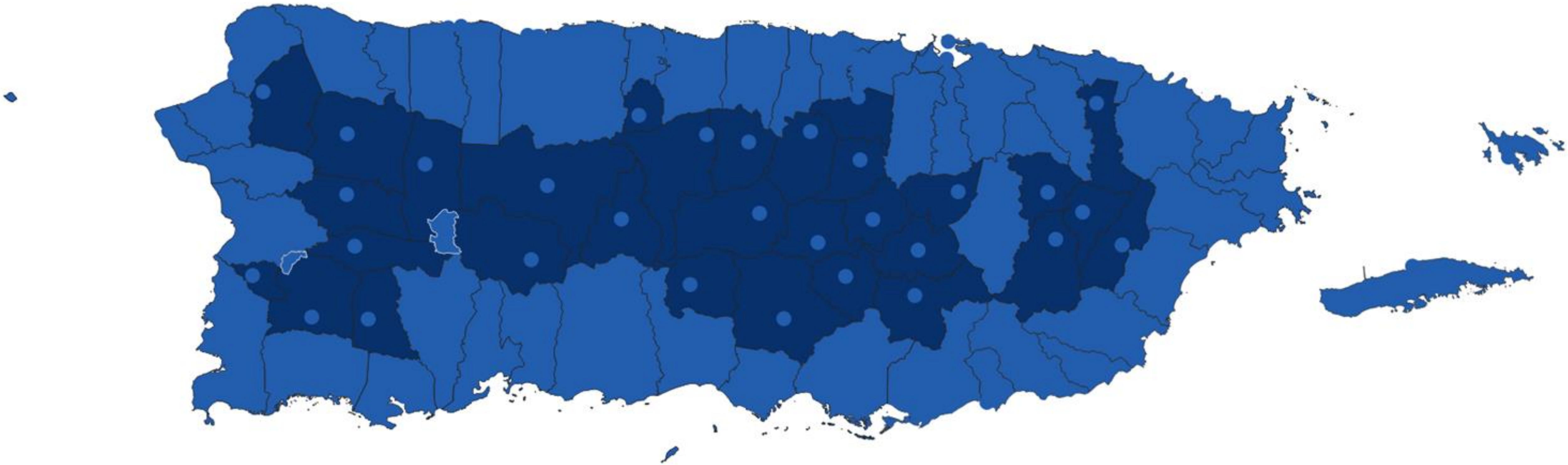


Marcel Castro-Sitiriche, NEPR Data Analysis, PR100 Update 2023. Source: Negociado de Energía de Puerto Rico (NEPR) https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/

Critical Microgrids for Puerto Rico

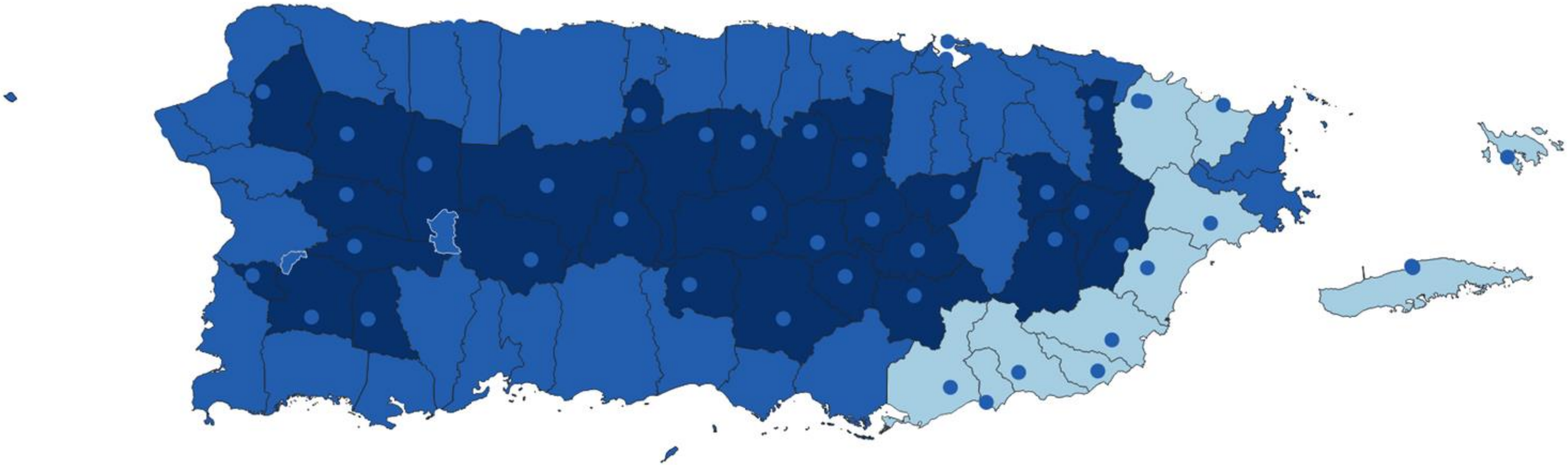
Critical Microgrids for Puerto Rico:

33 City Squares and Poblados of Municipalities in the Interior



M. Castro-Sitiriche, “Boricua Microgrids for Energy Justice”, PR100 Project March 30, 2023.
Source: https://gis.pr.gov/

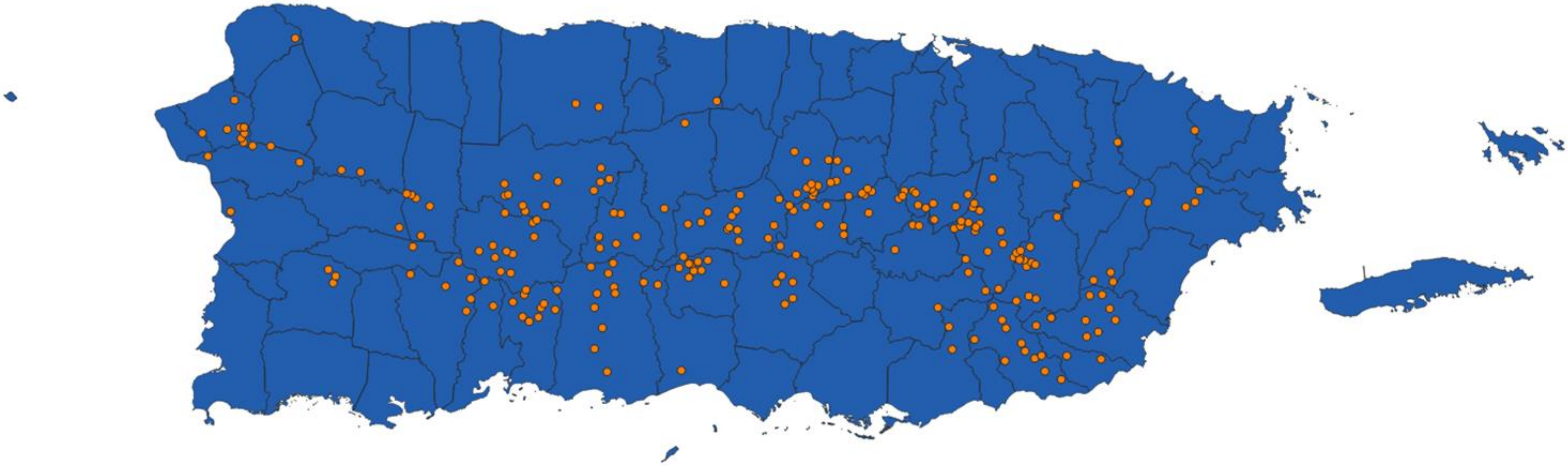
Critical Microgrids for Puerto Rico:
Plus 11 City Squares of Coastal Municipalities
(no power for more than 56 days after Hurricane María)



M. Castro-Sitiriche, "Boricua Microgrids for Energy Justice", PR100 Project March 30, 2023.
Source: https://gis.pr.gov/

Critical Microgrids for Puerto Rico:

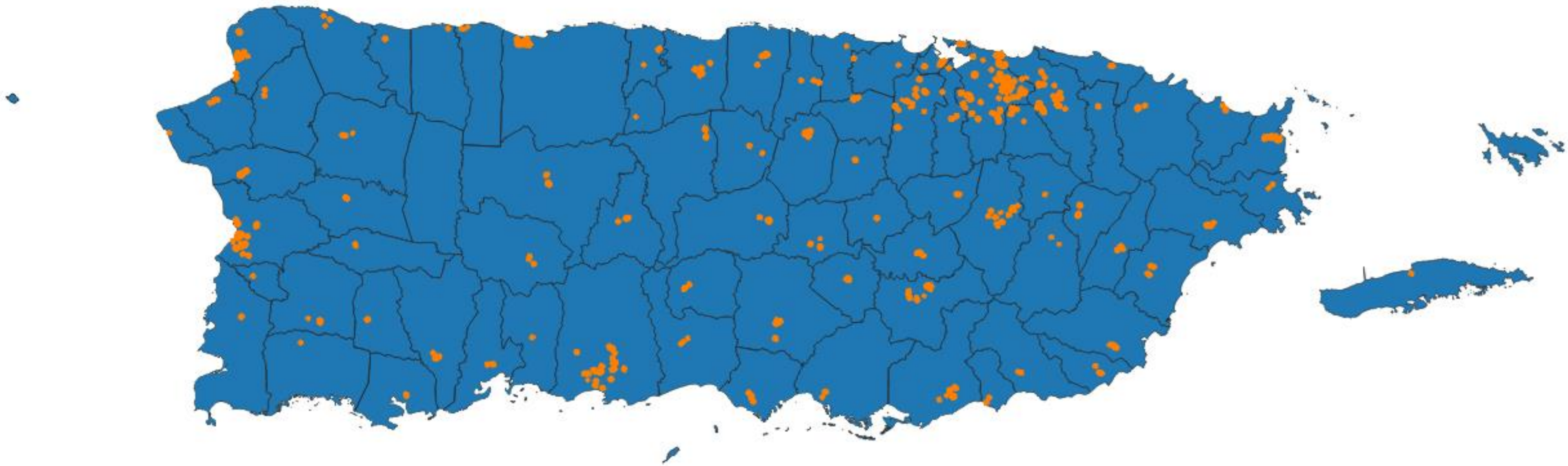
242 Non-PRASA Community Water Systems



M. Castro-Sitiriche, “Boricua Microgrids for Energy Justice”, PR100 Project March 30, 2023.
Source: https://cdbg-dr.pr.gov/wcrp/tools-social-maps.html

