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GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: PUERTO RICO ELECTRIC POWER AUTHORITY INTEGRATED RESOURCE PLAN

CASE NO. CEPR-AP-2018-0001

SUBJECT: MOTION TO SUBMIT EXPERT TESTIMONY

LOCAL ENVIRONMENTAL ORGANIZATIONS' MOTION TO SUBMIT EXPERT TESTIMONY

TO THE HONORABLE PUERTO RICO ENERGY BUREAU:

COME NOW, Local Environmental Organizations[1], by and through their legal counsel, to respectfully set forth and pray:

1. Submission of this motion with four written expert testimonies of:

   A. Agustín Irizarry-Rivera, *Professor at the University of Puerto Rico Mayagüez Campus (UPRM)*
   B. Anna Sommer, *Principal of Energy Futures Group (EFG)*
   C. Daniel Gutman, *Scientist and Consultant*
   D. Ronny Sandoval, *President of ROS Energy Strategies, LLC*

RESPECTFULLY SUBMITTED, on October 23, 2019.

s/Raghu Murthy
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CERTIFICATE OF SERVICE

We hereby certify that, on October 23rd, 2019, we have filed this Motion via the Energy Bureau's online filing system, and sent to the Puerto Rico Energy Bureau Clerk and legal counsel to: secretaria@energia.pr.gov; astrid.rodriguez@prepa.com; jorge.ruiz@prepa.com; n-vazquez@aeepr.com; c-aquino@prepa.com and to the following persons:

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GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: **Review of the Puerto Rico Electric Power** Authority Integrated Resource Plan	CASE NO.: CEPR-AP-2018-0001

EXPERT TESTIMONY OF AGUSTÍN A. IRIZARRY-RIVERA

ON BEHALF OF LOCAL ENVIRONMENTAL ORGANIZATIONS

Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. -Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico, Inc.

I. Background and Qualifications

Q: Please state your name, position, and business address:

A: My name is Agustín Alexi Irizarry-Rivera. I am Professor in the Electrical and Computer Engineering (ECE) Department at the Universityof Puerto Rico Mayagüez Campus (UPRM, for its Spanish acronyms). My business address is Road 348, km. 9.9, PobladoRosario, San Germán, Puerto Rico, 00683.

Q: On whose behalf are you testifying in this proceeding?

A: I am testifying on behalf of the following organizations: ComitéDiálogoAmbiental, Inc., El Puente de Williamsburg, Inc.- Enlace de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club, Inc. and its Puerto Ricochapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico, Inc.

Q: Please summarize your qualifications and work experience.

A:I obtained my bachelor degree, Magna Cum Laude, at the Universityof Puerto Rico, Mayagüez Campus (UPRM) in 1988; a masters at the University of Michigan, Ann Arbor in 1990; and a Ph.D. at Iowa State University, Ames in 1996 all in electrical engineering. I have been a licensed professional engineer in Puerto Rico since 1991, and a member of the Institute of Electrical and Electronics Engineers(IEEE). Since 1997,I have been a Professor at the

Electrical and Computer Engineering (ECE) Department at UPRM where I teach graduate and undergraduate courses such as: Electric Systems Analysis, Fundamentals of Electric Power Systems, Power System Analysis, Electric Machines, Electrical Systems Design, Advanced Energy Conversion, Power Systems Dynamics and Control and Transmission and Distribution Systems Design.

I have been elected member of the Electrical and Computer Engineering Department Personnel Committee and the School of Engineering Personnel Committee in three occasions and have served as President of both Committees twice. I have been elected as Academic Senator to represent the School of Engineering in the Academic Senate. Additionally, I have served as Assistant Dean of Academic Affairs UPRM and Associate Director for Academic Affairs of the Electrical and Computer Engineering Department at UPRM.

I have conducted research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources in our energy portfolio. I had a research internship at Plataforma Solar de Almería, Tabernas, Spain from 2008 to 2009 to study concentrated solar thermal systems. I contributed to the development of dynamic models to simulate the interaction between these plants and the electric grid. I have served as aconsultant on renewable energy and energy efficiency projects to Puerto Rico's government agencies, municipalities, private developers, and consulting firms, both in and outside Puerto Rico. I have also served as an expert witness in civil court cases involving electric hazard, shock or electrocution.

I am an author or coauthor of over 50 refereed publications, including two book chapters (see complete list in the CV section), and have organized local and international conferences such as the Tenth International Conference on Probabilistic Methods Applied to Power Systems (PMAPS 2008) in Rincón, Puerto Rico. PMAPS Conferences provide a regular forum for engineers and scientists worldwide to interact around the common theme of power engineering decision problems under uncertainty.

I have also received several awards and honors: Distinguished Engineer 2013 from Puerto Rico's Professional Engineers Society (CIAPR) and Distinguished Electrical Engineer 2005 from the Electrical Engineering Institute of CIAPR in recognition of services rendered to the profession and outstanding professional achievements in electrical engineering, the 2009 Distinguished Alumni Award from UPRM Alumni Association, the 2004 Professional Progress in Engineering Award from Iowa State University, in recognition of outstanding professional progress and personal development in engineering as evidenced by significant contributions to the theory and practice of engineering, distinguished service rendered to the profession, appropriate community service, and/or achievement in a leadership position and the 2003-2004 ECE Outstanding Faculty Award from UPRM's School of Engineering.

In May 2012,I was elected, by the consumers, to the Board of Directors of the Puerto Rico Electric Power Authority, in the first election of this kind in Puerto

Rico, to represent the interests of consumers. I was President of the Board's Audit Committee and an active member of the Engineering and Infrastructure, Legal and Labor Affairs and Consumer's Affairs Committees. In 2013, Board Members elected me as Vice President of the Board and I served in this capacity until September 2014 when my term expired.

I am a member of the Board of Directors, in the Interest of Consumers, of PREPA Holdings, LLC, a company registered in Delaware, whose sole owner is PREPA. PREPA Holdings owns PREPANET a communications network infrastructure provider that uses an optical network platform in Puerto Rico to provide wholesale telecommunication services.

Q: Please summarize your testimony and key findings.

A:I have been asked to assess if the proposed Integrated Resource Plan (IRP) Developed by Siemens/PREPA for the Puerto Rico Electric Power Authority (PREPA) version 2 dated July 7, 2019, seriously considers the integration of distributed renewable energy on the currently operating systems and on future systems. My analysis considers: the need for electric energy itself;cost conditions leading to grid defection according to Siemens/PREPA and a revision of Siemens/PREPA assumptions on this matter; Siemens/PREPA recommendations and the fact that none of Siemens/PREPA "sensitivity analyses" to methane cost come close to the actual cost of delivered methane to Puerto Rico, all of them are too optimistic. The results and recommendations of the proposed IRP are all dependent of this incorrectly assumed fuel cost. I then compare electric energy cost from the Utility to electric energy cost of self-generation plus energy storage considering the reliability and resiliencyprovided by both systems. I also propose a plan to increase resiliency through the deployment of distributed renewable energy systemsincludingenergy storage using electric batteries.

My conclusions are:

1. The Levelized Cost pf Energy (LCOE) calculated using current Puerto Rico cost results in a LCOE, in 2019, of 7.8 ¢/kWh, almost half of the cost calculated by Siemens/PREPA of 15.3 ¢/kWh. By 2038, our LCOE calculation is about 1/5 of the cost calculated by Siemens/PREPA.
2. The 2019 LCOE of residential solar photovoltaic including storage, 21.6 ¢/kWh ac, is lower than residential cost of electricity from PREPA during September 2019 at 22 ¢/kWh ac.
3. None of Siemens'/PREPA's "sensitivity analyses" to methane cost come close to the actual cost of delivered methane to Puerto Rico, $12/MBTU, all of them are too optimistic. The results and recommendations of the proposed IRP are all dependent of the assumed fuel cost. This fact alone should require a new IRP.
4. Distributed self-generation was not seriously considered in Siemens'/PREPA' analysis. There is no explanation on why this option was not considered.
5. The analysis performed on the proposed IRP of distributed generation is one-dimensional; it only considers cost of electric supply. It does not incorporate reliability of service in the analysis.
6. The LCOE of residential solar photovoltaic with storage in 2019 is 21.6 ¢/kWh and should be 15.8 ¢/kWh by 2024 while the proposed Debt Restructuring

Agreement (RSA) transition charge plus grid investment shall produce a cost of 33.4 ¢/kWh.

7. Siemens/PREPA significantly underestimates the amount of distributed, customer-owned generation that will be integrated into the grid over the next two decades.
8. Siemens'/PREPA's Integrated Resource Plan should include plans to encourage and optimize distributed generation, because it adds much-needed reliability benefits to the grid.
9. The Restructuring Support Agreement's transition charges and sun taxes will encourage grid defection.

II. Electricity Usage

Q: Why do we use electricity? What alternatives do we have to supply our energy needs?

A:Electricity is never an end in itself; it has no intrinsic value except for what we *do* with electricity. Although electricity exists in nature[1] we do not collect electricity from nature.

[1] Lightning is natural but we do not have the means to collect its energy. Interatomic bonds are fundamental to our understanding of matter but we do not use these to generate electricity.

We convert primary energy sources into electricity to conveniently, efficiently, and economically transportenergy from generation sites to consumption sites. Primary energy sources are energy sources found in nature that have not been subjected to any human engineered conversion process. Examples are fuels such as: coal, oil, natural gas and biomass; as well as renewable energy sources such as: solar radiation, wind, ocean waves and elevated natural water reservoirs such as mountain lakes. At the consumption site, electricity is converted intolight, heat, motion, sound, etc.; it is never used as electricity itself.

If citizens[2] could get, from non-electric devices, equal or better services, with similar or better reliability at a lower cost, they are likely to abandon electricity.[3] Therefore, if citizens can obtain more reliable and more affordable electric service from distributed renewable energy sources than from PREPA's grid, then PREPA has an obligation to enable those distributed sources. The framework adopted by Siemens and PREPA to develop the proposed IRP fails to consider this essential element; today's citizensdo have technologically and economically viable alternatives to supply their own electricity.In the following sections of my testimony, I present an electric system centered on distributed renewable electric energy generationas an alternative to the proposed IRP. I compare electric energy cost from PREPA to the current electric energy cost of self-generation, using distributed renewable energy systems, plus energy storage. I also consider the reliability and resiliency provided by both systems and the economic and environmental effect of displacing fuel burning as the source of electric energy.

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[2] In the United States, the electric utility industry calls citizens "clients" or "rate payers."

[3] Furthermore, in Regulation 9021, Section 1.03 it is declared "The purpose of this Integrated Resource Plan is to allow Puerto Rico's citizens and businesses to obtain electric power services from the most reliable, resilient, efficient, and transparent sources available."

III. Distributed rooftop solar photovoltaic generation by citizens is cheaper than utility options, even with Siemens/PREPA's inaccurate and costly assumptions.

Q: What are "prosumers," and under PREPA's proposed IRP, is it feasible for service consumers to become prosumers?

A: The Puerto Rico Legislature has imposed a mandate on PREPA "to make it feasible for energy service consumers to become prosumers... ." Act 17-2019, Section 1.6(4). Prosumers are customers with "the capacity to generate electric power for self-consumption that, in turn, have the capacity to supply any energy surplus through the electric power grid." Act 17-2019, Section 1.2(r). Siemens/PREPA's Integrated Resource Plan does not meet this mandate; on the contrary it favors centralized generation and ignores the benefits of distributed renewable energy generation by the citizens of Puerto Rico. Instead Siemens/PREPA buries distributed, customer-owned renewable generation in Appendix 4 of the IRP.[4] Distributed, customer-owned generation is a cost effective resource that the citizens of Puerto Rico require to reliably and economically supply their electric energy needs.

In Section 3 of Appendix 4, Siemens/PREPA defines Distributed Generation as "customer installed generation that is behind the meter and owned by customers," which "reduces the load served by PREPA's owned or contracted generation resources." Thus, Siemens/PREPA expressly views the defining characteristic of

[4] Specifically, on Section 3 Distributed Generation (DG) of Appendix 4 Demand Side Resources.

citizens' ability to self-provide electric energy in terms of resulting lost sales to PREPA. Reliability of the energy supply, cost efficiency for the citizen, the ability to cope with severe weather events are all notably absent from this definition.

Q: Did Siemens/PREPA correctly state the cost of solar?

A:No. In Section 3 Appendix 4, Exhibit 3-14 "Residential Solar PV with net metering Levelized Cost of Energy (LCOE)[5] Calculations" Siemens/PREPA estimates capital expenditure costs of solar photovoltaic equipment in Puerto Rico from US data resulting in a very costly, and inaccurate, estimate of capital expenditure costs. It further assumes a costly financing structure and a pessimistic projection of cost reduction over the next 20 years.With these assumed costs for distributed residential photovoltaic Siemens/PREPA calculates a LCOE of $153/MWh in 2019, corresponding to 15.3 ¢/kWh ac. This almost double the correct LCOE calculated using 2019 actual costs of solar photovoltaic equipment and batteries in Puerto Rico.

Q: How did you correct the LCOE for distributed solar PV?

A:To evaluate the true potential for residential solar PV in Puerto Rico, I first had to correct Siemens/PREPA's significantly overstated LCOE. To calculate an accurate LCOE, I used actual costs of equipment and retail prices from quotes in Puerto Rico.[6] Instead of a costly financing structure through a developer, I applied

[5] Levelized Cost of Energy (LCOE) is a summary metric that combines the primary technology cost and performance parameters: Capital expenditure (CAPEX), operation and maintenance cost (O&M), and capacity factor.

[6]The 2019 cost of residential solar photovoltaic equipment (modules, string inverter, balanced of system structural and electrical) in Puerto Rico plus supply chain cost, financing, taxes, labor for installation, permitting and overhead is $2.37/W AC. These costs are very similar to the values reported in "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018," October 2018, a report from NREL. (NREL/PR-6A20-72133).

a financing model available to private citizens—a simple personal loan—and use NREL's ATB R&D[7] only cost (mid development) as a reasonable model of cost reduction over time.Figure 1 demonstrates that a corrected LCOE calculation, using actual market prices, a realistic financing model, and more reasonable cost forecasts, is much lower than the total LCOE generation cost estimated by Siemens/PREPA.

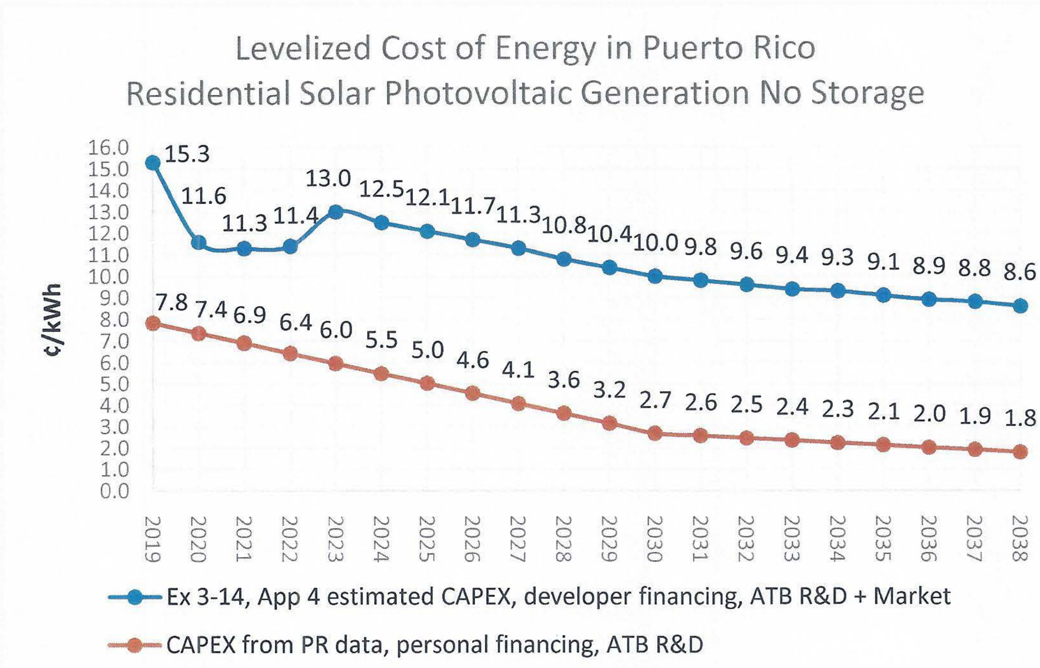

Figure 1. LCOE estimated by Siemens/PREPA as presented in Exhibit 3-14 Section 3, Appendix 4 of the proposed IRP.[8]

Note the significant difference in cost. The LCOE calculated using current Puerto Rico cost results in a LCOE of 7.8 ¢/kWh in 2019—roughly *half* the 15.3 ¢/kWh

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[7] National Renewable Energy Laboratory (NREL),*2019 Annual Technology Baseline*(2019), https://atb.nrel.gov/electricity/2019.

[8] Siemens/PREPA estimated capital expenditure cost using cost adders. It further assumes developer financing and use the ATB R&D plus Market model of cost reduction over time. I calculate the LCOE using Puerto Rico's equipment real costs, from quotes, personal loan financing, and ATB R&D only (mid development) model of cost reduction over time.

cost calculated by Siemens/PREPA. By 2038, my LCOE calculation is about 1/5 of the cost calculated by Siemens/PREPA.

Q: How does the price of utility scale solar PV generation compare to distributed PV generation?

A:Siemens'/PREPA's own analysis reveals that customer-owned, distributed photovoltaic generation is less expensive than utility-scale PV generation operated or contracted for by PREPA. In Exhibit 4-19, section 4 of the main document of the proposed IRP, Siemens/PREPA presents a power purchase and operating agreement (PPOA) starting in 2019 at a price of 15 ¢/kWh ac for utility scale solar photovoltaic generation. The preference for solar photovoltaic energy, at a cost to PREPA of 15 ¢/kWh ac at transmission level via PPOA a cost that will increase in time with escalators, makes no sense if Siemens/PREPA calculates a cost of 15.3 ¢/kWh ac at distribution level from residential rooftop solar photovoltaic.

Furthermore, to capture the full price that customers will be charged for utility-scale solar electricity generated and distributed by PREPA, several missing costs must be added to the 15 ¢/kWh ac at the PV array. These costs include, but are not limited to PREPA's Transmission and Distribution costs, debt servicing costs, administrative costs, and electric energylosses. Together, these costs are significantly higher than 0.3 ¢/kWh ac, more than wiping out any supposed cost advantage of utility solar from the first year of the study. Therefore, PREPA should reject any and all utility scale photovoltaic generation project through PPOA and instead should promote residential rooftop solar generation with net metering. This energy is sold by PREPA to other customers at retail prices higher than 15 ¢/kWh ac thus resulting in a profit for PREPA.

Q: Did Siemens/PREPA correctly state the cost of solar residential rooftop solar photovoltaic plus storage costs?

A:No. The assumptions, and calculation method, used by Siemens/PREPA to obtain an estimate of storage cost are incorrect.In Exhibits 3-18 "Storage System LCOE Calculations" and 3-19 "Grid Defection Total Costs" of Section 3 Appendix 4 of the proposed IRP, Siemens/PREPA estimates the cost to a citizen of abandoning electric service from PREPA and supplying her electric needs with a rooftop solar photovoltaic system with lithium ion batteries for energy storage. First Siemens/PREPA assume the amount of daily energy required by a residence is approximately 17.8 kWh when from 2010 thru 2019 the average daily energy use by a residence in Puerto Rico is approximately 13 kWh.[9] Then a series of "cost adders" are used to translate utility scale US based battery cost to Puerto Rico cost. The resulting estimates are much higher than the actual cost of residential scale lithium batteries in Puerto Rico.

Q: How did your analysis correct the LCOE for distributed solar plus battery storage?

A: I independently calculated the Levelized Cost of (storing) Energy using actual costs of lithium ion batteries, retail prices from quotes, in Puerto Rico[10]. Instead

[9]*See, e.g.*, Puerto Rico Electric Power Authority, Monthly Report to the Governing Board,,(August 2019),https://aeepr.com/es-pr/qui%C3%A9nes-somos/portal-inversionistas/financial-information. All other monthly reports from January 2009 through August 2019 are available at the above URL under "Monthly Reports (interim, unaudited)".

[10]The 2019 capital cost of lithium batteries (LiFEPO4) in Puerto Rico is $665.3/kWh.

of a costly financing structure through a developer, again I select a financing model available to private citizens, a personal loan, and use NREL's ATB R&D only cost (mid development) as a reasonable model of battery cost reduction over time. Figure 2 shows the LCOE for generation, storage and total cost.

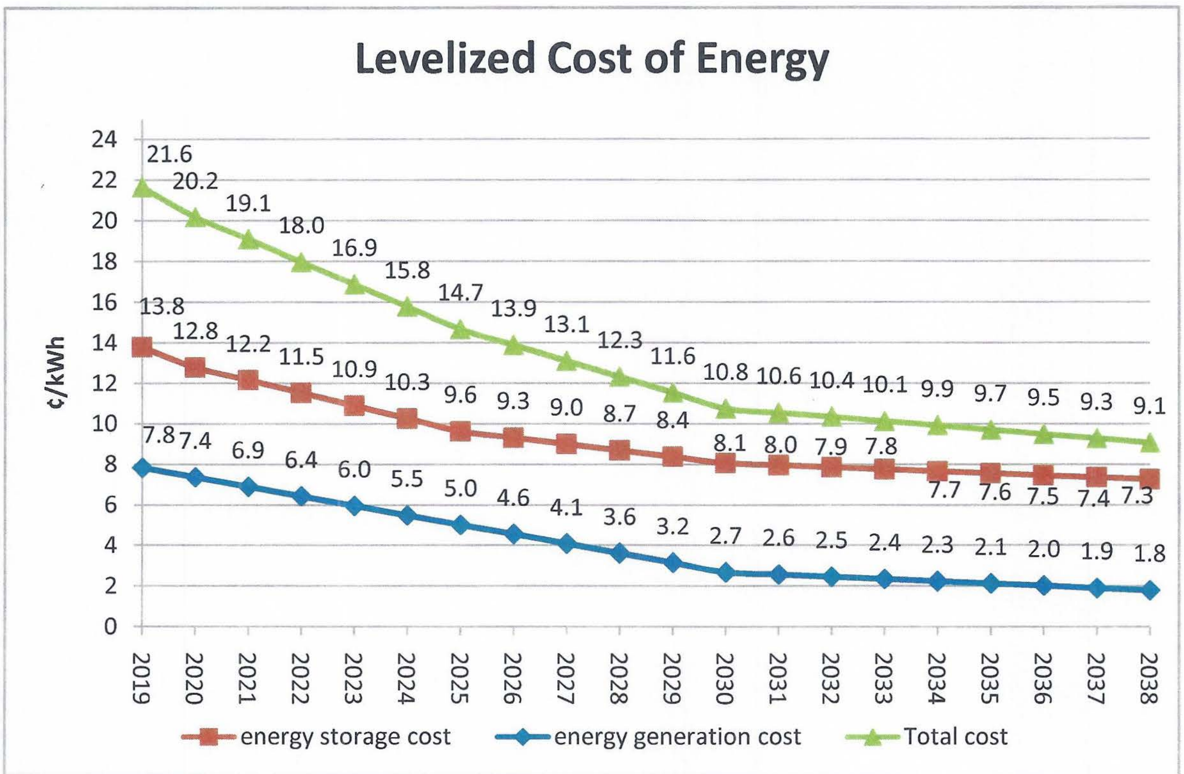

Figure 2. LCOE calculated using Puerto Rico's lithium ion battery real costs, from quotes (665.3 \$/kWh), personal loan financing (4.5% annual interest rate, 5 year loan through local Coop financing), and ATB R&D only (mid development) model of battery cost reduction over time.

Note that the residential cost of electricity from PREPA was 22 ¢/kWh ac during September 2019.Thus, the 2019 LCOE of residential solar photovoltaic including storage, 21 ¢/kWh ac, is lower.

In Figure 3, I further compare the LCOE of residential solar photovoltaic generation with storage with the cost of electricity from the grid including the proposed "transition charge" from PREPA's debt restructuring agreement.[11]

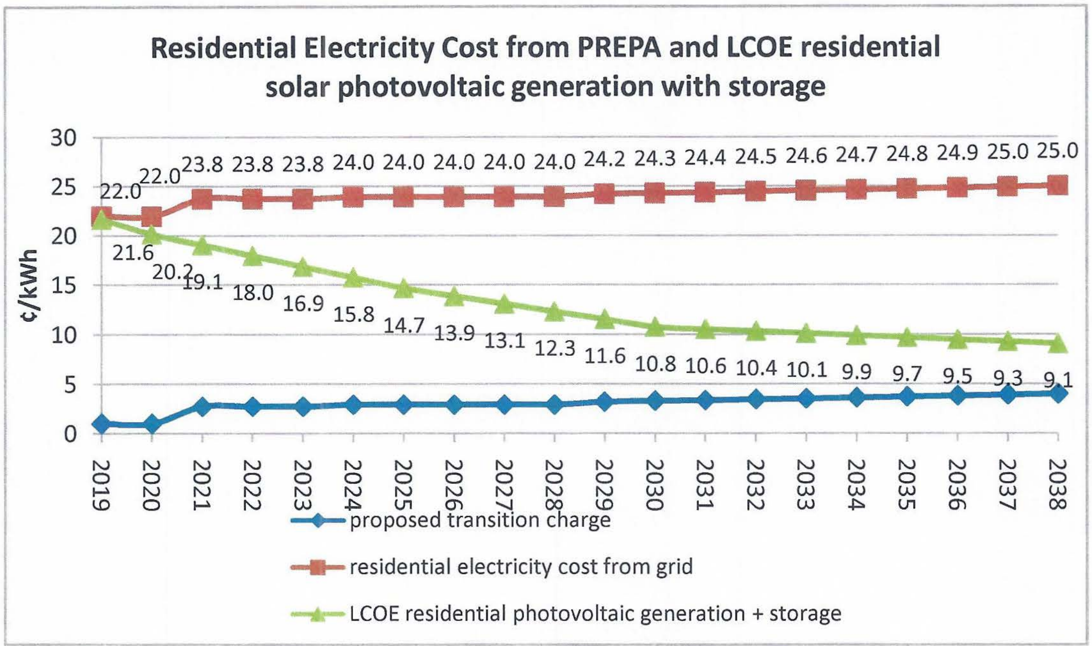

Figure 3. LCOE from residential solar photovoltaic generation with storage and electricity cost from the grid, including the proposed "transition charge" from PREPA's debt restructuring agreement.

The "Recovery Plan Term Sheet" of the RSA defines a "Transition charge" to pay for the new bonds. TheTransition charge supplements the currently active Transition charge of 1 ¢/kWh in effect during Fiscal Years (FY) 2019-2020. The Transition charge described in the "Recovery Plan Term Sheet" is 2.768 ¢/kWh

[11] On May 3, 2019, the Puerto Rico Fiscal Agency and Financial Advisory Authority (FAFAA) filed a Restructuring Support Agreement (RSA) for the Debt of the Puerto Rico Electric Power Authority (PREPA). The RSA exists between the Puerto Rico Electric Power Authority ("PREPA"), the Puerto Rico Fiscal Agency and Financial Advisory Authority ("AAFAF"), the Financial Oversight and Management Board for Puerto Rico ("FOMB"), the members of the Ad Hoc Group of PREPA Bondholders ("Ad Hoc Group Members), any other persons who beneficially own or control Uninsured Bonds ("Uninsured Supporting Holders") and Assured Guaranty Corp. and Assured Guaranty Municipal Corp. ("Assured").

during FY 2021-2023, 2.957 ¢/kWh during FY 2024-2028, 3.242 ¢/kWh in FY 2029, and at this point it increases by approximately 2.5% every fiscal year until FY 2042. In FY 2043 the Transition charge becomes 4.552 ¢/kWh and remains in effect until FY 2067.

Crucially, Figure 3 still understates the true cost of electricity from the electric grid as the values above do not include the capital expenditure and financing cost of much needed investment in the transmission and distribution network nor the cost of investing in new generation units.

IV. The cost data used in the distributed generation cost analysis is wrong.

Q: Did Siemens/PREPA correctly perform the cost analysis for distributed generation?

A: No. There are three main components in the cost analysis presented by Siemens/PREPA: a. capital expenditures (CAPEX);b. financing; and c.future projections. Each of these components was plagued by errors.

a. CAPEX

Q: What errors did Siemens/PREPA make in calculating CAPEX for distributed generation?

A: Siemens/PREPA used extrapolated values instead of actual Puerto Rico specific data and applied two cost correction values without explanation or justification. In section 3.5 of Appendix 4 "Estimated Cost of Residential Solar Photo-Voltaic (PV)" Siemens states:

> The capital costs for Residential PV are estimated using National Renewable Energy Laboratory's (NREL) Annual Technology Baseline (ATB) forecast for residential solar.

Relying on this forecast is unnecessary and more prone to error when direct quotes from photovoltaic equipment suppliers in Puerto Rico are readily available. Instead of extrapolating from NREL's data, Siemens/PREPA should have used actual data for Puerto Rico.

Siemens/PREPA also layer in two unexplained cost adders:

> A 16% cost adder to reflect Puerto Rico specific costs was applied to NREL's capital cost ($/kWdc) estimates. Another 20% cost adder was applied to convert the capital costs to $/kWac. Since the NREL estimates were in 2016 real dollars, a conversion factor was used to escalate the cost to 2018 real dollars.

Siemens/PREPA make no attempt to explain how the 16% "cost adder" was chosen.Furthermore, the NREL suggests a 1.15 ac to dcconversion ratio but Siemens/PREPA uses 1.20.This higher factor of 1.2 results in a larger photovoltaic system than it is necessary to supply the desired electric energy, thus making the system more expensive that it need to be. Having already decided to use NREL data, it is all the more striking that Siemens/PREPA substitutes their own ratio here without explanation. This estimation exercise produces a CAPEX of $268/kW*yr ac including financing. This is wrong and expensive. By correcting these errors and using accurate inputs,[12] I calculated a realistic CAPEX of $137.4/kW*yr.

b. Financing Structure

Q: What issues did you find with the financing structure on which Siemens/PREPA relied for the cost analysis?

A: The financing structure used in the distributed generation cost analysis assumes every residential system will be installed by a developer using an expensive financing structure, thus overstating costs. In Exhibit 3-14 "Residential Solar PV with net metering LCOE Calculations" (Section 3 Appendix 4), Siemens/PREPA calculates financing costs assuming that all residential distributed photovoltaic systems will be installed by a developer. The cost analysis then applies a financing structure that includes factors such as Investment Tax Credit (ITC), 32% income tax, capital recovery factor, project financing, and construction financing factors.

A financing and construction structure for distributed residential photovoltaics based on developers' financing is more expensive for a regular citizen than taking a loan. Thus, the most appropriate assumption is to select a financing mechanism normally employed by a common citizen, such as a personal loan. Credit unions are common and available to most citizens of Puerto Rico. I have selected for my analysis a common financing product: a 5 years personal loan at 4.5% annual interest.

[12] CAPEX calculated using actual costs of equipment, retail prices from quotes, in Puerto Rico and using a financing model available to private citizens, a personal loan.

c. Market Costs Projections

Q: How did Siemens/PREPA err in their assumptions regarding future cost projections?

A: Siemens/PREPAselects the Annual Technology Baseline (ATB)[13] R&D + Markets modelas a cost projection model to forecast the change in Levelized Cost of Energy. This results in a higher future LCOE than the one obtained using the alternative model the R&D Only model.

The R&D Only LCOE present the range of LCOE based on financial conditions that are held constant over time unless R&D affects them, and they reflect different levels of technology risk. This case excludes effects of tax reform, tax credits, and changing interest rates over time.

In the R&D + Market LCOE case, there is an increase in LCOE from 2018-2020, caused by an increase in weighted average cost of capital (WACC), and an increase from 2023-2024, caused by the reduction in tax credits.

Again Siemens/PREPA's selection is based on a financing structure for developers. It is however a model that results in higher LCOE over the years.Since the federal tax credits are of little use to citizen in Puerto Rico we have selected the ATB: R&D Only model to predict the future cost trend.

[13] National Renewable Energy Laboratory (NREL),*2019 Annual Technology Baseline* (2019),https://atb.nrel.gov/electricity/2019.

V. The IRP generally ignores the Distributed Generation option.

Q: Does the Siemens/PREPA IRP seriously consider distributed self-generation?

A: No.In one example of the IRP's characteristic ignoring of the distributed option, section 3.5 of Appendix 4 "Estimated Cost of Residential Solar Photo-Voltaic (PV)" states:

> While the cost of PV is not factored directly in the formulation of the IRP's long term capacity expansion decision, but rather these resources are incorporated via the projections discussed above, it is important to gain a sense of the likely costs that the customers in Puerto Rico may experience for comparison with the cost of supply that they may receive from the utility.

It is clear that distributed self-generation was not seriously considered in Siemens/PREPA's analysis. There is no explanation on why this option was not considered. I find that Siemens/PREPA did not seriously consider distributed self-generation because its study includes outdated data, ignores consideration of reliability benefits, and merely "lumps on" the analysis to its transmission study.

Q: How does Siemens/PREPA rely on outdated data?

A:Siemens/PREPA ignores current trends in favor of data historical data that is no longer valid or instructive. As Siemens/PREPAexplains,

> Given the economies of roof top and other forms of DG versus the cost of supply in the island, customer owned generation has experienced an explosive growth from negligible values seen as recently as 2012-2013. This trend, combined with the perception of customers of the need to gain control on their supply, are expected to result in a continued increase of DG, complemented by energy storage.

Despite this recognition of rapidly evolving circumstances, Siemens/PREPAinexplicably goes on to conclude that "projections (of distributed generation growth) based on history are considered valid."This is troubling considering the level of revisions these historical projections need to account for current developments such as significant decreases in cost of photovoltaic generation equipment and energy storage options, PREPA's proposed restructuring of current debt, and investments needed to ensure acceptable electric supply reliability from the currently weak electric grid.

Indeed, the deteriorated condition of the electric grid doesn't drive some abstract "perception of customers of the need to gain control on their supply," but represents an everyday reality to the citizens of Puerto Rico who suffer electric service interruptions even with blue skies.

Q: How do you mean that the IRP fails to consider the reliability benefits of distributed generation?

A: The IRP's analysis of distributed generation is one-dimensional, in that it only considers cost of electric supply. It does not incorporate reliability of service in the analysis. See Section VIII,"Resiliency through Distributed Renewable Energy" for further discussion of this point.

Q: You also note that distributed generation was analyzed as "a lumped effect" on transmission. What does that mean?

A:Siemens/PREPA decides not to model distributed energy resources at distribution level voltages, but it rather "lumps" distributed generation into the transmission system model and claims that this is enough because they only need to assess the effect this distributed generation has on the transmission system.

This decision is not further explained or justified despite the fact that there are a number of technical reasons not to model distributed energy resources this way. Examples are: 1. a "lumped equivalent" of distributed generation will incorrectly overestimate the energy injection into the transmission system and 2. usually residential rooftop solar photovoltaic generation is spread over a larger area than a solar farm, therefore the negative effect of cloud shadow is experienced differently. The "lumped equivalent" is expected to show greater variance in generation than the distributed residential rooftop solar photovoltaic generation.

VI. Siemens/PREPA assumption on the cost of delivered methane (Liquefied Natural Gas, LNG) is wrong.

Q: Did Siemens/ PREPA correctly perform the cost analysis of delivered methane?

A: No.Siemens and PREPA submit a proposed IRP that assumes a "Unit Cost" for methane of \$4.35/MBTU.[14] This \$4.35/MBTU unit cost is extraordinarily optimistic when it is compared to the signed contract for delivered methane to San Juan between New Fortress and PREPA with a "Unit Cost" of \$8.50/MBTU;[15] almost double the amount assumed by Siemens/PREPA in all their calculations of the proposed IRP.

[14] In Section 7.2.1 of the proposed IRP Siemens indicates "... \$4.35/MMBtu was used, which reflects a \$2.80 adder for liquefaction, a \$1.00 adder for transport, and a \$0.55 adder for margin." Fuel total cost will include 1.15x Henry Hub price in \$/MBTU + \$4.35/MBTU + unit conversion and port infrastructure costs.

[15] See signed contract between NFEnergía, LLC (New Fortress) and PREPA, Fuel Sale and Purchase Agreement, Exhibit C.

Siemens/PREPA assumes a 2019 delivered methane cost of $7.48/MBTU in Aguirre, San Juan, Palo Seco, Mayagüez and Yabucoa (Exhibit 7-11) and $8.89/MBTU in Costa Sur (Exhibit 7-13). The delivered 2019 cost of methane to San Juan, using the parameters described in the New Fortress/PREPA contract is $12/MBTU.[16]

None of Siemens "sensitivity analyses" to methane cost come close to the actual cost of delivered methane to Puerto Rico, all of them are too optimistic. The results and recommendations of the proposed IRP are all dependent of the assumed fuel cost. This fact alone should require a new IRP.

VII. PREPA's IRP does not guarantee the public continuity of electric service

Q: Is the public guaranteed continuity of electric service under the proposed IRP?

A:No. The proposed IRP does not mention reliability[17] of electric energy service, nor does it explain how the "transition charge," effectively a proposed rate

[16] The New Fortress contract uses 1.15% of the final settlement price, in $/MBTU, for the New York Mercantile Exchange's (NYMEX) Henry Hub natural gas futures contract + $8.50/MBTU Unit cost. A fixed unit conversion cost of $833,333.33/month for the first 60 months of contract, for a total of $50 million, must also be included. In my calculation, I use the average final settlement price NYMEX for 2019 (January thru October) and distribute the fixed monthly cost per unit of energy cost. For this distribution of the conversion cost, I assume maximum generation of San Juan Units 5 & 6 (Exhibit 4-8 of the proposed IRP) yielding $0.45/MBTU.

[17] NERC is the North American Electric Reliability Corporation, the entity certified by the Federal Energy Regulatory Commission (FERC) to establish and enforce reliability standards for the interconnected bulk power system in North America (www.nerc.com). NERC's definition of reliability is "[t]he degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply."

change, will provide for a resilient[18] electric power system for the public.[19] Thus, the proposed IRP completely ignores the primary reason the Utility has been granted a monopoly in exchange for cost-based regulated rates, the obligation to serve and provide an essential service.[20]

Q: Why does the RSA transition charge not invest in the grid?

A:Thesole purpose of the "transition charge" proposed in the RSA is to collect money to pay old debt. The "transition charge" collects no money to invest in the electric grid in order to make it more reliable and resilient. This is a crucially important task, as Puerto Rico's electric energy delivery infrastructure, or Transmission and Distribution (T&D) network, is already weak. The vulnerabilities of PREPA's T&D network are laid bare by its failed

[18]Resilience refers to "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."Presidential Policy Directive 21, Critical Infrastructure Security and Resilience (February 12, 2013), https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil.

[19] "[W]ithout some numerical basis for assessing resilience, it would be impossible to monitor changes or show that community resilience has improved. At present, no consistent basis for such measurement exists. We recommend therefore that a National Resilience Scorecard be established."
National Research Council,*Disaster Resilience: A National Imperative*, National Academy of Sciences, p. 92 (2012).