Critical Microgrids for Puerto Rico:

325 Public Housing Projects



M. Castro-Sitiriche, “Boricua Microgrids for Energy Justice”, PR100 Project March 30, 2023.
Source: https://gis.pr.gov/

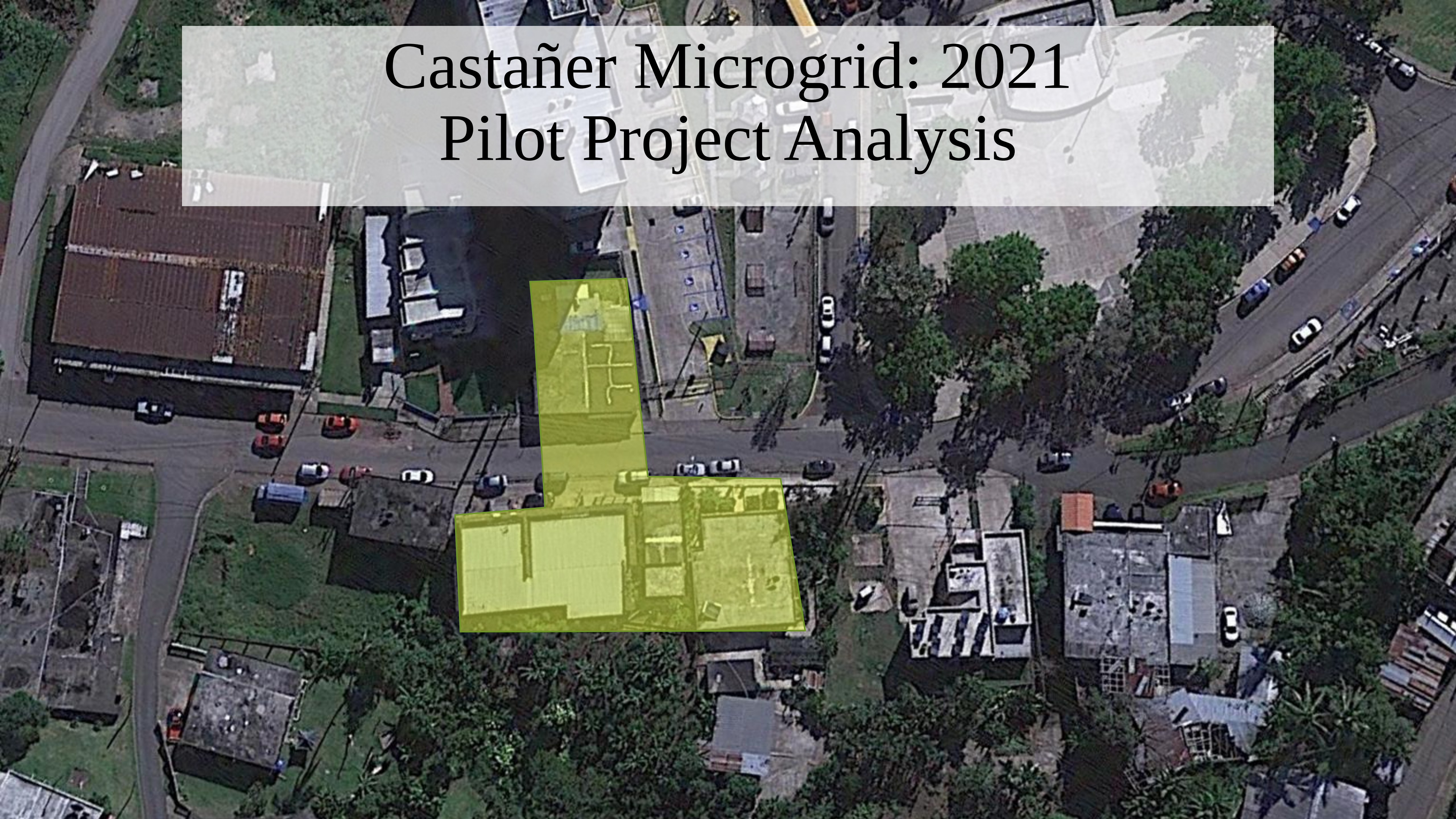
UPRM Power Community Engagement:

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




Castañer, Lares
Noviembre, 2020
Foto: marcel

Photo Credit: Cooperativa Hidroeléctrica de la Montaña
https://www.eesi.org/articles/view/microgrids-in-puerto-rico-keep-rural-communities-connected

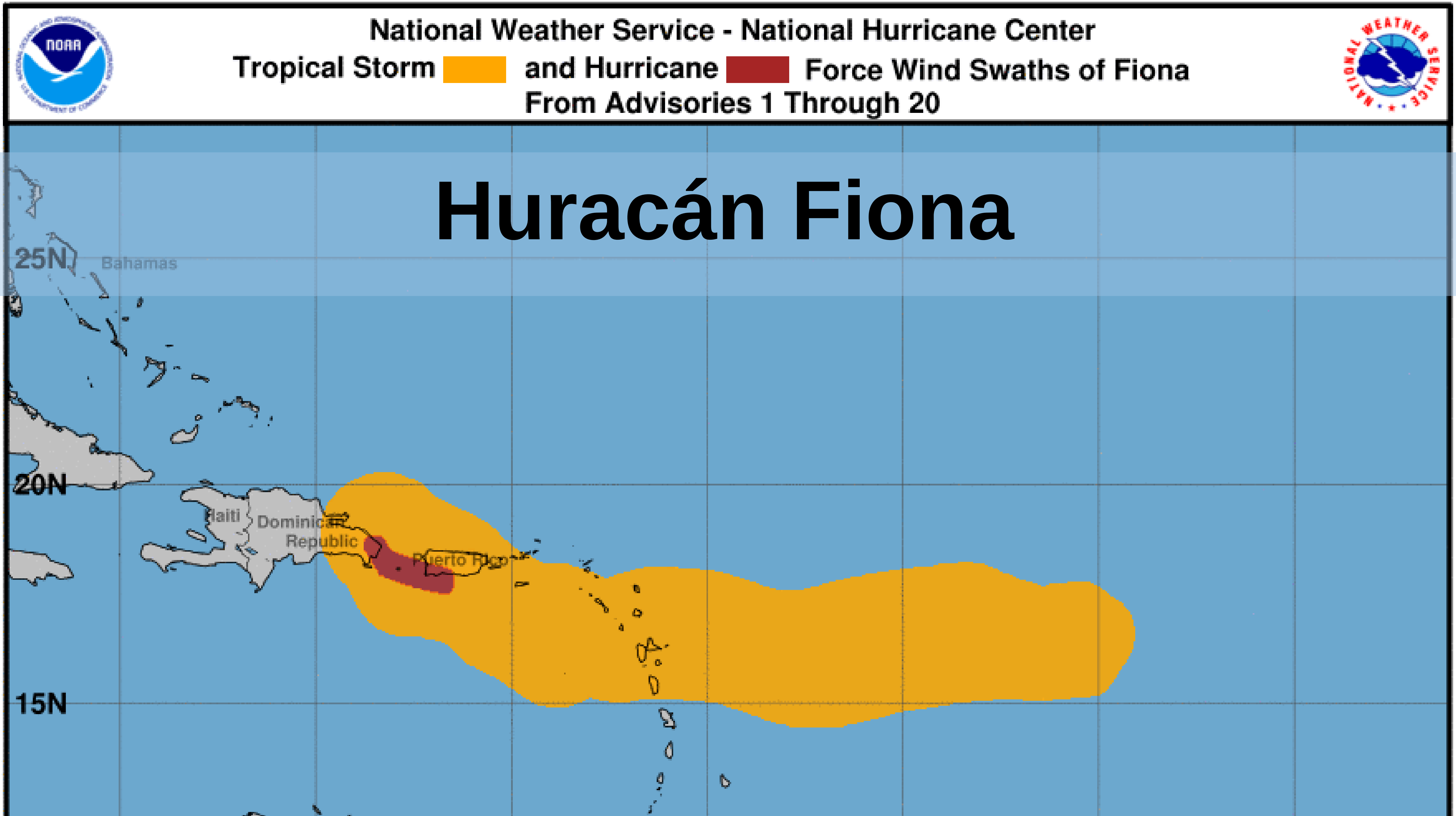
Castañer Microgrid Cooperative: Lessons Learned

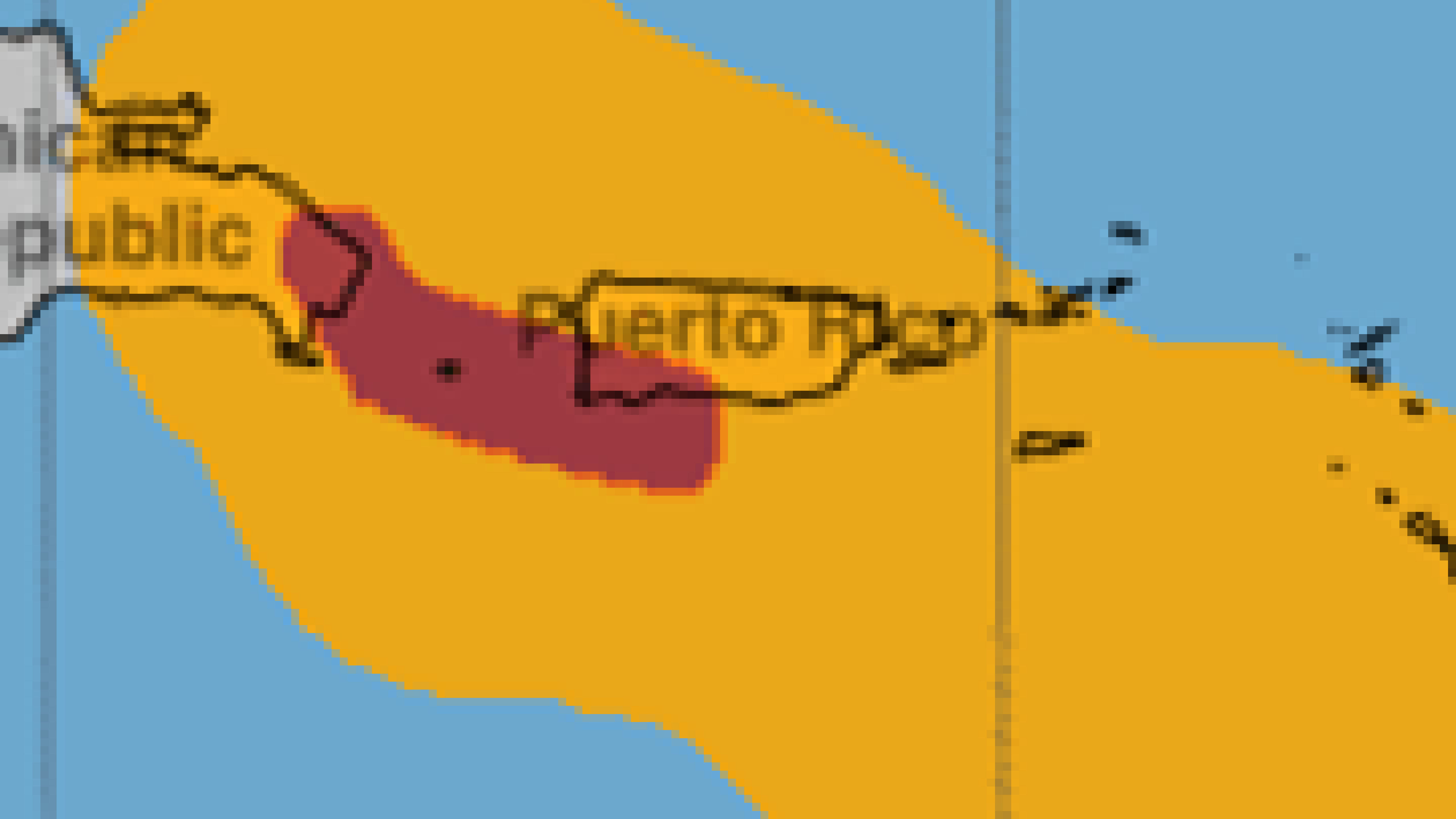
Photographer: Alejandro Granadillo/Bloomberg, https://www.bloomberg.com/news/features/2022-12-12/how-a-solar-microgrid-became-a-town-s-lifeline-in-blackout-prone-puerto-rico

Hurricane Fiona

September 2022

Huracán Fiona




public
Puerto Rico

VIGILANCIA

DE FATALIDADES ASOCIADAS AL HURACÁN FIONA

44 deaths:
Category 1 Hurricane Impact in Southwest.

*UNO POR ADJUDICAR.

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

Energy Injustice: Disregard to the last 10% of customers with service restored in each region

El 24 de septiembre (una semana):
33% de hospitales sin luz
Gran mayoría de muertes NO son de municipios más afectados

Casos Fatales asociados al Huracán Fiona

En total se han registrado 16 casos fatales, los cuales se desglosan de la siguiente forma:

Confirmados = 4

- Muerte directa = 1
- Muerte indirecta= 3

Bajo investigación = 12

Edad - Género - Región - Fecha
65 - M - Ponce - 09/18/2022
50 - F - Fajardo - 09/18/2022
52 - M- Caguas - 09/17/2022
70- M - Arecibo - 09/19/2022
89 - M - Metro - 09/19/2022
58 - M - Bayamón - 09/19/022
74 - F - Caguas - 09/19/2022
64 - M - Metro - 09/18/2022
77 - M - Fajardo - 09/17/2022
50 - M - Mayagüez - 09/18/2022
56 - M - Caguas - 09/22/2022
77 - M - Arecibo - 09/20/2022
89 - F - Aguadilla - 09/20/2022
N/A - M - Bayamón - 09/212/2022

Status Hospitales

67% de Hospitales y CDTs con energía eléctrica .

Clínicas y Operaciones Electivas reanudarán en el día de mañana, miércoles, 21 de septiembre en:

- Centro Médico
- Hospital Universitario de Adultos
- Hospital Pediátrico

Centro Cardiovacular de Puerto Rico y del Caribe
Reanudaron las cirugías, procedimientos y pre-adminisiones desde el martes, 20 de septiembre.

Actualización:
9/24/2022 11:00 PM

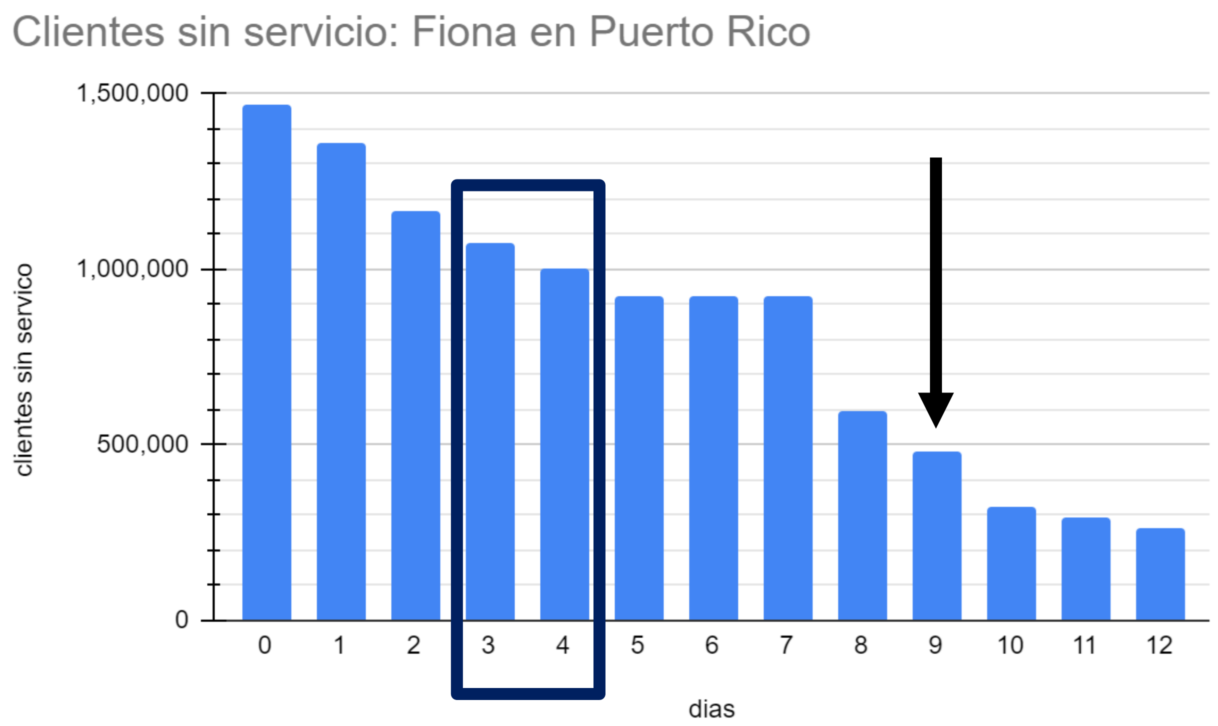
Dept. de Salud

https://twitter.com/marceljcastro/status/1574034401956012032

LUMA Energy y el gobierno prometen que “gran parte” de Puerto Rico tendrá luz entre hoy y mañana

En las zonas sur, suroeste y central, el restablecimiento demoraría “un poco más” por los daños en la red

martes, 20 de septiembre de 2022 - 7:52 a.m. | Por Gerardo E. Alvarado León



Sources: https://www.elnuevodia.com/noticias/locales/notas/luma-energy-y-el-gobierno-prometen-que-gran-parte-de-puerto-rico-tendra-luz-entre-hoy-y-manana/
Situation Reports by the Office of Cybersecurity, Energy Security, and Emergency Response: https://www.energy.gov/ceser/hurricane-fiona-situation-reports

Hurricane Fiona: Workforce

Response to Hurricane Fiona in 2022

En Florida: 44,000 trabajadores de 33 estados + DC

Electricity Sector Summary

- There are an estimated 33,000 customer outages in Florida as of 10 AM EDT, October 10, down from a peak of 2.7 million customers without power from the storm. Outages in Florida are down 99% from the peak on September 29.
- Restoration efforts continue in the hardest hit areas. At this some, some power outages are not related to impacts from Hurricane Ian.
- At the peak, more than 44,000 workers from 33 states and the District of Columbia were supporting power restorations.

https://twitter.com/DOE_CESER/status/1578769760891723777

En Puerto Rico habían aproximadamente:

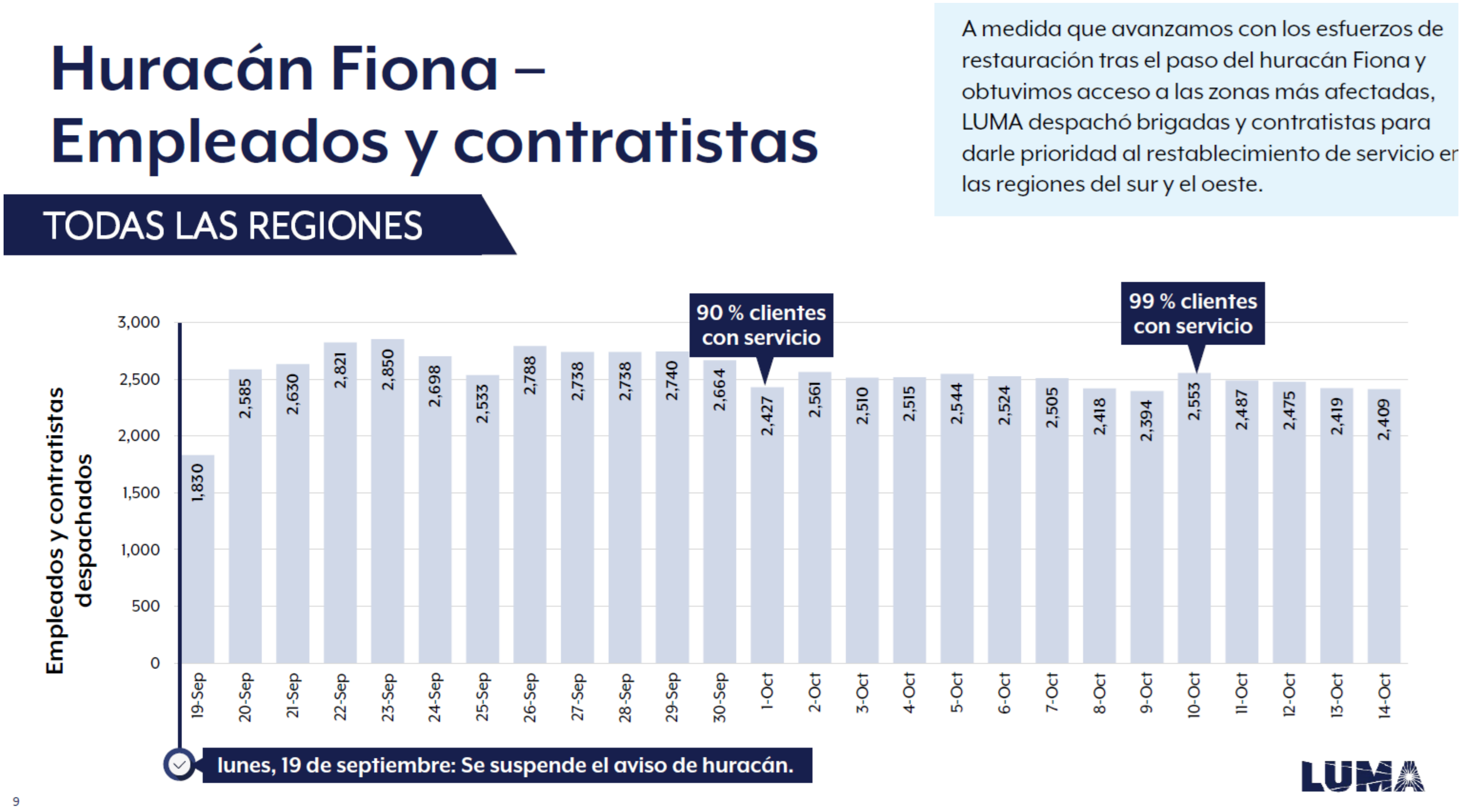
- 11,000 trabajadores en 1998 para Huracán Georges
- 5,000 trabajadores en 2017 para Huracán Maria
- 3,000 trabajadores en 2022 para Huracán Fiona