[20] In the United States electric energy is not called an essential service but rather a "critical commodity which the residential, commercial and industrial sectors rely on." Despite this, "the ability to provide public services" is an ever present indicator of resiliency in the US National Laboratories effort to develop a numerical basis for assessing resiliency.

performanceduring a series of events prior to Hurricanes Irma and María,[21] and by its performance after Hurricane María itself.[22]

Q: How much money is necessary to invest in the T&D network to obtain a reliable electric energy supply?

A:The following chart, Table 1,[23] summarizes the estimated rebuild cost needed to "harden and enhance the resiliency of PREPA's system."

Table 1. Rebuild Cost Summary

Rebuild Recommendations	**Total (millions, US$)**
Overhead Distribution (includes 38 kV)	$5,268
Underground Distribution	$35
Transmission – Overhead	$4,299
Transmission – Underground	$601
Substations – 38 kV	$856
Substations – 115 kV & 230 kV	$812
System Operations	$482
Distributed Energy Resources	$1,455
Generation	$3,115
Fuel Infrastructure	$683
Total Estimated Cost	$17,6064

[21] Prior to Hurricane María a fire at the switchyard of Aguirre generation station caused a complete blackout in Puerto Rico that lasted days. *See* Lizette Alvarez, *Fire at Power Plant Leaves Puerto Rico in the Dark*, N.Y. Times (Sept. 21, 2016), https://www.nytimes.com/2016/09/22/us/fire-at-power-plant-leaves-puerto-rico-in-the-dark.html.
[22] I. Umair, *Puerto Rico's blackout, the largest in American history, explained*, Vox, (May 8,2018), https://www.vox.com/2018/2/8/16986408/puerto-rico-blackout-power-hurricane.
[23] Table adapted from the Executive Summary of "Build Back Better: Reimagining and Strengthening the Power Grid of Puerto Rico," Puerto Rico Energy Resiliency Working Group members and Navigant Consulting, Inc., A Report for Governor Andrew Cuomo, New York, Governor Ricardo Rosselló, Puerto Rico and William Long, Administrator FEMA, (Dec. 2017), www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/PRERWG_Report_PR_Grid_Resiliency_Report.pdf

Items 1 through 6, inclusive, total $11,871 million US—nearly $12 billion—or 1.5 times the current debt of $8 billion proposed to be paid by the "transition charge."

By contrast Siemens claims that the required investment, from 2020 through 2024, in Priority 1 and Priority 2 Transmission investments (Exhibits 10-7, 10-9 and 10-11) should be $5,601.1 billion. Siemens does not mention investment in the Distribution system nor does it seem to incorporate this necessary investment in the cost analysis of the proposed IRP.

Q: How will this affect electricity prices?

A: The current residential electric energy cost in Puerto Rico is about 22 ¢/kWh (October 2019). Thus, the new rate of electricity, including the "transition charge", will provide unreliable electricity at a cost of approximately 24.5 to 25 ¢/kWh if the current fuel prices remain as they are now. Assuming the new debt is issued at a similar 5.25% interest Puerto Rico customers will pay an additional 6.828 ¢/kWh to cover the new debt. Imposing these surcharges over the current electric rate would lead to new residential electric energy cost of 33.4 ¢/kWh once the "transition charge" is fully implemented.

Q: Does this investment guarantee continuity of electric service after a strong Hurricane?

A: No.It is virtually impossible to protect every element of the T&D system from falling trees, flying debris, landslides due to flooding, and the most severe hurricane winds. It is important to understand that the "mini grid" concept presented in the proposed IRP will suffer the same vulnerability. The most resilient alternative is renewable electric energy generation plus electric storage.

Q: Is there an alternative to this expensive and unreliable system?

A: Yes. Distributed and renewable electric energy generation plus electric storage provides a better investment in Puerto Rico and in places with high electricity costs, severe local reliability challenges or both. As presented in the previous section of this testimony, the LCOE of residential solar photovoltaic with storage is currently 21.6 ¢/kWh and should be 15.8 ¢/kWh by 2024 while the transition charge plus grid investment shall produce a cost of 33.4 ¢/kWh.

Q:Are rooftop solar photovoltaic systems impervious to hurricanes?

A: No,but our experiences during Hurricane María show that, when properly installed, even a modest rooftop photovoltaic system can provide resiliency and continuity of electric service even after a major hurricane.

VIII. Resiliency through Distributed Renewable Energy.

Q: How can distributed PV generation increase resiliency?

A:A recently published article[24]describes a case study of residential electric service resiliency through the adaptation of a relatively small existing residential photovoltaic system, originally grid-tied under a net metering agreement with the

[24] A. Irizarry-Rivera, K.V. Montano-Martinez, S. Alzate-Drada, F. Andrade, *A Case Study of Residential Electric Service Resiliency thru Renewable Energy Following Hurricane María*, Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, (Nov. 12-15, 2018).

utility, to a stand-alone system with batteries to provide continuity of service after Hurricane María destroyed Puerto Rico's electric transmission and distribution system.

A modest rooftop photovoltaic system with batteries (1 kW in solar panel capacity, 10 kWh of energy storage, total cost of $2,812) provided resiliency and continuity of electric service post hurricane María. The electric service from the grid, at the location under study, stopped on September 20, 2017,and was restored 132 days lateron January 30, 2018.It took 31 days of old fashioned "walk around" to obtain the necessary equipment (charge controllers, batteries, off-grid inverter) to adapt the net metering system into a stand-alone system.[25] The rooftop solar photovoltaic system operated uninterrupted for 101 days and was later used as a backup system since the restored service from the grid was unreliable for several months.

The study also contrasts the cost of buying and operating the photovoltaic system to the cost of buying and operating a gasoline emergency generator to supply the same amount of energy. The cost of using a set of gasoline generators to provide the same energy is less only if electricity from the grid is available within four months of the blackout. This cost comparison does not include labor and transportation cost of procuring fuel and oil, and the labor cost of performing oil changes and refueling the generator. Moreover, the study did not assign a monetary value to lost sleep from re-fueling the generator in the middle of the

[25] There was no electricity nor communications, therefore no Internet, in Puerto Rico for close to a month after Hurricane María.

night. This is one case study out of hundreds, if not thousands, of rooftop solar photovoltaic systems that help the people of Puerto Rico survive a severe natural disaster. **The proposed IRP does not calculate the correct costs of residential rooftop solar photovoltaic systems and does not include in its analysis the ability to survive hurricanes in Puerto Rico these systems provide.** Notice that Puerto Rico lies squarely in the hurricane path of the Caribbean Sea as shown in Figures 4 and 5.

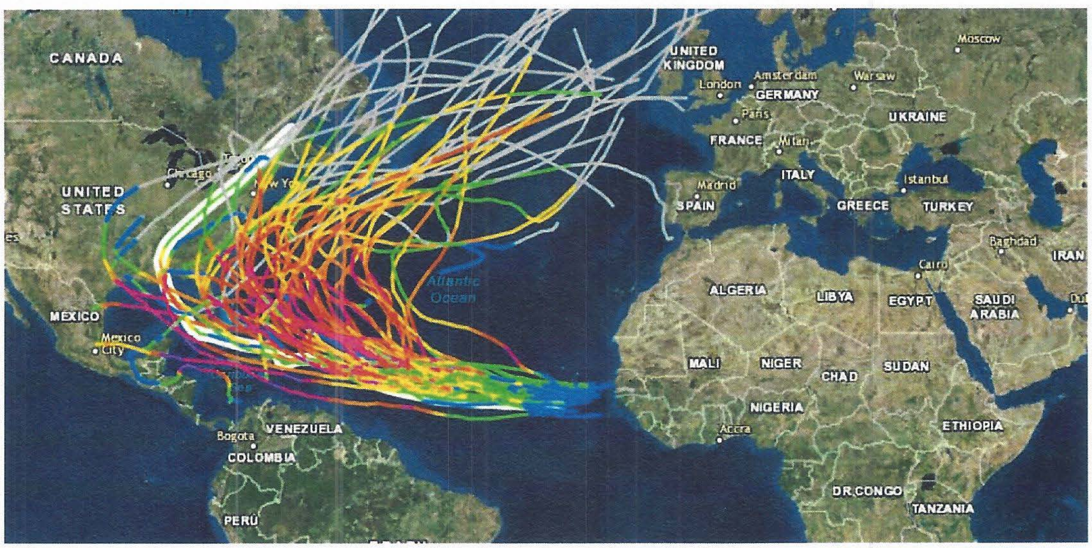

Figure 4.Category 4 and 5 hurricane tracks from 1851-2016 in the East Atlantic Ocean basin.[26]

Twenty-four (24) hurricanes have cross nearby Puerto Rico during 1851-2017. Seventeen (17) have made landfall during the same period, as shown in Figure 2. Ten (10) were category 3 and higher hurricanes, in the Saffir-Simpson scale, with nine (9) making landfall. Hurricanes categories 3 and higher are described as major hurricanes where neartotal to total power loss is likely for weeks.[27]

[26]National Ocean Service, National Oceanic &Atmospheric Administration, *Historical Hurricane Tracks*, oceanservice.noaa.gov/news/historical-hurricanes (last visited Oct. 22, 2019).
[27] T. Schott, et al., *The Saffir-Simpson Hurricane Wind Scale*, National Oceanic &Atmospheric Administration, (Jan. 1, 2012), https://www.nhc.noaa.gov/pdf/sshws.pdf.

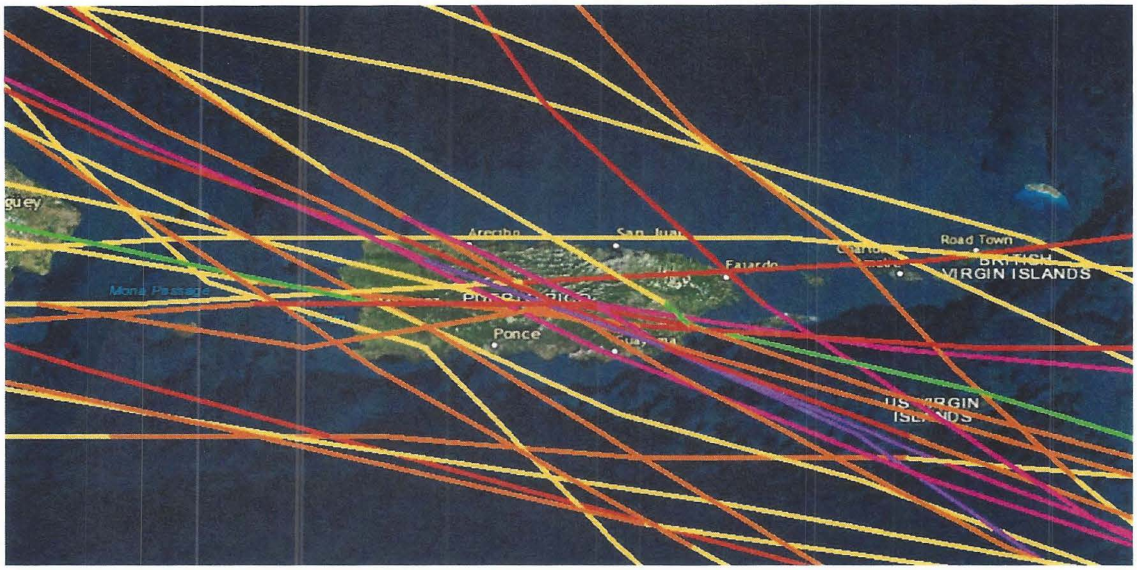

Figure 5.The path of the twenty-four (24) hurricanes from 1851-2017 crossing nearby Puerto Rico; seventeen (17) made landfall. [24]

The people of Puerto Rico should not be penalized for taking advantage of a market driven technological change, the significant drop in the retail price of solar photovoltaic systems and batteries, that allows them to use their clean endogenous resources, their rooftop and the sun that falls on it, to generate the totality or a portion of their electric energy needs. Furthermore,this technological change provides for increased resiliency of electric energy services after a major hurricane and breaks the "natural monopoly" of the traditional electric utility business.

Q: Does this conclude your testimony?

A: Yes, it does.

Expert Witness CV: Please refer to attached CV.

CERTIFICATION

I Agustín Alexi Irizarry-Rivera, of legal age, married, engineer and resident of San Germán, Puerto Rico, CERTIFY that the contents of my testimony are known to me and are the truth according to the best of my abilities and reasonable knowledge. The technical and operational aspects included in the testimony are based on information that has been gathered in good faith; but I cannot guarantee the truthfulness of information gathered from third parties.

Agustín Alexi Irizarry-Rivera, Ph.D., P.E.

Testimony # 336

Before me, the undersigned Notary Public, personally appeared Agustín Alexi Irizarry-Rivera, who acknowledges that the above is true this day of October 23, 2019 in San Germán, Puerto Rico.

[X] Personally known OR [ ] Identification Document provided ______________________.

Notary Public Name, Signature, Seal

Lcda. Ana J. Navarro Rodríguez
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EDUCATION

- Ph.D., Iowa State University, Ames, IA, 1996
  Dissertation Title: "Risk-based operating limits for dynamic security constrained electric power systems." Advisor: Dr. James D. McCalley, committee members: Dr. V. Vittal, Dr. V. Ajjarapu, Dr. G. Sheblé, Dr. H. T. David.

- MSEE, University of Michigan, Ann Arbor, MI, 1990

- BSEE, Magna Cum Laude, University of Puerto Rico, Mayagüez, PR, 1988

POST DOCTORAL TRAINING

(9/08 - 6/09) Researcher at Plataforma Solar de Almería (PSA), Tabernas, Spain. The PSA is the premiere European research and development laboratory for solar thermal concentration systems.

Integration of standard power system models, for the electric network, generator-turbine and controls, with thermo hydraulic models of a solar thermal power plant with no energy storage to provide a comprehensive, albeit simplified, dynamic model set to simulate and study the solar power plant/electric network interaction.

ACADEMIC WORK EXPERIENCE

- (7/05 – present) Professor, (6/00 – 6/05) Associate Professor and (1/97 – 6/00) Assistant Professor of Electrical Engineering at the University of Puerto Rico, Mayagüez (UPRM).
  During this time Dr. Irizarry Rivera has taught:

  1. INEL 3105 Electric Systems Analysis I
  2. INEL 4075 Electrical Engineering Fundamentals
  3. INEL 4103 Electric Systems Analysis III (Introduction to Electric Power Systems)
  4. INEL 4405 Electric Machines
  5. INEL 4407 Electrical Systems Design I
  6. INEL 4415 Electric Power Systems Analysis
  7. INEL 4048 Engineering Practice
  8. INEL 4998 Undergraduate Research
  9. INEL 5406 Transmission and Distribution Systems Design
  10. INEL 5495 Design Projects in Electric Power Systems: Design of the Distribution System for an Eolic Generation Park.
  11. INEL 5496 Design Projects in Power Electronics: Design, Simulation, Fabrication and Test of Brushless Commutation for Permanent Magnets DC Motors.
  12. INEL 5995 Special Problems - Environmental and Infrastructure Impact of Eolic Generation
  13. INEL 6025 Advanced Energy Conversion
  14. INEL 6027 Electric Power Systems Dynamics and Control
  15. INEL 6028 Optimization and Operation of Electric Power Systems
  16. INEL 6077 Over Voltage Phenomena in Electric Power Systems
  17. INEL 6995 Special Topics in Electrical Engineering: Reactive Power
  18. INEL 6995 Special Topics in Electrical Engineering: Power System Distribution

- President (8/16 – present and 1/11 – 8/12) and (08/10 – 12/10) Member, School of Engineering Personnel Committee

- President (8/16 – present and 8/06 – 06/07) and (08/09 – 08/12) Member, Electrical and Computer Engineering Department Personnel Committee

- (8/06 – 5/07) President, ADHOC Committee to Evaluate Proposals for a New UPRM Class Schedule

- (8/05 – 8/06) Elected Academic Senator UPRM.

  Duties included: Coordinator of the ADHOC Committee to Design Instruments to Evaluate the Chancellors' Performance, Coordinator of the ADHOC Committee to Evaluate Proposed Academic Work Schedules for the Mayagüez Campus, Member of the Courses Committee.

- (2/00 – 8/00) Assistant Dean of Academic Affairs UPRM.

  Duties included: supervisor of the Registrar Office and the Admissions Office, coordinator of the registration process for the whole Campus, author of the Academic Calendar proposal, coordinator of the Students Academic Progress Committee, supervisor of the Courses Central Archive keeper and coordinator of the Campus Early Admission Program.

- (10/00 – 01/02) and (8/99 – 2/00) Associate Director for Academic Affairs – Electrical and Computer Engineering Department, UPRM.

  Duties included: Graduate Programs Director, updating the faculty recruitment plan, coordinator of the curriculum revision and accreditation processes, evaluate the creation of new academic programs, coordinator and supervisor of the Department registration process, co-author of proposals to bring external funding to the Department, in charge of promoting and facilitating scientific research in the Electrical and Computer Engineering Department.

ACADEMIC INTERESTS AT GRADUATE LEVEL:

- ✓ Renewable/alternate energy sources such as; photovoltaic, eolic, waves and solar thermal and their integration to the grid
- ✓ Electric power system dynamics and operation
- ✓ Power systems risk assessment

EXAMPLES OF FUNDED RESEARCH and EDUCATION PROJECTS

GEARED (Grid Engineering for Accelerated Renewable Energy Deployment) – (2013-2018) A $929,000 project (UPRM budget out of $6.9 million for the Consortium) to develop and run a Distributed Technology Training Consortium in the Eastern United States, led by the Electric Power Research Institute (EPRI) in collaboration with four U.S. universities (University of Puerto Rico Mayaguez, Georgia Institute of Technology, Clarkson University, University of North Carolina at Charlotte) and seventeen utilities and system operators. The Consortium will leverage utility industry R&D results with power engineering educational expertise to prepare power engineers in management and integration of renewable energy and distributed resources into the grid.

Streamlined and Standardized Permitting and Interconnection Processes for Rooftop Photovoltaic (PV) in Puerto Rico (2012-2013) (Investigator) A $301,911 project sponsored by the US Energy Department that seeks to improve the PV energy market of rooftop systems up to 300 kW in Puerto Rico. The project strives to create not only a standardized framework for PV deployment, but also streamlined: organized, lean permitting and interconnection processes where most residential and small commercial PV systems can be installed safely and quickly.

Design of a Renewable Energy Track within the Electrical Engineering Program at UNAPEC, Dominican Republic (2011-2012) A $29,000 award to design a Renewable Energy Track within the existing Electrical Engineering Program of UNAPEC.

IGERT: Wind Energy Science, Engineering and Policy (WESEP) (2011-2015) A $171,600 sub-award from Iowa State University, the lead Institution, to fund master students doing research in wind technology, science, and policy as they relate to accomplishing three objectives: (a) increase the rate of wind energy growth; (b) decrease the cost of wind energy; and (c) extend penetration limits.

Center for Resources in General Education (CIVIS) – (2008-2016) A 2,500,000 (total for UPRM), approximately $500,000 for Engineering, education project to strengthen and further develop general education objectives at UPRM. Dr. Irizarry is the coordinator for the CIVIS supported UPRM Energy Systems Instrumentation Lab.

Achievable Renewable Energy Targets For Puerto Rico's Renewable Energy Portfolio Standard (2007-2009) A $327,197 project sponsored by the Puerto Rico Energy Affairs Administration (Administración de Asuntos de Energía), to produce an estimate, based in realistic boundaries and limitations, of renewable energy available in Puerto Rico for electricity production. The renewable energy resources studied were: biomass - including waste-to-energy, micro hydro, ocean - waves, tides, currents and ocean thermal, solar - photovoltaic and solar thermal, wind – utility as well as small wind, and fuel cells. The purpose of producing these estimates was to establish adequate targets, as a function of time, for Puerto Rico's Renewable Portfolio Standard.

Colegio San Ignacio - Ejemplo de Sostenibilidad (2007-2008) A $73,332 project to match the energy needs of Colegio San Ignacio with its available renewable energy sources. Demonstration projects with a strong educational component will be proposed to the School to be designed, installed and operated on the Scholl Campus with the participation of the School Faculty and students. The philosophy behind the program will be one of sustainable development.

Programa Panamericano de Capacitación en Ingeniería de Potencia Eléctrica (2006-2008) A $97,370 educational project to deliver a Web-broadcast master program in electric power engineering to engineers at UNAPEC University in the Dominican Republic. Courses in this program responded to the reality and necessities of the Dominican Republic electric power industry and aims for sustainable development.

Caguas Sustainable Energy Showcase, Phase I (2006-2007) A $90,055 project sponsored by the Municipality of Caguas, Puerto Rico to assess the current electric energy consumption profile, by sector; residential, commercial, industrial and governmental, of Caguas and to propose achievable goals (percentages of demand), by sector, to be satisfied using renewable energy sources.

Failure Probabilities for Risk-Based Maintenance and Parameter Estimation of Synchronous Machines (2003-2004) A $99,444 project sponsored by the National Science Foundation (NSF) to estimate parameters and failure probabilities for synchronous generators. The main outcomes of this work were the application of useful alternate robust estimation techniques and the identification of failure modes for risk-based maintenance of generators.

Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks (2002-2005) A $499,849 project sponsored by the National Science Foundation (NSF) and the Office for Naval Research (ONR) to develop a model for the next generation power network using a distributed concept based on scalable coordination by an *Intelligent Power Router* (IPR). Our goal was to show that by distributing network intelligence and control functions using the IPR, we will be capable of achieving improved survivability, security, reliability, and re-configurability. Our approach builds on our knowledge from power engineering, systems, control, distributed computing, and computer networks.

Puerto Rico Wind Resource Assessment - Phase I: Partnership formation and prospective site identification (2002-2003) A $32,465 project sponsored by the Puerto Rico Energy Affairs Administration to increase the knowledge of wind resources in Puerto Rico. We assessed wind velocity probabilities at sites that may be used to install wind farms. The criteria to select the prospective sites was not convenience of data gathering, such as existing towers or existing wind recording stations, but land availability for establishment of a wind farm, road access, available electric grid connections, zoning regulations and indicators of potential wind resource such as existing wind data, topography, wind-deformed vegetation or eolian landforms.

Puerto Rico SMES Project Phase I - Evaluation Study (1997-1999) A $579,188 project sponsored by FOMENTO's Science and Technology Board to determine the energy requirements (size) of an energy storage unit to provide Puerto Rico's electrical system with rapid response spinning reserve in order to prevent blackouts under generation deficiency conditions.

EXAMPLES OF FUNDED TECHNOLOGY TRANSFER PROJECTS

Wind Resource Assessment in Caguas (2010) A technology transfer project, derived from **Caguas Sustainable Energy Showcase, Phase I** (see below).

Inspección de Instalación de Calentadores de Agua Solares y Generación Fotovoltaica Suplementaria para la Urbanización Villa Turabo en Caguas (2010) A technology transfer project, derived from **Caguas Sustainable Energy Showcase, Phase I** (see below).

Sustainable Energy Projects for Bayamón's Sustainability Master Plan (2009) A technology transfer project. Duties included: assist Bayamón´s staff to define the scope of renewable energy projects. Pre-design a Photovoltaic Parking Roof for the Sports Complex Onofre Carballeira Umpierre, write the RFP sent to companies, evaluate the design submitted by companies that responded to the RFP, design performance criteria for the construction, test, and delivery phases of the project and evaluate the performance of the company/companies during the construction, test, and delivery phases of the project.

Ahorro Energético vía Calentadores de Agua Solares y Generación Fotovoltaica Suplementaria para la Urbanización Villa Turabo en Caguas (2007) A $37,800 technology transfer project, derived from **Caguas Sustainable Energy Showcase, Phase I** (see below), to produce an estimated 25% energy savings in 100 residences at Villa Turabo, Caguas via solar thermal water heaters and supplemental photovoltaic electricity generation.

INTERNATIONAL CONFERENCES AND WORKSHOPS COORDINATION

1. (06/06 – 06/10) Member of the Probabilistic Methods Applied to Power Systems International Society (PMAPS IS) The PMAPS IS, incorporated in Canada, is the governing body of the PMAPS Conferences. From 06/06 thru 05/08 Dr. Irizarry Rivera was the General Chair of the coming PMAPS 2008 Conference and his primary responsibility was to organize the PMAPS 2008 Conference. From 05/08 thru 06/10 Dr. Irizarry Rivera is the General Chair of the previous PMAPS Conference and his primary responsibility is to manage the selection of a venue for PMAPS 2012.

2. (06/06 – 05/08) General Chair of the 10th International Conference on Probabilistic Methods Applied to Power Systems (PMAPS 2008) Rincón, Puerto Rico, May 25-29, 2008. The PMAPS Conferences fill a needed role in the power engineering community by providing a regular forum for engineers and scientists worldwide to interact around the common theme of power engineering decision problems under uncertainty.

3. (01/06 – 05/06) Chair of the Sustainable Energy Workshop "**De Acuerdo con la Energía Sostenible y Ahora ¿Cómo llegar allí?**" at the University of Puerto Rico Mayagüez, May 22 and 23, 2007.

OTHER RECENT PROFESSIONAL EXPERIENCE

ELECTRIC POWER INDUSTRY

(09/14 – date) Member of the Board of Directors – PREPANet, LLC. A network infrastructure provider that uses an optical network platform in Puerto Rico to provide wholesale telecommunication services.
Member Representing the Interest of Consumers.

(06/12 – 09/14) Member of the Board of Directors - Puerto Rico Electric Power Authority (PREPA).
Elected Member Representing the Interest of Consumers.

- Vice-President of the Board
- President, Board Committee for Audits
- Member, Board Committee on Electric Power System State and Improvements
- Member, Board Committee on Labor and Legal Affairs
- Member, Board Committee on Customer Services

EXPERT WITNESS IN CIVIL COURT

1. (09/15 – 06/16) Expert witness – Case Number: A2CI2014-00122, VIP Energy Consultants Corp. y VIP Energy USA vs. Centro Diagnóstico y Tratamiento de San Sebastián.

2. (02/10 – 06/12) Expert witness - A DP 2007-0085 Héctor Soto Villanueva et al. vs. Puerto Rico Electric Power Authority et al. - Aguadilla Court House, Aguadillla, Puerto Rico.

3. (07/09 – 06/12) Expert witness – Civil case number 09-cv-01340 (SEC) Leticia Figueroa Villegas et al. vs. Autoridad de Energía Eléctrica et al. United States District Court for the District of Puerto Rico, San Juan, Puerto Rico.

4. (07/09 – 06/12) Expert witness – Civil case number EDP 2009-0097 (402) Luz Eneida Marcano Díaz et al. vs. Autoridad de Energía Eléctrica et al. Caguas Court House, Caguas, Puerto Rico.

5. (07/09 – 06/12) Expert witness – Civil case number EDP 2009-0022 Eduardo Nieves et al. vs. Autoridad de Energía Eléctrica et al. Caguas Court House, Caguas, Puerto Rico.

6. (05/07 – 06/12) Expert witness – Civil case number ADP 2003-0130 José A. Rosario Cordero vs. Municipio de Aguadilla, et al. Aguadilla Court House, Aguadillla, Puerto Rico.

7. (08/05 – 06/12) Expert witness – Civil case number A BCI2006-0085 Fabián Crespo Muñiz et al. vs. Autoridad de Energía Eléctrica et al. Aguada Court House, Aguadillla, Puerto Rico.

8. (07/09 – 04/11) Expert witness - Civil case number 09-cv-1844 (CCC) Francisco Antonio Frías Pujols et al. vs. Puerto Rico Electric Power Authority - United States District Court for the District of Puerto Rico San Juan, Puerto Rico

9. (06/07 – 06/08) Expert witness – Civil case number ISCI 2006-00937 (206) Emilio Malavé Ortiz y Enid Rivera Román vs. Autoridad de Energía Eléctrica Mayagüez Court House, Mayagüez, Puerto Rico.

10. (09/05 – 05/08) Expert witness – Civil case number I DP2002-0257 Marilyn Meléndez Vélez et al. vs. Autoridad de Energía Eléctrica et al. Mayagüez Court House, Mayagüez, Puerto Rico.

11. (10/04 – 06/12) Expert witness – Civil case number DKPD-2002-0610 (1008) Naomi Malavé Conde, et al. vs. Distribuidora de Provisiones y Comestibles, Inc., Bayamón Court House, Bayamón, Puerto Rico.

12. (12/02 – 06/12) Expert witness – Civil case number DKDP2002-0460 (1008) Dalia E. Rivera Ortiz, et al. vs. Autoridad de Energía Eléctrica. Bayamón Court House, San Juan, Puerto Rico.

13. (06/01 – 06/12) Expert witness – Civil case number K DP2002- 0108 (503) Maribel Lozada Rodríguez vs. Autoridad de Energía Eléctrica. San Juan Court House, San Juan, Puerto Rico.

14. (11/03 – 11/07) Expert witness – Civil case number DKDP2003-578 (1001) Francisco Colón Calcador vs. Autoridad de Energía Eléctrica. Bayamón Court House, San Juan, Puerto Rico.

15. (06/02 – 01/04) Expert witness – Civil case number K DP2002-1088 María Jiménez Carrión vs. Municipio de San Juan. San Juan Court House, San Juan, Puerto Rico.

16. (2/01 – 02/03) Expert witness – Civil case number E DP1997-0275 (402) Gerardo Pérez Viera vs. Autoridad de Energía Eléctrica y otros. Caguas Court House, Caguas, Puerto Rico.

17. (7/00 – 1/02) Expert witness – Civil case number F DP1999-0011, Pablo Sánchez Rosa y otros vs. Cooperativa de Seguros Múltiples y otros. Carolina Court House, Carolina, Puerto Rico.

18. (5/98 – 10/98) Expert witness - Civil Case number K DP1995-0084, María Elena Ravelo Egaña vs. Autoridad de Energía Eléctrica. San Juan Court House, San Juan, Puerto Rico.

ELECTRIC POWER GRID MANAGEMENT EVALUATION

- (05/07 – 06/09) Consultant – Engineering evaluation of power system transmission and distribution limitations for Cunningham Lindsey International, Inc. provided technical advice associated to a claim of increased operational costs due to restrictions on a power system operation.

RENEWABLE ENERGY

1. (05/15 – present) Consultant – Engineering services (assist in the definition of the project, pre-design, drafting of "Request for Proposals", evaluation of proposals and definition of performance criteria) in a 199 kW photovoltaic project for Rico Banana Inc., Guayanilla, Puerto Rico.

2. (04/16 – 05/16) Consultant – Engineering services (assist in the definition of the project, project inspector) in a 300 kVA, three-phase, pole-mounted substation for Rico Banana Inc., Guayanilla, Puerto Rico.

3. (07/15 – 12/16) Consultant - Engineering services (assist in the definition of projects, pre-design, drafting of "Request for Proposals", evaluation of proposals and definition of performance criteria) in energy efficiency and photovoltaic systems, Municipio Autónomo de Bayamón.

4. (01/11 – 05/12) Consultant - Wind Energy Resource Assessment for New Era Eolic LLC, Puerto Rico.

5. (07/10 – 08/11) Consultant – Engineering supervision of residential photovoltaic installations in Urbanización Villa Turabo, Municipio Autónomo de Caguas.

6. (07/09 – 08/10) Consultant - Engineering services (assist in the definition of the project, pre-design, drafting of "Request for Proposals", evaluation of proposals and definition of performance criteria) in a 250 kW photovoltaic project on the Onofre Carballeira Sports Complex, Municipio Autónomo de Bayamón.

7. (08/07 – 08/08) Consultant – Engineering design of residential photovoltaic generation for one hundred (100) dwellings in Urbanización Villa Turabo, Municipio Autónomo de Caguas.

8. (10/06 – 12/06) Consultant – Provided technical advice in sitting and interconnection issues for potential wind energy projects for UPC Wind.

9. (06/04 – 06/05) Consultant to, and Partner of, ecoEnergy - Provided engineering services and technical advice in wind data analysis, sitting, preliminary wind turbines selection, interconnection issues and preliminary power purchase agreement negotiations for potential wind energy projects in Puerto Rico.

10. (4/01 – 07/02) Consultant – Provided engineering services and technical advice in wind data analysis, sitting, preliminary wind turbines selection, interconnection issues with a proposed desalination plant and drafting of "Request for Information" and "Request for Proposals" documents for the Puerto Rico Energy Affairs Administration.

PEER REVIEWED PUBLICATIONS:

1. E. O'Neill-Carrillo, I. Jordan, A.A. Irizarry-Rivera, and R. Cintrón, "The Long Road to Community Microgrids," IEEE Electrification Magazine. Vol. 6, No. 4, pp. 6-17, December 2018.

2. A. Irizarry-Rivera, K.V. Montano-Martinez, S. Alzate-Drada, F. Andrade, "A Case Study of Residential Electric Service Resiliency thru Renewable Energy Following Hurricane María", Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, November 12-15 2018.

3. S. Alzate-Drada, K.V. Montano-Martinez, A. Irizarry-Rivera, F. Andrade, "Advanced Metering Applications in Microgrids: A hardware in the Loop (HIL) Electric Power Setup", Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, November 12-15 2018.

4. K.V. Montano-Martinez, S. Alzate-Drada, A. Irizarry-Rivera, F. Andrade, "Characteristics of Residential Battery Storage System for Better Integration with Electric Distribution System", Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, November 12-15 2018.

5. Carlos Vélez-Rivera, Emmanuel Arzuarga-Cruz, Agustín A. Irizarry-Rivera and Fabio Andrade, "Global Data Prefetching using BitTorrent for Distributed Smart Grid Control", Proceedings of the Forty-eight Annual North American Power Symposium, Denver, Colorado, September 18-20, 2016.

6. José R. Matagira-Sánchez and Agustín A. Irizarry-Rivera, "Feasibility Study of Micro Pumped Hydro for Integration of Solar Photovoltaic Energy into Puerto Rico's Electric Grid", Proceedings of the Forty-seventh Annual North American Power Symposium, University of North Carolina Charlotte, Charlotte, North Carolina, October 4-6, 2015.

7. Laura M. Adarme-Mejía and Agustín A. Irizarry-Rivera, "Feasibility Study of a Linear Fresnel Concentrating Solar Power Plant located in Ponce Puerto Rico", Proceedings of the Forty-seventh Annual North American Power Symposium, University of North Carolina Charlotte, Charlotte, North Carolina, October 4-6, 2015.

8. Mónica I. Mercado-Oliveras and Agustín A. Irizarry-Rivera, "Residential Grid-tied Photovoltaic Energy System Design in Puerto Rico", Proceedings of the Forty-seventh Annual North American Power Symposium, University of North Carolina Charlotte, Charlotte, North Carolina, October 4-6, 2015.

9. Armando L. Figueroa-Acevedo and Agustín A. Irizarry-Rivera, "Variability Assessment of Solar and Wind Resources in Puerto Rico", Proceedings of the Thirteenth Probabilistic Methods Applied to Power Systems (PMAPS) International Conference, Durham, UK, July 7-10, 2014.

10. Agustín A. Irizarry-Rivera, Efraín O'Neill-Carrillo and E. Jiménez-Toribio, "Puerto Rico Small Hydro Report", Status of the Caribbean Chapter on World Small Hydropower Report, International Network for Small Hydropower, Lara Jin Qiu-ting Esser (Editor), 2014.

11. Agustín A. Irizarry-Rivera, Manuel Rodríguez-Martínez, Bienvenido Vélez, Miguel Vélez-Reyes, Alberto R. Ramirez-Orquin, Efraín O'Neill-Carrillo and José R. Cedeño, "Chapter 3 Intelligent Power Routers: Distributed Coordination for Electric Energy Processing Networks", In J. Momoh, L. Mili (Editors) *Operation and Control of Electric Energy Processing Networks*, John Wiley and Sons/IEEE Press, 2010.

12. José A. Colucci Ríos, Efraín O'Neill-Carrillo and Agustín A. Irizarry-Rivera. "Renewable Energy in the Caribbean: A Case Study from Puerto Rico", In E. Laboy, F. Schaffner, A. Abdelhadi (Editors) *Environmental Management, Sustainable Development and Human Health*, Taylor and Francis Press, 2009, pp 291.

13. Efraín O'Neill-Carrillo, Marla Pérez-Lugo, Cecilio Ortiz-García, Agustín A. Irizarry-Rivera and José A. Colucci-Ríos, "Sustainable Energy: Balancing the Economic, Environmental and Social Dimensions of Energy," Proceedings of the IEEE Energy 2030 Conference, November 2008, Atlanta, Georgia.

14. Efraín O'Neill-Carrillo, Agustín A. Irizarry-Rivera, José A. Colucci-Rios, William Frey, Cecilio Ortiz-García and Marla Pérez-Lugo, "Advancing a Sustainable Energy Ethic Through Stakeholder Engagement," Proceedings of the IEEE Energy 2030 Conference, November 2008, Atlanta, Georgia.

15. Efraín O'Neill-Carrillo, Marla Pérez-Lugo, Cecilio Ortiz-García, Agustín A. Irizarry-Rivera and José A. Colucci-Ríos, "Sustainability, Energy Policy and Ethics in Puerto Rico", Proceedings of Energy and Responsibility: A Conference on Ethics and the Environment, April 10-12, 2008, Knoxville, Tennessee.

16. José A. Colucci Ríos, Agustín A. Irizarry-Rivera and Efraín O'Neill-Carrillo, "Sustainable Energy for Puerto Rico", Proceedings of the 2007 Energy Sustainability Conference, June 27-30, 2007, Hilton Long Beach, California, USA.

17. Agustín A. Irizarry-Rivera, Manuel Rodríguez-Martínez, Bienvenido Vélez, Miguel Vélez-Reyes, Alberto R. Ramirez-Orquin, Efraín O'Neill-Carrillo and José R. Cedeño, "Intelligent Power Routers: A Distributed Coordination Approach for Electric Energy Processing Networks", International Journal of Critical Infrastructures, Vol. 3 No 1/2 pp. 20-57, 2007.

18. Efraín O'Neill-Carrillo and Agustín A. Irizarry-Rivera, "Socially-Relevant Capstone Design Projects in Power Engineering," Proceedings of the IEEE/PES Power Systems Conference and Exposition, October 2006, Atlanta, GA.

19. Luis O. Jimenez, Efrain O'Neill, William Frey, Rafael Rodríguez-Solis, Agustín A. Irizarry-Rivera, and Shawn Hunt, "A Learning Module of Social and Ethical Implications for Electrical and Computer Engineering Capstone Design Courses", Proceedings of the Thirty-sixth Annual Frontiers in Education Conference, San Diego, California, October 28-31, 2006.

20. Efraín O'Neill-Carrillo, Eddie Marrero, Agustín A. Irizarry-Rivera, "Integrated Laboratory Experiences in Power Engineering Courses," Proceedings of the International Conference on Engineering Education, July 2006, San Juan, Puerto Rico.

21. Efraín O'Neill-Carrillo, Agustín A. Irizarry-Rivera, Jorge A. Cruz-Emeric, "Curricular Revisions in Electrical Engineering at UPRM," Proceedings of the Thirty-fifth Annual Frontiers in Education Conference, Indianapolis, Indiana, October 2005.

22. Carlos A. Ramos-Robles and Agustín A. Irizarry-Rivera, "Economical Effects of the Weibull Parameter Estimation on Wind Energy Projects", Proceedings of the Thirty-seventh Annual North American Power Symposium, Ames, Iowa, October 23-25, 2005.