Luma promete 5,000 trabajadores adicionales de ser necesario luego de Fiona

El presidente y principal oficial ejecutivo de Quanta, Duke Austin, aseguró en declaraciones escritas que "los recursos de la empresa están a la disposición de LUMA". El principal ejecutivo indicó además que, de ser necesario, "podrá añadir al equipo local de LUMA más de 5,000 trabajadores especializados en coordinación con la Hermandad Internacional de Trabajadores Eléctricos (IBEW, por sus siglas en inglés) para restaurar la energía tras los impactos de la tormenta tropical Fiona".

El Vocero, 18 de septeimbre de 2022, antes del paso de Fiona - https://www.elvocero.com/gobierno/agencias/sin-brindar-datos-concretos-luma-y-quanta-anuncian-que-atienden-aver-as-ante-el-paso/article_c33a9522-374c-11ed-afe3-d72dafded8f3.html

Nunca Sumaron 3,000 en total



https://lumapr.com/resumen-de-la-respuesta-y-la-restauracion-tras-el-huracan-fiona/

Luma trae menos de 300 celadores de Quanta para trabajar en la reconstrucción luego de Fiona

Huracán Fiona

RECURSOS DESPACHADOS

- **2,500+** trabajadores de campo
- **2,500+** vehículos
- **7** helicópteros
- Centro de Operaciones de Emergencias de LUMA **24/7**, según la Estructura de Comando de Incidentes
- **6** centros de operaciones regionales
- **$130 millones** en inventario disponible para operaciones de respuesta a emergencias

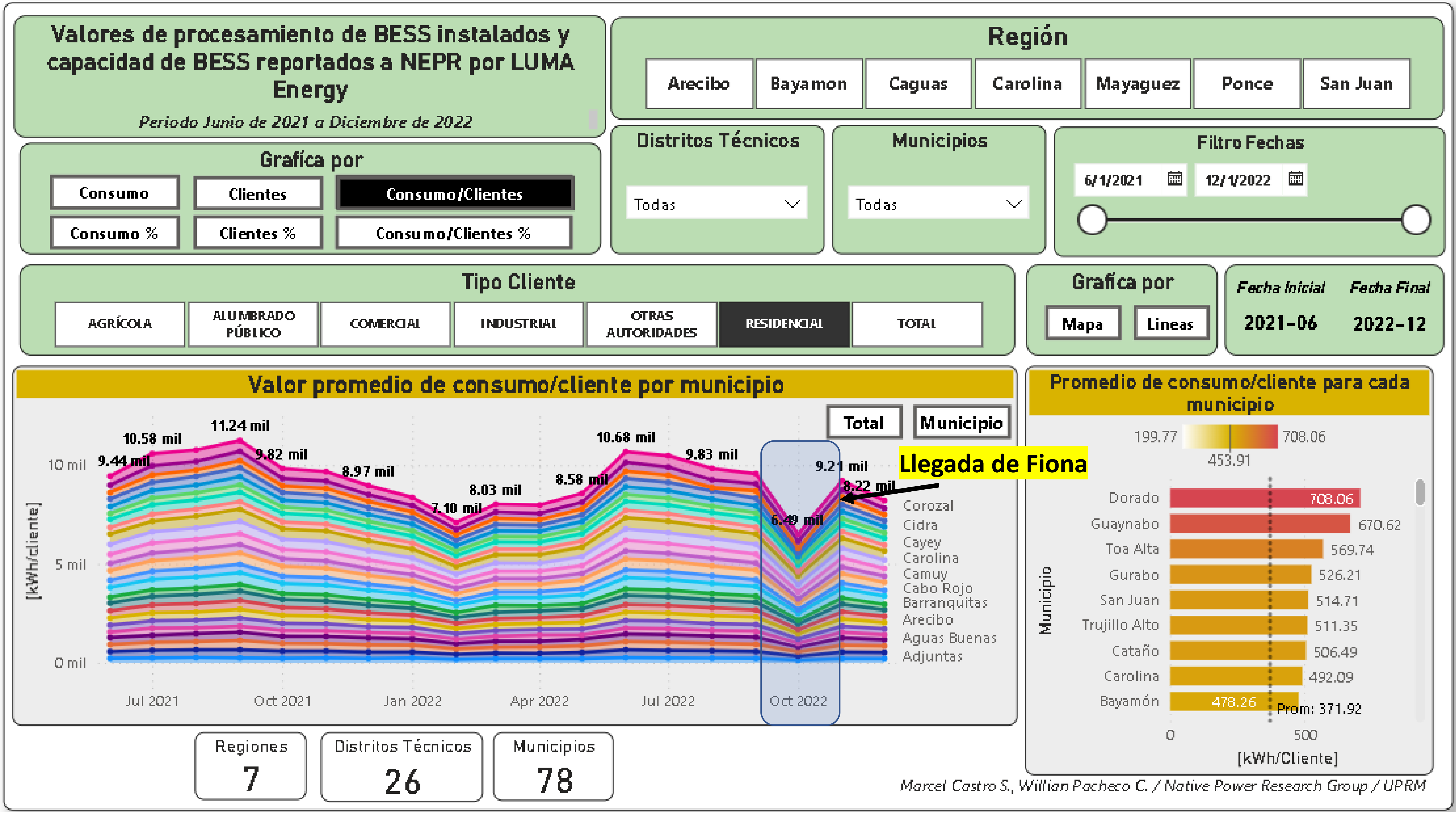
LUMA preposicionó brigadas, vehículos y equipos antes de que el huracán Fiona tocara tierra.

Movilización de Quanta Services

221	56	22
trabajadores de servicios públicos	camiones canasto	excavadoras

8

https://lumapr.com/resumen-de-la-respuesta-y-la-restauracion-tras-el-huracan-fiona/


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
Gráfica 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
Total
Municipio
Llegada de Fiona
[kWh/cliente]
10 mil
5 mil
0 mil
9.44 mil
10.58 mil
11.24 mil
9.82 mil
8.97 mil
7.10 mil
8.03 mil
8.58 mil
10.68 mil
9.83 mil
6.49 mil
9.21 mil
8.22 mil
Corozal
Cidra
Cayey
Carolina
Camuy
Cabo Rojo
Barranquitas
Arecibo
Aguas Buenas
Adjuntas
Jul 2021
Oct 2021
Jan 2022
Apr 2022
Jul 2022
Oct 2022
Promedio de consumo/cliente para cada municipio
199.77
453.91
708.06
Municipio
Dorado 708.06
Guaynabo 670.62
Toa Alta 569.74
Gurabo 526.21
San Juan 514.71
Trujillo Alto 511.35
Cataño 506.49
Carolina 492.09
Bayamón 478.26
Prom: 371.92
0
500
[kWh/Cliente]
Regiones
7
Distritos Técnicos
26
Municipios
78
Marcel Castro S., Willian Pacheco C. / Native Power Research Group / UPRM

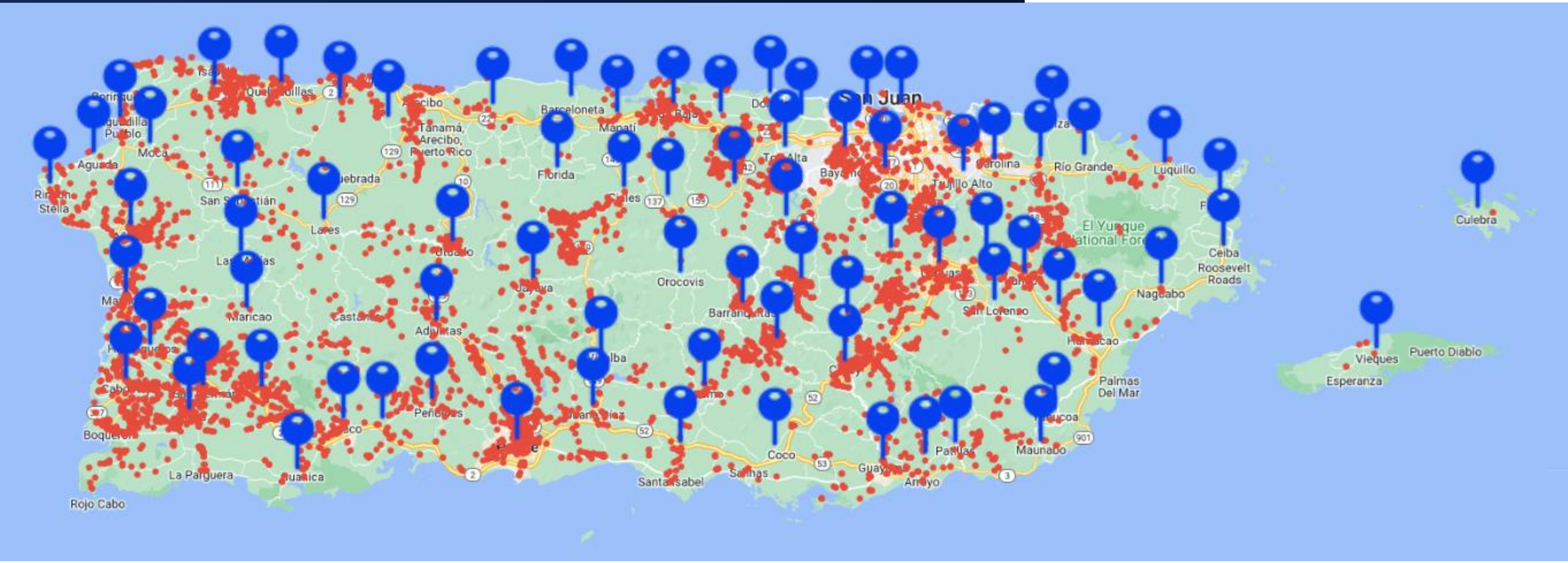
LUMA

RESIDENTIAL COMMERCIAL SUPPLIERS INDUSTRIAL OTHER GROUPS

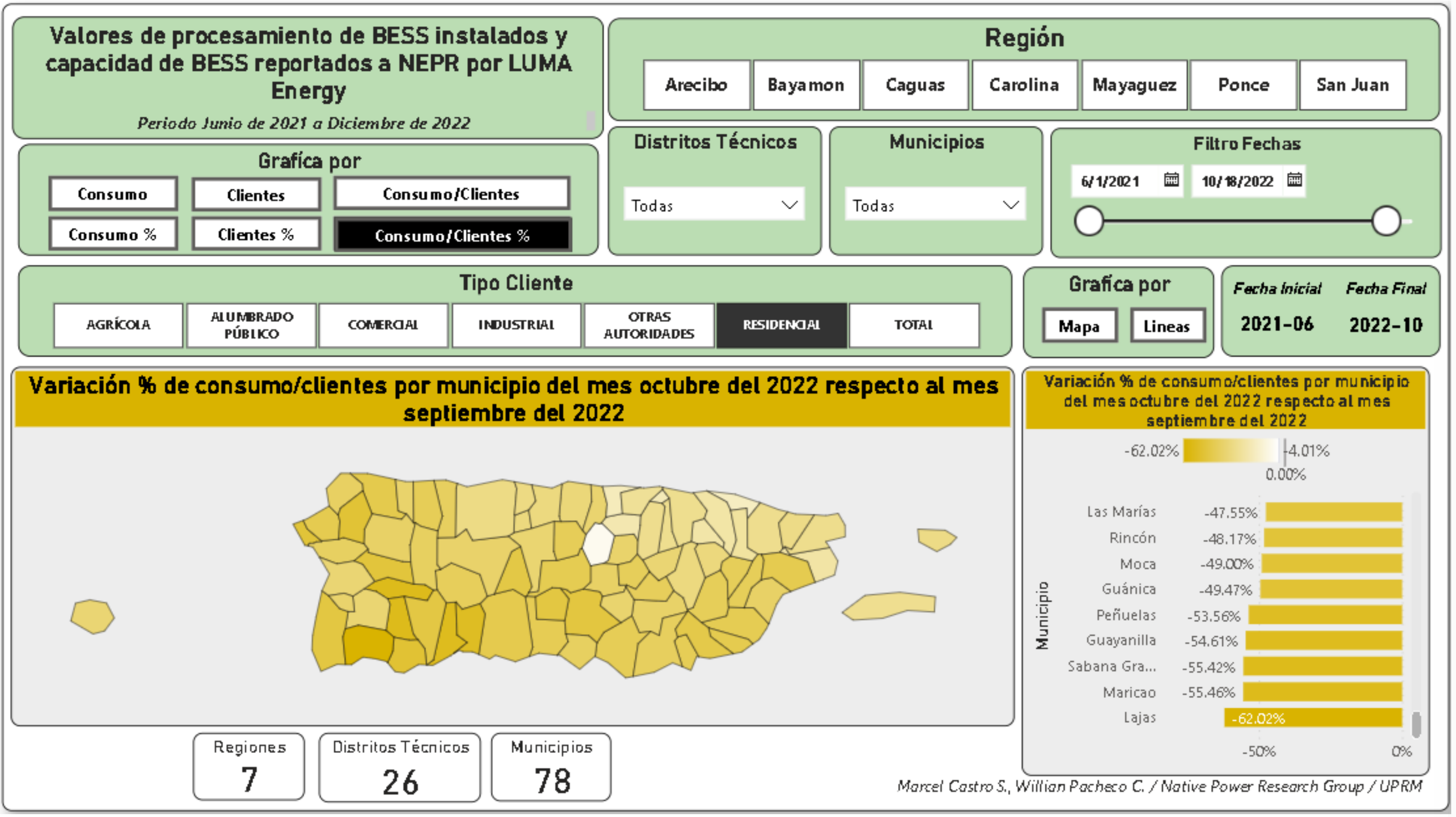
OUR OFFICES ABOUT LUMA

Hurricane Fiona Damage Map

Hurricane Fiona was a serious category 1 hurricane that brought winds reaching over 100 miles per hour and over 30 inches of rain that caused severe floods, mudslides and washed-out roads and bridges across Puerto Rico – resulting in more than $4 billion in damage to critical electric infrastructure. Below find an interactive map detailing the locations and examples of the damage to the island's distribution system that LUMA and our partners are working to repair.



Source - https://lumapr.com/fiona/?lang=en



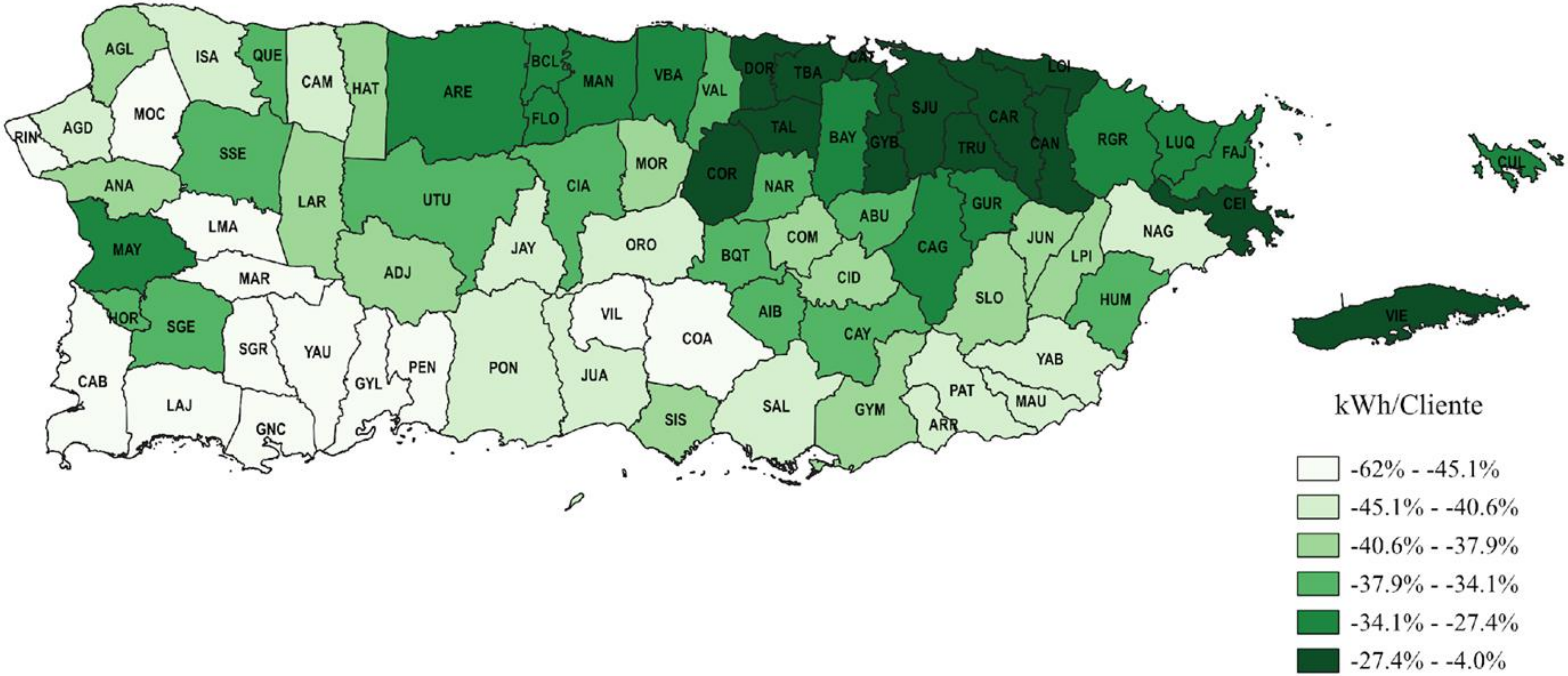
La variación de consumo por cliente entre los meses de octubre a septiembre de 2022 se encuentra entre el -15% y -62% para el 99% de los municipios.