23. Linda Monge-Guerrero and Agustín A. Irizarry-Rivera, "A Degradation Model of Synchronous Generator Stator Insulation to Compute Failure Probabilities", Proceedings of the Thirty-seventh Annual North American Power Symposium, Ames, Iowa, October 23-25, 2005.

24. Jennifer Jiménez-González and Agustín A. Irizarry-Rivera, "Generation Displacement, Power Losses and Emissions Reduction due to Solar Thermal Water Heaters", Proceedings of the Thirty-seventh Annual North American Power Symposium, Ames, Iowa, October 23-25, 2005.

25. Héctor R. Zamot, Efraín O'Neill-Carrillo and Agustín A. Irizarry-Rivera, "Analysis of Wind Projects Considering Public Perception and Environmental Impact," Proceedings of the Thirty-seventh Annual North American Power Symposium, Ames, Iowa, October 23-25, 2005.

26. Carlos A. Ramos-Robles and Agustín A. Irizarry-Rivera, "Development of Eolic Generation Under Economic Uncertainty", Proceedings of the Eighth Probabilistic Methods Applied to Power Systems (PMAPS) International Conference, Ames, Iowa, September 13-16, 2004.

27. Carlos M. Torres-Ortolaza and Agustín A. Irizarry-Rivera, "Failure Modes and Failure Probability of Intelligent Power Routers", Proceedings of the Eighth Probabilistic Methods Applied to Power Systems (PMAPS) International Conference, Ames, Iowa, September 13-16, 2004.

28. Agustín A. Irizarry-Rivera, Manuel Rodríguez, Miguel Vélez-Reyes, José R. Cedeño, Bienvenido Vélez Efraín O'Neill-Carrillo and Alberto Ramírez, "Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks", Proceedings of the 2003 EPNES Workshop, Orlando, Florida, October 23-24, 2003.

29. Tania Martínez-Navedo and Agustín A. Irizarry-Rivera, "Voltage Stability Assessment of an Island's Power System as a Function of Load Model", Proceedings of the Thirty-fifth Annual North American Power Symposium, University of Missouri-Rolla, Rolla, Missouri, October 20-21, 2003.

30. Agustín A. Irizarry-Rivera. "Benefits of Storing Electric Energy from Wind in Puerto Rico", Proceedings of the Caribbean Colloquium on Power Quality (CCPQ), Dorado, Puerto Rico, June 24-27, 2003.

31. Efraín O'Neill Carrillo, Miguel Vélez Reyes, Agustín A. Irizarry-Rivera and Eduardo Marrero. "The Power of Undergraduate Research", IEEE Power and Energy Magazine, Volume 1, Number 4, July/August 2003.

32. Agustín A. Irizarry-Rivera and J.D. McCalley. "Risk of Insecurity", Proceedings of the Euro Conference on Risk Management in Power System Planning and Operation in a Market Environment (RIMAPS 2001), Porto, Portugal, September 8-11, 2001.

33. Efraín O'Neill Carrillo, Agustín A. Irizarry-Rivera and Miguel Vélez Reyes. "Curriculum Improvements in Power Engineering", Proceedings of the Thirty-first ASEE/IEEE Frontiers in Education Conference, Reno, Nevada, October 10-13, 2001.

34. A.A. Irizarry-Rivera, Wenceslao Torres and Efran Paredes. "Evaluation and Technology Review of Energy Storage for the PREPA System", Proceedings of the Electric Energy Storage Applications and Technologies Conference, Orlando, Florida, September 18-20, 2000.

35. A.A Irizarry-Rivera. "Teaching Electric Power System Analysis Using Visually Attractive Tools," Proceedings of the Twenty-ninth ASEE/IEEE Frontiers in Education Conference, San Juan, Puerto Rico November 10-13, 1999.

36. A.A Irizarry-Rivera, Manuel A. Pérez Quiñonez and Rudolph P. Darken. "Using Virtual Worlds to Explore Electric Power Grids and Plants," Proceedings of the Twenty-ninth ASEE/IEEE Frontiers in Education Conference, San Juan, Puerto Rico November 10-13, 1999.

37. L.C. González-Carrasquillo and A.A. Irizarry-Rivera. "Calculation of Capacity Value of a Wind Farm in Puerto Rico's Electric Power System," Proceedings of the Sustainable Applications for Tropical Island States (SATIS '99) Conference, San Juan, Puerto Rico, August 25-27, 1999.

38. A.A. Irizarry-Rivera and Ivette Malpica Crespo. "Monolineal Animado y Equivalente del Sistema Eléctrico Existente en Puerto Rico: Una Herramienta de Enseñanza," Memorias del IX Simposio de Ingeniería Eléctrica, Universidad Central de las Villas, Santa Clara, Cuba, February 24-27, 1999.

39. E. Paredes-Maisonet and A.A Irizarry-Rivera. "Energy Storage Systems to Mitigate Frequency Decline under Generation Deficiency Conditions," Proceedings of the Thirtieth Annual North American Power Symposium, Cleveland State University, Cleveland, Ohio, 1998.

40. M. Rodríguez-Fernández and A.A Irizarry-Rivera. "Overview of the Dynamic Performance of a Small Electric Power System in the Presence of Eolic Generation," Proceedings of the Thirtieth Annual North American Power Symposium, Cleveland State University, Cleveland, Ohio, 1998.

41. Jiménez-Dávila and A.A Irizarry-Rivera. "Establishment of a Lightning Location System in Puerto Rico," Proceedings of the Thirtieth Annual North American Power Symposium, Cleveland State University, Cleveland, Ohio, 1998.

42. L.C. González-Carrasquillo and A.A Irizarry-Rivera. "A Procedure to Determine Wind Power Capacity Value and its Future Application to Puerto Rico's Electric Power System," Proceedings of the Thirtieth Annual North American Power Symposium, Cleveland State University, Cleveland, Ohio, 1998.

43. J.D. McCalley, A.A. Fouad, V. Vittal, A.A. Irizarry-Rivera, B.J. Agrawal and R.G. Farmer. ``A Risk-Based Security Index for Determining Operating Limits in Stability Limited Electric Power Systems," IEEE Transactions on Power Systems, Volume 12 , Issue 3 , Aug. 1997, pp. 1210-1219.

44. A.A. Irizarry-Rivera, J.D. McCalley and Vijay Vittal. ``Computing Probability of Instability for Stability Constrained Electric Power Systems," Electric Power Systems Research Journal, Volume 42, Issue 2, August 1997, pp. 135-143.

45. A.A. Irizarry-Rivera, J.D. McCalley and V. Vittal. ``Limiting Operating Point Functions and their Influence on Probability of Instability," Proceedings of the Fifth Probabilistic Methods Applied to Power Systems (PMAPS) International Conference, Vancouver, British Columbia, Canada, September, 1997.

46. Z. Zhu, S. Zhao, J.D. McCalley, V. Vittal and A.A. Irizarry-Rivera. ``Risk-Based Security Assessment Influenced by Generator Rejection," Proceedings of the Fifth Probabilistic Methods Applied to Power Systems (PMAPS) International Conference, Vancouver, British Columbia, Canada, September, 1997.

47. Nguyen, A.A. Irizarry-Rivera, J.D. McCalley and V. Vittal. ``Survey Development for Assessing Impact of Power System Disturbances," Proceedings of the Fifth Annual Midwest Electro-Technology Conference, Iowa State University, Ames, Iowa, 1996.

48. A.A. Irizarry-Rivera and J.D. McCalley. ``A Cartesian Product Approach to Determine the Probability of Instability for Stability Limited Electric Power Systems," Proceedings of the Twenty-seventh Annual North American Power Symposium, Montana State University, Bozeman, Montana, 1995.

49. A.A. Irizarry-Rivera, J.D. McCalley, V. Vittal, and A.A. Fouad. ``A Risk-Based Electric Power System Security Index: Moving from Frequency to Probability of Instability," Proceedings of the Fourth Annual Midwest Electro-Technology Conference, Iowa State University, Ames, Iowa, 1995.

50. A.A. Irizarry-Rivera and J.D. McCalley. ``A Security Assessment Approach for Stability-limited Electric Power Systems Using a Risk-based Index," Proceedings of the Thirty-second Annual Power Affiliate Meeting, Iowa State University, Ames, Iowa, 1995.

51. J.D. McCalley, A.A. Fouad, V. Vittal, A.A. Irizarry-Rivera, B.J. Agrawal and R.G. Farmer. ``A Probabilistic Problem in Electric Power System Operation: The Economy-Security Tradeoff for Stability Limited Power Systems," an invited paper, Proceedings of the Third International Workshop on Rough Sets and Soft Computing, San Jose State University, San Jose, California, 1994.

SELECTED PRESENTATIONS:

1. A.A. Irizarry-Rivera. "Renewables and the Power Sector: Renewable Integration into the Existing Grid, Workforce Development", New England Power Seminar, Avon Old Farms Hotel, Avon, Connecticut, September 21-25, 2015.

2. A.A. Irizarry-Rivera. "Update on Renewables: Context, Solar PV on Islands, Renewable Integration into the Existing Grid, Workforce Development", New York Power Conference, New York Sciences Academy, 7 World Trade Center, Manhattan, New York City, New York, May 14, 2015.

3. Armando Figueroa, A.A. Irizarry-Rivera. "Requisitos de Reserva Operacional de un Sistema de Potencia Eléctrica con Significativa Generación Renovable", Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), Viernes 360-Centro de Convenciones, San Juan, Puerto Rico, May 16, 2013.

4. A.A. Irizarry-Rivera, E. O'Neill-Carillo. "Streamlined and Standardized Permitting and Interconnection Processes for Rooftop Photovoltaic Systems in Puerto Rico", Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), Casa Capitular Calle Obispado, Mayagüez, Puerto Rico, May 14, 2013.

5. A.A. Irizarry-Rivera. "¿Cuál Crisis Energética? El uso racional de la energía y renovables", Convención de la Sociedad de Planificadores de Puerto Rico, Sede del Colegio de Arquitectos y Arquitectos Paisajistas, Calle del Parque 255, San Juan, Puerto Rico, November 14, 2012.

6. A.A. Irizarry-Rivera. "Generación Eólica: El Debate de Comida vs. Energía", Escuela de Leyes, Pontificia Universidad Católica de Ponce, March 20, 2012.

7. A.A. Irizarry-Rivera. "Concentrated Solar Thermal Electricity Production: Principles, Resource and Technology", Brickell Avenue Business Interruption and Energy Conference (BABIEC), JW Marriot, Miami, October 27-28, 2011.

8. A.A. Irizarry-Rivera. "Wave to Wire: An Overview of Electricity Generation from Waves; Resource, Technology, System Integration and Economics", New York Power Conference, Downtown Conference Center at Pace University, Manhattan, New York City, New York, May 19, 2011.

9. A.A. Irizarry-Rivera. "The estate vs. the citizens: Crisis (mis)management in education and energy", Lucidity and Engagement: The UPR Strikes (2010-2011) and Academic Activism in Puerto Rico (Part 2), A panel session in the American Ethnological Society (AES) and the Society for Urban, National and Transnational Anthropology (SUNTA) Meeting, Caribe Hilton Hotel, San Juan, Puerto Rico, April 15, 2011.

10. A.A. Irizarry-Rivera. "Recurso Solar en Puerto Rico y la Tecnología Solar Térmica para la Producción de Electricidad", Universidad Interamericana Recinto de Guayama, April 8, 2011.

11. A.A. Irizarry-Rivera. "A usar el español en la investigación tecnológica: reflexión de un ingeniero a su regreso de Andalucía", Universidad de Puerto Rico, Mayagüez, Octuber 12, 2010.

12. A.A. Irizarry-Rivera. "Achievable Renewable Energy Targets for Puerto Rico", Universidad Interamericana Recinto de Guayama, April 15, 2010.

13. A.A. Irizarry-Rivera. "Renewable Portfolio Standards", Convención Anual Colegio de Químicos de Puerto Rico 2007, Puerto Rico Conventions Center, August 10, 2007.

14. A.A. Irizarry-Rivera. "Alternativas Energéticas Sostenibles. Energía Solar: Termal y Fotovoltaica", Convención Anual Colegio de Ingenieros y Agrimensores de Puerto Rico 2007, Cambio Climático: Ingeniería, Agrimensura y Sostenibilidad, Hotel El Conquistador, Fajardo, Puerto Rico, August 3, 2007.

15. A.A. Irizarry-Rivera. "Energía Eólica, Conservación y el Ejemplo de Caguas", Noveno Congreso de Investigación y Creación Académica de la Universidad de Puerto Rico en Ponce, Teatro General UPR – Ponce, May 11, 2007.

16. A.A. Irizarry-Rivera. "Energía Eólica", Mega Viernes Civil, Seminario de Diseño y Construcción Verde del Instituto de Ingenieros Civiles, Colegio de Ingenieros y Agrimensores de Puerto Rico, Centro de Convenciones de Puerto Rico, May 18, 2007.

17. A.A. Irizarry-Rivera. "Generación Eólica y Solar: Fotovoltaica, Termal", Tercera Reflexión Ambiental, Foro de Desarrollo de Energía Sustentable, Teatro de la Universidad de Puerto Rico, Río Piedras, April 18, 2007.

18. A.A. Irizarry-Rivera & Gerson Beauchamp "Generación Fotovoltaica para Puerto Rico", Workshop sponsored by the Alianza Ciudadana para Educación en Energía Renovable (ACEER), Centro Cultural de Mayagüez, April 21, 2007.

19. A.A. Irizarry-Rivera. "Costo de la generación eólica y ahorro por desplazamiento de generación", Conference sponsored by the Puerto Rico Chamber of Comerce, Hotel Condado Plaza, San Juan Puerto Rico, February 21, 2007.

20. A.A. Irizarry-Rivera. "Energía eléctrica en Puerto Rico: generación, transmisión y conservación", Workshop sponsored by the Alianza Ciudadana para la Educación en Energía Renovable (ACEER), Centro Cultural de Mayagüez, February 3, 2007.

21. A.A. Irizarry-Rivera and E. Juan-García "Electrical Shock and Trauma: Causes, Mechanisms of Injury and Case Studies", Workshop sponsored by the Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), CIAPR Mayagüez, November 8, 2005.

22. A.A. Irizarry-Rivera. "Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks: Second Year Progress Report", Electric Power Networks Efficiency and Security (EPNES) Workshop, sponsored by the National Science Foundation (NSF), Mayagüez, Puerto Rico, July 12-14, 2004.

23. A.A. Irizarry-Rivera. "Environmental Impact of Eolic Power", Sustainable Energy Workshop sponsored by the Instituto de Ingenieros Electricistas del Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), CIAPR Headquarters, May 19, 2004.

24. A.A. Irizarry-Rivera. "Electricity Hazards", Energy Systems Seminal Series (ES^3) Electrical and Computer Engineering Department, University of Puerto Rico, Mayagüez, March 30, 2004.

25. A.A. Irizarry-Rivera, M. Vélez Reyez and E. O'Neill-Carrillo. "Risk-Based Maintenance and Parameter Estimation of Synchronous Machines", Power System Engineering Research Center (PSERC) Industrial Advisory Board Meeting, December 10-12, 2003.

26. A.A. Irizarry-Rivera. "Future Power Systems", Industry University Symposium on Electrical Engineering, sponsored by the Instituto de Ingenieros Electricistas del Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), CIAPR Headquarters, November 14, 2003.

27. A.A. Irizarry-Rivera. "Electric Power from the Wind", Energy Systems Seminal Series (ES^3) Electrical and Computer Engineering Department, University of Puerto Rico, Mayagüez, October 30, 2003.

28. A.A. Irizarry-Rivera. "Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks: First Year Progress Report", Electric Power Networks Efficiency and Security (EPNES) Workshop, sponsored by the National Science Foundation (NSF), Orlando, Florida, October 23-24, 2003.

29. A.A. Irizarry-Rivera. "Eolic Generation", Energy Forum sponsored by the Colegio de Ingenieros y Agrimensores de Puerto Rico (CIAPR), Hotel Wyndham El Conquistador, August 1st, 2003.

30. A.A. Irizarry-Rivera. "EPNES: Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks", Modernizing the National Grid Workshop, sponsored by the National Science Foundation (NSF), New Orleans, Louisiana, November 18-19, 2002.

31. A.A. Irizarry-Rivera. "Puerto Rico SMES Project", Puerto Rico Chamber of Commerce and Guests, Puerto Rico Chamber of Commerce Headquarters, Old San Juan, Puerto Rico, January 28, 1998.

GRADUATE THESES and PROJECTS SUPERVISED:

1. Carlos García. "Ocean Wave Energy into Electricity Using Point Absorbers in the North Coast of Puerto Rico", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, In progress.

2. Karen Montaño. "Characteristics of Electric Batteries for Residential Use and Better Integration with the Electric Distribution System", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2018.

3. Laura Adarme. "Feasibility of Linear Fresnel Solar Thermal Generation in Puerto Rico", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2018.

4. José Matagira. "Feasibility of Micro Pumped Hydro Storage for Photovoltaic Energy", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2016.

5. Luis de Jesús. "Design and Characterization of Fresnel Solar Concentrator for Solar Thermal Drying of Coffee in Puerto Rico", ME Report, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2014.

6. Armando Figueroa. "Requisitos de Reserva Operacional de un Sistema de Potencia Eléctrica con Significativa Generación Renovable", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2013.

7. Felipe Hernández. "Feasibility of Dish/Stirling Solar Thermal Generation in Puerto Rico and in the Dominican Republic", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2012.

8. Franchesca Aponte. "Ocean Wave Energy into Electricity Using Offshore Wave Energy Devices in the North Coast of Puerto Rico", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2009.

9. Magaby Quintero. "Ocean Wave Energy into Electricity Using Shoreline Devices in Puerto Rico", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2009.

10. Miguel Rios. "Small Wind / Photovoltaic Hybrid Renewable Energy System Optimization", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2008.

11. Linda Monge. "Effect of Distributed Energy Storage Systems in Voltage Stability of an Island Power System", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2006.

12. Jennifer Jiménez. "Benefits of Electric Generation Displacement Using Solar Thermal Water Heating", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2005.

13. Carlos Ramos. "Determination of Favorable Conditions for the Development of a Wind Power Farm in Puerto Rico", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2005.

14. Carlos Torres. "Failure Probability of Intelligent Power Routers", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2005.

15. Orlando Leal Flores. "Analysis and Simulation of EM Fields of a Permanent Magnets DC Linear Motor used to Propel a Magnetically Levitated Train", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2004.

16. Tania Martínez Navedo. "Voltage Stability Assessment of an Island Power System as a Function of Load Model", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2002.

17. Jorge Valenzuela Valenzuela. "Development of Small Signal Analysis Tools to Study Power System Dynamics Using Simulink", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2001.

18. Ismael A. Jiménez Dávila. "Calibration of Magnetic Finder System for Lightning Location Using AM Carrier Signals", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2000.

19. Francisco Quiles Torres. "Identifying Electrical Needs and Implementing Improvements on the Main Power Substation of a Manufacturing Plant", ME Project, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2000.

20. Luis C. González Carrasquillo. "A Procedure to Determine Wind Power Capacity Value and its Future Application to Puerto Rico's Electric Power System", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 2000.

21. Efran Paredes Maisonet. "Determination of Required Rapid Response Spinning Reserve to Avoid Under frequency Load Shedding under Generation Deficiency Conditions in Puerto Rico's Electric Power System", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 1999.

22. Mireya Rodríguez Fernández. "Power System Dynamic Analysis for the Integration of Wind Farms to Puerto Rico's Electric Grid", MS Thesis, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, 1999.

HONORS AND OTHER PROFESSIONAL ACTIVITIES:

- Recipient "Ingeniero Electricista Distinguido 2013" (Distinguished Electrical Engineer 2013) from the Mayagüez Chapter of the Puerto Rico Professional Engineers Society (Capítulo de Mayagüez del Colegio de Ingenieros y Agrimensores de Puerto Rico) - In recognition of services rendered to the profession, achievements in engineering education and his performance as Vice-President of the Puerto Rico Electric Power Authority Board of Directors.

- Recipient "2010 Distinguished UPRM Alumni" from the University of Puerto Rico Mayagüez Alumni Association.

- Recipient "Ingeniero Electricista Distinguido 2005" (Distinguished Electrical Engineer 2005) from the Electrical Engineering Institute of the Puerto Rico Professional Engineers Society (Instituto de Ingenieros Electricistas del Colegio de Ingenieros y Agrimensores de Puerto Rico) - In recognition of services rendered to the profession and outstanding professional achievements in the field of electrical engineering.

- Recipient "2004 Professional Progress in Engineering Award" (PPEA) from Iowa State University

  PROFESSIONAL PROGRESS IN ENGINEERING AWARD - Established in 1988

  In recognition of outstanding professional progress and personal development in a field of engineering specialization as evidenced by significant contributions to the theory and practice of engineering, distinguished service rendered to the profession, appropriate community service, and/or achievement in a leadership position. There shall also be evidence of recognition through citations and acceptance of achievements by colleagues, and of the promise of continued progress and development.

- Recipient “2003-2004 Electrical and Computer Engineering Outstanding Faculty Award” from the School of Engineering, Mayagüez, Puerto Rico
- Recipient ``Iowa State University Research Excellence Award'' for Ph.D. dissertation
- Registered Professional Electrical Engineer in Puerto Rico (6/91) and Member of the “Colegio de Ingenieros y Agrimensores de Puerto Rico”
- Magna Cum Laude – BSEE, University of Puerto Rico, 1988
- Member Institute of Electrical and Electronic Engineers (IEEE) - Power Engineering Society and Faculty Advisor of the Power Engineering Society Student Chapter at the University of Puerto Rico Mayagüez
- Advocate – American Wind Energy Association
- Engineering Futures Facilitator and Member of Tau Beta Pi the National Engineering Honor Society. (06/98 – 06/08) Principal Faculty Advisor of Puerto Rico’s Tau Beta Pi Alpha Chapter, (06/08 - present) Faculty Advisor of Puerto Rico’s Tau Beta Pi Alpha Chapter

SERVICES RENDERED TO THE PROFESSION

- Member of the Energy Committee of the Puerto Rico Engineers and Surveyors Association (CIAPR, from the Spanish “Colegio de Ingenieros y Agrimensores de Puerto Rico”).
- Member of the AD HOC Committee for Renewable Energy and Climate of the Puerto Rico Engineers and Surveyors Association (CIAPR, from the Spanish “Colegio de Ingenieros y Agrimensores de Puerto Rico”).
- Instructor of Continuous Education Courses at the Puerto Rico Engineers and Surveyors Association (CIAPR, from the Spanish “Colegio de Ingenieros y Agrimensores de Puerto Rico”)
- Member of the AD HOC Committee to Evaluate the Technical Administration of the Puerto Rico Electric System by the Puerto Rico Electric Power Authority during the Tropical Storm (TS) Jeanne of September 15, 2004 - The official state inquiry by the CIAPR into what caused a general electric blackout in the Island of Puerto Rico during Tropical Storm Jeanne. It is part of the CIAPR public responsibility to conduct such inquiries when technical matters are in dispute. Responsibilities included: analysis of technical evidence, as submitted by PREPA, of the power system state and behavior as TS Jeanne crossed over Puerto Rico, the formulation of a hypothesis to explain such behavior, and to judge the decisions made on the administration of the power system during the storm.

EXAMPLES OF UNDER GRADUATE RESEARCH and DESIGN PROJECTS:

1. **Design of the Distribution System for an Eolic Generation Park**. The complete design of the Distribution System for an Eolic Generation Park. This included the decision to install an aerial or underground system and specification of: transformers, conductors, protection system, grounding system, conduits, junction boxes, lighting protection and design of the substation to connect the eolic park with the local electric utility. Other requirements included: estimate of materials and construction costs, a construction and project management schedule and analysis to determine the required reactive compensation. Students: Franchesca Aponte Santiago, Dumeng Roman Johana,

Melissa Hernandez Bernier, Erika Padilla Ocasio, Magaby Quintero Lopez, Marilyn Ramirez Alvarado, Sharlene Rivera Gonzalez, Rodolfo Morales Medina and Giancarlo Santos Santiago.

2. **Environmental and infrastructure impact of eolic generation in Puerto Rico**. The study of key aspects of eolic generation and their environmental impact with emphasis in: noise, electromagnetic interference, avian issues and aesthetic considerations. Student studied the infrastructure impact of eolic generation projects specifically on roads, sea ports and sea bottom. Students were aware of socio-economic and political considerations and implications on eolic generation projects. Students: Camille T. Ocasio, Verónica Narváez and David Marrero.

3. **Design Projects in Power Electronics: Design, Simulation, Fabrication and Test of Brushless Commutator for Permanent Magnets DC Motors**. Project involved the preliminary design of a brushless commutator including computer simulations of the proposed circuit, identification of components to be used including component costs and manufacturer data, necessary tools and materials needed to construct and test the commutator, and detailed work schedule of the steps needed to complete the design and prototype construction tasks. A working prototype and documented results of tests performed to the prototype to ensure its compliance with design specifications was required. Proposed modifications to solve any problems found during testing, computer simulations of the proposed modifications to the commutator circuit were also required. Students: Noel G. Figueroa Urdaz, Camille Guzmán Torres, Lourdes Orona Jiménez, José J. Rodríguez Alvarez, Reyes M. Ruiz Donate, José L. Valenzuela Rivera and Miguel D. Vázquez Peña.

4. **Development of an Animated One-line Equivalent of Puerto Rico's Existing Electric Power System**. Project involved the use of the commercially available **PowerWorld Simulator**, a user-friendly, highly interactive package for engineering analysis, to develop a one-line equivalent of Puerto Rico's existing electric power system. The animated and graphical one-line equivalent of Puerto Rico's electric system is geographically accurate as well as electrically equivalent to the generation and transmission (115 kV and above) of the Puerto Rico Electric Power Authority (PREPA). This equivalent has being used by engineering students to study the behavior of Puerto Rico's electric power grid under a variety of system conditions. It will also provides an excellent teaching tool to demonstrate the principles of electric power flow, voltage profiles and their relation to reactive power, economic dispatch and steady-state system security. Students: Ivette Malpica

5. **Using Virtual Worlds to Explore Electric Power Grids and Plants.** Virtual worlds provide the capability of visiting spaces difficult to explore because of: time constraints, natural hazards, and cost of accessibility or access restrictions. Electric power system courses are constrained to show primary components of a power system using drawings and photos. Development of virtual worlds tailored to suit the topic being discussed is an attractive solution. Student may browse around the system learning as they go along. They provide motivation and the electric utility may use these tools to familiarize new personnel with their system and inform and educate non-technically trained decision-makers using accurate and visually attractive presentations. Two undergraduate students participated in the project developing virtual worlds of a power plant. Students: Iomar Vargas and Emmanuel Arzuaga.

OTHER PROFESSIONAL EXPERIENCE

- (2006) Implementation Specialist – Alliance for the Strengthening of Mathematics and Science Teaching (AFAMaC): An Alliance among the Puerto Rico Department of Education and University of Puerto Rico Mayagüez (UPRM) to professionally advance Mathematics and Science school teachers of 7^{th}, 8^{th} and 9^{th} grade in three Educational Districts; Mayagüez, Moca and San Sebastian. The primary goal of the project is to improve knowledge and practice of Mathematics and Science teachers thru summer and weekend long internships at the UPRM taking courses that will focus on content (Math, Physics, Chemistry, Geology, Basic Engineering, and Information Technology) rather than teaching methods.

- (01/03) Consultant – Engineering evaluation of electrical installation at a private residence in Mayagüez, Puerto Rico. Identified electrical design deficiencies and failures to comply with the National Electric Code.

- (05/98 – 08/98) Consultant – Electric Energy Audit and Consumption Estimates for a small Hotel in Aguadilla, Puerto Rico. Analyzed electric bills and estimated energy consumption of the Hotel including internal generation to settle a billing dispute between the Hotel Management and the Puerto Rico Electric Power Authority.

- (02/98 – 04/98) Consultant – Redesign the electric distribution system of a Trailer Camp Facility in La Parguera, Puerto Rico.

- (1/94 - 5/96) Computer Network System Administrator at Iowa State University, Ames, Iowa
  Performed software and hardware system administration for UNIX workstation network serving 50 users.

- (7/93 - 10/96) Research Assistant at Iowa State University, Ames, Iowa

  - Developed a risk-based method to assess security and determine operating limits for electric power systems, a project sponsored by Electric Power Research Institute (EPRI).
  - Utilized state of the art industry-grade power systems software applications (power flow, stability, etc).
  - Performed large scale system studies of WSCC network
  - Supervised two undergraduate students in their undergraduate research projects

- (8/90 - 6/93) Assistant Researcher at the University of Puerto Rico, Mayagüez, Puerto Rico

  Administered the optics and laser facilities of the Physics Department and supervised authorized personnel in the operation of the equipment

- (9/89 - 2/90) Research Assistant at the University of Michigan, Ann Arbor, Michigan

  Developed a novel and simple technique to create an optical source capable of providing high peak power at a desired frequency or a short pulse with a tunable, spectrally pure frequency

- Summer Intern at Aluminum Company of America, ALCOA Center, Pennsylvania

  - (5/90 - 7/90) Characterized electromagnetic field properties of electromagnetic acoustic transducers and eddy current sensors
  - (5/89 - 8/89) Implemented the Digital Holographic Interferometry Technique for surface displacement measurements
  - (6/88 - 8/88) Implemented the Synthetic Aperture Focusing Technique for ultrasonic testing using an HP1000 computer
  - (6/87 - 8/87) Designed, fabricated and analyzed electromagnetic acoustic transducers

ADDITIONAL EDUCATIONAL INFORMATION:

Graduate Coursework:

23 hours in Power Systems, 23 hours in optics, 12 hours in electromagnetics, 9 hours in Control Systems, 12 hours in Math and 9 hours in probability and statistics.

Salient Ph.D. Research Contributions:

- Developed a method that allows risk-based security assessment in an operating environment considering any type of security violation.
- Developed, using probability theory, expressions to calculate the conditional probability of insecurity given a fault occurs for thermal overloads and transient instability.
- Developed a method to generate risk-based operating limits in terms of parameters available to system operators, illustrated using nomograms based on risk rather than deterministic limits. The change from deterministic to risk-based operating limits is transparent to system operators since they just see new nomograms or tables.
- Investigated the effect of conventional protection systems on risk of an operating point.

Participated in investigation of the effect of special protection schemes on risk of transient instability.

GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: **Review of the Puerto Rico Electric Power** Authority Integrated Resource Plan	CASE NO.: CEPR-AP-2018-0001

EXPERT TESTIMONY OF ANNA SOMMER

ON BEHALF OF LOCAL ENVIRONMENTAL ORGANIZATIONS

Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. - Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico

TABLE OF CONTENTS

I. INTRODUCTION & QUALIFICATIONS

Q. Ms. Sommer, please state for the record your name, position, and business address.

A. My name is Anna Sommer. I am a Principal of Energy Futures Group (EFG), a Hinesburg, Vermont, based consulting company. My business address is 30 Court Street, Canton, NY 13617.

Q. On whose behalf is this testimony being offered?

A. I am testifying on behalf of the Local Environmental Organizations: Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. - Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico.

Q. Please summarize your educational experience.

A. I hold a B.S. in Economics and Environmental Studies from Tufts University and an M.S. in Energy and Resources from University of California Berkeley. I have also taken coursework in data analytics at Clarkson University and in Civil Engineering and Applied Mechanics at McGill University and participated in the U.S. Department of Energy sponsored Research Experience in Carbon Sequestration ("RECS").

Q. Please summarize your work experience.

A. I have worked for over 15 years in electric utility regulation and related fields. During that time I have reviewed dozens of integrated resource plans ("IRPs") and related planning exercises. I have reviewed planning modeling based on multiple models including AURORA, Capacity Expansion Model, Plexos, PowerSimm, PROSYM, PROMOD, SERVM, and System Optimizer and have had formal training on the Strategist and EnCompass planning models.

Prior to joining to EFG, I founded my own consulting firm, Sommer Energy, LLC in 2010 to provide integrated resource planning, energy efficiency, renewable energy, and carbon capture and sequestration expertise to clients around the country.

I was previously employed at Energy Solutions where I helped implement energy efficiency programs on behalf of utilities like Pacific Gas & Electric. Prior to that, I was a Research Associate at Synapse Energy Economics where I provided regulatory and expert witness support to clients on topics including integrated resource planning.

Finally, I am a member of GridLab's[1] Expert team and sit on the Board of the Public Utility Law Project of New York ("PULP"), New York State's advocate for residential low-income consumers of utility services.

My work experience is summarized in my resume, provided as Exhibit LEO-AS-1.

[1] GridLab's mission is to provide "technical grid expertise to enhance policy decision-making and to ensure a rapid transition to a reliable, cost effective, and low carbon future."

Q. Have you testified before this Commission or as an expert in any other proceeding?

A. Yes, I previously testified in Case No. CEPR-AP-2017-0001 and contributed to comments submitted in Case Nos. CEPR-AP-2015-0002 and CEPR-MI-2018-0010.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to discuss my review of the Puerto Rico Electric Power Authority's June 7, 2019 Integrated Resource Plan filing. My principal conclusions with respect to that review are:

1. PREPA fails to act upon a principal conclusion of its own analysis – that customers can save money by exiting from the PREPA system;
2. PREPA's modeling returns the nonsensical result that dramatically overbuilding Puerto Rico's electric system is cost-effective;
3. PREPA overestimated the cost of solar and underestimated the cost of gas combined cycle units and gas commodity prices.
4. PREPA's stakeholder process did not employ best practices.

III. OVERVIEW OF PREPA's IRP

Q. Please describe PREPA's June 7, 2019 filing.

A. PREPA's IRP filing focused on three so-called Strategies:

> ***Strategy 1*** *reflects a traditional and centralized energy program that emphasizes reliability and economic metrics.*
>
> ***Strategy 2*** *reflects a distributed system of flexible generation, and micro or mini-grids and hardening of existing infrastructure around Puerto Rico, which emphasizes resiliency and closeness to*

the customer. In this strategy, most of the load is supplied from local supply resources that can be isolated from the remainder of island during a major event but still supply all or a portion of the nearby load. It is defined in terms of a minimum level of the load to be supplied by local resources (e.g., 80%).

Strategy 3 *reflects a hybrid of the first two strategies that embodies a combination of the benefits of Strategy 1 and Strategy 2. In this strategy, economies of scale are taken advantage of, and some of the load may be served under normal conditions from remote resources. In this strategy, the potential for greater levels of rotating load shed during a major event is greater than Strategy 2 but should result in lower operating costs.* [2]

Siemens describes the manner in which it defined these Strategies as follows:

For each strategy, a combination of assets was developed by putting constraints on the generation, transmission, and distribution assets that are available to Puerto Rico for a specific strategy. For example, a fully distributed strategy did not consider traditional high capacity generating assets such as large gas fueled combined cycle plants or diesel fueled assets. A partially distributed system or hybrid system considered only a limited amount of larger traditional generators.[3]

Some of these Strategies were tested in scenarios defined by Siemens as:

Scenario 1: No new gas-fired generation is installed. The Scenario uses the base case assumptions of solar and storage costs and availability. The only new gas generation considered in this scenario is the conversion of the combined cycle at San Juan 5 & 6.

Scenario 2: Gas to North: The land-based LNG at San Juan in the North is assumed to acquire the required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability. This scenario was eventually dropped as Scenario 4 collapsed to the same conditions in this scenario; only gas was developed in the north and the south.

Scenario 3: Gas to Yabucoa (east) and to Mayagüez (west) through ship-based LNG and gas to the north is supplied through

[2] Taken from page 4-2 of the IRP.
[3] Taken from page 4-3 of the IRP.

land-based LNG at San Juan. The land-based LNG at San Juan is assumed to acquire the required permitting approval. The Scenario assumes the deeper drop (NREL Low Case) of solar and storage costs coupled with high availability of renewables (early ramp up).

Scenario 4: Gas to Yabucoa (east) and to Mayagüez (west) through ship-based LNG and gas to the north is supplied through land-based LNG at San Juan. The land-based LNG at San Juan is assumed to acquire the required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability.

Scenario 5: Aguirre Offshore Gas Port (AOGP), gas to Yabucoa (east) and to Mayagüez (west) is supplied through ship-based LNG. Gas to the north is supplied through land-based LNG at San Juan which is assumed to achieve required permitting approval. The Scenario uses the base case assumption of solar and storage costs and availability. The Scenario also places no restriction on the size of the combined cycle units (CCGT) and up to H-Class (449 MW) could be added. All previous Scenarios had a maximum size of 302 MW F-Class CCGT. The scenario eventually did not select the AOGP, thus confirming that other options modeled were superior.

ESM: Energy System Modernization (ESM); this is a variation of Scenario 4 advanced by PREPA and that includes a set of pre-defined investments decisions that considers procurement options presented by the Public Private Partnership Authority, pricing structures necessary to retain existing natural-gas fired generation in the south, and locational alternatives for new large scale CCGTs. The ESM is benchmarked against the formulated least cost plans. See further details below. [4]

Q. What is your overall opinion of PREPA's IRP filing?

A. My overall opinion is that this IRP, and by extension PREPA, fails to grasp one of the key conclusions of its own analysis – that customers who defect from the grid will *save* money. The entirety of the IRP is based on the presumption that a discrete and rather limited number of customers will choose to self-serve. If PREPA/Siemens is

[4] Taken from pages 4-4 and 4-5 of the IRP.

wrong about that projection there could be devastating consequences for rates because rates will necessarily need to increase even further to recover unamortized capital. Those rate increases could further push ratepayers to leave the system or leave Puerto Rico altogether and would further financially destabilize PREPA and Puerto Rico. Yet despite these facts, the IRP is written as if PREPA is already solvent and would remain so throughout the planning horizon irrespective of the resource planning decisions PREPA makes. PREPA and its consultants also minimize the significance of sensitivities such as low load, despite their own analysis that reveals the ESM to be by far less desirable if PREPA serves less load than is forecasted (see Figure 1). Notably, the poor performance of the ESM under a lower-than-forecasted load would occur regardless of the reason for that lower load, including load reductions caused by grid defection.

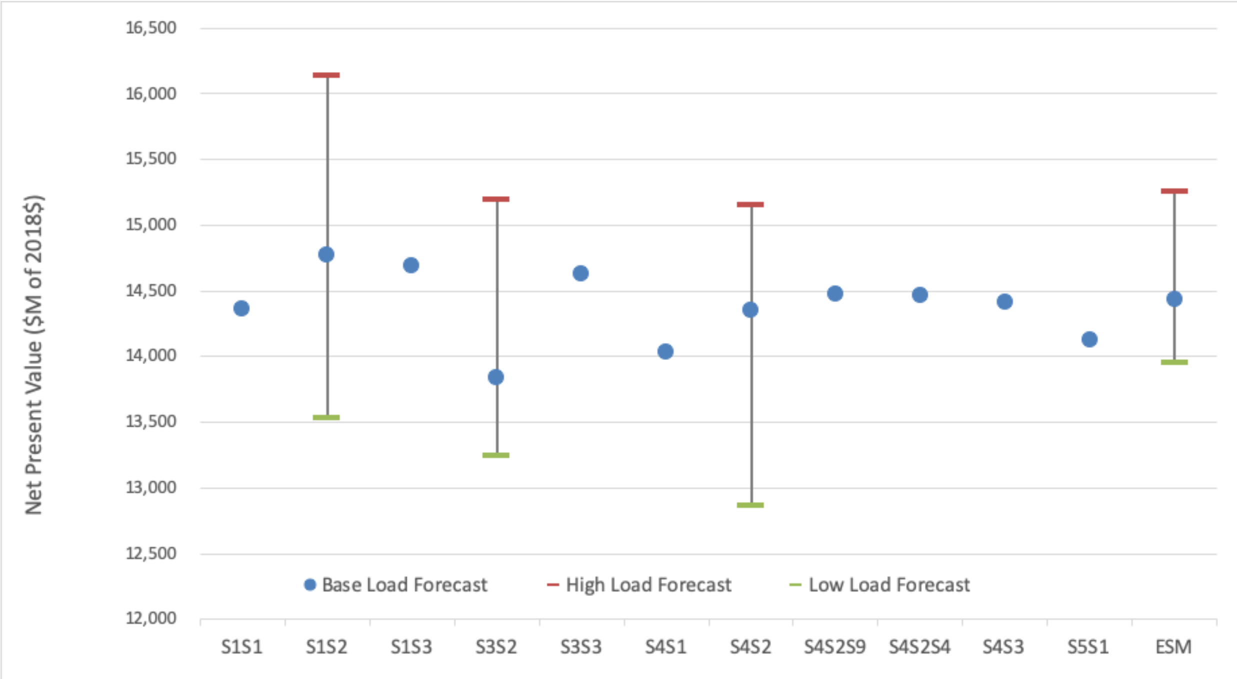


Figure 1. Range of NPVs Under High, Base, and Low Load[5]

As shown in Figure 1, even under Base load conditions, the ESM does not stand out as more desirable than most of the other scenario and strategy combinations and under the Low load sensitivity it performs significantly worse.[6]

Q. What evidence is there that exiting the PREPA system would be cheaper for ratepayers than remaining connected to PREPA?

A. One of the workpapers provided to the Bureau was titled "ESM_Rate_Impact_v3". That workpaper combined fixed costs, variable operation and maintenance costs ("O&M"), and fuel from the ESM metrics workbook (another PREPA/Siemens workpaper) and a separately tracked "non-generation component"[7] into an estimated annual rate. The workbook then compared these combined cost streams on

[5] Taken from PREPA workpaper Summary PREPA IRP Cases-06032019.
[6] Conversely, under the High Load sensitivity the ESM performs roughly on par with two of the three other scenario/strategy combinations evaluated.
[7] I presume, but do not know for sure, that the costs included in this component would be T&D and other "non-generation" costs.

a dollar per MWh basis to alternative supply sources including "residential self-supply,"[8] "diesel generation @ 80% capacity factor," "CHP @ 80% capacity factor," and "residential/commercial DG." In almost every year, PREPA rates are higher. Figure 2 shows this comparison, which is taken from PREPA's ESM rate impact workpaper with only the following modifications: 1) I updated capital, fixed costs, variable O&M, and fuel to be consistent with the ESM Metrics workpaper that was provided and 2) changed the font size to be more readable.

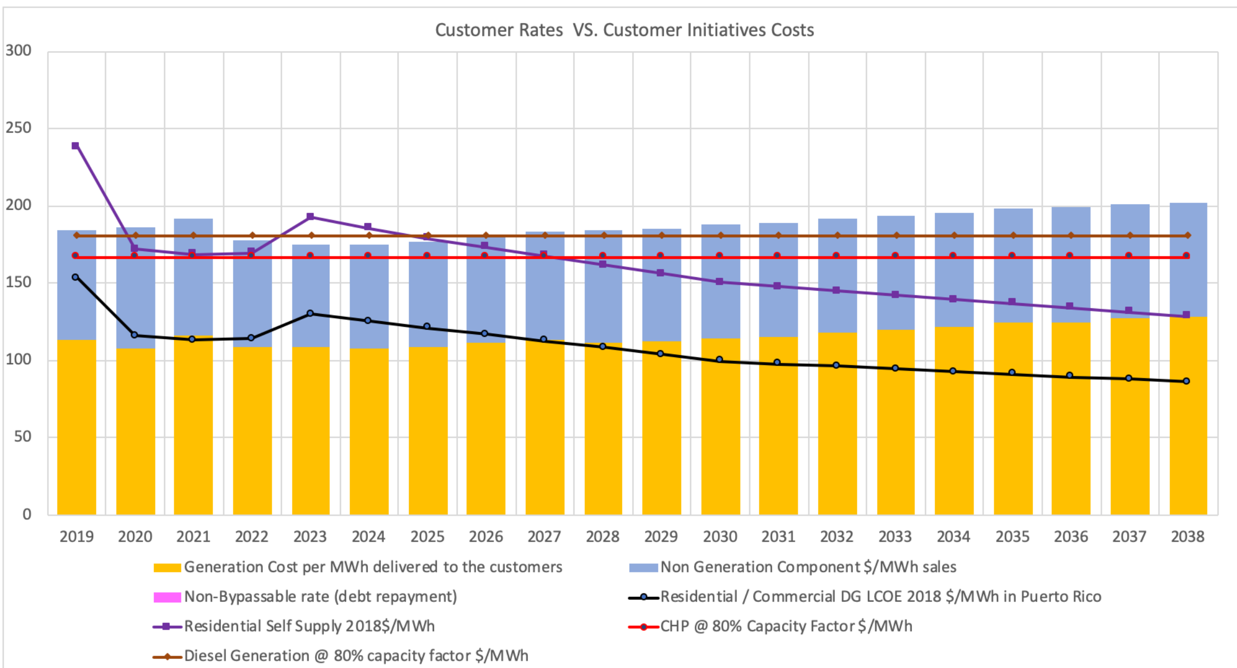


Figure 2. PREPA Comparison of its Rates to Various Alternative Customer Supply Options

The light blue and yellow bars represent the sum of the estimated costs from supply by PREPA and each of the lines represent the alternative supply options. While the legend indicates that there is also a pink bar representing "Non-Bypassable rate (debt repayment)", it is missing from the graph. Siemens representatives stated during the

[8] Residential self-supply is based on a calculation of the levelized cost of photovoltaics combined with a 6-hour battery.

September 4, 2019, technical hearing that it removed any debt repayment from this calculation. To account for the Restructuring Support Agreement ("RSA"), which PREPA endorses, I added the costs contained in the RSA back into Figure 3.

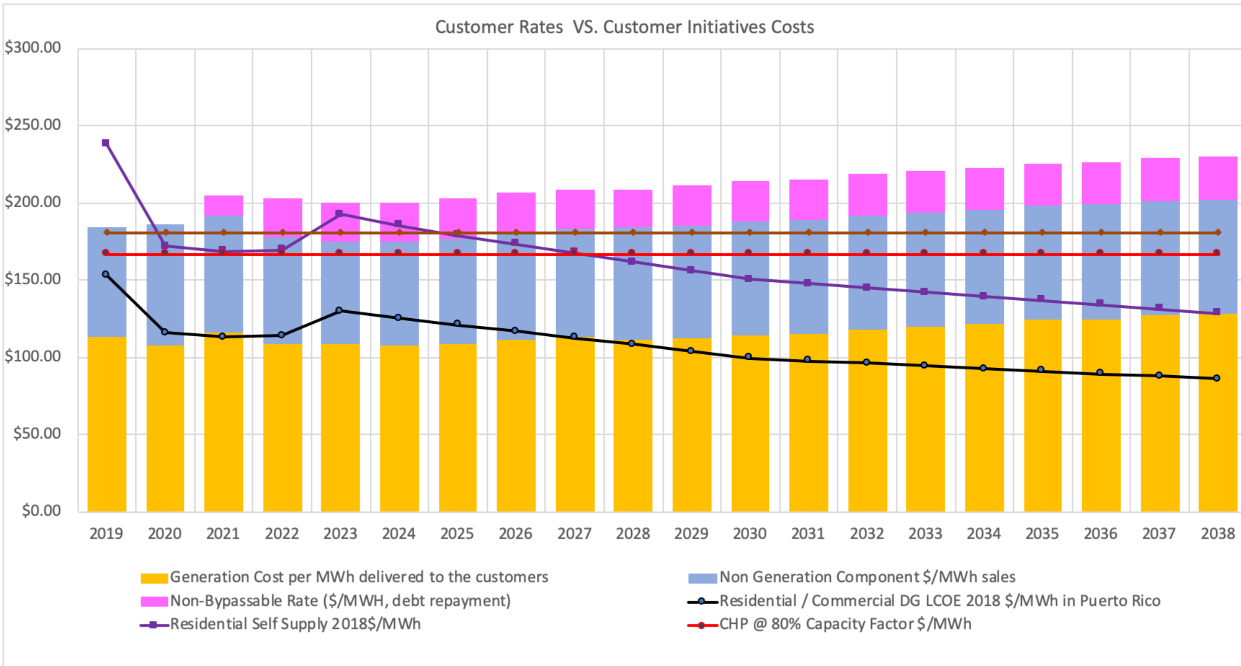


Figure 3. PREPA Comparison of its Rates to Customer Supply with RSA Charges Added

There are some likely conservatisms in both Figure 2 and Figure 3. First, concerning capital recovery because all capital costs appear to be reflected as annuities, i.e., equal annual payments. Oftentimes capital for owned assets is not recovered from customers in this fashion but instead as revenue requirements in which payments made by customers decline over time. This has the effect of raising rates in the short term, which is not reflected in these figures. If this is true of a material amount of ESM capital investments, the effect will be to exacerbate incentives to exit PREPA's system. Second, these graphs may understate rates under the ESM because the calculations may not include costs associated with PREPA's MiniGrid proposal. The so-called "Non-Generation Component" is hardcoded in the rate impact workpaper, so it is impossible to tell how it is derived. However, PREPA's average rates are roughly in the 20 cent per kWh or $200 per MWh range. I interpret the MiniGrid proposal to be an additional capital requirement and therefore would have a rate impact above and beyond "typical" rates. Since the average projected 2019 rate is $185 per MWh it seems highly unlikely that the MiniGrid investments are included. Finally, it is worth noting that the rates shown in both Figures are in real 2018 dollars so rates inclusive of the RSA charges are projected *to go up over time*.

Q. Do you have any additional overall conclusions regarding the IRP?

A. Yes. The IRP violates key aspects of the Bureau's IRP rule and contains nonsensical results and flawed inputs that make it impossible to conclude that the ESM is the preferred plan.

Q. In what ways does the IRP not comply with the Bureau's IRP regulation?

A. The IRP violates the Bureau's IRP regulation in at least three key ways. First, PREPA failed to submit required modeling files. Regulation 9021 requires that "PREPA shall, at a minimum," file workpapers with the Bureau including both the "Resource Plan modeling input files" and the "Resource Plan modeling output files as used by PREPA."[9] Neither were included in the workpapers. I have reviewed another IRP based on Aurora modeling and have gathered from that experience and from conversations with Aurora's vendor, Energy Exemplar, that Aurora does not have the ability to export the entirety of its database. Because of the Bureau's existing requirement for sharing modeling files,[10] both PREPA and Siemens ought to have been aware of the Bureau's requirement in this

[9] Regulation 9021, Section 2.02(F)(1)(c)-(d).
[10] The IRP rule was finalized on April 24, 2018.

regard and either a) made provisions for a read-only license at no expense to the Bureau and intervenors in order to access the data, or b) used a different model with the capability to create exportable input and output files. This lack of data is not remedied by the workpapers that were supplied—indeed, the workpapers that were provided (i.e., the "Metrics" workbooks) just serve to underscore how important this information is to a full and complete review of any IRP.

Second, the IRP rule at Section 2.02(F)(2) states:

> *PREPA shall provide to the Commission any computer model including the software and licensure necessary for the Commission, or its consultants, to independently run any analysis relied upon by PREP A. Alternatively, PREPA may provide the Commission reasonable access to the computer model at the Commission's offices or at another mutually agreeable location. Such access shall be adequate to enable the Commission to replicate the results and may include PREPA manipulating the computer model according to instructions or inputs from the Commission. Reasonable access shall be made available to intervenors. If PREPA seeks to limit access to the program or application to intervenors, the Commission will determine the appropriate access to the program or its output.*

To my knowledge, PREPA did not provide the Bureau access to an Aurora license nor did any intervenor have access to an Aurora license at PREPA's cost. Even a read-only license would have greatly aided in understanding and auditing the modeling Siemens performed on behalf of PREPA. Put another way, in the words of Siemens' Engagement Manager, Marcelo Saenz,

> *[T]he model is not only about input assumptions, it is also about switches and commands that you provide to the model and the complexity of the model. One of the complexities is that you may have more than one command in different locations. Sometimes one command may overwrite another one and without the expertise to know which one is affecting it, you may misinterpret the inputs and the settings in the model. In other words, you may need to have two things. One is the*

> *license for the model and second similar expertise in handling these types of models.*[11]

Q. In its order dated March 14, 2019 the Bureau granted PREPA what it termed not a waiver per se, but approval of PREPA's alternative proposed approach for providing access to the modeling files. How do you respond?

A. Yes, in its order the Bureau stated:

> *PREPA's Waivers Request also included a proposed approach to the subject of Computer Modeling and Software, stemming from Section 2.02(F)(2) of Regulation 9021,and suggests that this is not a waiver request.*[55] *PREPA proposes to make available to the Energy Bureau the databases used to conduct its analysis and the Energy Bureau then either (a) provides PREPA the modifications it wishes to analyze and permits PREPA to run the software and provide the results to the Energy Bureau, or (b) provides PREPA a list of changes and permits PREPA to modify the database, run the software, and provide the output. PREPA further states that it makes a similar proposal regarding intervenor access to modeling and software.*

It is my professional opinion that PREPA's proposed alternative is not sufficient. I have direct experience with a similar process in another IRP case. In that case, much like this one, the model returned nonsensical results. Unlike this case, we had access to a significant portion of the model's input and output files but even so were not able to determine why the results were nonsensical. I think our team could have troubleshooted the issue with two things 1) a copy of the model's manual and 2) interest and time on the part of the utility to do iterative runs that would test out our theory of why the results were so nonsensical. Neither of those circumstances applied in that case nor do they apply here. I know that Aurora's vendor will not permit non-licensees to see the model manual even under a confidentiality agreement and Siemens/PREPA have struggled to file this IRP and its workpapers in a timely fashion. That combined with the

[11] September 4, 2019 Technical Hearing at https://youtu.be/spMJQLhv6rQ?t=9061.

short timeframe for review and testimony would not permit the kind of back and forth necessary to understand why Aurora would, for example, return results that overbuild PREPA's system so dramatically as I describe in Section V of my testimony.

IV. STAKEHOLDER PROCESS

Q. Dr. Nelson Bacalao of Siemens testifies that "the IRP's development included a robust stakeholder process in which plans for the IRP were shared and stakeholders gave feedback, input, and proposals, on strategies, scenarios, sensitivities, and other aspects of the plans."[12] Do you agree with Dr. Bacalao?

A. No, while I was not able to participate in all the stakeholder workshops, the workshop I did listen to (the March 12, 2019 workshop) did not provide much meaningful opportunity for input and lacked what I would consider some best practices for pre-IRP stakeholder workshops.

Q. What best practices should have been employed?

A. In my experience IRP stakeholder workshops function best when the utility takes seriously the feedback stakeholders offers it and makes a good faith attempt to model the resources, portfolios, and scenarios that stakeholders would like to see modeled. It's hard to be prescriptive about these qualities, but they are important not just for the robustness of the IRP but for the perceived seriousness and comprehensiveness of any IRP. Some other, more easily defined best practices include:

1. Use of a credible third-party moderator (i.e., not the utility nor its IRP consultant) to facilitate questions and answers and keep all parties on

[12] Bacalao Testimony at page 31, lines 48 – 50.

schedule. The moderator can also be responsible for making sure that parties on the phone can hear everyone in the room where the presentation is happening and vice versa.

2. Sharing of power point presentations and data well in advance of meetings.
3. Allowing interested stakeholders the opportunity to make their own presentations on topics relevant to the IRP.
4. A schedule of meeting topics, dates, and times shared well in advance of the meetings.
5. The opportunity and time for stakeholders both in the room and in person to ask questions at each meeting.

The stakeholder workshop I participated in did not employ any of these best practices.

V. MODELING APPROACH AND ASSUMPTIONS

Q. You stated previously that the workpapers supporting the Aurora capacity expansion modeling in this case "just serve to underscore how important [the modeling files are] to a full and complete review of any IRP." Can you explain what you mean by that statement?

A. Yes, there are a number of modeling issues that strike me as significant and for which I don't think PREPA or Siemens have provided satisfactory answers. The first is the extraordinarily high reserve margins in a number of scenarios as shown in Figure 4.

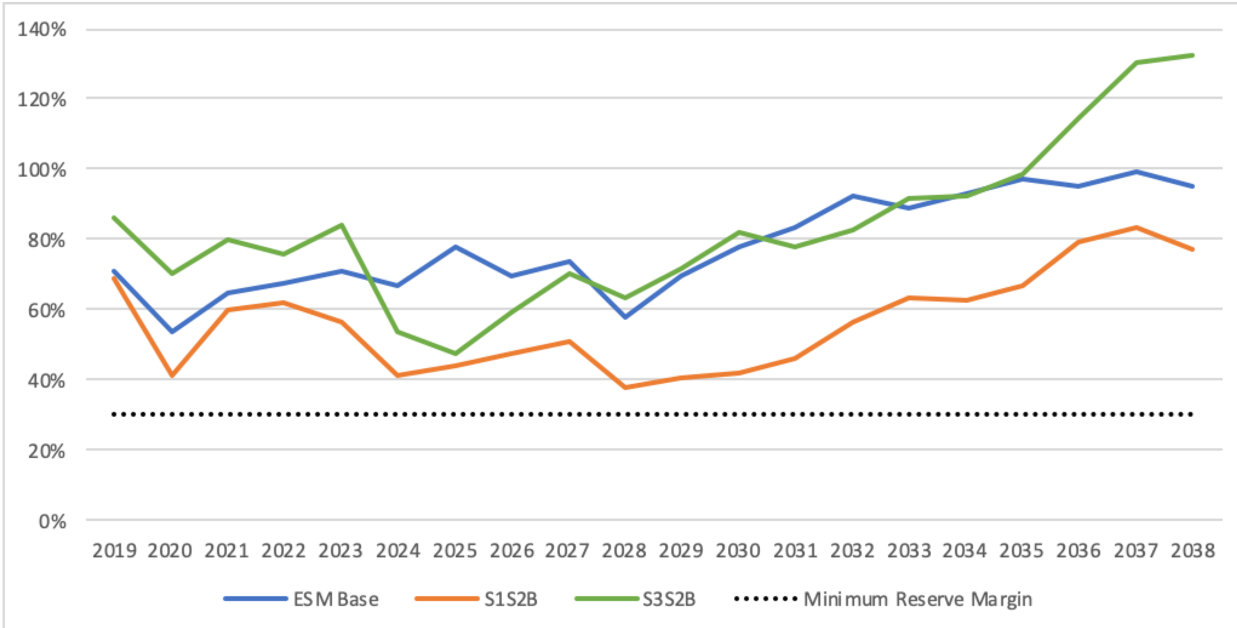


Figure 4. Effective Reserve Margins in Selected Plans

In all my years of experience with IRP filings I've concluded that it is very nearly a truism that a higher reserve margin equals higher cost. Increasing reserve margins are generally satisfied with increasing megawatts of power plant capacity which in turn mean increasing dollars both for capital and maintenance and operation of those units. A downward revision to the reserve margin requirement normally saves customers money and while a utility may exceed its reserve margin requirement in many years, it is relatively rare for a utility to hold the levels of excess capacity contemplated in these plans and virtually unheard of for a utility to *plan* to acquire this level of excess capacity.

I did not find Section 8.7 Planning Reserve Margin Considerations sufficiently persuasive in its assessment of the importance of the reserve margin requirement to the modeling optimization. It should not satisfy anyone including the Bureau to simply know that the reserve margin constraint is non-binding on most plans. The question is why that the case and it is precisely this type of counterintuitive result that necessitates a thorough review—not of the summary of the Company's modeling runs nor its qualitative representation of those runs—but rather of the actual modeling files themselves. With respect to the ESM, in which significant resource choices were fixed, it should raise serious questions about how PREPA can justify this plan as the preferred plan, as a cost-efficient plan, when significant ratepayer dollars are at risk and such significant overbuilding would occur.

Q. Does the fact that PREPA is projected to have significantly declining load factor into a possible explanation for this result?

A. Many mainland utilities are expected to have flat to declining loads, though I'm not aware of any projecting declines in line with the magnitude forecasted by PREPA. The decline does lead to a phenomenon of decreasing utilization of assets, specifically the thermal assets. I would expect that to result in some assets becoming stranded, meaning that they will no longer be useful in serving customers simply because there is not sufficient load to justify their operation. If those units remain in service they will indeed contribute to higher than necessary reserve margins. However, I do not believe this fully explains why reserve margins would be so high given that PREPA's reserves are extraordinarily high from the very first year of the planning period, rather than increasing over time as would be associated with declining load. As previously stated, I think this issue deserves close scrutiny within the Aurora interface itself and neither the Bureau nor intervenors have the capability to do so.

Q. Do have any possible theories for why these runs would be so overbuilt?

A. I have suspicions, but no one theory of why this could be happening. Some of those suspicions include:

1. **Loss of Load Hours ("LOLH") –** Siemens implies that the reserve margin requirement is intended to get the system to no more than 4 loss of load hours ("LOLH") per year.[13] Oftentimes, one cannot do capacity expansion modeling for a 20 year period *and* simulate the dispatch of all units for 8,760 hours in each year within a single run. So the modeler will either condense timesteps into greater than hourly intervals or model representative days intended to be "typical" of a given month or s/he will do both. This is a normal limitation on IRP models that is necessary to make the model return a result. As a hypothetical, if one week in each month is simulated then the results of that month are multiplied by roughly 4 (for the number of weeks in the month). So if it a loss of load hour occurs in the typical week representation in the month of February then from an annual perspective, four loss of load hours are expected to have occurred because all weeks are assumed to be identical. Any additional LOLH would then violate Siemen's criteria. To the extent that LOLH influence the modeling result, because there is a price on unserved energy or otherwise, this could drive the acquisition of excess capacity and would not be a good approximation of actual system operations.
2. **Forced Outage Rates in General –** A system PREPA's size with no interconnection will be very sensitive to generation outages and the manner in which those outages are modeled, i.e., as the unit being offline or as a proportional reduction in generator output and probabilistically versus deterministically. All of which can overly influence loss of load hours. For

[13] Page 8-

example, deterministic runs in which a unit goes offline entirely is likely to result in greater loss of load and therefore more need for generation than that same deterministic run but with generator output adjusted proportionately downward for the forced outage rate. Because I lack access to Aurora's model manual and the modeling files I do not know how forced outages were simulated by Siemens.

Q. Are there other problems with the Aurora modeling that would significantly influence the results?

A. Yes, Siemens did not correctly calculate the cost of solar. As shown in Exhibit 6-34 of the IRP, it used a "AC/DC Conversion" factor or inverter loading ratio ("ILR") of 1.3. However, the source of Siemens' solar capital cost estimates, the National Renewable Energy Laboratory's ("NREL") 2018 Annual Technology Baseline ("ATB") specifically states:

> *Capacity factor is the ratio of the annual average energy production (kWh_{AC}) of an energy generation plant divided by the theoretical maximum annual energy production of a plant assuming it operates at its peak rated capacity every hour of the year. The formula for calculating capacity factor is given by:*
>
> $$CF = \frac{Annual\ energy\ production\ (kWhAC\ /\ year)}{System\ rated\ capacity\ (kW) \times 24\left(\frac{hours}{day}\right) x\ 365\ \left(\frac{days}{year}\right)}$$
>
> *For a PV system, the rated capacity in the denominator is either reported in terms of the aggregated capacity of (1) all its modules or (2) all its inverters. PV modules are rated using standard test conditions and produce direct current (DC) energy; inverters convert DC energy/power to alternating current (AC) energy/power. Therefore, the capacity of a PV system is rated either in MW_{DC} via the aggregation of all modules' rated capacities or in MW_{AC} via the aggregation of all inverters' rated capacities. The ratio between these two capacities is referred to as the inverter loading ratio (ILR).*
>
> *Because the capacity factor is calculated using a system's rated capacity, it can be represented using exclusively AC units or using AC units for*

> *electricity (the numerator) and DC units for capacity (the denominator). Both capacity factors will result in the same LCOE as long as the other variables use the same capacity rating (e.g., if capacity factor is calculated in kWh_{AC}/kWh_{DC}, then CAPEX should use the units of $\$/kW_{DC}$). Both capacity factors will also produce the same estimated energy generation as long as they use consistent units.*[14]

In other words because the ATB's capital cost estimates are in $\$/kW_{DC}$ and capacity factor is in units of kWh_{AC}/kWh_{DC}, no additional conversion for the inverter loader ratio is needed. In effect, Siemens has needlessly included a 30% adder to the price of solar.

Q. Are there other capital cost assumptions that give you concern?

A. Yes, in my opinion Siemens underestimated the cost of the new combined cycle gas turbine ("CCGT") resources. I would expect the actual cost of those resources to be 15 percent or more than is estimated by Siemens.

Q. What is the basis for your assessment?

A. Siemens appears to have modeled the Palo Seco and Yabucoa CCs (302 MW each) with a capital cost of $1,096 per kW on a nominal basis for every year. This means that in real terms the capital costs of those units are projected to decline so that by the time the Yabucoa and Palo Seco CCs come online they have a capital cost of $945 per kW in 2018 dollars.[15] There are relatively few combined cycle units of this size proposed and/or built in recent history in the U.S. which makes finding comparable data difficult. However, in 2018, Northern Indiana Public Service Company issued an all-source RFP and received multiple bids for CCGT facilities. The average bid price was $960 per kW

[14] See https://atb.nrel.gov/electricity/2019/pv-ac-dc.html.
[15] Using Siemens' inflation assumptions show in its ESM Rate Impact workbook.

for an average project size of 764 MW.[16] In addition, S&P Global collects data on power plant projects under development or construction. While there was no data for a project of comparable size to Yabucoa or Palo Seco, the average capital cost for combined cycle projects under 600 MW was $1101 per kW. The projects upon which this calculation is based are shown in Appendix 1.

While Siemens' cost assumption is $32 - $155 per kW lower than the average of current projects under 600 MW in size, it is important to keep in mind that most of these projects are nearly twice as big as the Yabucoa and Palo Seco CCGTs. So there is an open question as to whether the cost ought to be even higher because of the inability to capitalize on the same economies of scale available to the much bigger projects.

Q. Is this the only reason you think Siemens may have underestimated the cost of constructing a new combined cycle in Puerto Rico?

A. No. I understand from Section 6.3.2.2 of the IRP that Siemens added the same 16% Puerto Rico specific adder to combined cycle capital costs that it applied to solar capital costs. Meaning that whether one views $1069 per kW or $945 per kW as the appropriate point of comparison to the average project cost of $1101 per kW for CCGTs under 600 MWs, there is a 16% adder embedded in the Yabucoa and Palo Seco costs that is unlikely to be present in any of the capital costs for mainland projects. If the adder applied to all costs, the true comparison to the $1101 per kW figure would be $922 per kW or $816 per kW --- $179 to $285 per kW less expensive than projects in Appendix 1 that are almost double in size. I can think of no reason why it would be dramatically cheaper to build a smaller combined cycle unit in Puerto Rico than it would to build a

[16] From *Figure 4-11: Summary of Proposals by Price*, NIPSCO 2018 IRP Submission, p. 56

much larger unit in the mainland U.S. Indeed, I would expect a combined cycle in Puerto Rico to be *more* expensive that a project of similar size, let alone a larger size, on the mainland. Each of these data points is given in Table 1, below. Notably, while Siemens ran a sensitivity with higher solar and storage costs it did not perform a sensitivity with higher gas capital costs.

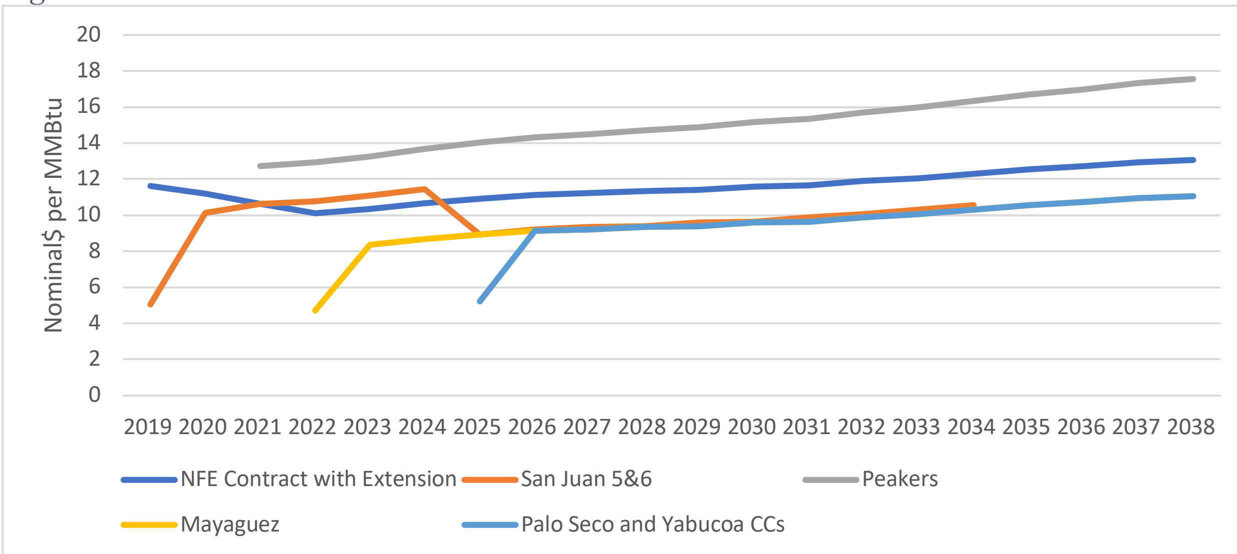
Table 1. Comparison to Costs of Other Combined Cycle Projects in the U.S.

Project	**Cost**
Average of S&P Global Tracked Projects Under 600 MW	$1101/kW
Yabucoa and Palo Seco CCs (302 MW each)	$945 – 1096/kW
Yabucoa and Palo Seco CCs (302 MW each) with assumed 16% adder removed	$816 – 922/kW

Q. Do you have concerns about other input assumptions in PREPA's IRP?

A. Yes. I think PREPA is likely understating the price for natural gas fuel. First, modeled gas prices, as shown in Figure 5 in the orange line, are inconsistent with the contract PREPA signed with New Fortress Energy ("NFE") to supply natural gas to the converted San Juan 5 and 6 units (the dark blue line through the first half of 2024).

Figure 5. Natural Gas Prices Modeled in the ESM



In some years the prices are lower and in some they are higher. The New Fortress Energy contract is informative in that it is the first and so far only indication of the charges associated with liquefaction and transportation of LNG to Puerto Rico. That charge starts at $8.50 per MMBtu for the first 12 months and then drops to $6.50 per MMBtu for months 24 through the end of the 5-year contract term. No matter which year of the contract one chooses to use, the charge is significantly higher than the $4.35 per MMBtu assumed by Siemens. Given that, I think it would have been most reasonable to use the last year of the NFE contract as the best indicator of the liquefaction and transportation adder that ought to be applied. The impact of this assumption is reflected in the dark blue line from 2024 to 2038. This can be compared to the assumption that Siemens used shown in the both orange and the ligher blue lines, "Mayagüez", "San Juan 5&6", and "Palo Seco and Yabucoa CCs", which are materially lower.

Note that there is some additional conservatism built into both Siemens' assumptions and Figure 5. The Mayagüez, Palo Seco and Yabucoa CCs, and NFE Contract Extension lines are predicated on the assumption that the transportation and liquefaction adder is constant in nominal dollars, but declining in real dollars. I would not expect this to actually be the case for the entirety of the planning period. Modifying this assumption will raise the cost of fuel throughout the planning period.

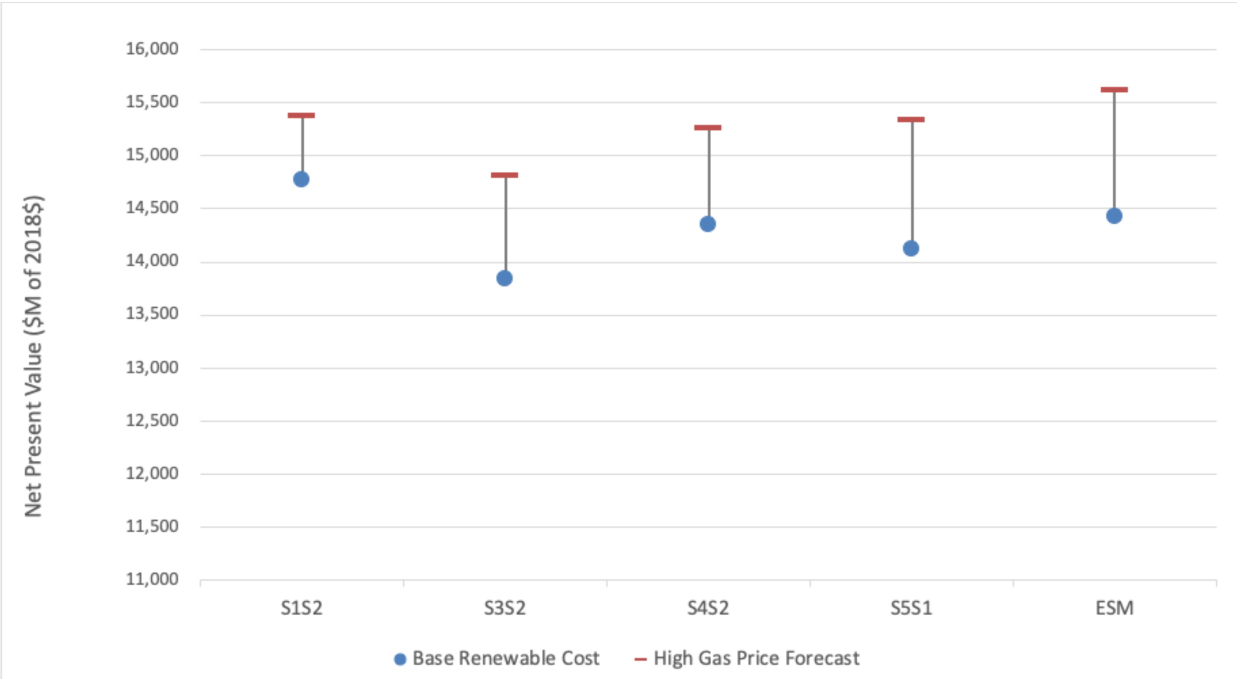
In general, the modeled prices start out at a surprisingly low value.[17] In subsequent years Siemens continues to forecast significant and consistent price separation between the gas prices for the peakers versus the combined cycle and Mayagüez units. I do not know why that would be the case. I don't believe this is a reflection of the difference in heat rate, it would not make sense to account for that in the fuel price. Rather, this would seem to be based on an unspecified difference in assumed transportation charges that are not described by PREPA/Siemens in the IRP.

Q. Does the high gas price sensitivity fall close to the dark blue line of Figure 5?

A. I do not know. According to Exhibit 5-4 of the IRP Siemens did not rerun any plans using higher gas prices (Sensitivity 5). Indeed, the workpapers for the Sensitivity 5 runs don't actually reflect a higher gas price. So I have no sense of how much higher gas prices would be under that sensitivity or if Siemens actually and appropriately performed that sensitivity. However, in its summary workbook, PREPA provided Figure 6.

[17] Throughout my review I observed a tendency to underestimate fuel cost, overestimate heat rate, and halve nameplate capacity in the first year a unit comes online. I do not know if this is an artifact of how data was reported out of Aurora or is how Siemens represented units coming online midway through the year.

Figure 6. NPV Under Base and High Gas Prices



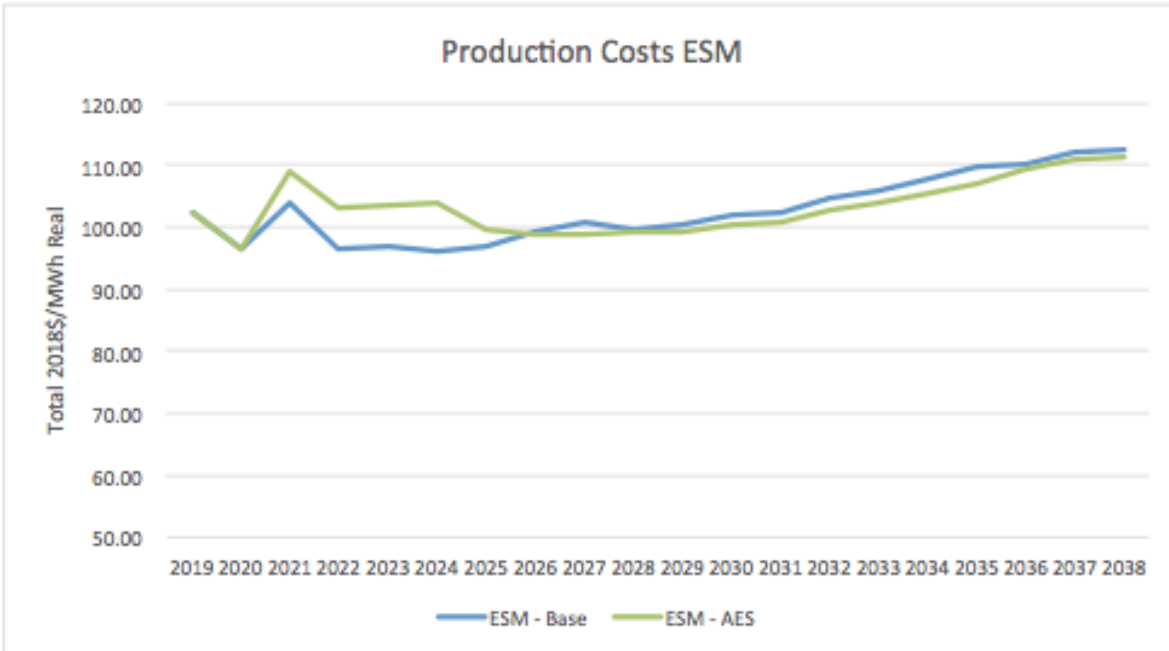
As with the High and Low Load sensitivities, the other plans outperform under the High Gas Price sensitivity. Again, I cannot verify the source of these numbers, but simply show them to demonstrate that Siemens reports that the Higher Gas Price sensitivity does not weigh in favor of selection of the ESM.

<u>VI. AES CONVERSION ASSESSMENT</u>

Q. What do you take away from the assessment, performed by Siemens, of the conversion or early retirement of the AES coal units?

A. As required by the Energy Bureau, Siemens performed an assessment of the economics of converting the AES coal units to a different fuel, or retiring them at the end of 2020 rather than 2028. Siemens predicts that the NPV of the ESM, with AES retiring at the end of 2020, is 1.2% higher than the ESM base case. The assessment shows that the difference in annual cost between the as modeled ESM and the ESM with AES retired is one percent or less from the period 2022 – 2026 and then actually lower in cost for the remainder of the planning period, see Figure 7.[18]

Figure 7. Costs of ESM versus ESM with AES Retired at the end of 2020[19]



[18] Confusingly, what Siemens terms "ESM – AES" means AES is retired at the end of 2020.
[19] Figure 3-10: ESM Production Costs $/MWh, p. 2-10 of Siemens' AES Coal Plant Conversion Assessment.