Willian Pacheco, Marcel Castro, Native Power Research Group, UPRM - agosto/2023

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%
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%

PORCENTAJE DE CAMBIO MES DE OCTUBRE 2022

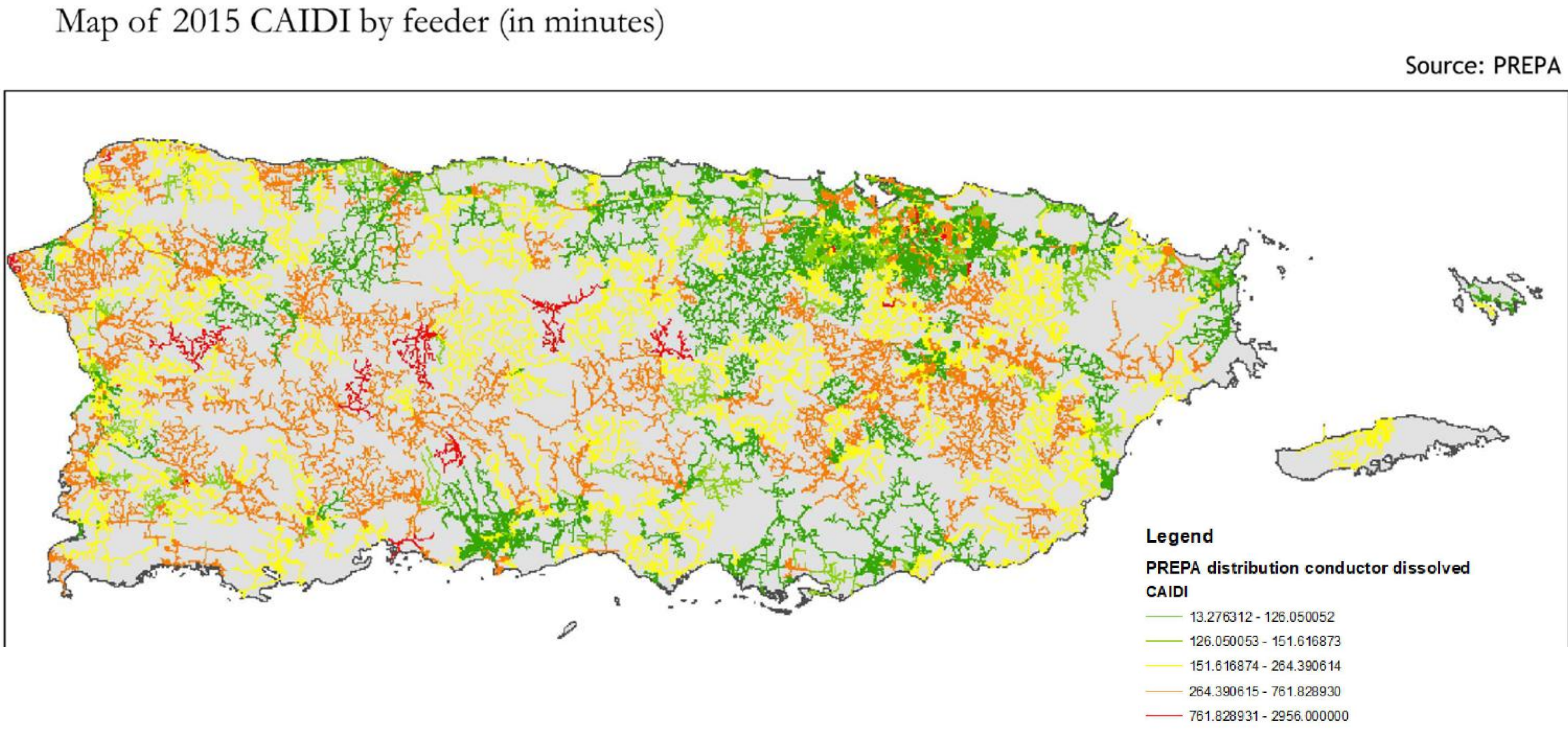
Municipios de Puerto Rico



Carlos Peña, Graduate Student, Native Power Research Group. Source: Negociado de Energía de Puerto Rico (NEPR) https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/

Resiliency (in)Justice

Reliability (in)Justice



Jeffers, Robert Fredric, DeRosa, Sean, Byrne, Raymond H., and Baca, Michael J.. *Siting of Microgrids in Puerto Rico to Improve Community Resilience.*. United States: N. p., 2018. Web.

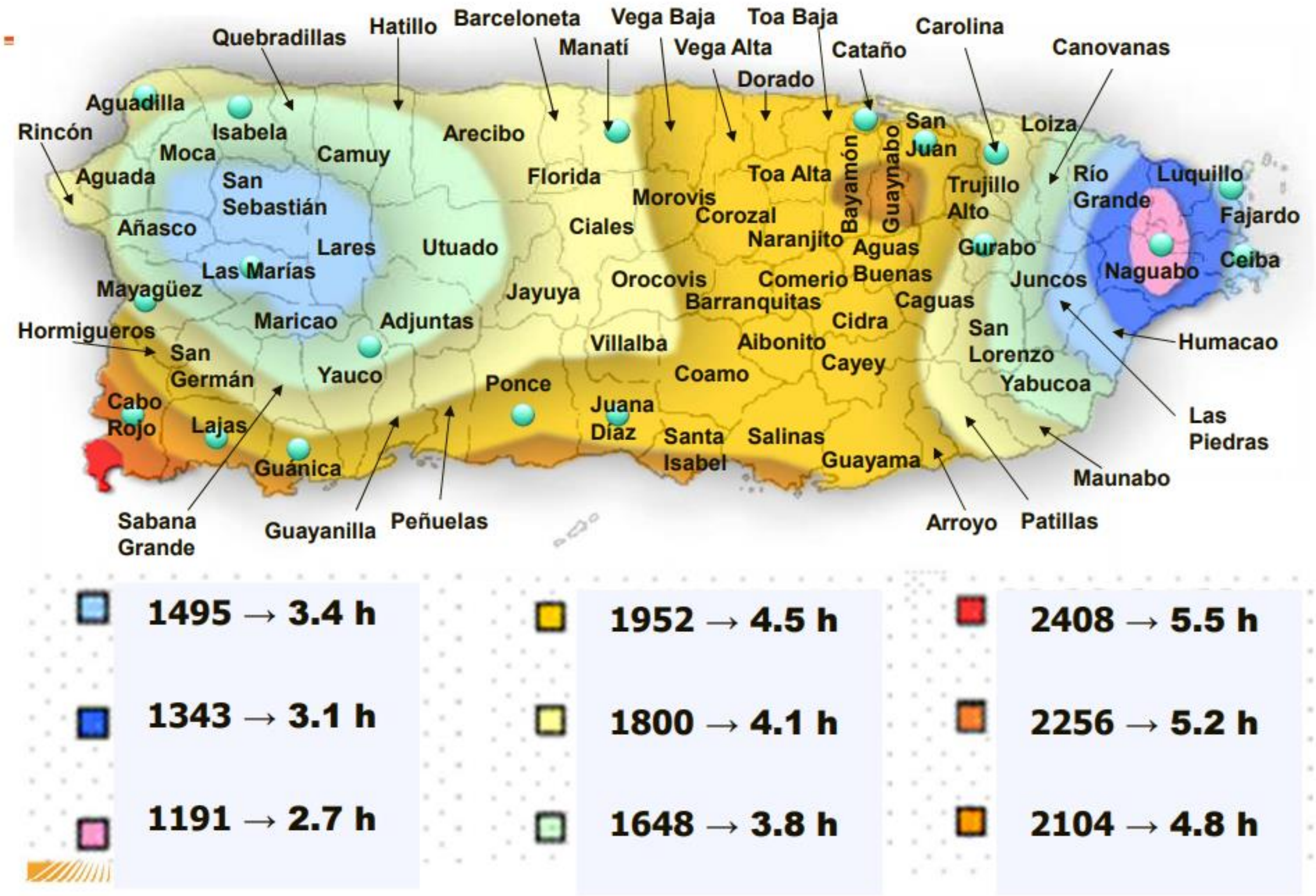
Cost

Ejemplo: $21,000 de costo capital

5.5 kW PV (capacidad) + 28.8 kWh almacenamiento

$3.85 / W instalado con net metering

Estimated average insolation in Puerto Rico, kWh/m² per year



Fuente - http://prsolar.ece.uprm.edu/docs/PV-Summit-October-30-2012.pdf lámina 77