What Siemens terms "production costs" include fuel, variable O&M, and fixed costs which include at least some amount of capital costs. This figure does not include debt repayment or "non-generation" costs included in *Figure 2*. Including debt repayment costs and "non-generation" costs would further dampen the rate impact of retiring AES early. Siemens' assessment also does not include quantification of the non-energy impacts (e.g., environmental or health) from earlier retirement of the AES plant.

VII. RECOMMENDATIONS TO RECTIFY THIS IRP

Q. What recommendations would you have the Bureau make to PREPA to rectify the problems with this IRP?

A. At a high level, I would recommend the following:

1. Direct PREPA/Siemens to test sensitivities with differing and higher levels of customer owned generation. I would also note that the issue of customers leaving the PREPA system in general requires more attention than just modeling sensitivities. It should be reflected in decision making about how to improve interconnection practices and standards, how to finance and acquire new generation, debt repayment negotiations, and other ratemaking, planning, and financial activities of PREPA. The purpose of all these activities should not be to discourage customer owner generation but rather to reorient PREPA to a much more distributed system so as to encourage customers to remain connected and avoid a situation in which the customers who cannot exit are not bearing the burden of stranded costs and debt repayment charges.

2. Direct PREPA/Siemens to use a model that is capable of sharing input files, output files, and model manuals with the Bureau and intervenors.
3. Direct PREPA/Siemens to modify solar capital, CCGT capital, and gas prices to better reflect current realities.
4. Engage in a stakeholder process that invites and supports stakeholder input and uses the best practices laid out in my testimony.

Q. Does this complete your testimony?

A. Yes, however I reserve the right to supplement my testimony based on late filed discovery responses from PREPA.

CERTIFICATION

I Anna Sommer, CERTIFY that the contents of my testimony are known to me and are the truth according to the best of my abilities and reasonable knowledge. The technical and operational aspects included in the testimony are based on information that has been gathered in good faith; but I cannot guarantee the truthfulness of information gathered from third parties.

Anna Sommer
Signature

Before me, the undersigned Notary Public, personally appeared Anna Sommer, who acknowledges that the above is true this day of October 22, 2019 in 2019.

Personally known ____ OR Identification Document provided Drivers License.

Notary Public Name, Signature, Seal

JENNIFER E. GOLLINGER
Notary Public, State of New York
No. 01GO6323115
Qualified in St. Lawrence County
Commission Expires April 13, 2023

STATE OF NEW YORK
ST LAWRENCE COUNTY

I, Sandra W. Santamoor, Deputy Clerk of the County of St. Lawrence and of the Supreme Court of said State within and for said County, which is a Court of Record, and keeper of the Seal thereof,
DO HEREBY CERTIFY that Jennifer Gollinger whose name is subscribed to the certificate or proof of acknowledgment, affidavit or oath on the annexed instrument was at the time of taking such acknowledgment, proof or affidavit or administering such oath, duly authorized to take or administer the same and was a Notary Public within and for said State, dwelling in said County, duly appointed, commissioned, and sworn, and authorized by the laws of this State to administer oaths for general purposes and take affidavits and the acknowledgment or proof of deeds to be recorded in this State: that I am well acquainted with his handwriting and verily believe that the signature to the said acknowledgement or proof, affidavit or oath is genuine; and that such certificate is not required by the law of said State to be under Seal.

IN TESTIMONY WHEREOF, I HAVE HEREUNTO SET MY HAND AND THE Seal of said Supreme Court at Canton, in said County,
This 23rd day of October 20 19.

Sandra W. Santamoor
Sandra W. Santamoor, Deputy County Clerk

Appendix 1

Project Name	*New Capacity (MW)*	*State, Province, or Admin Region*	*Year in Service*	*Current Development Status*	*Estimated Construction Cost ($000)*	*Capital Cost ($ per kW)*
Big Bend CC Project	1090	FL	2023	Construction Begun	853000	783
Birdsboro Combined Cycle Plant	488	PA	2019	Completed	600000	1230
Blue Water Energy Center (Belle River Combined Cycle Plant)	1146	MI	2022	Construction Begun	1000000	873
Cadiz Combined Cycle Plant (Harrison County Industrial Park)	1050	OH	2021	Early Development	900000	857
Clear River Energy Center (Burrillville Power Plant)	1080	RI	NA	Early Development	1000000	926
CPV Three Rivers Energy Center	1250	IL	2021	Early Development	1312500	1050
Danskammer Energy Center (Repowering)	636.4	NY	2023	Early Development	649128	1020
ESC Brooke County Power I	830	WV	2022	Advanced Development	884000	1065
Guernsey Power Station	1875	OH	2022	Advanced Development	1600000	853
Harrison County Project	578.9	WV	2022	Advanced Development	615000	1062
HenderSun Energy Center (Cash Creek)	790	KY	2021	Early Development	816900	1034
Indeck Niles Energy Center	1171.4	MI	2022	Advanced Development	1000000	854
Killingly Energy Center	647	CT	2022	Early Development	537000	830
La Paloma Energy Center	735	TX	2021	Advanced Development	650000	884
Lincoln Land Energy Center (Pawnee Natural Gas Plant)	1100	IL	2023	Early Development	1000000	909
Long Ridge Energy Generation Project (Hannibal CC Project)	485	OH	2021	Advanced Development	600000	1237
Mankato Power Plant	200	MN	2019	Completed	300000	1500
Moundsville Power Project	673	WV	2022	Advanced Development	700000	1040
Nemadji Trail Energy Center	625	WI	2024	Early Development	700000	1120
North Bergen Liberty Generating Project	1200	NJ	2022	Early Development	1500000	1250
R.D. Morrow Repower Project	550	MS	2023	Advanced Development	442000	804
Reidsville Energy Center	475	NC	2022	Advanced Development	500000	1053
South Field Energy	1132	OH	2021	Construction Begun	1300000	1148
Trumbull Energy Center	940	OH	2023	Advanced Development	900000	957
West Riverside Energy Center	732	WI	2020	Construction Begun	700000	956
Projects Under 600 MW						1101
Projects Over 600 MW						963

Anna Sommer
Principal

Professional Summary

Anna Sommer is a principal of Energy Futures Group in Hinesburg, Vermont. She has more than 15 years' experience working on a wide variety of energy planning related issues. Her primary focus is on all aspects of integrated resource planning (IRP) including capacity expansion and production costing simulation, scenario and sensitivity construction, modeling of supply and demand side resources, and review and critique of forecast inputs such as fuel prices, wholesale market prices, load forecasts, etc. Additionally, she has experience with various aspects of DSM planning including construction of avoided costs and connecting IRPs to subsequent DSM plans. Anna is trained to run the Strategist and EnCompass models and has reviewed modeling performed using numerous models including AURORA, Capacity Expansion Model, Plexos, PROSYM, PROMOD, and System Optimizer. She has provided expert testimony in front of utility commissions in Indiana, Michigan, Minnesota, New Mexico, North Carolina, Puerto Rico, and South Dakota.

Experience

2019-present: Principal, Energy Futures Group, Hinesburg, VT
2010-2019: President, Sommer Energy, LLC, Canton, NY
2007-2008: Project Manager, Energy Solutions, Oakland, CA
2003-2007: Research Associate, Synapse Energy Economics, Cambridge, MA

Education

M.S. Energy and Resources, University of California Berkeley, 2010

Master's Project: *The Water and Energy Nexus: Estimating Consumptive Water Use from Carbon Capture at Pulverized Coal Plants with a Case Study of the Upper Colorado River Basin*

B.S., Economics and Environmental Studies, Tufts University, 2003

Additional training

Graduate coursework in Data Analytics – Clarkson University, 2015 – 2016.
Graduate coursework in Civil Engineering and Applied Mechanics – McGill University, 2010.
Research Experience in Carbon Sequestration (RECS), 2009.

Selected Projects

EfficiencyOne. Supporting EfficiencyOne's participation in Nova Scotia Power's integrated resource planning process. (2019 to present)

Energy Futures Group, Inc
PO Box 587, Hinesburg, VT 05461 – USA | 315-386-3834 | asommer@energyfuturesgroup.com

Minnesota Center for Environmental Advocacy. Evaluation of Xcel Energy's 2020 Integrated Resource Plan and Strategist modeling in support of that evaluation. (2019 to present)

Coalition for Clean Affordable Energy. Evaluation of Public Service Company of New Mexico's abandonment and replacement of the San Juan generating station. (2019 to present)

Earthjustice. Evaluation of the Puerto Rican Electric Power Authority's 2019 Integrated Resource Plan. (2019 to present)

Citizens Action Coalition of Indiana. Advising stakeholders on stakeholder workshops in preparation for Indianapolis Power & Light's integrated resource plans to meet future energy and capacity needs. (2019 to present)

Environmental Law and Policy Center. Evaluation of DTE Energy's 2019 Integrated Resource Plan modeling and Strategist modeling in support of that evaluation. (2019)

Citizens Action Coalition of Indiana. Advising stakeholders on stakeholder workshops in preparation for Duke Energy Indiana's integrated resource plans to meet future energy and capacity needs and critiquing the subsequent IRP filing. (2018 to present)

Citizens Action Coalition of Indiana. Advising stakeholders on stakeholder workshops in preparation for Indiana Michigan Power Company's integrated resource plans to meet future energy and capacity needs and critiquing the subsequent IRP filing. (2018 to present)

Citizens Action Coalition of Indiana. Comments on Northern Indiana Public Service Company's integrated resource plans to meet future energy and capacity needs. (2019)

Citizens Action Coalition of Indiana. Evaluation of Southern Indiana Gas and Electric's proposal to build a new natural gas combined cycle power plant. (2018)

Minnesota Center for Environmental Advocacy. Evaluation of Minnesota Power Company's proposal to build a new natural gas combined cycle power plant and Strategist modeling of alternatives to the plant. (2018)

Minnesota Center for Environmental Advocacy. Comments regarding Great River Energy's integrated resource plan to meet future energy and capacity needs. (2018)

New Energy Economy. Evaluation of Public Service Company of New Mexico's Strategist modeling of coal plant retirement scenarios. (2017)

Citizens Action Coalition of Indiana. Evaluation of Duke Energy Indiana's proposal to offer DSM programs to its customers. (2017)

Citizens Action Coalition of Indiana. Evaluation of Southern Indiana Gas and Electric's proposal to offer DSM programs to its customers. (2017)

Institute for Energy Economics and Financial Analysis. Evaluation of Puerto Rico Electric Power Authority's plan to build an offshore LNG port. (2017)

Citizens Action Coalition of Indiana. Comments regarding Southern Indiana Gas and Electric Company's integrated resource plans to meet future energy and capacity needs. (2017)

Citizens Action Coalition of Indiana. Comments regarding Indianapolis Power & Light's integrated resource plan to meet future energy and capacity needs. (2017)

Citizens Action Coalition of Indiana. Comments regarding Northern Indiana Public Service Company's integrated resource plan to meet future energy and capacity needs. (2017)

Minnesota Center for Environmental Advocacy. Comments regarding Otter Tail Power's integrated resource plan to meet future energy and capacity needs. (2016)

Minnesota Center for Environmental Advocacy. Comments regarding Xcel Energy's integrated resource plan to meet future energy and capacity needs and conducting Strategist modeling of additional planning scenarios. (2016)

Institute for Energy Economics and Financial Analysis. Evaluation of Puerto Rico Electric Power Authority's proposal to meet future energy and capacity needs. (2016)

Minnesota Center for Environmental Advocacy. Comments regarding Minnesota Power's integrated resource plan to meet future energy and capacity needs. (2016)

Institute for Energy Economics and Financial Analysis. Comments regarding Duke Energy Indiana and Indiana Michigan Power's integrated resource plans to meet future energy and capacity needs. (2016)

Minnesota Center for Environmental Advocacy. Comments regarding Great River Energy's integrated resource plan to meet future energy and capacity needs. (2015)

Minnesota Center for Environmental Advocacy. Comments regarding Otter Tail Power's integrated resource plan to meet future energy and capacity needs. (2014)

Minnesota Center for Environmental Advocacy. Comments regarding Xcel Energy's Sherco 1 and 2 Life-Cycle Management Study. (2013)

Minnesota Center for Environmental Advocacy. Comments regarding Minnesota Power's proposal to retrofit Boswell Unit 4. (2013)

Minnesota Center for Environmental Advocacy. Comments regarding Minnesota Power's integrated resource plan to meet future energy and capacity needs. (2013)

Minnesota Center for Environmental Advocacy. Comments regarding Xcel Energy's integrated resource plan to meet future energy and capacity needs. (2013)

Minnesota Center for Environmental Advocacy. Evaluation of Otter Tail Power's plan to diversify its baseload resources. (2012)

Minnesota Center for Environmental Advocacy. Comments regarding Minnesota Power's "Baseload Diversification Study" – a resource planning exercise examining the use of fuels other than coal to serve baseload needs. (2012)

Minnesota Center for Environmental Advocacy. Comments regarding IPL's integrated resource plan to comply with pending EPA regulations and meet future capacity and energy needs. (2011)

Minnesota Center for Environmental Advocacy. Evaluation of a proposal by seven utilities to build a new supercritical pulverized coal plant including alternatives to the plant and potential for greenhouse gas regulation. (2006)

Publications

The Husker Energy Plan: A New Energy Plan for Nebraska, prepared by Anna Sommer, Tyler Comings, and Elizabeth Stanton for the Nebraska Wildlife Federation. January 16, 2018.

Pennsylvania Long-Term Renewables Contracts Benefits and Costs, prepared by Elizabeth Stanton, Anna Sommer, Tyler Comings, and Rachel Wilson for the Mid-Atlantic Renewable Energy Coalition. October 27, 2017.

Implementing EPA's Clean Power Plan: A Menu of Options [Pursue Capture Capture and Utilization or Storage, Establish Energy Savings Targets for Utilities, & Tax Carbon Dioxide Emissions chapters], prepared by Anna Sommer for the National Association of Clean Air Agencies and the Regulatory Assistance Project. June 7, 2015.

Overpaying and Underperforming: The Edwardsport IGCC Project, prepared by Anna Sommer for Citizens' Action Coalition, Save the Valley, Valley Watch, and Sierra Club. February 3, 2015.

Public Utility Regulation Without the Public: The Alabama Public Service Commission and Alabama Power, prepared by David Schlissel and Anna Sommer for Arise Citizens' Policy Project. March 1, 2013.

A Texas Electric Capacity Market: The Wrong Tool for a Real Problem, prepared by Anna Sommer and David Schlissel for Public Citizen of Texas. February 12, 2013.

Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes, prepared by John Gerhard, Camille Kadoch, Edith Pike-Biegunska, Anna Sommer, Wang Xuan, Nancy Wasserman and Elizabeth Watson for the International Energy Agency. June 2012.

A Study of the Economics and Risks of Operation of Boiler 4 by the New Ulm Public Utilities Commission, prepared by Anna Sommer for Sierra Club – Northstar Chapter and Minnesota Center for Environmental Advocacy. July 15, 2011.

Comments on the Technical Memorandum for the Georgia Statewide Energy Sector Water Demand Forecast, prepared by Anna Sommer and David Schlissel for the Southern Alliance for Clean Energy. June 22, 2011.

Don't Get Burned: The Risks of Investing in New Coal-Fired Generating Facilities, prepared by David Schlissel, Lucy Johnston, Jennifer Kallay, Christopher James, Anna Sommer, Bruce Biewald, Ezra Hausman and Allison Smith for Interfaith Center of Corporate Responsibility. February 26, 2008.

Quantifying and Controlling Fine Particulate Matter in New York City, prepared by Alice Napoleon, Geoff Keith, Charles Komanoff, Daniel Gutman, Patricio Silva, David Schlissel, Anna Sommer, Cliff Chen and Amy Roschelle for Coalition Helping Organize a Kleaner Environment, Natural Resources Defense Council and Reliant Energy. August 28, 2007.

Independent Administration of Energy Efficiency Programs: A Model for North Carolina, prepared by David Nichols, Anna Sommer and William Steinhurst for Clean Water for North Carolina. April 13, 2007.

Integrated Portfolio Management in a Restructured Supply Market, prepared by Paul Chernick, Jonathan Wallach, William Steinhurst, Tim Woolf, Anna Sommer and Kenji Takahashi. June 30, 2006.

Ensuring Delaware's Energy Future: A Response to Executive Order No. 82, prepared by the Delaware Cabinet Committee on Energy with technical assistance at Synapse Energy Economics from William

Steinhurst, Bruce Biewald, David White, Kenji Takahashi, Alice Napoleon, Amy Roschelle, Anna Sommer and Ezra Hausman. March 8, 2006.
Mohave Alternatives and Complements Study: Assessment of Carbon Sequestration Feasibility and Markets, a Sargent & Lundy and Synapse Energy Economics, Inc. report prepared for Southern California Edison by Anna Sommer and William Steinhurst. February 2006.
Potential Cost Impacts of a Renewable Portfolio Standard in New Brunswick, prepared by Tim Woolf, David White, Cliff Chen and Anna Sommer for the New Brunswick Department of Energy. October 2005.
Considering Climate Change in Electric Resource Planning: Zero is the Wrong Carbon Value, a Synapse Energy Economics, Inc. report prepared by Lucy Johnston, Amy Roschelle, Ezra Hausman, Anna Sommer and Bruce Biewald. September 20, 2005.
Potential Cost Impacts of a Vermont Renewable Portfolio Standard, a Synapse Energy Economics, Inc. report prepared for the Vermont Public Service Board, by Tim Woolf, David E. White, Cliff Chen, and Anna Sommer. October 16, 2003.
Estimating the Environmental Benefits of Renewable Energy and Energy Efficiency in North America: Experience and Methods, a report for the Commission for Environmental Cooperation, by Geoffrey Keith, Bruce Biewald, Anna Sommer, Patrick Henn, and Miguel Breceda, September 22, 2003.
Comments on the RPS Cost Analyses of the Joint Utilities and the DPS Staff, a Synapse Energy Economics, Inc. report prepared for the Renewable Energy Technology and Environment Coalition, by Bruce Biewald, Cliff Chen, Anna Sommer, William Steinhurst, and David E. White. September 19, 2003.
Cleaner Air, Fuel Diversity and High-Quality Jobs: Reviewing Selected Potential Benefits of an RPS in New York State, a Synapse Energy Economics, Inc. report prepared for the Renewable Energy Technology and Environment Coalition, by Geoff Keith, Bruce Biewald, David White, Anna Sommer and Cliff Chen. July 28, 2003.

Presentations and Articles

"Practical Strategies for the Electricity Transition." A presentation at Energy Finance 2019. June 18, 2019.
"Carbon Capture and Storage." A presentation at Energy Finance 2018. March 13, 2018.
"Puerto Rico's Electric System, Before and After Hurricane Maria." A webinar with Cathy Kunkel on behalf of the Institute for Energy Economics and Financial Analysis. October 24, 2017.
"Rebutting Myths About Energy Efficiency." A presentation at the Beyond Coal to Clean Energy Conference sponsored by Sierra Club and Energy Foundation. October 8, 2015.
"The Energy and Water Nexus: Carbon Capture and Water." A presentation at the Water and Energy Sustainability Symposium. September 28, 2010.
"Carbon Sequestration." A presentation to Vermont Energy Investment Corporation. August 17, 2009.
"Carbon Dioxide Emissions Costs and Electricity Resource Planning." A presentation before the New Mexico Public Regulation Commission with David Schlissel. March 28, 2007.
"Electricity Supply Prices in Deregulated Markets – The Problem and Potential Responses." A presentation at the NASUCA Mid-Year Meeting with Rick Hornby and Ezra Hausman. June 13, 2006.

“IGCC: A Public Interest Perspective.” A presentation at the Electric Utilities Environmental Conference 2006. January 24, 2006.
Woolf, Tim, Anna Sommer, John Nielsen, David Barry and Ronald Lehr. “Managing Electric Industry Risk with Clean and Efficient Resources,” The Electricity Journal, Volume 18, Issue 2, March 2005.
Woolf, Tim and Anna Sommer. “Local Policy Measures to Improve Air Quality: A Case Study of Queens County, New York,” Local Environment, Volume 9, Number 1, February 2004.

Professional Affiliations

Board Member, **Public Utility Law Project of New York,** 2018 – present
Board Member, **Community Development Program of St. Lawrence County,** 2017 – present

GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE: **Review of the Puerto Rico Electric Power** Authority Integrated Resource Plan	CASE NO.: CEPR-AP-2018-0001

EXPERT TESTIMONY OF DANIEL GUTMAN

ON BEHALF OF LOCAL ENVIRONMENTAL ORGANIZATIONS

Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. -Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico, Inc.

I. Introduction and Qualifications

Q: Please state your name, position, and business address:

A: My name is Daniel Gutman. I am a consultant in environmental analysis of air pollution. My business address is 407 West 44th Street, New York, New York l0036.

Q: On whose behalf are you testifying in this proceeding?

A: I am testifying on behalf of the following organizations: Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc.- Enlace de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club, Inc. and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc. CAMBIO PR, Inc.

Q: Please summarize your qualifications and work experience.

A: In more than a dozen matters, I have provided expert analysis of the harmful impacts of emissions from utility projects on human health. I have testified before administrative agencies as an expert, on behalf of the Environmental Protection Agency (EPA) and local environmental organizations. I hold a Bachelor of Science degree from the Massachusetts Institute of Technology and a Master of Science degree from the University of Illinois. My resume is attached as Exhibit A.

Q: What is the scope of your testimony?

A: I have been asked to review the air quality surrounding the major power plants in Puerto Rico and the implications of continued operation of the Puerto Rico Electric Power Authority (PREPA) power plants for air quality and public health.

II. PREPA's Violations and Health Impacts from Emissions at Puerto Rico's Fossil Fuel Power Plants

Q: What are the conclusions of your review?

A: My review indicates that if the current power plant output and fuel type are maintained in the future, then the area surrounding the Puerto Rico Electrical Power Authority (PREPA) power plants at Costa Sur, San Juan, and Aguirre will fail to comply with the Environmental Protection Agency's (EPA) 2010 sulfur dioxide National Ambient Air Quality Standard (NAAQS). The 2010 NAAQS sulfur dioxide standard was based on new health research that established for the first time a causal relationship between respiratory morbidity and short-term sulfur dioxide concentrations (75 FR 35525). Therefore, my review indicates that continued operation of these plants will cause harmful health impacts to Puerto Ricans living nearby.

Q: Considering the importance of compliance with the 2010 sulfur dioxide standard, what are your views for PREPA's preferred plans in the Integrated Resource Plan (IRP)?

A: Because of the expense and difficulty of either adding pollution control equipment or cleaner fuel, the best way for Puerto Rico to comply with the 2010 sulfur dioxide standard is for PREPA to move away from generation in fossil fuel power plants and toward generation from non-polluting sources. PREPA's preferred plans, the Energy System Modernization Plan (ESM) and Scenario 4, invest too many resources into fossil fuel generation, and not enough in non-polluting sources.

Q: Please explain the air quality standards that PREPA must meet.

A: The Clean Air Act sets up a regulatory framework whose main purpose is protection and enhancement of air quality. To achieve this purpose, the Clean Air Act encompasses broad authority for EPA to evaluate health effects of air pollutants, set ambient air pollution standards, set emission standards for both new and existing equipment, and require states to submit plans to control air pollutants (or have EPA adopt its own plan).

Under §108 of the Clean Air Act, EPA issues "air quality criteria" to control certain air pollutants that are widespread in the human environment, largely because they are emitted whenever fuel is burned. These include sulfur dioxide, carbon monoxide, nitrogen oxides, particulate matter, ozone, and lead. Under §109 of the Clean Air Act, EPA has set National Ambient Air Quality Standards (NAAQS) "requisite to protect the public health" for each of these pollutants, which apply wherever the public is exposed. States submit plans under §110 to achieve NAAQS by dates set by EPA. Plans can include mechanisms such as state regulation of fuel type, required permits for major polluters (Clean Air Act, §172), economic incentives, etc. Since ambient concentrations are proportional to emissions, the purpose of the plan is to reduce emissions enough to meet ambient standards. EPA typically helps the states by setting emission standards for equipment, providing research on effectiveness of control techniques, providing guidance on developing a plan, and many other activities.

Q: Why are these air quality standards especially important in Puerto Rico?

A: In 2010, EPA adopted a stricter NAAQS for sulfur dioxide (75 FR 35520). This is particularly relevant in Puerto Rico, where power plants emit significant levels of this toxic chemical. The new standard is primarily designed to limit short-term high concentrations of sulfur dioxide that cause breathing problems. Short-term peaks of sulfur dioxide cause constriction of bronchial passageways and respiratory symptoms in susceptible populations, which include children, older adults, those with pre-existing respiratory disease, those who spend time exercising outdoors, persons of lower socio-economic status, and asthmatic individuals. Notably, the prevalence and severity of asthma is higher among Puerto Ricans (75 FR 35527). The health data, epidemiological, human exposure, and other data on the relationship between short-term sulfur dioxide exposure and adverse respiratory effects is convincing enough for the relationship to be characterized as causal, the “strongest finding” that EPA can make (75 FR 35520 [2010]).

Q: How does EPA determine compliance with standards in Puerto Rico?

A: EPA set a one-hour limit of 75 ppb (parts per billion) for sulfur dioxide, based on a three-year average of the 99th percentile daily maximum sulfur dioxide concentrations in an area. A short-term standard at the level adopted by EPA will reduce longer-term sulfur dioxide concentrations as well. Consequently, EPA eliminated its previous 24-hour and yearly average standards at the same time as it adopted a one-hour standard.

EPA recognized that violations of the 2010 sulfur dioxide standard could be expected near large facilities that burn oil or coal and emit more 2,000 tons of sulfur dioxide per year. EPA accordingly determined that areas near those facilities are of special concern. Prior to submitting a plan to meet the 2010 sulfur dioxide standard, air agencies must first determine whether their air is in attainment or non-attainment with the standard. While air agencies could characterize their air quality using an existing air quality monitoring network, Puerto Rico's network apparently does not meet minimum standards for data collection. Consequently Puerto Rico characterized its air primarily using computer modeling, in accordance with EPA regulations (40 CFR §51.1203).

Q: Are PREPA's power plants in compliance with air quality standards?

A: No. In 2016, the Puerto Rico Environmental Quality Board (EQB) found that the areas around four PREPA power plants are likely in violation of the 2010 sulfur dioxide NAAQS—including the Aguirre, Costa Sur, San Juan, and Palo Seco plants. The EQB projections, based on actual sulfur dioxide emissions during the years 2013-15, are shown in the table below.[1]

Table 1. Summary of the Puerto Rico 1-hour SO_2 Designation Modeling Results, 2016.

Emission Sources with SO_2 emissions at or above 2,000 tpy	Name of geographical area	Maximum impact area (radius in kilometers)	1-Hour SO_2 Design Value (μg/m³)	1-hour SO_2 NAAQS (μg/m³)
PREPA Aguirre	Guayama-Salinas	5.4	232	196*
PREPA Costa Sur	Guayanilla	7.0	1,046	
PREPA San Juan	San Juan	3.6	343	
PREPA Palo Seco	San Juan	2.7	207	

* For sulfur dioxide, 196 μg/m³ is equivalent to 75 ppb.

The EQB is expected to submit to EPA its Implementation Plan for achieving compliance with the 2010 sulfur dioxide standard later this year.[2] PREPA has three difficult options to achieve compliance, if it wishes to keep these plants running:

[1] Letter from EQB to EPA, December 19, 2016. A true and accurate copy of this letter, with Puerto Rico 1-Hour SO2 Designation Modeling Results including Appendix A, is attached as Exhibit B.

[2] See "Status of SIP Required Elements for Puerto Rico Designated Areas," at https://www3.epa.gov/airquality/urbanair/sipstatus/reports/pr_elembypoll.html.

- Lower the sulfur content of the oil burned at PREPA's power plants
- Install emission control equipment, or
- Reduce the maximum power generated.

Q: Can control equipment be effectively applied in Puerto Rico?

A: A previous study by Puerto Rico's Intersectoral Committee on Environmental Compliance and Energy Alternatives (ICECEA), convened by the Governor of Puerto Rico, found that three of the four power plants do not have the space for control equipment and that, in any case, the cost of installing and operating the equipment would have the effect of increasing the cost of electricity, making control equipment "not a viable compliance alternative."[3] The study also determined that using a lower sulfur fuel, for example one containing 0.3% sulfur instead of the current 0.5% sulfur, "is not an option, as it would increase energy costs significantly and would not comply with emission limits for contaminants imposed by new federal regulations."[4]

[3] ICECEA, Report on the Necessary Measures to Comply With New EPA Regulations, and the Conversion to, and Use of Natural Gas in, the Northern Power Plants 13, June 15, 2012, http://www.gdb.pr.gov/documents/FINAL-InformeCICAAEGobernador-English-firmado.pdf

[4] *Id.*.

According to the ICECEA report:

> As part of our evaluation, both the EQB and PREPA used dispersion models in order to determine the generating units' maximum emission levels. Both agencies agreed that in order to meet NAAQS compliance, [PREPA] must burn liquid fuel with a sulfur content of 0.1 percent per weight or less. This would imply that PREPA would be burning diesel in all of its combustion units. Currently, this fuel is only utilized in the most efficient combined cycle units, since its high cost is not economically feasible for use in other units. Increasing the use of No. 2 diesel fuel in turn increases the cost of fuel purchases.[5]

Furthermore, PREPA's current fuel risks exacerbating its non-compliance with the 2010 sulfur dioxide standard. Two power plants in Puerto Rico, the Aguirre and Palo Seco plants, are operating substantially below capacity, as shown in Table 2. If operations at either plant increase in the future without adding pollution control equipment or reducing the sulfur content of the fuel, sulfur dioxide emissions, and therefore sulfur dioxide concentrations, will increase above those projected in Table 1.

Table 2. Large SO_2 Sources in Puerto Rico.

Emission sources with SO_2 emissions at or above 2,000 tons/year	Name of geographical area	SO_2 Emissions (tons/yr)				Average Emissions as % of Allowable
		Allowable*	2013	2014	2015	
PREPA Aguirre	Guayama-Salinas	30,038	9,641	9,261	9,585	32%
PREPA Costa Sur	Guayanilla	11,506	6,975	8,337	9,323	71%
PREPA San Juan	San Juan	7,787	5,308	5,136	6,064	71%
PREPA Palo Seco	San Juan	17,344	5,701	3,128	2,979	23%

* Exhibit B, Puerto Rico 1-Hour SO2 Designation Modeling Results, Appendix A.

[5] *Id.*

Q: What would happen if current emissions levels were maintained?

A: If current emission levels are maintained in the future, areas surrounding the Palo Seco plant will comply with the 2010 sulfur dioxide NAAQS, while areas surrounding the other plants will continue to be in non-compliance. Modeling results show that the Palo Seco area did comply with the sulfur dioxide concentration standard in 2014 and 2015, but that the three-year average was pushed above compliance due to higher plant emissions in 2013, as shown in Table 3. If sulfur dioxide emissions from Palo Seco are maintained at the 2014-15 level, the surrounding area will eventually comply with the standard, which is based on a three-year average.

Table 3. Puerto Rico 1-hour SO_2 Designation Modeling Results, 2013–15.[6]

Emission sources with SO_2 emissions at or above 2,000 tons/year	Name of geographical area	SO_2 Concentrations (μg/m³)			1-hour SO_2 NAAQS (μg/m³)
		2013	2014	2015	
PREPA Aguirre	Guayama-Salinas	236	226	233	196*
PREPA Costa Sur	Guayanilla	1,003	1,037	1,098	
PREPA San Juan	San Juan	316	325	387	
PREPA Palo Seco	San Juan	263	172	185	

* For sulfur dioxide, 196 μg/m³ is equivalent to 75 ppb.

If the current power plant output and fuel type are maintained in the future, then the area surrounding the PREPA Palo Seco power plant is the only area that can comply with EPA's 2010 sulfur dioxide NAAQS. Areas surrounding the other major PREPA power plants—Costa Sur, San Juan, and Aguirre—will not be able to achieve compliance with that important health-based standard.

[6] Exhibit B, Puerto Rico 1-Hour SO2 Designation Modeling Results, Appendix A.

Because of the expense and difficulty of either adding pollution control equipment or cleaner fuel, the best way for Puerto Rico to comply with the 2010 sulfur dioxide standard is for PREPA to move away from generation in fossil fuel power plants and toward generation from non-polluting sources, as required by the recent Climate Change Mitigation, Adaption and Resiliency Law signed by Governor Ricardo Rosselló.[7] The requirements of this law should be reflected in Puerto Rico's forthcoming Implementation Plan for achieving the sulfur dioxide NAAQS.

Q: What has been PREPA's history in terms of compliance with sulfur dioxide standards?

A: PREPA has a history of poor compliance or non-compliance with federal air and water quality regulations governing its power plants. Prior to 1999, PREPA allowed virtually uncontrolled emissions of sulfur dioxide mist from its power plants, polluting nearby air and creating health problems for nearby residents.[8] A 1999 consent decree between PREPA and EPA, modified in 2004, addressed those failures in part by restricting the sulfur content of fuel burned at PREPA's facilities. Subsequent to the consent decree PREPA has apparently engaged in a scheme to falsify tests of fuel quality required by the consent decree.[9]

Provisions of the consent decree are incorporated into Title V air permits issued by the EQB. In addition to the sulfur content of fuel, these provisions include several aimed at ensuring proper maintenance and optimum operating conditions of the Aguirre power station. Title V of the Clean Air Act was adopted in order to consolidate the issuance and enforcement of permits under the authority of one agency (42 USC Chapter 85, subchapter V). Given PREPA's previous bad

[7] See Governor Ricardo Rosselló Signs Historic Climate Change Bill," May 23, 2019, available at http://prfaa.pr.gov/governor-ricardo-rossello-signs-historic-climate-change-bill/.

[8] Mary Williams Walsh, "At Puerto Rico's Power Company, a Recipe for Toxic Air, and Debt," New York Times, February 16, 2016, available at https://www.nytimes.com/2016/02/16/business/dealbook/at-puerto-ricos-power-company-a-recipe-for-toxic-air-and-debt.html.

[9] *Id.*

behavior, it is important that one agency, in this case the EQB, has oversight and enforcement authority over all activities covered by the Title V permit, including those provisions added as a result of the 2004 consent decree.

In particular, among PREPA's large power plants, PREPA's Aguirre power complex emits the most sulfur dioxide, while the Palo Seco power plant emits the least, as shown in Table 2 above. The area around the Aguirre plant does not comply with the 2010 sulfur dioxide NAAQS, as shown in Table 3, above.[10] Palo Seco is the only plant that could meet the 2010 sulfur dioxide standard while using the current fuel—0.5% sulfur oil. Consequently no modifications should be allowed to PREPA Aguirre's Title V permit that may dilute EQB's enforcement authority, since any such modification could hamper enforcement by EQB and weaken compliance with conditions of the permit, making the existing violation of the 2010 sulfur dioxide NAAQS worse and endangering the health of nearby residents.

Q: What other pollutants are emitted by PREPA's power plants?

A: Sulfur dioxide is only one of the pollutants emitted from PREPA's power plants. Emissions of other criteria pollutants are shown in Table 4, below. Of particular concern are emissions of nitrogen oxides, which contribute to formation of ozone (80 FR 65292 [2015]). and emissions of particulate matter—PM_{10} and $PM_{2.5}$—which exacerbate asthma symptoms and adversely impact respiratory function, especially of children, in the short term and increase death rates, especially of the elderly, in the long term (78 FR 3085 [2013]).

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[10] The PREPA Aguirre Power Complex also does not comply with its Clean Water Act (CWA) permit. See https://echo.epa.gov/detailed-facility-report?fid=110000307800#pane3110000307800.

Table 4. Criteria Pollutants Emitted by PREPA Power Plants in 2014 (tons/year).[11]

Emissions Source	Carbon Monoxide	Nitrogen Oxides	PM 10	PM 2.5	Sulfur Dioxide	VOC
PREPA Aguirre6	287,0866985	199,26495				
PREPA Costa Sur	3278,89787	66778,33630				
PREPA San Juan	1,0704,0874	682824,90340				
PREPA Palo Seco	2082,40723	01673,12532				

A review of monitoring data that the EQB submits to EPA shows that EQB's monitoring program is substandard. Most EQB monitors fail to collect sufficient data to even determine whether areas of Puerto Rico meet federal air quality standards. Sometimes when EQB monitors do collect sufficient data, they show what should be violations of the federal standard. For example, in 2016, EQB ozone monitors showed violations of the federal one-hour ozone standard in Bayamón, Cataño, and Juncos municipalities. Unfortunately EPA revoked the one-hour ozone standard in 1997 believing that a new, lower 8-hour standard would protect against both short-term (1–3 hours) and medium-term (6–8 hours) exposures (62 FR 38856 [1997]). In Puerto Rico this appears not to have been the case. Consequently, emissions of nitrogen oxides from PREPA's fossil fuel power plants continue to pose a health hazard for island residents.

[11] EPA, Enforcement and Compliance History Online (ECHO) Air Pollutant Reports, available at https://echo.epa.gov/.

Q: What emissions are the comparable emissions for the AES Puerto Rico and EcoElectrica power plants?

A: Emissions for the AES and EcoElectrica power plants are shown in the Table 5.

Table 5. Criteria Pollutants Emitted by Other Power Plants in 2014 (tons/year).[12]

Emission Source	Carbon Monoxide	Nitrogen Oxides	PM 10	PM 2.5	Sulfur Dioxide	VOC
AES Puerto Rico	861	1,729	402	100	245	7
EcoElectrica, L.P.	204	311	49	49	0	7

Q: Does this conclude your testimony?

A: Yes.

[12] EPA, Enforcement and Compliance History Online (ECHO) Air Pollutant Reports, available at https://echo.epa.gov/ and EPA emission factors, AP-42, at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors.

CERTIFICATION

I, Daniel Gutman, CERTIFY that the contents of my testimony are known to me and are the truth according to the best of my abilities and reasonable knowledge. The technical and operational aspects included in the testimony are based on information that has been gathered in good faith; but I cannot guarantee the truthfulness of information gathered from third parties.

Daniel Gutman

Daniel Gutman, M.S.

Before me, the undersigned Notary Public, personally appeared Daniel Gutman, who acknowledges that the above is true this day of October 23, 2019 in New York, NY.

( )Personally known OR

(X)Identification Document provided Driver's License.

JONATHAN JAMES SMITH
NOTARY PUBLIC-STATE OF NEW YORK
NO. 02SM6335228
QUALIFIED IN NEW YORK COUNTY
MY COMMISSION EXPIRES 01-04-2020

Notary Public Name, Signature, Seal

Jonathan James Smith
New York City, NY

Apostille

(Convention de La Haye du 5 Octobre 1961)

1. Country: United States of America

   This public document

2. has been signed by **Milton Adair Tingling**

3. acting in the capacity of **County Clerk**

4. bears the seal/stamp of the **county of New York**

Certified

5. at New York City, New York

6. the 23rd day of October 2019

7. by Deputy Secretary of State for Business and Licensing Services, State of New York

8. No. NYC-1357280

9. Seal/Stamp

10. Signature

STATE OF NEW YORK ★ DEPARTMENT OF STATE ★ EXCELSIOR

Whitney A. Clark

Deputy Secretary of State for Business and Licensing Services

Form 1

State of New York
County of New York } *ss:*

No. 618501

I, Milton Adair Tingling, Clerk of the County of New York, and Clerk of the Supreme Court in and for said county, the same being a court of record having a seal, **DO HEREBY CERTIFY THAT**

JONATHAN JAMES SMITH

whose name is subscribed to the annexed original instrument has been commissioned and qualified as a NOTARY PUBLIC...
and has filed his/her original signature in this office and that he/she was at the time of taking such proof or acknowledgment or oath duly authorized by the laws of the State of New York to take the same: that he/she is well acquainted with the handwriting of such public officer or has compared the signature on the certificate of proof or acknowledgment or oath with the original signature filed in his/her office by such public officer and he/she believes that the signature on the original instrument is genuine.

IN WITNESS WHEREOF, I have hereunto set my hand and my official seal this
23rd day of October, 2019

[signature]

County Clerk, New York County

Daniel Gutman
407 West 44th Street
New York, New York l0036
212 586-3888

<u>Education:</u>

Massachusetts Institute of Technology Cambridge, Massachusetts	B.S., Physics June, l964
University of Illinois Urbana, Illinois	M.S., Physics February, l966

<u>Summary of Consulting Experience:</u>

Environmental Protection Agency

Chief analyst for the United States Environmental Protection Agency on traffic and environmental impacts of Westway, a highway proposed for Manhattan. Responsible for preparing cross-examination of State Department of Transportation witnesses and for developing and presenting EPA's direct testimony during administrative hearings.

Environmental Defense Fund
Scenic Hudson

Analyzed the local impact of increased sulfur dioxide emissions due to the proposed conversion to highsulfur coal of Orange and Rockland's Lovett and Danskammer, and the conversion to coal of Con Edison's Arthur Kill and Ravenswood power plants for presentation at administrative hearings.

The Municipal Art Society
STAND
The ATURA Coalition
Committee to Preserve Brighton Beach and
Manhattan Beach

Conducted traffic and air pollution analyses of several major development projects in New York City, including the Coliseum Redevelopment, Metrotech, Atlantic Terminal, and Brighton Beach projects.

Union of Concerned Scientists

Analyzed the potential for accidental releases of radioactive gases reaching New York City from the nearby Indian Point nuclear reactor.

Environmental Defense Fund
Natural Resources Defense Council

Provided technical analysis and evaluations of EPA regulations concerning all sulfur dioxide emitting facilities, as well as those specifically applying to copper smelters.

Association to Save the Hutch
Montgomery Township, New Jersey
Elizabeth and East Brunswick, New Jersey

Provided analyses of the air pollution and traffic impacts of the proposed expansions of the Hutchinson River Parkway, Route US 206 through Montgomery Township, and the New Jersey Turnpike.

Port Authority of New York and New Jersey

Evaluated the impacts of diesel particulates and carbon monoxide due to a proposed busway connecting the Holland and Lincoln tunnels just outside New York City.

Environmental Defense Fund

Investigated the environmental impacts of both toxic and non-toxic emissions from waste-to-energy resource recovery plant proposed for New York City for presentation at administrative hearing.

Citizens for Westpride

Analyzed traffic, air pollution, noise, sewage disposal, and zoning and density with respect to both a massive development proposed by the Trump Organization for a disused rail yard on the West Side of Manhattan, and a number of other projects in the immediate area.

The Parks Council
The Municipal Art Society
The Regional Plan Association

Devised a smaller-scale, more civic-minded alternative to the Trump project, based on relocating a portion of the West Side Highway in order to extend Riverside Park. Evaluated the air pollution and noise impacts of the relocated West Side Highway and investigated various noise control techniques. Known as Riverside South, this alternative was ultimately embraced by the developer and approved by the City.

The Municipal Art Society
Beekman Hill Association

Studied potential air pollution impacts of Con Edison's Waterside power plant in New York City on a proposed very tall, nearby building.

Environmental Defense
New York Lawyers for the Public Interest

Analyzed air quality impacts of diesel emissions from a proposed waste transfer station on nearby residential areas as part of an administrative hearing. Developed legal and technical arguments to require an air quality analysis of fine particulate matter (PM 2.5).

East River Environmental Coalition
Manhattan Community Board #3

In connection with an application by Con Edison to add two electric and steam generators to the East River power plant, analyzed air quality impacts, focussing on fine particulate matter, evaluated noise impacts, helped develop alternative proposals, analyzed the air quality and land-use impacts of the alternatives, and represented client groups in administrative hearings.

Natural Resources Defense Council
Coalition Helping Organize a Kleaner Environment
Borough President of Queens, New York

In connection with applications by Keyspan, SCS Astoria, Orion Power, and the New York Power Authority to add power plants in the Astoria section of New York City, analyzed air quality impacts, focussing on fine particulate matter, analyzed the air quality impacts of the alternatives, and represented client groups in administrative hearings.

Adirondack Communities Advisory League

Presented testimony in administrative hearings regarding impacts of toxic air emissions from a proposed landfill in Ava, New York.

Greenpoint/Williamsburg Waterfront Task Force
Borough President of Brooklyn, New York

In connection with an application by TransGas Energy to add power plants in the Greenpoint/Williamsburg section of New York City, analyzed air quality impacts, focussing on fine particulate matter, analyzed the air quality impacts of the alternatives, and represented client groups in administrative hearings.

Hell’s Kitchen Neighborhood Association

Prepared a major zoning and land use plan for the West Side of Manhattan between 30th and 42nd streets as an alternative to City-sponsored plan.

Exhibit B

COMMONWEALTH OF
PUERTO RICO
Environmental Quality Board

December 19th 2016

MRS. JUDITH A. ENCK
REGIONAL ADMINISTRATOR
USEPA -REGION 2
290 BROADWAY
NEW YORK NY 10007-1866

Dear Mrs. Enck:

PUERTO RICO'S MODELING RESULTS FOR THE 2010 PRIMARY S02 NAAQS RECOMMENDATION FOR NON-ATTAINMENT AREAS DESIGNATION

As required by Title 40 of the Code of Federal Regulations, Section 51.1203(d)(3), Air Agencies shall conduct and submit to the EPA Regional Office the Modeling Analysis for Emission Sources with SO_2 emissions on or above 2,000 tons per year (tpy), for its associate area and nearby area. Air Agencies shall conduct and submit Modeling Analysis on or before January 13th 2017.

PREQB performed a 1-hour S02 Designation Modeling Analysis for the following geographical areas of the Commonwealth of Puerto Rico: Guayama-Salinas, Guayanilla and San Juan. Table 1 summarizes Modeling Results.

Table 1. Summary of the Puerto Rico 1-hour S02 Designation Modeling Results.

Emission Sources with S02 emissions on or above 2,000 tpy	Name of Geographical area	Maximum impact area (radius in kilometers)	1-Hour S02 Design Value (µg/m3)	1-hour S02 NAAQS (µg/m3)
PREPA Aguirre	Guayama-Salinas	5.4	232	196
PREPA Costa Sur	Guayanilla	7.0	1,046	
PREPA San Juan	San Juan	3.6	343	
PREPA Palo Seco	San Juan	2.7	207	

According to the modeling results, the S02 emissions of the four facilities included in the study do not comply with the 1-hour S02 NAAQS of 196 $\mu g/m^3$.

Environmental Agencies Building
San Jose Industrial Park
1375 Ponce de Le6n Ave.
PO Box 11488, San Juan, PR 00910
Tel. 787-767-8056, fax 787-767-4861
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EQB
Environmental Quality Board
Commonwealth of Puerto Rico

Based on the Modeling Results, PREQB recommends to EPA the designation of Guayama-Salinas, Guayanilla and San Juan as Non-Attainment Areas for the 1-hour S02 NAAQS, and the designation of Unclassified/Attainment Area for the remaining geographical areas of the Commonwealth of Puerto Rico.

If you have any question, please, feel free to contact the PREQB's Air Quality Manager at (787)767-8181 x-3269, or Mrs. Lucia Fernandez, Chief of the Air Monitoring, Validation & Data Management Division at (787)767-8181 x-3254.

Cordially,

Weldin Ortiz-Franco
Chairman

Enclosure: *Puerto Rico I-hour S02 Designation Modeling Results*

c Mr. John Filippelli, CASO Director
Mr. Richard Ruvo, EPA Air Program Branch Director
Mrs. Carmen Guerrero, CEPD Director

Exhibit B

COMMONWEALTH OF
PUERTO RICO
Environmental Quality Board

PUERTO RICO 1-HOUR SO_2 DESIGNATION MODELING RESULTS

PUERTO RICO ENVIRONMENTAL QUALITY BOARD
AIR MONITORING, VALIDATION & DATA MANAGEMENT

SEPTEMBER 2016

EQB
ENVIRONMENTAL QUALITY BOARD
COMMONWEALTH OF PUERTO RICO

Table of Contents

List of Tables

Table of Figures

List of Acronyms

DRR	Data Requirements Rule
NAAQS	National Ambient Air Quality Standards
SO_2	Sulfur Dioxide
PPB	Parts Per Billion
EPA	Environmental Protection Agency
EQB	Environmental Quality Board
PREPA	Puerto Rico Power Electric Authority
SO2TAD	SO_2 NAAQS Designations Modeling Technical Assistance Document

Introduction

This document presents the modeling results for the designation of the 2010 1- hour SO_2 NAAQS in Puerto Rico. In June 2010, the EPA promulgated the new 1-hour primary SO_2 NAAQS of 75 parts per billion (ppb), which is met at an ambient air quality monitoring site, when the 3-year average of the 99th percentile of 1-hour daily maximum concentrations does not exceed 75 ppb.

According to the 40 CFR Part 51, Data Requirements Rule (DRR)[1] for the 2010 1-hour SO_2 Primary NAAQS signed on August 10 2015, EPA is promulgating a rule directing state and tribal air agencies to provide data to characterize current air quality areas with large sources of SO_2 emissions (2,000 tons per year or more) to identify maximum 1-hour SO_2 concentrations in ambient air. The final rule set a process and timetable for agencies to either establish ambient monitoring sites or conduct air quality modeling and submit the air quality data to EPA.

On January 2016, EQB submitted EPA a list of the sources with SO_2 emissions over 2000 tons/yr. EQB determined three areas in Puerto Rico that have SO_2 sources with emissions over 2,000 tons/yr. The areas are San Juan, Guayama-Salinas and Guayanilla. The sources in San Juan area with SO_2 emissions over 2,000 tons/yr are PREPA San Juan and PREPA Palo Seco. In Guayama-Salinas area is PREPA Aguirre and in Guayanilla is PREPA Costa Sur.

EQB decided to characterize the air quality in the areas with SO_2 emissions sources over 2,000 tons/yr with dispersion modeling. The air quality model for the analysis is AERMOD, with three years of meteorological data and three years of actual SO_2 emissions, as recommended in the SO_2 NAAQS Designations Modeling Technical Assistance Document (SO2TAD)[2]. On July 2016, EQB submitted to EPA the Puerto Rico 1-Hour SO_2 Designation Modeling Protocol[3] for its revision and approval. After that, EQB started the modeling process for the 1-hour SO_2 standard designation.

Emission Inventory

The emission inventory used for the study was three years of SO_2 actual emissions data, from the years 2013 to 2015. EQB followed the recommendation in the SO2TAD of using the three most recent available years of SO_2 actual emissions. EQB used the SO_2 actual emissions certified data, submitted annually by PREPA.

This report is revised by the Inspection and Compliance Division of the Air Quality Area, to determine conformity with the air quality permit and regulations.

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[1] Data Requirements Rule for 2010 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard (NAAQS). 40 CFR Part 51.
[2] SO_2 NAAQS Designations Modeling Technical Assistance Document, USEPA. August, 2016.
[3] Puerto Rico 1-Hour SO_2 Designation Modeling Protocol. Environmental Quality Board. Air Quality Area. July, 2016.

The PREPA emission report presents the annual SO_2 actual emissions for the emission points of PREPA facility. For a complete information about the emission inventory, please refer to the modeling protocol document. A copy of the emission inventory table is in Appendix A.

Background Concentration

For the 1- hour SO_2 background concentration, EQB used the less conservative "first tier" approach recommended in the SO2TAD of the 1- hour SO_2 background concentration based on the monitored design value for the most recent 3-year period, regardless of the years of meteorological data used in the modeling. EQB have SO_2 air quality monitors in the vicinity of San Juan area, but are source oriented, for that reason they are not representative of the nearby sources impacts.

EQB determined more adequate use a regional site monitor that is impacted by similar natural and distant man-made sources. EQB selected the data from the Guayama SO_2 monitor to be used as background concentration for San Juan area. This background concentration is from the years 2010-2012 and also will be used in Guayama-Salinas and Guayanilla area. The concentration background is the most recent 3-year period design value for 1- hour SO_2 and the value is 58 $\mu g/m^3$ (22 ppb).

This background concentration will be used in Guayanilla because EQB does not have a SO_2 monitor in this municipality and the most representative air quality monitor for the area is the Guayama monitor. This background concentration is not source oriented and is impacted by similar natural and distant man-made sources. The concentration background data is in Appendix B.

Model

The model used for the SO_2 designation modeling is AERMOD. This model is the preferred recommended by EPA for air quality modeling studies. The version used is the most recent or 15181. The default options will be selected for each run. The urban option will be used in San Juan because the facilities are in an urban environment.

The input data for PREPA emission points is for the EQB emission inventory and the SO_2 actual emissions is from the PREPA annual emission reports. The emission sources inside the facilities are point sources (boilers and gas turbines) and actual stack height data will be used. The parameters for each emission point source and their coordinates were from the information provided by the facilities in their construction permits.

The AERMOD model output options MAXDAILY, MAXDCONT and MXDYBYYR output options will be selected to calculate the model 1-hour SO_2 design value. Background concentration[4] will be added to the 1-hour SO_2 model design value for the comparison with the NAAQS.

Meteorology

The SO2TAD recommends the most recent three years of meteorological data for the designation modeling, to allow the modeling to simulate a monitor. The SO2TAD also recommends that the meteorological data will be concurrent with the years of the actual SO_2 emissions used in the designation modeling. EQB will use three years of site-specific data, in the three areas of the designation modeling.

The three years of meteorological data are not concurrent with the three years of SO_2 actual emissions data, but EQB addressed this using the recommendation in the Section 7.4 Use of Older Meteorological Data[5] of the SO2TAD. The three years data periods were manually changed (change of the year on AERMET output files) as if these were the 2013 to 2015 data period.

The meteorology for the San Juan model is from the years 2007-2009, in Guayama-Salinas the meteorological data is from 2001-2003 and in Guayanilla is from 1991-1993. All this data was collected on-site. Full meteorological reports with the methodology used to process the data are available in the modeling protocol document[6].

Receptors

Two receptor grids were used in each run of the 1-hour SO_2 designation model. The receptor grids considered populated areas and places where is feasible to place an air quality monitor. Discrete receptors across the facility fenceline were used in all modeling cases.

The first receptor grid is a 250 meters of space to determine the facility maximum impact radius. This is an exclusionary grid used to determine where is the SO_2 maximum impact. A refined grid of 50 meter of space was used in the area of maximum impact concentrations, to determine compliance with the 1- hour SO_2 NAAQS. Discrete receptors were placed at the facility fenceline in all modeling runs. For complete information about the receptor grids, please refer to the modeling protocol document.

[4] See Air Quality Monitoring Design Value Report in Appendix B.

[5] Section 7.4: Use of Older Meteorological Data. SO_2 NAAQS Designations Modeling Technical Assistance Document, USEPA. August, 2016.

[6] Puerto Rico 1-Hour SO_2 Designation Modeling Protocol. Environmental Quality Board. Air Quality Area. July, 2016.

Model Results

The model results for the four emission sources in the modeling study are presented below. The 1-hour SO_2 NAAQS is represented by the model design value, which is calculated using the three years average of the 4^{th} highest of the daily maximum. EQB used the following methodology to determine the SO_2 design value for each emission source in the study.

Separate modeling runs for each facility by year of meteorological and actual emissions data were performed to determine the SO_2 4^{th} highest of the daily maximum by year. The modeling runs for each facility have the same receptor network and emission point parameters data, the only data that changes in each run is the SO_2 actual emissions and the concurrent meteorological data.

For each modeling run, the 4^{th} highest value was determined using the MAXDAILY file. The SO_2 design value for each facility in the study is the three years average of the 4^{th} highest. The SO_2 background concentration was added to this design value.

EQB used separate model runs because the receptor networks are extensive and this complicate the evaluation of the output files. The MAXDCONT file was used to determine the contribution of each facility emission point to the design value. Modeling runs output files are in the Appendix C and electronic copies of the MAXDAILY, MAXDCONT and MXDYBYYR files will be provided. The SO_2 designation modeling results are presented below.

A. PREPA San Juan

The model results for PREPA San Juan are presented in the next tables. The 1-hour SO_2 design value is above the NAAQS of 75 ppb or 196 $\mu g/m^3$. The maximum results impact area is approximately 3.6 km radius. The 4^{th} highest for each modeling run, plus the background concentration and the SO_2 design value for PREPA San Juan are presented in Table 1. The Table 2 presents the modeling results by emission point or MAXDCONT output file data.

Table 1: PREPA San Juan 1-Hour SO_2 Modeling Results

Year	Coordinates (m)		SO_2 Concentrations µg/m^3			
	East	North	4th Highest Model Result	Background Concentration	Total Concentration	1-Hour SO_2 Design Value
2013	805450	2039622	258	58	316	343
2014	805550	2038922	267		325	
2015	805550	2038922	329		387	

Table 2: PREPA San Juan 1-Hour SO_2 Modeling Results by Emission Point

Year	4th Highest SO_2 Model Concentrations µg/m^3						
	SJ5/6	Boiler7	Boiler8	Boiler 9	Boiler10	Background Concentration	Total Concentration
2013	0.89787	64.81184	52.32642	66.97350	72.74486	58	315.75449
2014	0.21331	88.40702	108.53339	53.99018	15.75475		324.89865
2015	0.33223	99.65805	82.97753	144.13036	2.33466		387.43283

The modeling scenario with the highest SO_2 concentrations was 2015 and therefore have the maximum impact area with a radius of 4.1 km. The maximum impact area for 2013 and 2014 was approximately 3.4 km radius. The Figures 1-3 showed the modeling results isopleths and the 1-hour SO_2 4th highest concentration by year of data.

Figure 1: PREPA San Juan 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2013

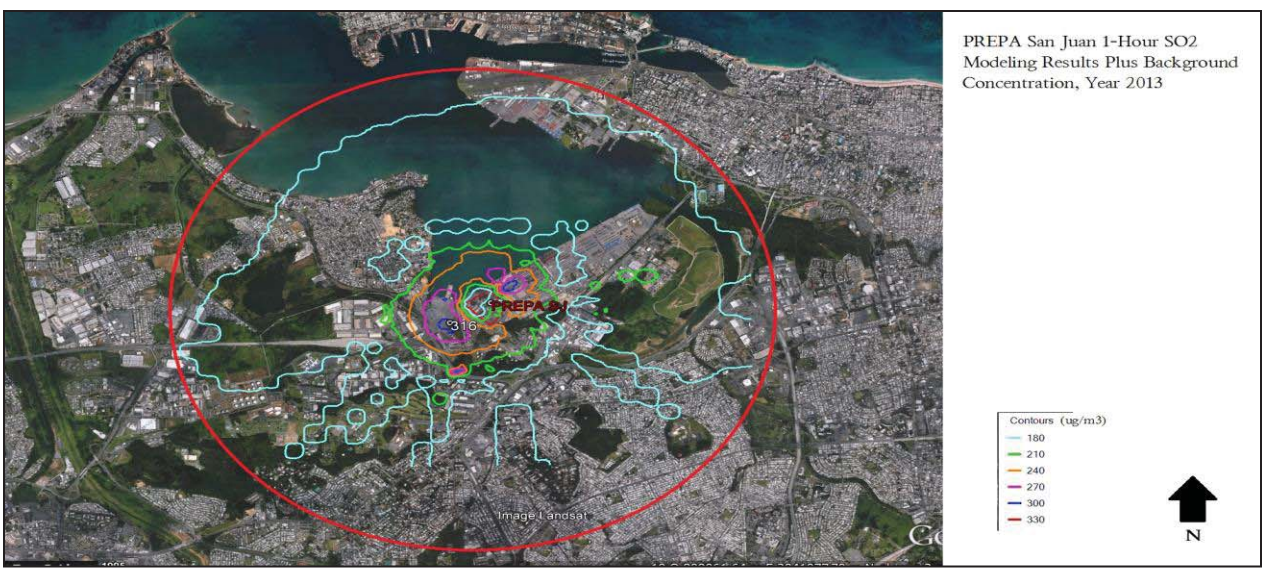


Figure 2: PREPA San Juan 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2014

Figure 3: PREPA San Juan 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2015

B. PREPA Palo Seco

The model results for PREPA Palo Seco are presented in the following tables. The 1-hour SO_2 design value is above the NAAQS of 75 ppb or 196 µg/m³. The maximum results impact area is approximately 2.7 km radius. The 4th highest for each modeling run, plus the background concentration and the 1-hour SO_2 design value for PREPA San Juan are presented in Table 3. The Table 4 presents the modeling results by emission point or the MAXDCONT output file data.

Table 3: PREPA Palo Seco 1-Hour SO_2 Modeling Results

Year	Coordinates (m)		SO_2 Concentrations µg/m³			
	East	North	4th Highest Model Result	Background Concentration	Total Concentration	1-Hour SO_2 Design Value
2013	800700	2043072	205	58	263	207
2014	800700	2043072	114		172	
2015	801550	2042022	127		185	

The SO_2 modeling results for 2013 data are over de 1-hour SO_2 NAAQS, the other years are below the standard. The three years average of the 4th highest is above the 1-hour SO_2 NAAQS. The next table presents the modeling results by the emission points of PREPA Palo Seco.

Table 4: PREPA Palo Seco 1-Hour SO_2 Modeling Results by Emission Point

Year	4th Highest SO_2 Model Concentrations µg/m³								
	PS1	PS2	PS3	PS4	GT1	GT2	GT3	Background Concentration	Total Concentration
2013	38.50191	32.42061	29.33763	104.71084	0.00286	0.00532	0.00407	58	262.98324
2014	30.88408	34.61644	0.000	48.33751	0.03621	0.07657	0.07159		172.0224
2015	43.25716	47.47828	27.54117	8.59734	0.00056	0.09414	0.07945		185.0481

The modeling results for year 2013 were the highest and the maximum impact area have approximately 2.7 km radius. The modeling results for 2014 and 2015 were below the 1-hour SO_2 NAAQS. Figures 4-6 showed the modeling results isopleths and the 1-hour SO_2 4th highest concentration by year of data.

Figure 4: PREPA Palo Seco 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2013

Figure 5: PREPA Palo Seco 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2014

Figure 6: PREPA Palo Seco 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2015

C. PREPA Aguirre

The following tables presents the model results for PREPA Aguirre. The 1-hour SO_2 design value is above the NAAQS of 75 ppb or 196 µg/m^3. The 4th highest for each modeling run, plus the background concentration and the SO_2 design value for PREPA Aguirre are presented in Table 5. The Table 6 presents the modeling results by emission point or MAXDCONT output file data.

Table 5: PREPA Aguirre 1-Hour SO_2 Modeling Results

Year	Coordinates (m)		SO_2 Concentrations µg/m^3			
	East	North	4th Highest Model Result	Background Concentration	Total Concentration	1-Hour SO_2 Design Value
2013	792100	1988250	178	58	236	232
2014	790750	1988000	168		226	
2015	791500	1986500	175		233	

The SO_2 modeling results for PREPA Aguirre are over de 1-hour SO_2 NAAQS. The three years average of the 4th highest is 232 ug/m^3 and is above the 1-hour SO_2 NAAQS. The next table presents the modeling results by each emission point of PREPA Aguirre.

Table 6: PREPA Aguirre 1-Hour SO_2 Modeling Results by Emission Point

Year	4th Highest SO_2 Model Concentrations µg/m^3						
	AG1	AG2	CC1	CC2	AGGT	Background Concentration	Total Concentration
2013	92.42972	85.24826	0.08780	0.21629	0.00038	58	235.98245
2014	60.94587	106.07054	0.25548	0.35438	0.00489		225.63116
2015	81.81814	91.93863	0.76722	0.49448	0.02302		233.04149

The modeling results for year 2013 were the highest and the maximum impact area extends approximately 5.4 km from the source. The modeling results for 2014 and 2015 were also above the 1-hour SO_2 NAAQS and the maximum impact areas extends from the source, 5 and 4.7 km, respectively. Figures 7-9 showed the modeling results isopleths and the 1-hour SO_2 4th highest concentration by year of data.

Figure 7: PREPA Aguirre 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2013

Figure 8: PREPA Aguirre 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2014

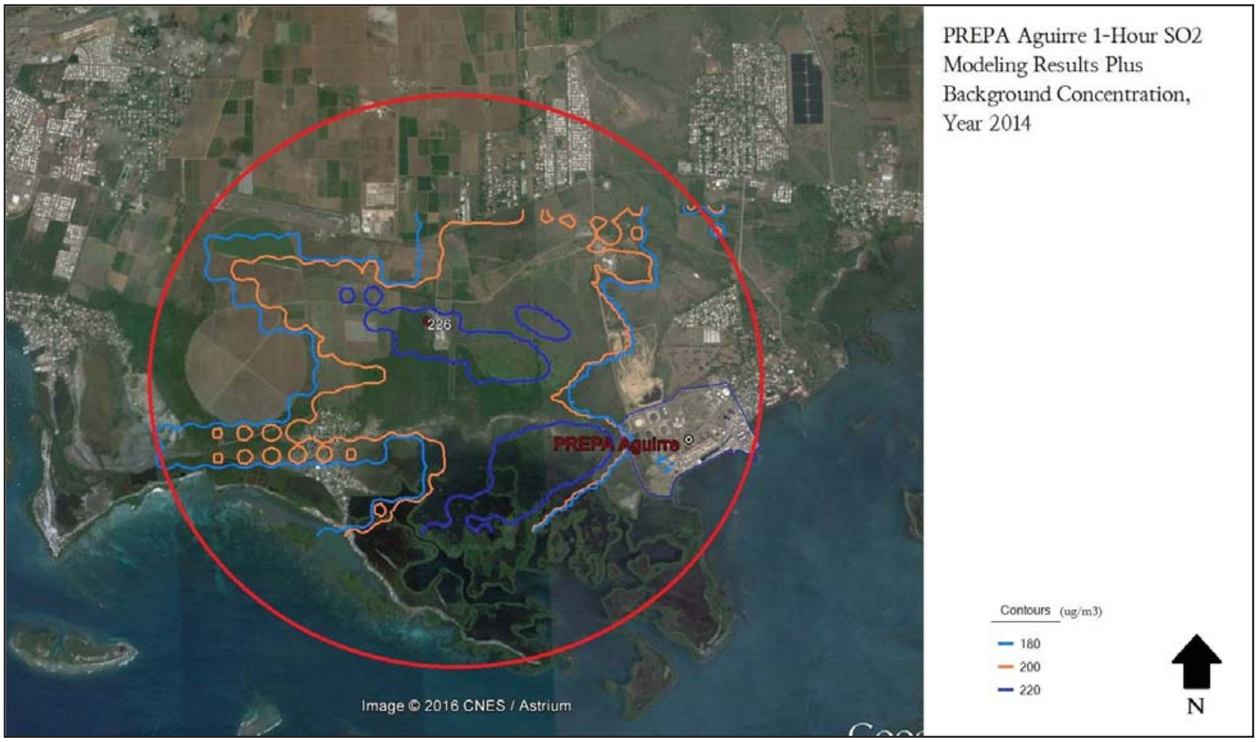
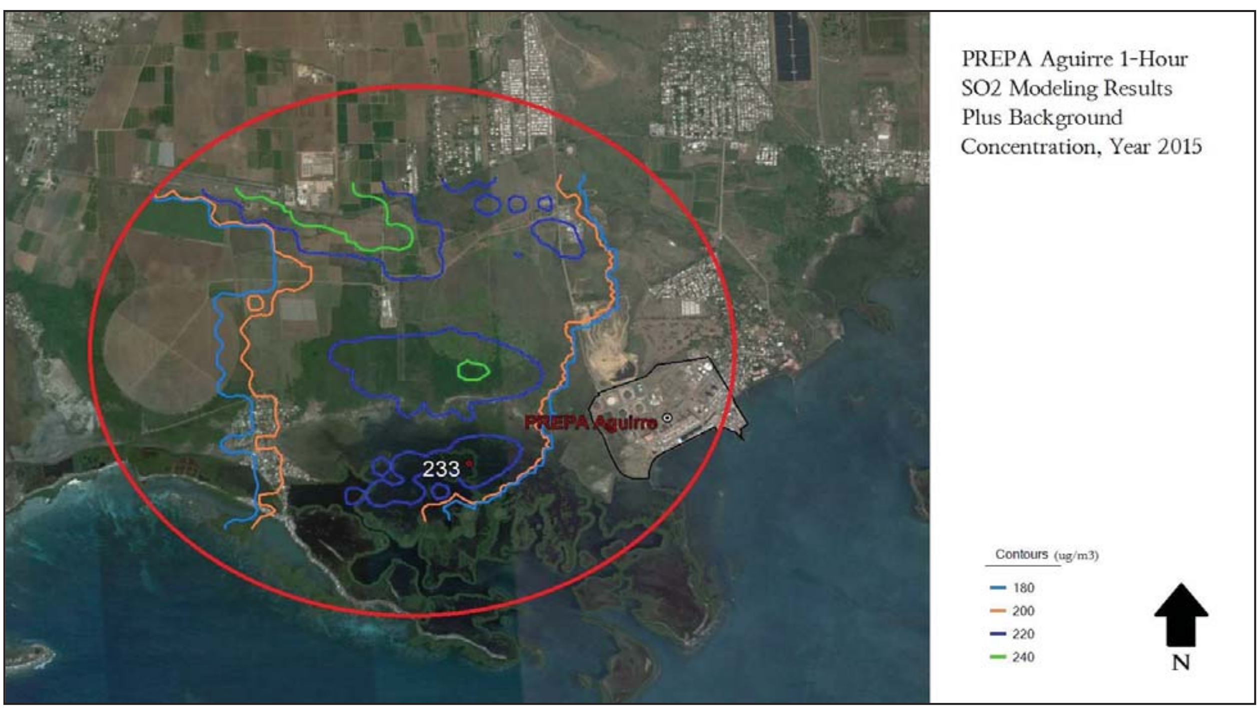


Figure 9: PREPA Aguirre 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2015



D. PREPA Costa Sur

The following tables presents the model results for PREPA Costa Sur. The 1-hour SO_2 design value is above the NAAQS of 75 ppb or 196 μg/m^3. The 4th highest for each modeling run, plus the background concentration and the SO_2 design value for PREPA Costa Sur are presented in Table 7. The Table 8 presents the modeling results by emission point or MAXDCONT output file data.

Table 7: PREPA Costa Sur 1-Hour SO_2 Modeling Results

Year	Coordinates (m)		SO_2 Concentrations μg/m^3			
	East	North	4th Highest Model Result	Background Concentration	Total Concentration	1-Hour SO_2 Design Value
2013	738250	1994900	945	58	1003	1046
2014	735250	1994800	979		1037	
2015	737400	1995750	1040		1098	

The SO_2 modeling results for PREPA Costa Sur are over de 1-hour SO_2 NAAQS. The three years average of the 4th highest is 1046 μg/m^3 and is above the 1-hour SO_2 NAAQS. The next table presents the modeling results by emission point of PREPA Costa Sur.

Table 8: PREPA Costa Sur 1-Hour SO_2 Modeling Results by Emission Point

Year	4th Highest SO_2 Model Concentrations μg/m^3						
	SC3	SC4	SC5	SC6	PB1	Background Concentration	Total Concentration
2013	3.74367	0.99801	303.53343	636.15715	0.10537	58	1002.53763
2014	0.0	0.0	515.76028	463.07010	0.00757		1036.83795
2015	17.03536	1.70005	511.64441	509.33306	0.00074		1097.71362

The modeling results for year 2015 were the highest and the maximum impact area extends approximately 7 km from the source. The modeling results for 2014 and 2015 were also above the 1-hour SO_2 NAAQS and the maximum impact areas extension from the source were also 7 km. Figures 10-12 showed the modeling results isopleths and the 1-hour SO_2 4th highest concentration by year of data.

Figure 10: PREPA Costa Sur 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2013

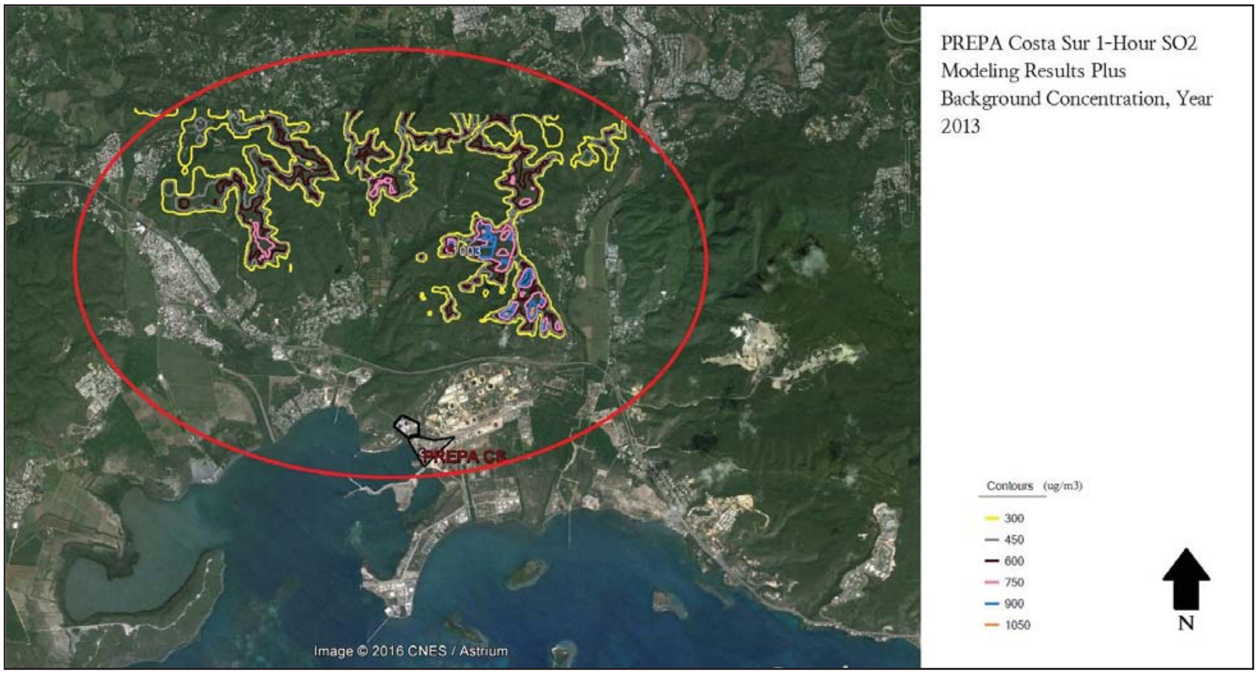


Figure 11: PREPA Costa Sur 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2014

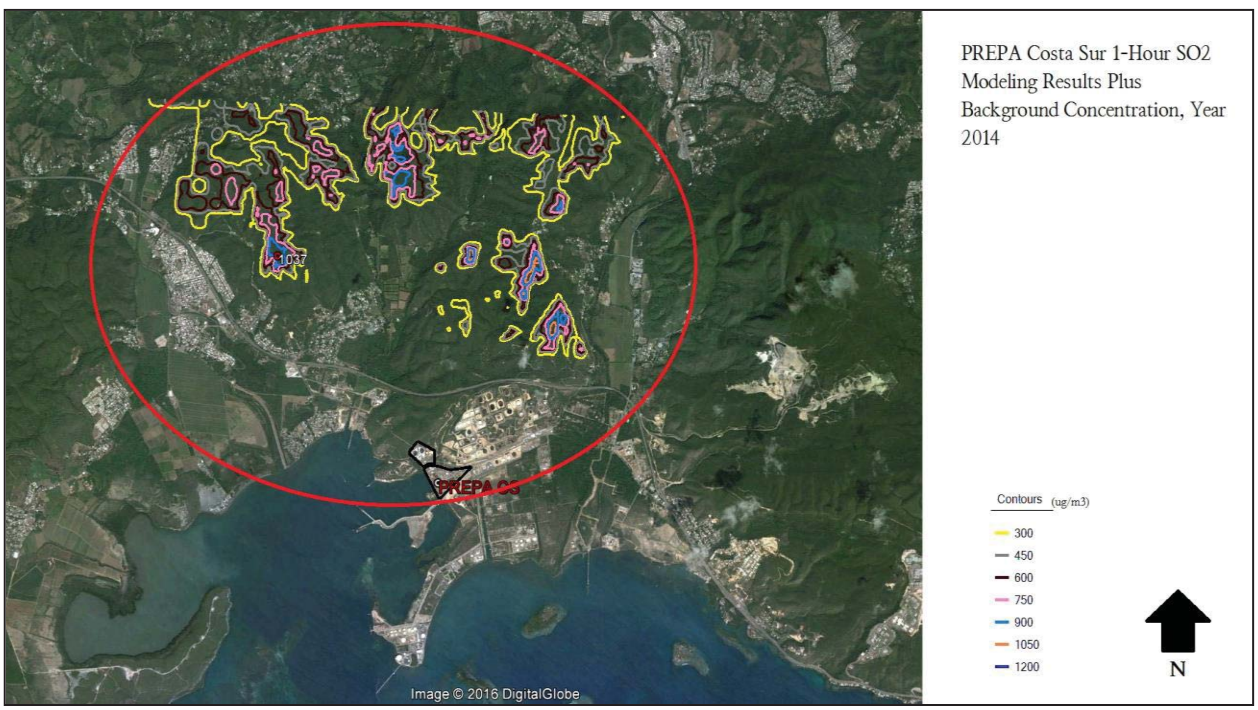
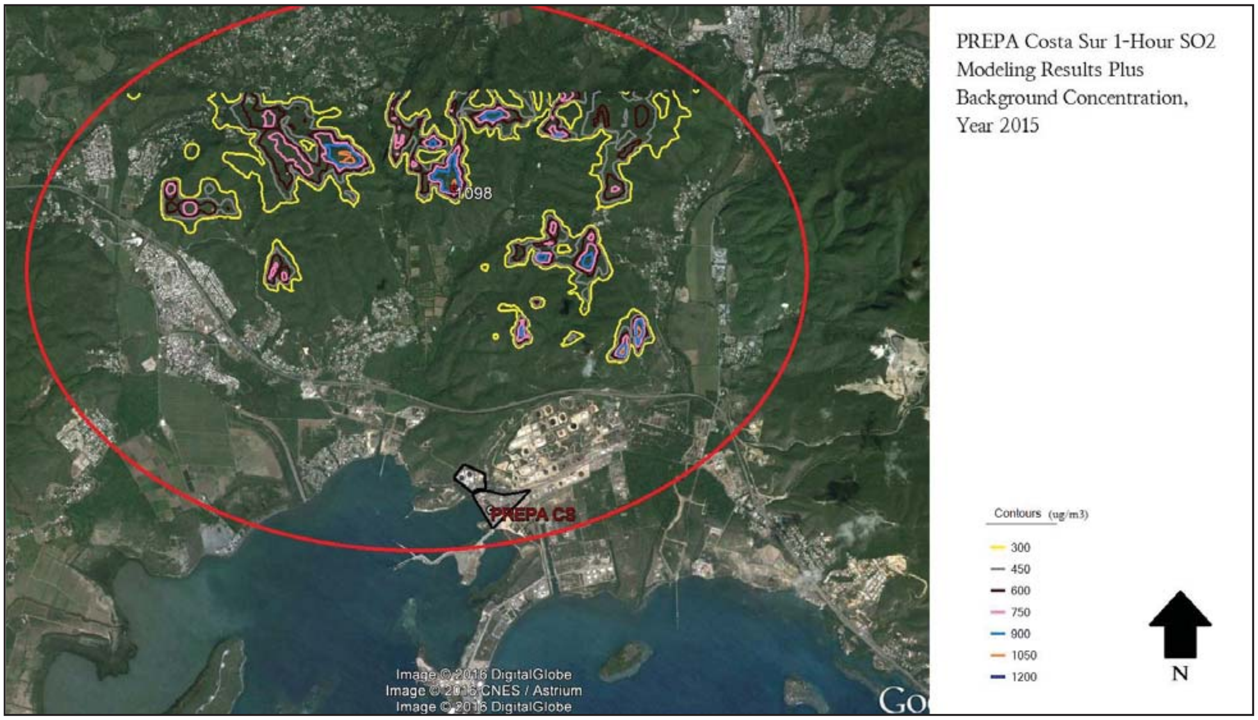


Figure 12: PREPA Costa Sur 1-Hour SO_2 Modeling Results Plus Background Concentration, Year 2015



Conclusion

According to the modeling results, the SO_2 emissions of the four facilities in the study do not comply with the 1-hour SO_2 NAAQS of 196 $\mu g/m^3$. The facility with the highest results was PREPA Costa Sur in Guayanilla, with the 1-hour SO_2 design value of 1046 $\mu g/m^3$. The facility with the lowest results was PREPA Palo Seco in San Juan area, with the 1-hour SO_2 design value of 207 $\mu g/m^3$. The model concentration results in all the areas under the study are above the 1-hour SO_2 NAAQS of 196 $\mu g/m^3$.