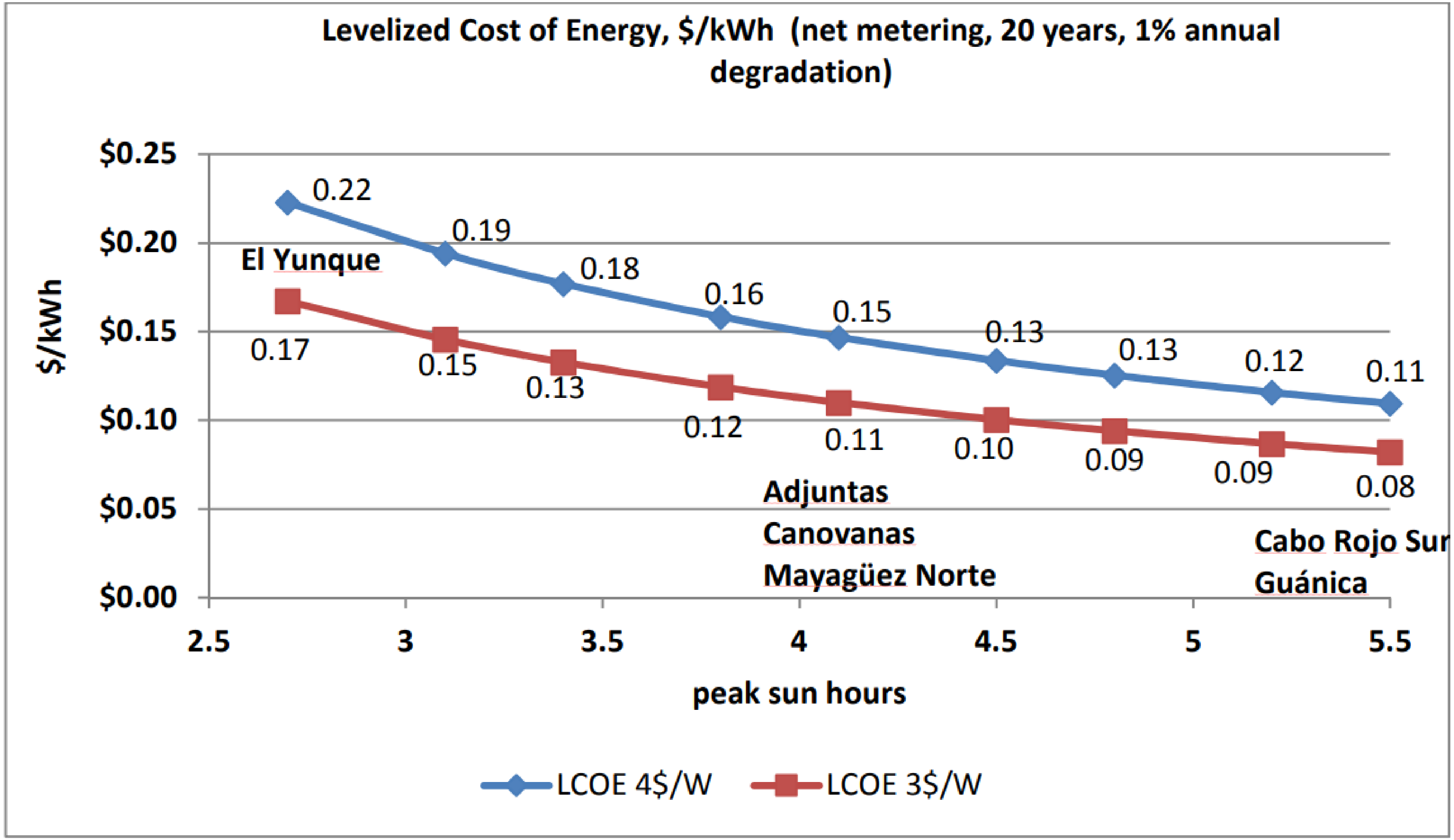


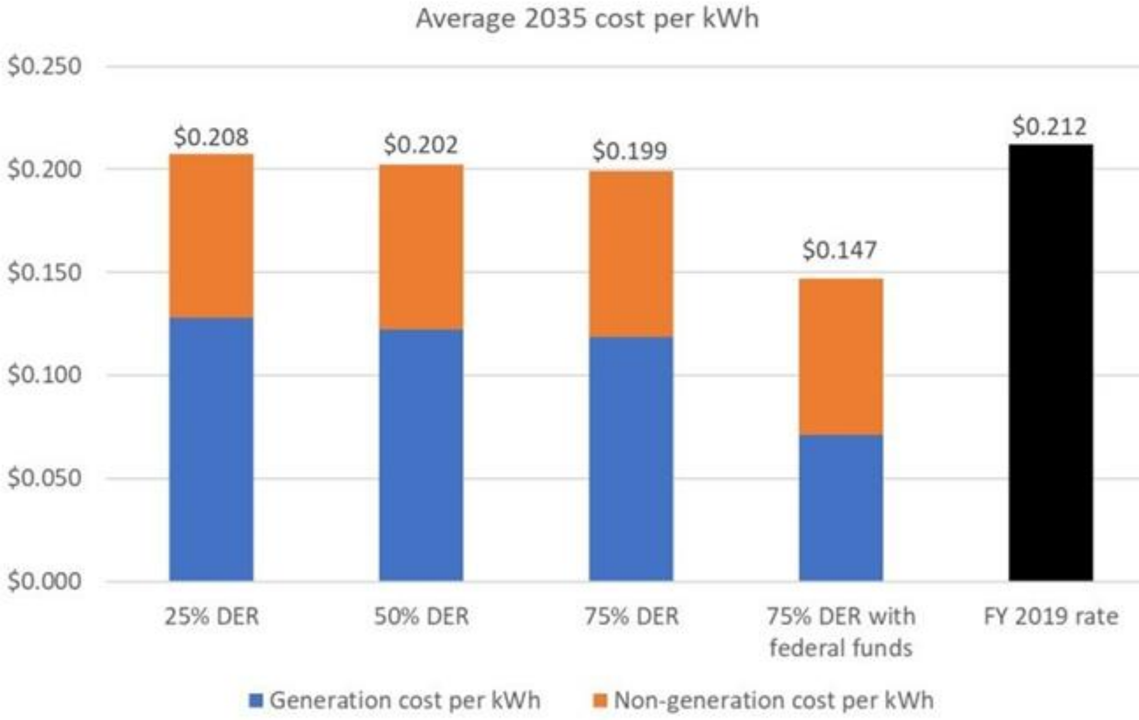
Figure 3.3: Levelized Cost of Energy (LCE), in $/kWh, at different sites in Puerto Rico as a function of peak sun hours.

BOOK: Improved Permitting and Interconnection Processes for Rooftop PV Systems in Puerto Rico

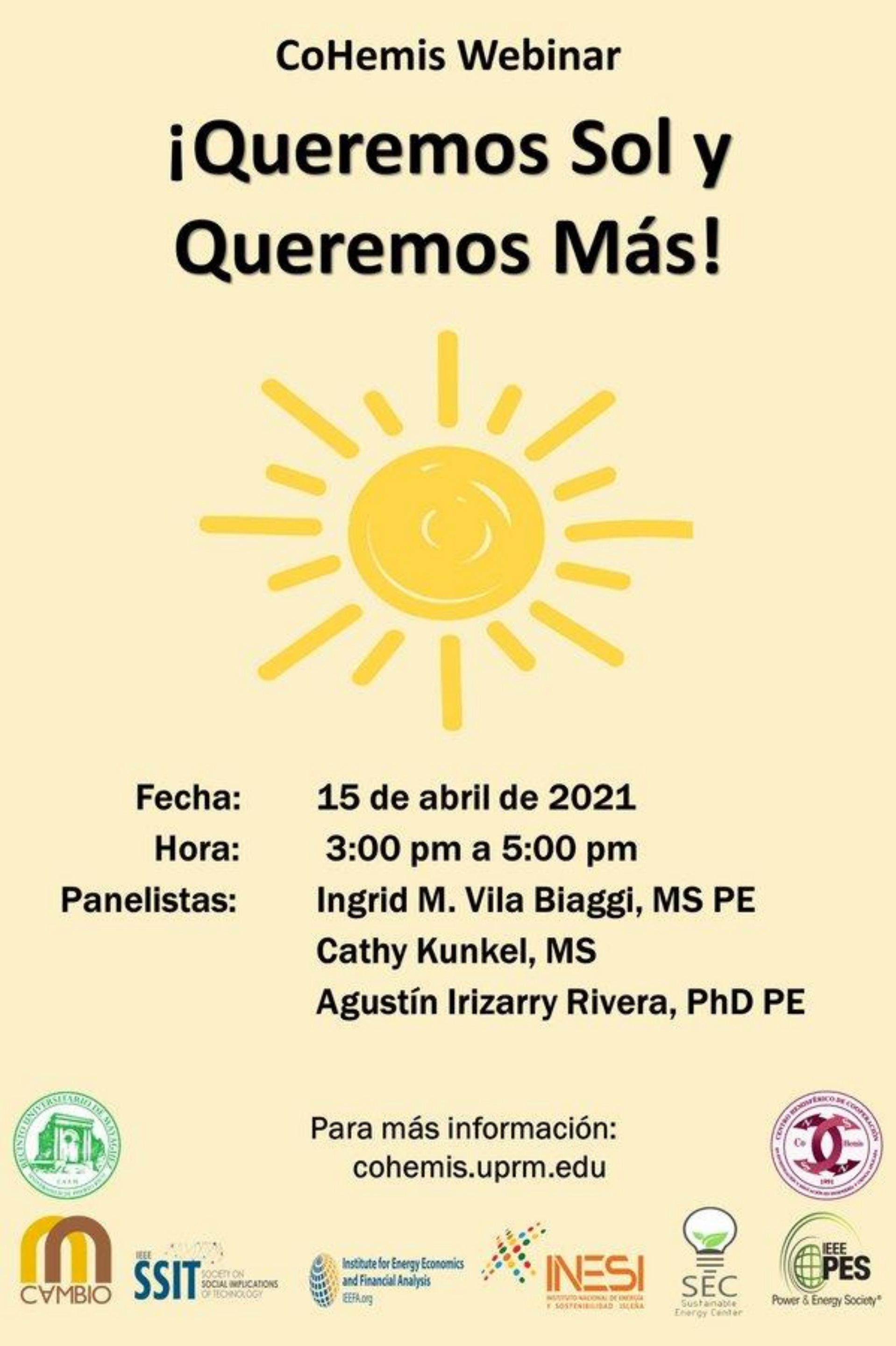
http://prsolar.ece.uprm.edu/resources.html

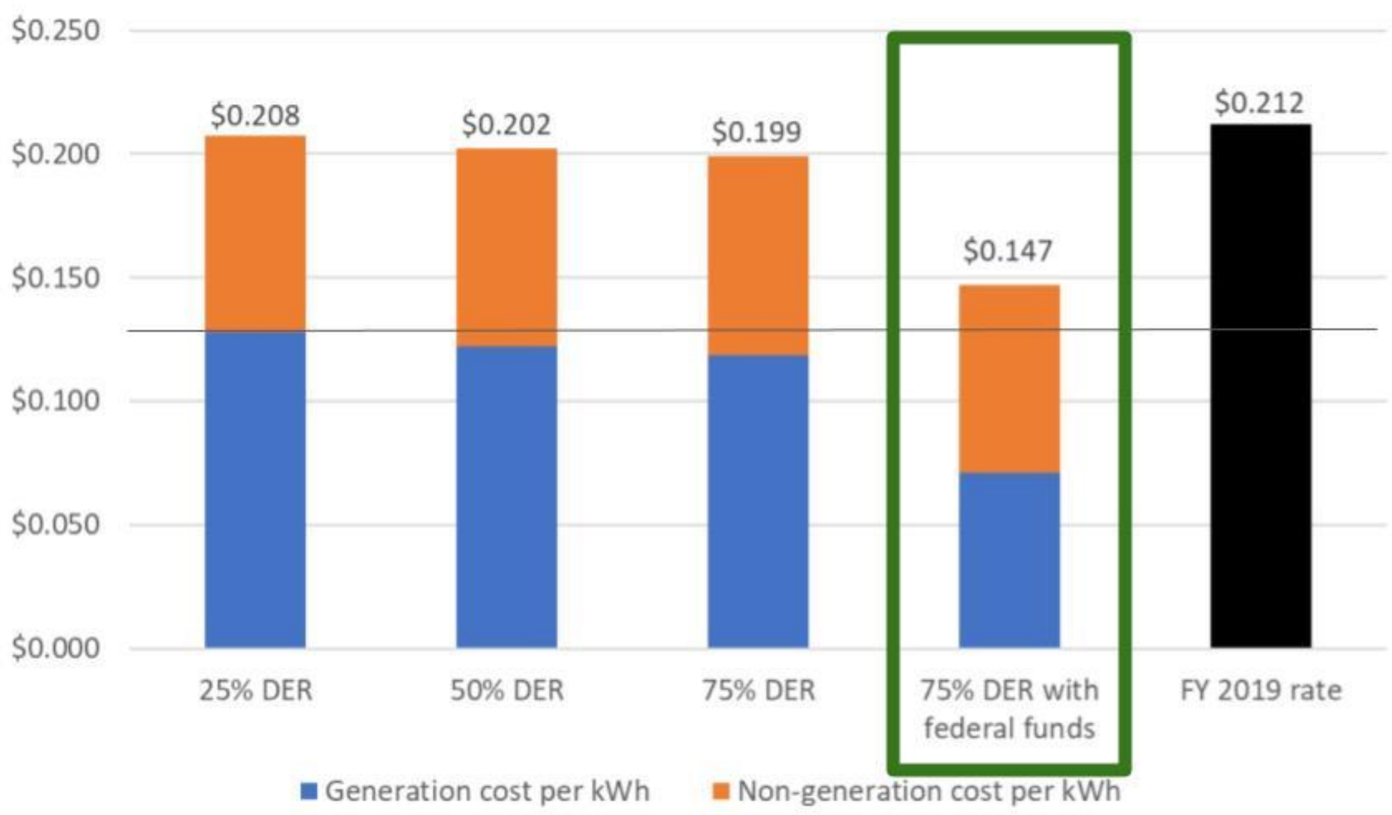
Costos del sistema al 2035

- Escenario final 75% incluye $9,650 millones en fondos federales
  - $9,000 millones para solar y baterías y $650 en mejoras al sistema de distribución
  - FEMA 404 y 428, fondos HUD para reconstrucción de la red
- Escenarios reflejan el costo promedio del sistema. El estudio no propone una estructura tarifaria.