I. APPENDIX A: Emission Inventory for the 1-Hour SO_2 Designation Model

Exhibit B

Commonwealth of Puerto Rico\Puerto Rico Environmental Quality Board

1-Hour SO_2 Designation Modeling Results

Emission Inventory for the 1-Hour SO_2 Designation Model

PUERTO RICO SO2 DESIGNATION EMISSION INVENTORY

PREPA San Juan

Emission Unit	Address Physical/Postal	Municipality	SCC	Model Point ID	UTM East	UTM North	Control Equipment	Control Efficiency %	Actual Emissions (ton/yr) 2013	2014	2015	Stack Height (m)	Stack Diameter (m)	Stack Exit Velocity (m/s)	Stack Temperature (K)
HRSG 5&6	Mercado Central Ave, Zona Central Ave, PR-28, San Juan, PR/PO Box 364267 San Juan, PR 00936-4267	San Juan	2-01-001-01	SJ56	805942	2040125	n/a	n/a	360.45	250.2	352.31	85.6	5	29.2	422
Boiler 7			1-01-004-04	BOILER7	805971	2040146			1188.6	1446.8	1487.10	53.5	1.8	28.028	408.15
Boiler 8			1-01-004-04	BOILER8	805991	2040156			928.6	1657	1199.80	53.5	1.8	28.028	408.15
Boiler 9			1-01-004-04	BOILER9	805832	2040053			1339.8	1333.78	2971.30	55.2	1.8	29.46	408.15
Boiler 10			1-01-004-04	BOILER10	805813	2040043			1490.2	448	53.40	55.2	1.8	29.46	408.15
								Total	**5307.65**	**5135.78**	**6063.91**				

PREPA Palo Seco

Emission Unit	Address Physical/Postal	Municipality	SCC	Model Point ID	UTM East	UTM North	Control Equipment	Control Efficiency %	Actual Emissions (ton/yr) 2013	2014	2015	Stack Height (m)	Stack Diameter (m)	Stack Exit Velocity (m/s)	Stack Temperature (K)
Palo Seco 1	Road 165, Km 3.8, Toa Baja/PO Box 364267 San Juan, PR 00936-4267	San Juan	1-01-004-04	PS1	801146	2043049	n/a	n/a	1033.90	809.45	1012.66	53.5	2.5	27.46	430
Palo Seco 2			1-01-004-04	PS2	801116	2043049			854.10	889.15	1127.85	53.5	2.5	27.46	430
Palo Seco 3			1-01-004-04	PS3	801096	2043049			811.80	0.00	629.08	64.3	2.4	26.6	420
Palo Seco 4			1-01-004-04	PS4	801036	2043049			3000.00	1418.80	203.18	64.3	2.4	26.6	420
Power Block 1			2-01-001-01	PSGT1	801017	2042958			0.19	1.90	0.02	12	2.9	19.19	783
Power Block 2			2-01-001-01	PSGT2	800987	2042958			0.38	4.32	3.48	12	2.9	19.19	783
Power Block 3			2-01-001-01	PSGT3	800967	2042958			0.31	4.40	3.08	12	2.9	19.19	783
								Total	**5700.68**	**3128.02**	**2979.36**				

PREPA Aguirre

Emission Unit	Address Physical/Postal	Municipality	SCC	Model Point ID	UTM East	UTM North	Control Equipment	Control Efficiency %	Actual Emissions (ton/yr) 2013	2014	2015	Stack Height (m)	Stack Diameter (m)	Stack Exit Velocity (m/s)	Stack Temperature (K)
Boiler AG1	Road PR-3, Km 152.3, Salinas/PO Box 364267 San Juan, PR 00936-4267	Salinas	1-01-004-04	AG1	793522	1987168	n/a	n/a	4992	3353	4472.33	75.9	2.5	58.6	422
Boiler AG2			1-01-004-04	AG2	793473	1987108			4623	5865	5025.10	75.9	2.5	58.6	422
Gas Turbines CC1-1 to CC1-4			2-01-001-01	CC1	793255	1986905			6.41	16.5	50.5	17.8	2.4	69.3	491
Gas Turbines CC2-1 to CC2-4			2-01-001-01	CC2	793106	1986822			19.51	26.3	35.4	17.8	2.4	69.3	491
AGGT2-1, 2-2			2-01-001-01	AGGT	793381	1987227			0.031	0.354	1.89	12.2	2.9	40.9	777
								Total	**9640.951**	**9261.154**	**9585.22**				

PREPA Costa Sur

Emission Unit	Address Physical/Postal	Municipality	SCC	Model Point ID	UTM East	UTM North	Control Equipment	Control Efficiency %	Actual Emissions (ton/yr) 2013	2014	2015	Stack Height (m)	Stack Diameter (m)	Stack Exit Velocity (m/s)	Stack Temperature (K)
Boiler SC-3	Road 127, Guayanilla/PO Box 560580 Guayanilla, PR 00656-0580	Guayanilla	1-01-004-04	SC3	737815	1991827	n/a	n/a	46.7	0	258.60	62.8	2.2	30.2	430
Boiler SC-4			1-01-004-04	SC4	737828	1991811			12.51	0	26.56	62.8	2.2	30.2	430
Boiler SC-5			1-01-004-04	SC5	737843	1991749			2188.72	4382.95	4532.5	75.9	3.2	30.8	422
Boiler SC-6			1-01-004-04	SC6	737856	1991734			4726.06	3953.48	4505.34	75.9	3.2	30.8	422
Power Block 1			2-01-001-01	PB1	737898	1991808			1.31	0.11	0.01	12	2.9	40.9	777
								Total	**6975.3**	**8336.54**	**9323.01**				

GOVERNMENT OF PUERTO RICO
PUBLIC SERVICE REGULATORY BOARD
PUERTO RICO ENERGY BUREAU

IN RE:	**CASE NO.:**
	CEPR-AP-2018-0001
Review of the Puerto Rico Electric Power Authority Integrated Resource Plan	

EXPERT TESTIMONY OF RONNY SANDOVAL

ON BEHALF OF LOCAL ENVIRONMENTAL ORGANIZATIONS

Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. - Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico, Inc.

OCTOBER 23, 2019

TABLE OF CONTENTS

Testimony of Ronny Sandoval
CEPR-AP-2018-0001
October 23, 2019

I. BACKGROUND AND QUALIFICATIONS

Q. Please state your name, employer and business address.

A. My name is Ronny Sandoval. I am President of ROS Energy Strategies, LLC, a Colorado based limited liability company specializing in energy consulting. My business address is 1905 15th St. #7241, Boulder, CO 80306.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of the Local Environmental Organizations: Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc. - Enlace Latino de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club and its Puerto Rico chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti-Incineración, Inc., Amigos del Río Guaynabo, Inc., Campamento Contra las Cenizas en Peñuelas, Inc., and CAMBIO Puerto Rico.

Q. Would you briefly discuss your educational background?

A. I hold a Bachelor of Science degree in Mathematics from New York University, a Bachelor of Engineering in Electrical Engineering from Stevens Institute of Technology, and a Master of Business Administration from New York University.

Q. Please summarize your work experience.

A. I have over ten years of management experience in the utility business, including areas of transmission and distribution system planning and demand side management. In my more recent roles in the non-profit advocacy space, I developed strategies to modernize and increase the efficiency of the electric grid across various state proceedings and forums, through cost-effective system investments, greater adoption of intelligent system operations, and transparency through metric reporting and stakeholder engagement.

I sit on the board of GridWise Alliance, an organization that champions the transformation of the electric grid by leveraging its diverse membership to support key decision makers through the development of strategies, action plans, best practices, education, outreach and more.

I also sit on the board of Interstate Renewable Energy Council, a non-profit organization that focuses on building the foundation for a clean energy economy, by providing leadership and expertise across areas of regulatory reform, workforce development, and customer empowerment.

My resume, with further details on my work experience, is provided as Exhibit LEO-RS-1.

Q. Have you previously testified before this Bureau?

A. No.

Q. Have you reviewed PREPA's Integrated Resource Plan filing?

A. Yes.

Q. Having reviewed PREPA's IRP, what conclusions do you reach in your testimony?

A. PREPA's IRP lacks several elements and safeguards that are critical to ensuring that its customers will actually receive the benefits that the Company claims they will as a result of the Plan. While I do not comment on every issue raised in and by PREPA's Plan, my silence on any issue does not constitute an endorsement of or agreement with PREPA's position on that issue.

Q. What is the Purpose of your testimony in this proceeding?

A. Generally, I explain why Puerto Rico Electric Power Authority's ("PREPA" or "Company") Integrated Resource Plan ("IRP" or "Plan") is deficient. I describe how the Commission can strengthen the Plan and help ensure that it benefits PREPA's customers, including through additional safeguards and recommendations for the Action Plan component of the IRP.

Q. Please describe how your testimony is organized.

A. In Section II of this testimony, I review key components of the IRP's Action Plan and provide my observations. In Section III, I explore key capabilities of an Integrated Distribution Planning process with direct implications to the IRP and provide recommendations that could strengthen the Plan and its implementation. In Section IV, I discuss methods of evaluating performance of the IRP in meeting policy objectives and desired outcomes, including through periodic reporting of metrics. Finally, I conclude my testimony in Section V.

II. SUMMARY OF ACTION PLAN COMPONENTS

Q. Please describe the Action Plan components of PREPA's IRP.

A. The IRP characterizes the Action Plan as "the recommended actions that the Energy Bureau should approve and PREPA should undertake in the period from 2019 to 2023 to implement the Preferred Plan." It makes the case for "immediate action" across three categories, including:

(1) Greening the Supply,
(2) Creating a Resilient Grid, and
(3) Engaging the Customer.

Q. What is PREPA's proposal for "Creating a Resilient Grid"?

A. PREPA envisions configuring its transmission and distribution system into "eight MiniGrid 'islands' to support resiliency and facilitate the integration of renewable and distributed energy resources."[1]

Q. How are MiniGrids defined?

A. PREPA defines MiniGrids as "regions of the system that are interconnected with the rest of the electric power system via lines that may take over a month to recover after a major event, and should be able to operate largely independently, with minimum disruption for the extended period of time that would take to recover full interconnection."[2]

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[1] 2019 Fiscal Plan for the Puerto Rico Electric Power Authority; Certified June 27, 2019 https://aeepr.com/es-pr/Documents/Exhibit%201%20-%202019%20Fiscal_Plan_for_PREPA_Certified_FOMB%20on_June_27_2019.pdf
[2] IRP 2019 – Main Report REV2 06182019 wERRATA, p 8-31 http://energia.pr.gov/wp-content/uploads/2019/06/IRP2019-Main-Report-REV2-06182019-wERRATA.pdf

Q. Do you have recommendations with regards to PREPA's proposed approach to MiniGrid deployments?

A. Yes. I'll discuss these recommendations across the following set of issues.

(1) Resilience Planning Process

From a process standpoint, the recommended MiniGrid investment actions identified in the IRP completely bypass the Bureau's stakeholder efforts identified in the scope of the Resilience Working Group of the Bureau's Distribution System Planning process[3] by committing to a specific solution and approach, with large associated expenditures, before critical aspects of design around resiliency are decided .

This stakeholder process has several goals, but some notable objectives include:

(i) defining what constitutes resilient design,

(ii) understanding the nature of critical loads and infrastructure,

(iii) measuring progress associated with strategies that support resilience, and

(iv) determining roles that PREPA, electric customers, third party energy service providers each can play in meeting system-wide resilience.

According to PREPA's IRP filing, projects that support the MiniGrids may already be underway as these are "assumed to have the engineering/permitting/outage scheduling

[3] Distribution System Planning Process; PREB; NEPR-MI-2019-0011
http://energia.pr.gov/en/?s=&tipo=orden&expediente=nepr-mi-2019-0011&numero=&from=&to=&orderby=date&order=DESC&lang=

work start as early as July 2019."[4] While the IRP allows for leeway in the exact generation mix that may ultimately be selected, the Plan is decidedly inflexible in characterizing the MiniGrid architecture as "the foundation for the future of Puerto Rico's electrical system."[5]

Without developing a common understanding with stakeholders on how to measure progress towards achieving resilience, examining the conditions one is trying to become resilient against, etc., it's not possible to determine whether the investments proposed truly deliver the most effective and sufficiently resilient systems that can be developed. The Bureau's Distribution System Planning process for defining resilience and arriving at the appropriate associated solutions is just now getting underway. The large investments proposed in this IRP to address the needs around resilience have thus not benefitted from the outcomes of this process and may ultimately not result in an optimal set of solutions.

(2) Making Utilities, Customers, and Third-parties part of the Solution

Resilience can be defined as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions."[6] Resilience differs from reliability in that it focuses more closely on the impact to humans as opposed to the performance of the system.[7] The extended disruptions to the Puerto Rican grid following Hurricane

[4] IRP 2019 – Main Report REV2 06182019 wERRATA, p 9-11
http://energia.pr.gov/wp-content/uploads/2019/06/IRP2019-Main-Report-REV2-06182019-wERRATA.pdf
[5] IRP 2019 – Main Report REV2 06182019 wERRATA, p 9-11
http://energia.pr.gov/wp-content/uploads/2019/06/IRP2019-Main-Report-REV2-06182019-wERRATA.pdf
IRP 2019 – Main Report REV2 06182019 wERRATA, p 9-11

content/uploads/2019/06/IRP2019-Main-Report-REV2-06182019-wERRATA.pdf" http://energia.pr.gov/wp-content/uploads/2019/06/IRP2019-Main-Report-REV2-06182019-wERRATA.pdf
N. p., 2017. Web. doi:10.2172/1367499.

Maria imposed significant burdens on the island's communities. Accordingly, a central purpose of this Integrated Resource Planning process is to assess the grid's resilience to future storms, and proactively address that problem. Engaging stakeholders directly on these issues is the only way to ensure the associated human impacts of power disruptions are effectively managed.

Stakeholders agree that the grid must be transformed in order to improve resilience. However, customers, the utility, and third-party energy service companies all have roles to play in achieving this transformation. The "Resilience" workgroup, a part of the Bureau's Distribution System Planning process, is the ideal forum for determining what the role of customers, the utility, and third-party energy service companies could be in meeting the island's on-going resilience needs.

Participants in a recent stakeholder workshop of this Distribution System Planning process observed that the idea of the grid on its own solving all of the issues and needs around resiliency "isn't really the most plausible approach". It was additionally noted that "customers take actions too"8. PREPA has taken a flawed approach, in unilaterally applying a "top-down" solution with its MiniGrid design - prioritizing centralized generation resources and redundancy in its delivery system across eight broad geographic areas to address future potential large disruptions to its customers. Applying a uniform

[8] NEPR-MI-2019-0011; Stakeholder Workshop; October 11, 2019 @55:58
https://youtu.be/hvVK-yyezBc?t=3358

solution may not be the most effective approach across all of these areas, as the characteristics of each of the regions including customer types, resilience risks, and existing energy resources are all very different. In addition, it may not be appropriate or cost-effective for the utility to take on all of the meaningful activities to solve issues of resilience, without consulting stakeholders.

(3) Leveraging Private dollars to mitigate Ratepayer impact

Because of the extended outages brought about by Hurricane Maria, many PREPA customers have sought to install distributed solar and storage systems in order to enhance their energy resilience. These projects often leverage a variety of funding streams, including private dollars, to facilitate their installation. PREPA should account for the ability of systems that are already online to meet their own resilience needs in determining how much additional infrastructure PREPA needs to invest in. This could reduce the amount of load PREPA would need to serve as it works to restore its system after another potential large-scale disruption. PREPA should also proactively work with customers and third parties to support emerging DER projects at various stages of development in order to further manage investments for serving critical loads. This support should involve expediting access to hosting capacity maps, streamlining interconnection processes, and other elements of the Distribution System Planning process.

(4) Addressing Transparency in Resilient Design

Much of the supporting information behind the MiniGrid designs and investments decisions are only found in Appendix 1 of the IRP, which is designated as Confidential. Though it is important to ensure sensitive information is protected, some design aspects of resiliency solutions selected would have benefitted from stakeholder and community input, including:

- PREPA's arbitrary requirement that Critical Loads, as identified by PREPA, exclusively be "served by dispatchable thermal resources;"[9]
- PREPA's failure to present the potential vulnerabilities of the system-wide MiniGrids approach (for example, potential critical failures that could force large portions or an entire MiniGrid out of service - preventing these systems from operating as intended);
- PREPA's approach "assumed that a major hurricane occurs every five years impacting major interconnection transmission lines and placing the system into MiniGrids operation for 1 Month, starting in 2022." The type of disruption, impact, frequency, duration and resilience response here is very narrowly defined and could have benefitted from stakeholder discussion on what is being planned for and the solutions selected; and

[9] 2019 Fiscal Plan for the Puerto Rico Electric Power Authority; Certified June 27, 2019 p. 80 https://aeepr.com/es-pr/Documents/Exhibit%201%20-%202019%20Fiscal_Plan_for_PREPA_Certified_FOMB%20on_June_27_2019.pdf

- PREPA's approach failing to examine alternatives to a full system wide deployment of MiniGrids, including the selection of customer-owned distributed resources, particularly in regions with the potential for more distributed resources.

PREPA's representatives acknowledged during one of the IRP's technical hearings, that there was "room for optimization" [10] across core aspects of the MiniGrid design, including in further evaluating the extent that PVs and storage could contribute to meeting critical loads through an extended disruption, thereby lowering the level of required thermal peaking resources needed in the Plan. PREPA's representatives further acknowledged that the MiniGrids operate in a way that supplies all the load on a feeder "before the critical load and after". An alternative approach could include meeting the resiliency needs of some of these critical facilities through a more targeted approach, such as through microgrids and DERs, and then making strategic investments in resiliency needs of the remaining sites (including non-critical loads) in a more equitable manner. A more inclusive planning process around these design considerations could help customers and other stakeholders understand the planning challenges and arrive at a consensus on the most effective solutions.

(5) Maximizing benefits to increase efficiency and support economic recovery

PREPA's proposed MiniGrid expenditures total about $5.9 Billion (2018 Dollars) through the year 2028.[11] These expenditures are heavily loaded towards the first few years of the plan. Capital expenditures for MiniGrid Transmission Investments across

[10] CEPR-AP-2018-0001; PREB; Initial Techical Hearing September 4, 2019 @ 1:08:50 https://youtu.be/spMJQLhv6rQ?t=4130
[11] IRP 2019 – Main Report REV2 06182019 wERRATA, p 9-12, 9-13, 9-14.

the 38 kV and 115 kV voltage classes for the first three years of the plan alone (2020-2022) are projected at about $3.9 Billion, or 66% of the total MiniGrid expenditures through 2028. These incremental and cumulative expenditures are summarized in Figures LEO-RS-1 and LEO-RS-2. Across the first five years of the plan, the MiniGrid Transmission investments total about $4.8 Billion, or 82% of the total MiniGrid expenditures through 2028.

Figure LEO-RS-1
Incremental 38kV and 115 kV MiniGrid Transmission investments, calculated from sum of Exhibits 10-7 and 10-9 of the IRP.
Note: Small variation due to rounding.

	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
Technical Justification	2020-2022	2023-2024	2025-2026	2027	2028
Interconnection of Critical Loads	1766.4	444.8	248.8	75.3	33.1
Interconnection of MiniGrids	91.5	20.9	16.5	0.0	13.6
MiniGrid Backbone Extensions	109.3	49.0	18.9	28.5	0.0
MiniGrid Main Backbone	1644.4	220.2	66.0	101.9	70.3
Existing Infrastructure Hardening for Reliability	130.8	167.9	164.6	122.1	53.5
Aging Infrastructure Replacement - MG	126.0	38.8	11.3	15.5	5.0
Total	**3868.4**	**941.6**	**526.1**	**343.3**	**175.5**

Figure LEO-RS-2
Cumulative 38kV and 115 kV MiniGrid Transmission investments, calculated from sum of Exhibits 10-7 and 10-9 of the IRP.
Note: Small variation due to rounding.

	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
Technical Justification	2020-2022	2023-2024	2025-2026	2027	2028
Interconnection of Critical Loads	1766.4	2211.2	2460.0	2535.3	2568.4
Interconnection of MiniGrids	91.5	112.4	128.9	128.9	142.5
MiniGrid Backbone Extensions	109.3	158.3	177.2	205.7	205.7
MiniGrid Main Backbone	1644.4	1864.6	1930.6	2032.5	2102.8
Existing Infrastructure Hardening for Reliability	130.8	298.7	463.3	585.4	638.9
Aging Infrastructure Replacement - MG	126.0	164.8	176.1	191.6	196.6
Total	**3868.4**	**4810.0**	**5336.1**	**5679.4**	**5854.9**

The business case is supported by traditional Value of Lost Load (VOLL) calculations. This approach could overlook some alternatives, including customer-owned microgrids and distributed energy resources, that may result in effective approaches to meeting resiliency needs, but also advance additional benefits in the public interest, including community ownership and local economic development.

As this is the first time PREPA is pursuing the deployment of MiniGrid designs, and requirements for resiliency are currently being understood and defined, the Company may want to consider a more gradual deployment, beginning with areas that have generation resources already in place, and may require comparatively lower incremental investments in transmission infrastructure. For instance, it may make sense to make gradual MiniGrid investments in the San Juan Planning region, where the area is expected to have sufficient generation without the need for additional peaking units. The relatively dense area here may also limit the required T&D investments. Other areas on the other hand may call for a less extensive MiniGrid buildout, but higher levels of say, community microgrids.

Q. What are some potential alternatives to PREPA's proposed system-wide deployment of MiniGrids?

In 2018, Sandia National Laboratories conducted a study titled "Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico,"[12] which pursued a localized and risk-based approach to identify critical facilities and consider the burden imposed on communities in order to arrive at its recommendations. The study's

> results provide siting of microgrids explicitly to improve a community-focused and risk informed resilience metric. With the high-level cost estimation performed, the system of all 159 potential resilience nodes would cost $1,165M if only the critical loads were served by these microgrids, and approximately $2,027[M] to serve both critical and non-critical load. A large cluster of portfolios

[12] Jeffers, Robert Fredric, Staid, Andrea, Baca, Michael J., Currie, Frank M, Fogleman, William Ernest, DeRosa, Sean, Wachtel, Amanda, and Outkin, Alexander V. *Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico.*. United States: N. p., 2018. Web. doi:10.2172/1530167.

> achieves performance benefits close to the do-everything scenario at greatly reduced cost: on the order of $300-$400M.

The study recognized some of its limitations including potentially refining the definition of "burden" across communities that informs its metrics for resiliency, high-level estimates for microgrid systems, and the "absence of PREPA data on the electric utility's most critical restoration and recovery assets." Had PREPA opened a consultative stakeholder process to address resiliency, Sandia National Laboratory could have obtained data to resolve some of these limitations. Ultimately, Sandia's study identifies a sound approach to understand how resiliency can be defined, measured, addressed in a targeted manner, while recognizing local community impacts and a role for distributed generation.

Preliminary analysis by Rocky Mountain Institute (RMI) similarly identified a role for distributed solar and storage showing that "equipping over 20,000 critical facilities – including hospitals, clinics, airports, elderly care facilities, shelters, water treatment plants, and more – across Puerto Rico with solar and storage microgrid systems to power their critical loads in the event of grid outage could total 650-700 MW solar and 900-1,000 MWh of battery storage." [13] RMI observed that potential costs to PREPA ratepayers could be offset "to the extent additional funding (public, private, and philanthropic) can be used to help fund critical facility energy resilience."

[13] Amicus Brief filing of Rocky Mountain Institute; September 20, 2019 https://drive.google.com/file/d/1xFY7Qa3-0XSPd9Ybv2F99szHFyobLO0N/view

Additionally, a report by ICF International on the concept of Integrated Distribution Planning observed that "DER may be a viable non-wires alternative (NWA) for transmission upgrades identified in the transmission planning process". The report concluded that "a jurisdiction that anticipates DER growth should begin to think about how to align the recurring cyclical processes for long-term load forecasting, resource procurement, and T&D planning so as to specify the timing and content of essential information flows among these processes."[14]

These alternatives (including MiniGrids deployments) offer their own unique benefits and limitations, that should be discussed through a robust stakeholder process. Stakeholders should have a common understanding of needs, hardships burden, etc. before committing to any approach to meet the island's resilience needs.

III. ROLE OF INTEGRATED DISTRIBUTION PLANNING

Q. What is Integrated Distribution Planning?

A. Integrated Distribution Planning ("IDP") is an evolution in utilities' traditional distribution grid planning processes. Utilities and their customers can derive substantial benefits from transitioning to IDP, including:

- lowering costs to reduce rate pressure in a low load growth environment;
- enhancing the efficiency of existing assets and processes;

[14] Integrated Distribution Planning – Prepared for the Minnesota Public Utilities Commission; ICF; August 2016 https://www.energy.gov/sites/prod/files/2016/09/f33/DOE%20MPUC%20Integrated%20Distribution%20Planning%208312016.pdf

- creating more cost-effective programs with better returns for customers and shareholders;
- identifying new capabilities required to better align operations with changing customer expectations; and
- providing greater support for the deployment of distributed energy resources.

GridLab's[15] IDP Report (Exhibit LEO-RS-2) presents an IDP framework developed through an assessment of grid modernization and distribution planning activities across various states. If implemented, the IDP framework can help maximize customer benefits from grid modernization investments (and related investments in enhanced energy customer products and services).

Q. Please describe the IDP framework in more detail.

A. The IDP framework identifies five essential capabilities needed to ensure utilities and their customers get the most out of investments in grid modernization and the products and services that may be developed as a result of these investments.[16] Specifically, these capabilities include:

(1) Advanced Forecasting and System Modeling
(2) Hosting Capacity Analysis
(3) Disclosure of Grid Needs and Locational Value
(4) New Solution Acquisition

[15] GridLab is a non-profit organization that provides technical expertise to enhance policy decision-making.
[16] Attachment RS-2, IDP Report at 9.

(5) Meaningful Stakeholder Engagement

Q. Does transitioning to IDP require that a utility implement all five "capabilities" in the IDP framework immediately?

A. No. To some extent, the utility may pursue each of these capabilities independent of each other. However, the value of these capabilities is maximized when they work in concert. Meaningful stakeholder engagement is key to any IDP process, and ensures investments, programs, and operations align with the need of customers and others that may be impacted. Acquiring new solutions to systems constraints is more effective when there is more transparency on the nature of a specific need and the value of meeting that need. Similarly, advanced forecasting and system modeling that considers distributed energy resources ("DER") allows energy service companies to have forward-looking information about the market. When incorporated into a hosting capacity analysis, this information becomes more actionable to developers than only having information on the present status of the grid.

Q. Does the IDP framework prescribe specific technologies or solutions?

A. No. The goal of the framework is not to be prescriptive in recommending specific technologies or solutions, but rather to provide a foundation for utilities, customers, and other energy stakeholders to develop a common understanding of the essential capabilities that arise from grid modernization investments and integrated distribution planning practices. This process also facilitates discovery amongst stakeholders of the prioritization and weight that should be assigned to each IDP capability based on the objectives of the collaborative. In addition, all investments that impact the distribution system—whether for reliability, resiliency, modernization, capacity, or efficiency are provided a dedicated forum where cross-impacts and synergies can be identified and understood.

Q. Why is it important for the Energy Bureau to require an IDP at this time?

A. Traditional utility planning criteria are expanding to include enhancing resiliency and meeting emerging policy objectives. At the same time, the market for customer energy products and services is rapidly changing, accelerating the deployment of distributed energy resources. Given these forces, it is important for the Bureau to institute a deliberate process that maximizes the value of these new opportunities while preserving cost-effective, reliable electric service for customers.

In addition, the aforementioned ICF report notes that "distribution planning is typically done outside the context of integrated resource planning and transmission planning. To the extent DER are considered in resource and transmission planning it is essential to align those assumptions and plans with those used for distribution planning."[17]

Q. Has the Energy Bureau established an IDP process?

A. Yes. The Energy Bureau recently initiated a Distribution System Planning process that engages stakeholders and incorporates the core components of an IDP. This process involves a series of working groups that focus on issues including hosting capacity,

[17] Integrated Distribution Planning – Prepared for the Minnesota Public Utilities Commission; ICF; August 2016 https://www.energy.gov/sites/prod/files/2016/09/f33/DOE%20MPUC%20Integrated%20Distribution%20Planning%208312016.pdf

resilience, and coordination with other planning efforts such as the IRP. This last effort at coordination is particularly notable since it recognizes the potential issues that could arise as a result of having separate planning processes for transmission, distribution and resources including inefficiencies, gaps in planning, and missed opportunities to harness synergies.

Though the IRP and the emerging IDP process are currently carried out as separate efforts, there is great potential for coordination and ensuring there are fewer missed opportunities, particularly in employing energy resources closer to the customer in meeting long-range energy needs.

Q. Have utilities in other states started a transition to IDP?

A. Yes. Utilities across various states have begun to grapple with changes in planning criteria, customer expectations, and market conditions by implementing distribution planning processes that are transparent, engage energy stakeholders, and ensure grid investments align with intended objectives.

Q. Please provide an example of a utility's recent implementation of an IDP process.

A. Consolidated Edison's Distributed System Implementation Plan[18] exemplifies the essential IDP capabilities previously described working in concert in one dedicated forum. After much stakeholder feedback, the New York State Public Service

[18] Consolidated Edison, Distribution System Implementation Plan (July 31, 2018), available at :https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/distributed-system-implementation-plan.pdf?la=en.

Commission Staff developed guidance[19] for all investor-owned utilities in the state to modernize their grids and enhance their distribution planning practices. This standardized expectations around customer engagement and minimum functionalities to be explored, while allowing each utility to consider the specifics of their territories and starting points on grid modernization. National Grid[20] and the other New York utilities similarly filed their own version of these distribution plans.

Q. What do you recommend to the Bureau regarding IDP?

A. The Bureau should expedite core components of the Integrated Distribution Planning process to support customer adoption of Distributed Energy Resources, especially hosting capacity analyses and streamlined interconnection processes. Achieving the level of Distributed Energy Resources projected in the IRP is by no means guaranteed. Providing this additional level of support for DER as early as possible in the planning horizon is critical to meeting established policy goals.

Q. What are the specific steps PREPA should take to initiate an Integrated Distribution Planning process?

A. While a full transition from PREPA's current distribution planning process to an Integrated Distribution Planning process cannot happen immediately, below, I discuss specific steps PREPA should take to initiate that process.

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[19] N.Y. Pub. Serv. Comm'n, Case 16-M-0411, In the Matter of Distributed System Implementation Plans ("DSIP Proceeding"), DPS Staff Whitepaper: Guidance for 2018 DSIP Updates (issued May 30, 2018) ("2018 DSIP Guidance").
[20] Distribution System Implementation Plan Update of Niagara Mohawk Power Corporation d/b/a National Grid (July 31, 2018), available at http://nyssmartgrid.com/wp-content/uploads/NationalGrid2018.pdf

(1) Forecasting and System Modeling

Q. What role does forecasting play in traditional utility distribution planning?

A. Utilities traditionally have developed load forecasts at the system- and substation-level in order to allow utility planners to assess areas of growth in demand and identify infrastructure plans to meet this demand over a specified planning horizon. As the penetration of DER including solar, storage, and electric vehicles grows, planners will need to understand how the supply and consumption patterns of these resources impact peak demand and other planning considerations. In accounting for DER in forecasts, it is important to consider at a more granular level how the magnitude of supply and consumption varies over the course of the day. In addition, it becomes more important to forecast these impacts down to the individual feeder level, where variations in DER supply and consumption patterns are more pronounced.

Q. What role does system modeling play in traditional utility distribution planning?

A. System models have traditionally been used to assess the ability of existing system assets and configurations to meet the projected future load requirements as part of a long-range planning process. For the most part however, this has traditionally involved relatively few snapshots of these future load requirements.

Q. Please describe how utility forecasting and system modeling are different in an Integrated Distribution Planning process as compared to a traditional distribution planning process.

A. Under an Integrated Distribution Planning process, planners would model load and DER performance in a more granular manner, with consideration for local dynamics at the feeder level and reflecting hourly and sub-hourly variations associated with the various forms of DER. Performing system modeling across a few static points in time and at higher system or substation level would not adequately assess the dynamics of DER deployments closer to the customer, especially at higher levels deployment levels of these resources.

Q. What do you recommend with respect to PREPA's forecasting and system modeling processes?

A. PREPA should develop forecasts that consider the adoption rates of DER technologies, including solar, energy storage, and electric vehicles. These forecasts should reflect the supply and consumption patterns of each DER category, as appropriate. PREPA should then conduct system modeling to understand the impact forecasted DER would have on the system, including at the local feeder level.

(2) Hosting Capacity Analysis

Q. What is a hosting capacity analysis?

A. The Electric Power Research Institute defines[21] hosting capacity as the "amount of distributed energy resources that can be accommodated without adversely impacting power quality or reliability under current configurations and without requiring infrastructure upgrades." A hosting capacity analysis is location-dependent and produced at the feeder level in order to enable strategic siting of distributed energy resources.

[21] "Defining a Roadmap for Successful Implementation of a Hosting Capacity Method for NY"; J. Smith, L. Rogers; EPRI; July 28, 2016.

Q. Please explain the role that a hosting capacity analysis plays in Integrated Distribution Planning.

A. Hosting capacity analyses allow utilities to develop a better sense of the amount of distributed energy resources that may be integrated at the local feeder level, with current system assets and without impacting power quality or reliability. When this hosting information is shared through maps and other accessible tools, customers and DER developers are able to make more informed decisions with regards to siting and project design. As hosting capacity analyses are further informed by feeder level DER forecasts and modeling, utilities and its stakeholders can identify where future system upgrades may be required in order to support DER growth. Access and presentation to customers is key in following through and ensuring the utility meets changing customer demands.

Q. Please provide an example of other utilities that have carried out a hosting capacity analysis.

A. Utilities including Southern California Edison[22] have developed interactive maps containing actionable information for installing distributed generation by leveraging, in part, data obtained from its investments in grid modernization. As a result, customers and developers can optimize energy projects using data provided by these visual tools including existing generation, load, and integration capacity.

Q. What do you recommend with respect to hosting capacity analysis?

[22] "SCE's Distributed Energy Resource Interconnection Map (DERiM) User Guide" ; https://www.sce.com/sites/default/files/inline-files/DERiM_User_Guide_Final_AA_0.pdf ; accessed 10/02/2019

A. PREPA states that its efforts for "Engaging the Customer," as part of the Action Plan, include "changes to the transmission and distribution system to support the incorporation of rooftop PV and the recommended energy efficiency and demand response programs."[23] In addition, one of the five key pillars adopted by the PREPA Governing Board commits to an energy future that is "Customer-Centric" and empowers "customers to participate and take ownership on their energy security and affordability." Expanding the Company's hosting capacity capabilities would allow it to go beyond increasing capacity across its feeders and would inform customers and third parties of distribution system conditions that could impact siting and design.

In addition, the "Engaging the Customer" section of the IRP's Action Plan recognized that the analysis PREPA conducted to identify distribution system investments needed to integrate PV systems over the next five years is insufficient. PREPA notes this analysis

> can only be used for screening purposes and it is not a substitute for the necessary detailed system studies that must consider the feeder topology, assets in service, and location of the load and PV systems. This future detailed analysis, which is beyond the scope of this evaluation, must include an evaluation of the expected performance of equipment; refinement of the definition of the necessary improvements, capital expenditures, and timing to implement the projects.

PREB recently initiated a collaborative Distribution System Planning stakeholder process which includes an exploration of hosting capacity issues that can examine many of these integration issues. This stakeholder process should be expedited to allow PV systems to

[23] IRP 2019 – Main Report REV2 06182019 wERRATA, p 9-1

come online without unnecessary delays and progress should be tracked as part of the implementation of the IRP.

(3) Consideration of Non-Wires Alternatives

Q. What is a non-wires alternative?

A. The New York State Energy Research and Development Authority ("NYSERDA") defines Non-Wires Alternatives as "projects [that] allow utilities to defer or avoid conventional infrastructure investments by procuring distributed energy resources (DER) that lower costs and emissions while maintaining or improving system reliability."[24]

Q. What role do non-wire alternatives play in Integrated Distribution Planning?

A. Non-wire alternative solicitations initiated by utilities allow developers in the DER market to propose solutions that could defer or avoid costly infrastructure investments otherwise required to meet a clearly defined system need. Through these competitive solicitations, utilities communicate the requirements of the system needs to be addressed including the location, magnitude of the load relief needed, and the required in-service date for the proposed solution. Developers, working alongside customers and the utility, can expand the solution set of investments available for meeting system needs to include cost-effective DERs—resulting in significant savings for all customers in the form of avoided infrastructure investments.