✓ No incluye pagos por concepto de deuda u otros pagos como pensiones.





http://cohemis.uprm.edu/sol2021/

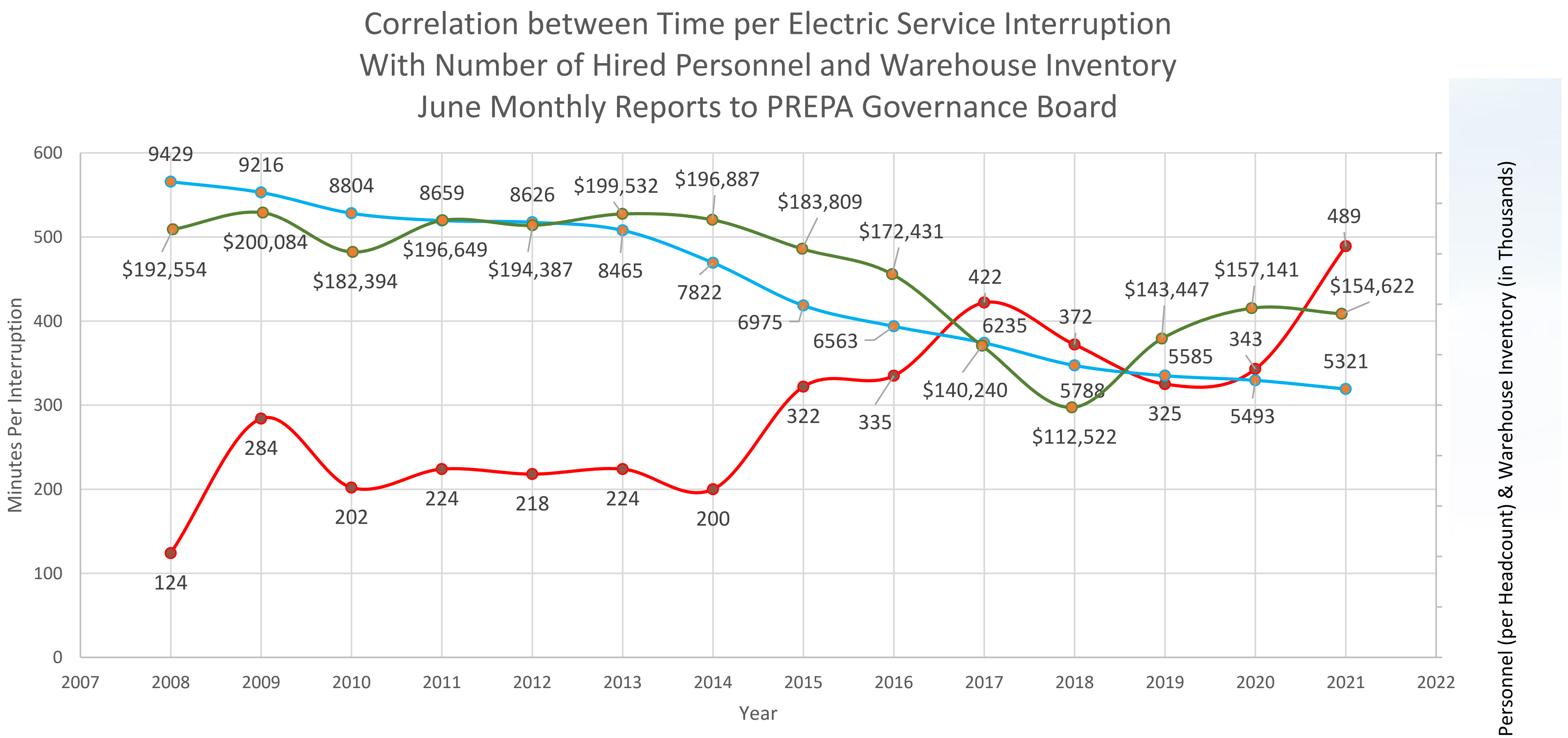
https://twitter.com/marceljcastro/status/1402582449113210884

Costo de Apagones

Ing. Robert García Cooper, EIT, MSEE

¿Cuál es el costo real de la falta de confiabilidad?

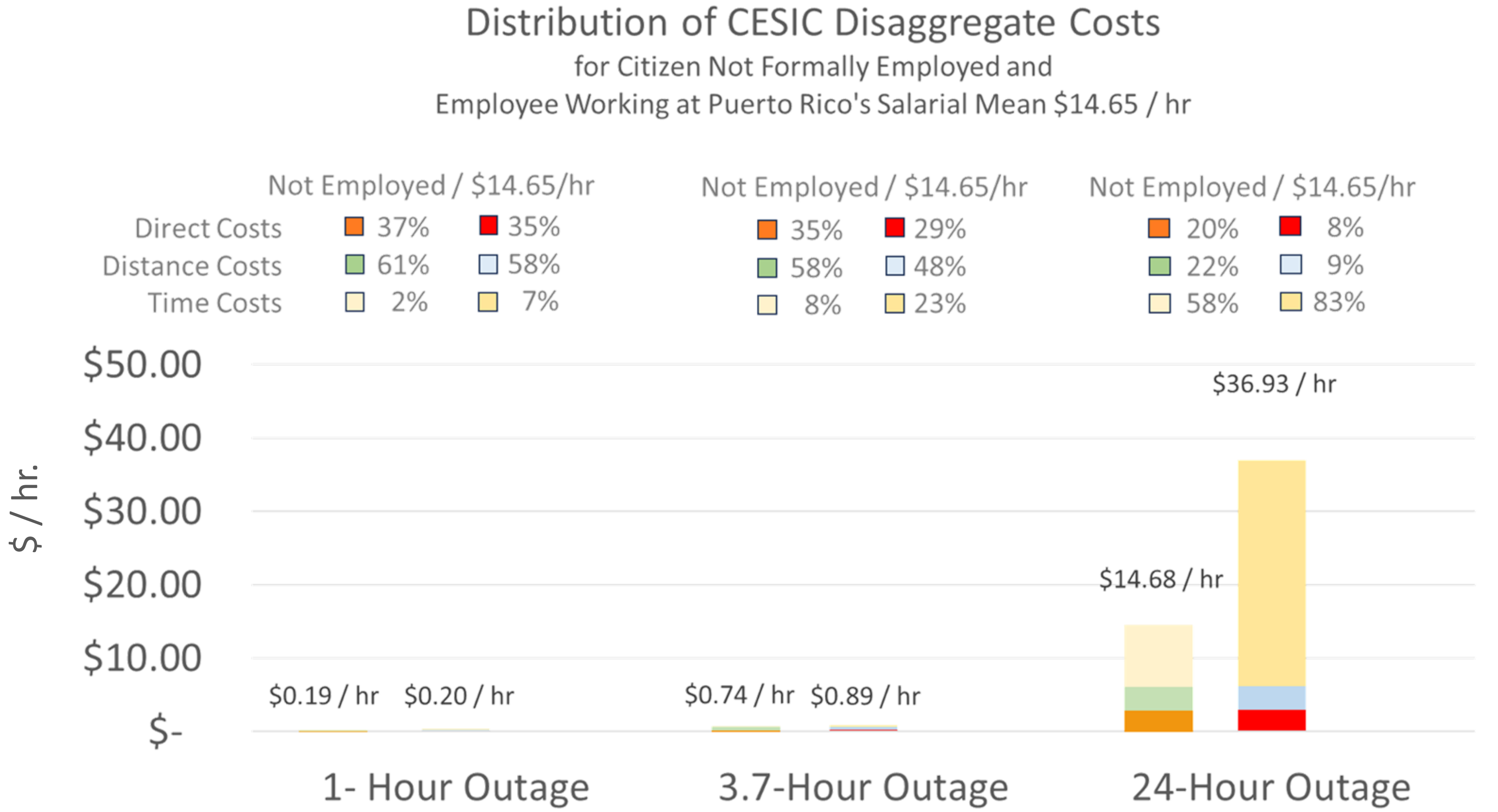
Imposed Austerity and Grid Unreliability



Return

Household CESIC

$$Total\ Cost = [Direct\ Costs + Distance\ Costs + Time\ costs + Subjective\ Value]$$



Ing. Robert García Cooper, Tesid de Maestría 2023, Departmento de Ingeniería Eléctrica y Computadoras, Recinto Universitario de Mayagüez, Universidad de Puerto Rico.

CESIC
Expanded Equation

$$C_{T_i}(j) = \left[C_{D_i}(j) + C_{d_{DR_i}}(j) + t_{TR_i} T_{WMV_O}(j) + V_{I_i}(j) \right]$$

C_{D_i}	=	Direct cost corresponding to the lost service or good i to be replaced or forgone
$C_{d_{DR_i}}$	=	Distance cost to replace an energy service corresponding to service i
t_{TR_i}	=	Time in hours taken to replace energy service corresponding to service i
$T_{WMV_O}(j)$	=	Weighted market value of household member’s time per occupation as a function of j
$V_{I_i}(j)$	=	Intangible subjective value corresponding to service i as a function of j
i	=	Service to be replaced or forgone
j	=	Number of hours of outage or outage time, from 0 to 24. Above 24 hours, the value of j = 24.

…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