Q. Have other utilities deployed non-wires alternatives?

[24] NY REV CONNECT; NYSERDA https://nyrevconnect.com/non-wires-alternatives/

A. Yes. For instance, Bonneville Power Administration (BPA) evaluated the deferral of an investment in a proposed 500kV transmission line, estimated to cost over $1 billion.[25] Through a competitive market solution solicitation, BPA sought out "a more flexible, scalable, and economically and operationally efficient approach to managing [their] transmission system."

BPA received a diverse set of market responses for alternatives to the transmission line, including energy storage, generation redispatch, demand response, and alternatives like Conservation Voltage Reduction ("CVR"), that can not only realize energy savings, but also could defer capital investments identified in other planning processes when benefits such as peak demand reduction are accounted for.

The transmission line deferral was successfully achieved through a combination of demand response and generation redispatch, and the project was ultimately delivered underbudget. The key takeaways of this experience highlight the importance of stakeholder engagement and performance data collection that are core to an IDP process.

Q. What do you recommend with respect to non-wires alternatives?

A. PREPA should investigate the potential for the deployment of distributed energy resources to serve as non-wire alternatives that could defer or avoid the need for investment in conventional, more costly utility infrastructure. With enough transparency on the magnitude and location of grid needs, including resiliency, customers and third

[25] Non-Wires Alternatives – Case Studies from Leading U.S. Projects; E4theFuture, PLMA, SEPA ; November 2018 https://e4thefuture.org/wp-content/uploads/2018/11/2018-Non-Wires-Alternatives-Report_FINAL.pdf

parties would be empowered to provide practical solutions in a cost-effective manner. For instance, by reducing the amount of energy demand across critical facilities through well-designed Energy Efficiency and Demand Management programs, these sites may reduce the energy needed to serve some loads, allowing on-site generation to serve more of other critical loads.

(4) Meaningful Stakeholder Engagement

Q. What role does stakeholder engagement play in Integrated Distribution Planning?

A. Stakeholder engagement is perhaps the most critical element of an Integrated Distribution Planning process. This creates a forum for the open sharing of information on the purpose, progress, and opportunities in an environment that is far less contentious than traditional regulatory proceedings. It allows for communication amongst stakeholders on goals and objectives for these investments and associated programs, identification of opportunities to enhance customer offerings, and facilitates the discovery of new and innovative solutions and approaches to long-standing and emerging planning challenges.

Q. Please provide an example of a state in which regulators have required a transparent stakeholder process to inform utility distribution planning.

A. In Michigan, the Public Service Commission required each regulated utility to file five-year distribution plans. It then opened a separate docket "to allow a comprehensive and concerted review by all distribution system stakeholders of issues related to five-year distribution plans in one central, efficient location."[26] As a part of that docket, the Commission invited input on the utilities' filed distribution plans, and hosted a series of

[26] Mich. Pub. Serv. Comm'n, Case No. U-20147, Order (Sept. 11, 2019).

technical workshops allowing experts and utilities to confer on best practices with respect to distribution planning, with the objective of setting expectations for the utilities' next set of distribution plans.

Q. What do you recommend with respect to stakeholder engagement?

A. Energy Stakeholders in Puerto Rico have been presented with various engagement opportunities across formal proceedings, workshops, and less formal facilitated working groups across a broad range of issues. As a result, a very engaged and vibrant community has developed that is well-versed in a variety of energy issues. However more can be done to bring together the strategic elements of these activities to demonstrate vision where the entire effort is ultimately going. PREPA should work with stakeholders to organize and tie together the strategic elements and touchpoints of these proceedings, workshops, etc., in a manner that maximizes meaningful stakeholder engagement.

IV. PERFORMANCE EVALUATION AND REPORTING

Q. Does PREPA propose any reporting associated with its IRP?

A. No.

Q. What is your recommendation with respect to reporting and evaluation?

A. PREPA should evaluate the performance of its IRP deployment efforts and benefits realized over time and work alongside stakeholders to identify opportunities for maximizing value from those investments, including course correction as appropriate.

A series of performance metrics should be developed to accompany a series of well-defined benefit categories that align with the core desired outcomes of the IRP. This would allow PREPA to report on the progress it has made over time to realize these benefits, including throughout the process of project implementation and, ultimately, use of investments made. These reports should be updated periodically and made publicly available as part of PREPA's ongoing engagement with stakeholders.

Q. Have regulators in other states required utilities to track and report performance metrics associated with their grid modernization investments?

A. Yes. The New Jersey Board of Public Utilities required metrics reporting in order to verify the anticipated savings associated with the deployment of AMI across Rockland Electric Company's territory. In addition to tracking progress over time, these metrics enable one to identify ways of refining on-going investments and strategies.

The Rockland Electric metrics required in the New Jersey Board of Public Utilities' Order[27] included:

- O&M cost reduction through emergency response labor reduction;
- Number of power quality issues identified; and
- Environmental benefits due to efficiency measures, including Conservation Voltage Reduction.

[27] N.J. Board of Pub. Utils., Docket No. ER16060524; Petition of Rockland Electric Program for Approval of an Advanced Metering Program; August 23, 2017

Similarly, Con Edison and its stakeholders worked together to define a series of metrics to measure progress across various stages of implementation and operation of its AMI deployment project.[28] These performance metrics included customer adoption of time-variant rates and number of regions where Conservation Voltage Reduction was been deployed.

Some of these metric categories can also be used to indicate the level of progress being made during implementation, before a project is fully completed.

Q. Are there any other considerations for the development of performance metrics in the PREPA's Plan?

A. Yes, specifically related to the concept of resilience. Resilience is defined as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions."[29]

Reliability and resiliency are different concepts. These terms are not interchangeable and should not be combined into one benefit category. One can theoretically maintain a reliable system that performs well on blue-sky days and through common disruptions, but the same system can fail to meet resilient designs, if it cannot quickly recover from more severe disruptions resulting in extensive and prolonged outages.

[28] AMI Metrics Report; Con Edison; October 31, 2018
[29] Presidential Policy Directive: PPD-21; Department of Homeland Security; February 12, 2013

Though there is not universal consensus on resilience methods yet, the U.S. Department of Energy has been assessing use cases and developing metrics on this emerging concept.[30] Some metrics it has explored for resilience include:

- Cumulative daily power outages;
- Repair and recovery costs bore by the utility; and
- Emergency service assets without power for more than 48 hours.

Q. What performance metrics should the Bureau require PREPA to track in association with its IRP?

A. PREPA should work with stakeholders to define the appropriate metrics that would allow one to measure the performance of projects that support the successful execution of its IRP. These metrics should be designed to ensure the data required to provide periodic updates is easily accessible and does not provide a barrier to reporting. In addition, these metrics should be closely aligned with the planning requirements and policy objectives identified in the plan to ensure performance can be tracked, and the reports are meaningful and actionable. The metrics discussed earlier may serve as a solid foundation for those ultimately adopted and reported on by the Company.

[30] Resilience Metrics for the Electric Power System: A Performance-Based Approach; Sandia National Laboratories; February 2017 https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2017/171493.pdf

A summary of some potential metrics is presented below:

Benefit Category	Metric	Units of Measurement
Resiliency	Cumulative daily power outages	Customer-days without power
Resiliency	Repair and recovery costs bore by the utility	$ (dollars)
Resiliency	Emergency service assets without power for more than 48 hours	# of assets
Customer Engagement	Mean-time to DER interconnection by customer class	# of days per class
Customer Engagement	Customer awareness of energy efficiency, demand management, and distributed generation options and programs.	Awareness surveys to be conducted, including the development of a baseline for measuring progress.
Customer Engagement	Access to Hosting Capacity Mapping Information	% of system with hosting capacity maps availability

V. CONCLUSION

Q. Q. Please summarize your recommendations to the Bureau.

A. I recommend that the Commission require PREPA to:

1. Work with the Bureau to expedite core capabilities of the Integrated Distribution Planning process to support customer adoption of Distributed Energy Resources, especially hosting capacity analyses and streamlined interconnection processes;
2. Develop forecasts that consider the adoption rates of DER technologies, including solar, energy storage, and electric vehicles, including at the local feeder level;

3. Investigate the potential for the deployment of distributed energy resources to serve as non-wire alternatives that could defer or avoid the need for investment in conventional, more costly utility infrastructure - including for resiliency;
4. Work proactively with customers and third parties to support emerging DER projects at various stages of development in order to further manage investments for serving critical loads;
5. Work with stakeholders to organize and tie together the strategic elements and touchpoints of these proceedings, workshops, etc., in a manner that maximizes meaningful stakeholder engagement.
6. Work with stakeholders to define the appropriate metrics that would allow one to measure the performance of projects that support the successful execution of its IRP over time and identify opportunities for maximizing value, including course correction as appropriate.

Q. Does this conclude your prepared direct testimony?

A. Yes.

CERTIFICATION

I, Ronny Sandoval, CERTIFY that the contents of my testimony are known to me and are the truth according to the best of my abilities and reasonable knowledge. The technical and operational aspects included in the testimony are based on information that has been gathered in good faith; but I cannot guarantee the truthfulness of information gathered from third parties.

Ronny Sandoval

Before me, the undersigned Notary Public, personally appeared Ronny Sandoval, who acknowledges that the above is true this day of October 23, 2019 in Broomfield, Colorado

(_) Personally known ____ OR (✓) Identification Document provided New York Driver License

YUHWEN SEAH
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20094041592
MY COMMISSION EXPIRES DECEMBER 22, 2021

Notary Public Name, Signature, Seal

OFFICE OF THE SECRETARY OF STATE
OF THE STATE OF COLORADO

CERTIFICATE OF FACT OF CURRENT NOTARY STATUS

I, Jena Griswold , as the Secretary of State of the State of Colorado, hereby certify that the records of this office do reveal a current notary public commission in the name of:

Yuhwen Seah

with Notary ID 20094041592 for a term of 12/22/2017 through 12/22/2021.

This certificate reflects facts established or disclosed by documents delivered to this office on paper through 10/21/2019 that have been posted, and by documents delivered to this office electronically and approved through 10/23/2019 @13:45:06.

I have affixed hereto the Great Seal of the State of Colorado and duly generated, executed, and issued this official certificate at Denver, Colorado on 10/23/2019 @ 13:45:06 in accordance with applicable law. This certificate is assigned Confirmation Number 164908.

WARNING: This certificate does **NOT** certify the correctness or authenticity of any notarization, notarized document, or notarial act by the above named individual.

Secretary of State of the State of Colorado

End of Certificate

Notice: A certificate issued electronically from the Colorado Secretary of State's Web site is fully and immediately valid and effective. However, as an option, the issuance and validity of a certificate obtained electronically may be established by visiting the Validate a Certificate page of the Secretary of State's Web site, http://www.sos.state.co.us/notary/pages/public/verifyCert.xhtml, entering the certificate's confirmation number displayed on the certificate, and following the instructions displayed. Confirming the issuance of a certificate is merely optional and is not necessary to the valid and effective issuance of a certificate. For more information, visit our Web site, http://www.sos.state.co.us, click Notary Public and select "Frequently Asked Questions."

Exhibit LEO-RS- 1

RONNY SANDOVAL

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UTILITIES & SUSTAINABLE ENERGY PROFESSIONAL

EDUCATION

New York University - Stern School of Business, New York, NY
Master of Business Administration **2011**
Specializations: Finance, Law & Business, Management of Technology & Operations

Stevens Institute of Technology, Hoboken, NY
Bachelor of Engineering, Electrical Engineering **2004**

New York University, New York, NY
Bachelor of Science, Mathematics **2004**

PROFESSIONAL EXPERIENCE

Interstate Renewable Energy Council, Latham, N.Y.
Board of Directors **January 2017 – Present**
Perform all board duties including serving on strategy and policy committees.

GridWise Alliance, Washington D.C.
Board of Directors **January 2017 – Present**
Perform all board duties including serving on board operations, member products, and outreach committees.

ROS Energy Strategies, LLC, Boulder, CO
President **August 2019 – Present**
Provide strategy consulting services to non-profit and public service clients on energy issues.

Environmental Defense Fund, New York, NY
Senior Director, Grid Modernization **April 2018 – April 2019**
Manage and execute EDF's national grid modernization program and play leadership role in the development of the existing and emerging areas of the Clean Energy organization's strategy.

Develop grant proposals and cultivate relationships with existing and potential program funders through direct contact with supporters and developing of accessible communications.

Environmental Defense Fund, New York, NY
Director, Grid Modernization **April 2015 – March 2018**
Managed and executed EDF's national grid modernization program in driving investments that increase the efficiency of the electric system and enable the integration of emerging sources of energy.

Developed effective partnerships to socialize thought leadership and experiences across regions, sectors, and formal regulatory engagements.

Managed annual program budget, internal staff, and teams of consultants to drive program's mission and project outcomes.

Environmental Defense Fund, New York, NY
Senior Manager, Clean Energy Idea Bank **October 2013 – March 2015**
Developed and executed effective grid modernization deployment plans with EDF Clean Energy Program state and regional directors through collaboration, advocacy, and thought leadership.

Consolidated Edison Company of New York, Inc., New York, NY
Senior Specialist, Energy Efficiency and Demand Management **October 2010 – September 2013**
Managed efforts to increase energy efficiency and reduce peak electricity use in capacity constrained areas of the system and forecasted the long-range impacts of energy efficiency programs for system and capital planning.

Consolidated Edison Company of New York, Inc., New York, NY
Engineer, Transmission Planning **January 2008 – September 2010**
Associate Engineer, Transmission Planning **January 2006 – December 2007**
Performed technical studies and developed capital system reinforcement plans needed to serve customers' growing demand for electricity.

Consolidated Edison Company of New York, Inc., New York, NY
Management Associate **June 2004 – December 2005**
Supervised operations staff and performed management functions across Con Edison's electric, gas, and steam organizations, as part of company's management training "GOLD" program.

THOUGHT LEADERSHIP

Including:

EDF Comments on Hawaiian Electric Companies' "Modernizing Hawai'i's Grid for Our Customers
Public Utilities Commission, State of Hawai'i **September 2017**

EDF Testimony on Rockland Electric Company Advanced Metering Program
Board of Public Utilities, State of New Jersey **September 2016**

EDF Settlement Supporting Testimony – Duke Energy Indiana Transmission, Distribution and Storage System Improvement Charge
Indiana Utility Regulatory Commission **March 2016**

EDF Testimony on First Energy Rate Cases
Pennsylvania Public Utilities Commission **June 2016**

EDF Comments on Straw Proposal on the Modernization of the Electric Grid
Commonwealth of Massachusetts, Department of Public Utilities **January 2013**

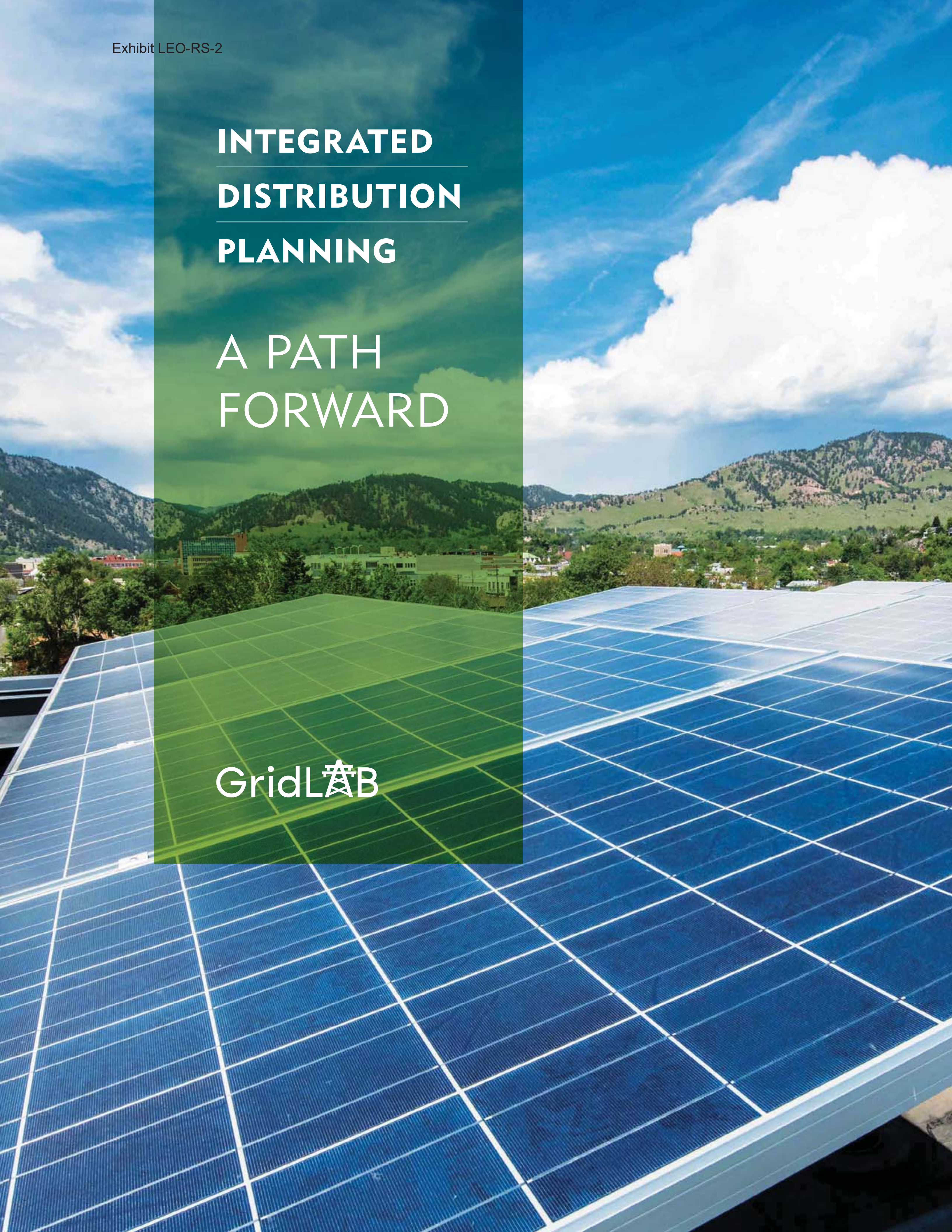
PUBLICATIONS AND COMMUNICATIONS

"The Climate Champions Podcast: Ronny Sandoval, Board Member, IREC & GWA"" Krevat Energy Innovations	**May 2019**
"New Microgrid Initiative Launches in Puerto Rico Amid Energy Policy Uncertainty"" Greentech Media	**March 2019**
"The Interaction Between Distributed Solar and Wholesale Markets" SEIA / SEPA Solar Power New York	**December 2018**
"Grid Reliability and Resilience" Vermont Law School Energy Symposium – Wires, Wind, and Resiliency	**October 2018**
"Voltage Management: Quick Wins for System Efficiency"" Smart Grid Northwest – GridFWD 2018	**October 2018**
"Building Resilient Cities: Emergency Preparedness and Smart Solutions" Congressional Hispanic Caucus Institute Leadership Conference	**September 2018**
"A Roadmap for a Clean, Modern Electric Grid" Smart Energy Consumer Collaborative	**August 2018**
"Making the Grid Smart: Moving Toward Two-Way Communication in the Digital Age" Department of Energy Peer Exchange	**April 2018**
"State Grid Modernization Trends" Smart Electric Power Alliance Utility Conference	**April 2018**
"Grid Modernization: The Foundation for Climate Change Progress" GridWise Alliance – GridCONNEXT 2017	**December 2017**
"Grid Modernization: The Foundation for Climate Change Progress" Environmental Defense Fund	**December 2017**
"Transportation, Energy and the Environment: Modernizing the Grid" Texas Tribune Festival	**September 2017**
"Valuing Distributed Energy Resources" Smart Electric Power Alliance Grid Evolution Summit	**July 2017**
"The US Electric Grid: Present and Future" Columbia University Energy Symposium	**February 2017**
"A Missing Piece: What Smart Grid Means for the Environment" Smart Grid Consumer Collaborative	**August 2016**
"The Benefits of a Smarter Grid: The 3rd Grid Modernization Index" Department of Energy / International Smart Grid Action Network	**May 2016**
"Carbon Emissions and Energy Storage Systems" Electricity Today Magazine	**March 2015**
"Harnessing the Hidden Efficiency: Voltage and Reactive Power Management" National Conference and Global Forum on Science, Policy and the Environment	**January 2015**
"Grid Modernization Strategies" The Electricity Forum Magazine	**April 2014**
"Energy Efficiency as a Transmission and Distribution Resource" Regulatory Assistance Project	**September 2012**

CERTIFICATIONS

Certified Energy Manager	**2012**
Business Energy Professional	**2011**
Six Sigma Champion	**2011**

Exhibit LEO-RS-2



INTEGRATED DISTRIBUTION PLANNING

A PATH FORWARD

GridLAB

GridLAB

ABOUT GRIDLAB

GridLab provides comprehensive and credible technical expertise on the design, operation, and attributes of a flexible and dynamic grid to assist policy makers, advocates, and other energy decision makers in navigating the energy transformation.

ABOUT THE AUTHOR

Curt Volkmann is President of New Energy Advisors, LLC and a member of the GridLab network. He has over 34 years of experience in the utilities industry including 9 years as a distribution planning engineer for Pacific Gas & Electric and 18 years with Accenture advising U.S. and international gas, electric and water utilities. As an independent consultant, he currently supports clients across multiple states in a variety of regulatory proceedings related to distribution system planning, distributed energy resources, and grid modernization. Among other engagements, he assists clients in the California Distribution Resources Plan (DRP), Illinois NextGrid, Minnesota Investigation into Grid Modernization, New York Reforming the Energy Vision (REV), and Ohio PowerForward proceedings.

Cover and page 4 photos courtesy of NREL

INTEGRATED DISTRIBUTION PLANNING

A PATH FORWARD

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Electric distribution utilities have successfully designed and operated safe and reliable distribution systems for over 100 years using proven, but not publicly understood, distribution planning practices. As customers increasingly adopt distributed energy resources (DER) such as energy efficiency, demand response, distributed generation, combined heat and power, electric vehicles, and storage, it becomes important for utilities to proactively determine how to best take advantage of these resources to minimize costs while maintaining service quality. It also becomes important for regulators to more clearly understand the rationale and justification for utilities' proposed grid modernization investments in light of this increased DER adoption to ensure prudency and cost-effectiveness. With a well-designed and transparent distribution planning process, regulators can lower overall distribution system costs and save money for customers. This requires the development of new capabilities in distribution planning for it to become a valuable tool for guiding utility investment and marketplace activity.

Many state regulatory commissions and utilities are addressing this transition to Integrated Distribution Planning (IDP) to lower costs and enhance customer relationships. This paper was developed for the Public Utilities Commission of Ohio's PowerForward proceeding and provides a synthesis of existing literature on IDP and activity in various states, a summary of anticipated changes and new required capabilities, and recommendations for regulators on potential next steps for beginning the transition to IDP.

New IDP capabilities include:

- **Advanced Forecasting and System Modeling**
  Enhanced forecasting to reflect the uncertainty of DER growth, more detailed system modeling of loads and DER impacts on the distribution system.
- **Hosting Capacity Analysis**
  Determining how much additional DER each distribution circuit can accommodate without requiring upgrades.
- **Disclosure of Grid Needs and Locational Value**
  Identification and publication of opportunities for DER to provide grid services as non-wires alternatives; identification and publication of locations on each circuit where DER deployment can provide grid benefits.
- **New Solution Acquisition**
  Acquiring or sourcing DER from customers and third parties to provide grid services using pricing, programs

or procurement. For example, using the peak demand reduction capability of smart thermostats in a targeted way to reduce circuit peak loads and avoid the need for circuit or substation upgrades.

- **Meaningful Stakeholder Engagement**
  Establishing processes for open dialogue, transparent information sharing, collaboration, and consensus building among stakeholders.

DER ADDRESSING DISTRIBUTION GRID NEEDS

Central Hudson Gas & Electric in New York is targeting deployment of smart Wi-Fi thermostats and pool pump controls to reduce local distribution peak demand by 16 MW in select areas. Michael Mosher, President and CEO of Central Hudson, explained "Through our Peak Perks program, we've identified areas and specific circuits that are approaching capacity on peak days and may require future upgrades to reliably serve customers when energy use is highest, typically on the hottest summer days when the use of air conditioning is maximized. By working with our customers to control energy use in these locations on peak days, we are seeking to avoid or postpone system upgrades in these areas, ultimately saving money for all our customers."[1]

Even for states where customer adoption of DER is lower than other states referenced in this paper, it is not too early to take proactive steps toward establishing the new IDP capabilities, and begin taking advantage of existing DER resources, such as energy efficiency and demand response. GridLab recommends the following next steps for regulatory commissions that are in the early stages of the transition to IDP:

1 | Establish clear objectives and guiding principles for the development of IDP, including the extent to which the commission intends to establish an open market for distribution grid services.

2 | Require each utility to file a report describing its current distribution planning process and any planned improvements or investments in improved capabilities. The report should include proposed hosting capacity use cases and methodologies, proposed non-wires alternative (NWA) suitability criteria and the identification of candidate capacity, voltage or reliability projects for NWA pilots that would cost-effectively substitute DER for planned distribution investments. These reports will reveal similarities and differences in utility approaches and provide a common understanding of the starting points for each utility in building new capabilities for the transition to IDP.

3 | Establish an IDP Technical Working Group applying the best practices for stakeholder engagement referenced in this paper and involving the commission staff, all utilities, and all interested stakeholders. The Technical Working Group should develop recommendations to the commission on the following:

a. Future scenarios for customer DER adoption across the state, and how these scenarios should be incorporated into forecasting and transmission, distribution, and integrated resource planning processes.

b. Modifications to interconnection standards defining required functions and settings for advanced inverters.

c. Development of NWA suitability criteria, and a process and timeline for implementing pilots identified in the utility reports from step 2.

d. Definition of hosting capacity analysis (HCA) use cases; identification of the appropriate HCA methodology and associated tools and data requirements to satisfy the use cases; and a timeline for initial HCA analysis and publication of results for each utility.

d. Development of portals for sharing information on circuit load profiles, peak load forecasts, capital investment plans, hosting capacity maps, heat maps reflecting locational value and other key data.

1 https://www.cenhud.com/news/news/july15_2016. For program details, see https://www.cenhubpeakperks.com

Exhibit LEO-RS-2

INTRODUCTION

The current electric distribution systems in the U.S. have provided safe and reliable delivery of electricity to consumers for over 100 years. Using proven but not publicly understood planning practices, distribution engineers have designed the systems to accommodate one-way power flow from bulk transmission to end-use customers, and sufficiently sized the systems to meet projected peak loads in each local area.

Technological advancements in distributed energy resources, rapid cost declines, and consumer interest in clean energy are causing two significant market changes: customers adopting distributed energy solutions–in some places quite rapidly–and utilities thinking proactively about how to pursue new opportunities to take advantage of these technologies.[2]

The industry is transitioning to a future in which distributed energy resources[3] (DER) will play an important role in providing grid services when and where they are needed most. To fully realize the value of these DER and save money for customers, distribution planning must evolve from a largely closed process to one that provides transparency into distribution system needs, explicitly considers DER growth and DER capabilities, and ensures that these capabilities are fully utilized to address system needs.[4]

At least 15 states have proceedings planned or underway related to electric distribution system planning[5] and there is extensive literature available on the evolution of distribution planning and related topics. As input into the Public Utilities Commission of Ohio's PowerForward proceeding, the author reviewed over 35 papers, articles, presentations, and other publications related to distribution planning (*see References list beginning on page* 22). This paper provides a synthesis of the existing literature on IDP and activity in several states, a summary of anticipated changes and new required capabilities, and recommendations for regulatory commissions on potential next steps.

2 Robison, Pickles, Fine, Sakib, and Duffy, p. 1

3 DER include energy efficiency, demand response or other active load management, combined heat and power (CHP), distributed generation such as photovoltaic (PV) solar or wind, stationary energy storage, electric vehicles and microgrids.

4 Gahl, Smithwood, and Umoff, p. 2

5 Homer, Cooke, Schwartz, Leventis, Flores-Espino, and Coddington, p. iv

TODAY'S DISTRIBUTION PLANNING

Distribution Planning (DP) involves a set of activities performed by utilities to assess the grid's performance under changing future conditions and to identify and implement solutions to proactively address identified needs.[6] Typical DP activities include:

- Forecasting future circuit and substation loads and peak demands.
- Power flow modeling and system assessment to determine if the existing grid can accommodate forecasted demand, maintain adequate voltage, and safely operate during normal and abnormal system conditions. The system assessment also typically includes a review of system reliability and components at risk of failure, which may require refurbishment or replacement.
- Identification of grid needs[7] and solutions to address the needs. Utilities typically identify multiple alternatives to address needs, ranging from low cost (e.g., reconfiguring a circuit) to higher cost (e.g., reconductoring a circuit, adding a new circuit or substation, etc.).
- Prioritization of solutions and development of capital and operations and maintenance (O&M) plans and associated budgets.
- Design and support for construction of various projects to address grid needs.
- Ongoing monitoring and control of the distribution system, including adjustments to equipment settings or circuit configurations as load conditions change.

The typical utility distribution planning process (*see Figure 1*) has historically been the exclusive domain of utility engineers, offering limited external stakeholder or regulator visibility into the utility's underlying data, assumptions, methodologies or calculations. There are periodic opportunities for stakeholders to examine a utility's distribution investment plan through general rate case proceedings, but this is often a very contentious, time consuming, and resource intensive process for regulators and other parties.

6 Rhode Island, p. 43.

7 Grid needs may include additional capacity to meet peak loads during normal or emergency conditions, voltage regulation, reactive power compensation, system protection modifications, increased hosting capacity, equipment replacement, or other investments to improve reliability or power quality.

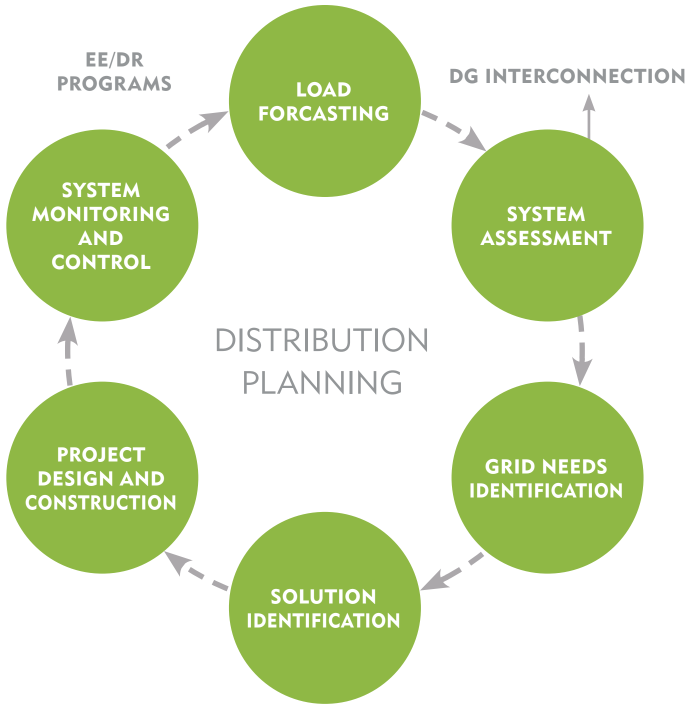


FIGURE 1. Typical Distribution Planning Process

Today, solutions to address grid needs are typically limited to traditional utility equipment (poles, wires or cable, transformers, voltage regulators, etc.). In cases where utilities are piloting the deployment of DER to provide grid services, they strongly prefer to own and directly control the DER assets. Opportunities for third parties to participate in providing non-traditional DER solutions have to date been very limited.

Distribution planners often take a reactive approach to the proliferation of distributed energy resources, treating DER as problems to be addressed or behind-the-meter activities to be ignored rather than opportunities to be embraced and integrated. Energy efficiency and demand response programs are typically disconnected from distribution planning and not considered as potential resources to address grid needs. For distributed generation (DG), utilities provide little guidance to customers and developers, who themselves decide the type, size and location of DG to install and how they will operate it. Utilities must then manage integration of the DG even though the location may be unfavorable and lead to expensive interconnection. Although utilities often compensate customers through net metering or a fixed tariff, the compensation may not reflect the full value that could be provided by the resource.[8]

8 Lew, p. 4

With increasing numbers of customer and developer applications to interconnect DG to the distribution system, utilities often lack a close integration between the interconnection and distribution planning processes. It is not uncommon for the distribution system models used in planning to lack any details about installed or planned DER. As described later, the impacts of existing and anticipated DER (including energy efficiency and demand response) are often not included in a utility's distribution system local load forecast, a foundational element in determining its need for capital investment.

KEY CHANGES

In today's evolving utility industry, a diverse set of DER technologies offer the potential to substitute for conventional utility infrastructure solutions. Although many of these technologies are not new, their pace of deployment is accelerating as falling technology costs drive market maturity and broader consumer adoption.[9]

In many cases, these DER solutions are financed, installed, owned and operated by customers or third parties rather than the utility. Increased customer and third-party investment on the electric system can offer a variety of economic and environmental benefits including, but not limited to, the possibility of reducing the need for ratepayer-funded distribution infrastructure investments. In other words, not only are customers and third parties impacting the system in new ways, but they are also now able to become part of the solution set to address grid needs through their own investment choices.[10]

In the utility industry today, the question is rapidly shifting from "should DER be allowed to expand across the grid?" to "how can the growth of DER be enabled in a manner that supports customer demands, maintains grid reliability and ensures reasonable costs?"[11] Distribution planning must adapt to this increased complexity in order to become a valuable tool for not only guiding utility investment, but also customer and marketplace activity.[12]

Leading regulators and utilities are recognizing this opportunity and are developing ***Integrated Distribution Planning*** (IDP) processes in response. IDP expands upon the current distribution planning process (see *Figure 2*)

9 Rhode Island, p. 43
10 *Id.*
11 Colman, Wilson, and Chung, p. 21
12 Rhode Island, p. 43

by including:

- Explicit consideration of the impacts from all DER types, including energy efficiency and demand response, in load forecasting and transmission, distribution and integrated resource planning.
- ***Enhanced forecasting*** to reflect the uncertainties of DER growth and its impact on load and peak demands.
- Analysis of the distribution systems' ability to accommodate DER without requiring upgrades. This is commonly referred to as a ***Hosting Capacity Analysis***.
- Identification of ***Locational Value*** for nodes on the distribution system where DER deployment could provide grid services[13].
- Consideration of third-party DER or portfolios of DER to address grid needs as ***non-wires alternatives (NWA)***[14].
- Acquisition of NWA grid services from customers and third parties using ***pricing, programs or procurement***.
- Active monitoring, management and optimization of DER.
- ***Streamlined DG interconnection*** processes using insights from the hosting capacity analysis.
- Increased external transparency through enhanced data availability and ***meaningful stakeholder engagement***.

Utilities and their customers can derive substantial benefits from IDP, including lowering costs to reduce rate pressure in a low load growth environment, creating more cost-effective programs with better returns for customers and shareholders, and enhancing customer relationships as interest in DER continues to grow.[15] Customers and developers will have the opportunity to propose, provide and be compensated for grid services, while experiencing more efficient and predictable interconnection processes. Regulators will benefit from increased transparency and data access for optimal solution identification, more efficient regulatory proceedings, and opportunities for more meaningful engagement with utilities and other stakeholders.[16]

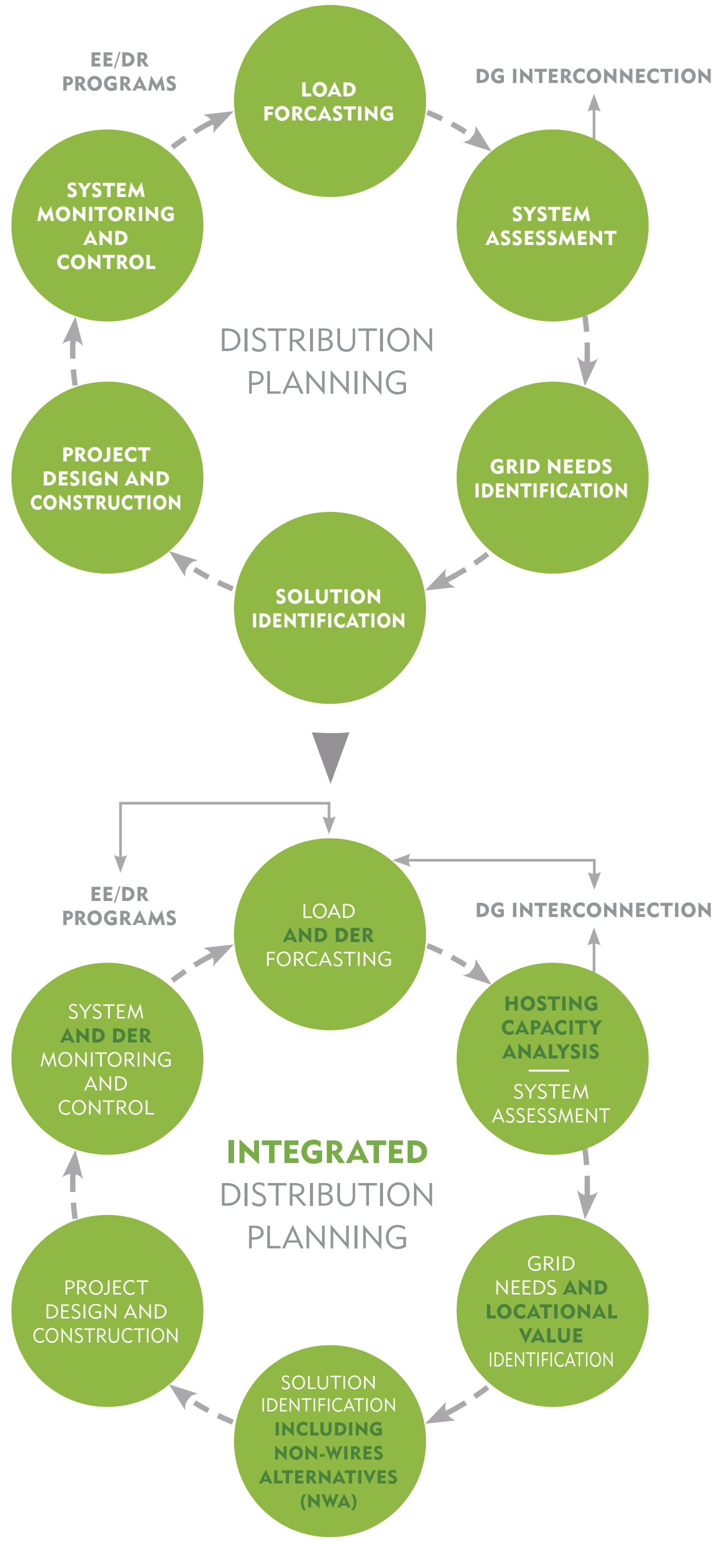


FIGURE 2. Transitioning to Integrated Distribution Planning

13 DER grid services may include peak load reduction or other capacity relief, reactive power support, voltage regulation, frequency regulation, increased hosting capacity, provision of data on asset performance, and enhanced reliability, resiliency or power quality.

14 NWA are deployments of DER or combinations of DER – owned by the utility, customers or other third parties - to defer or avoid the need for investment in conventional, more costly utility infrastructure.

15 Robison, Pickles, Fine, Sakib, and Duffy, pp. 2

16 De Martini, Brouillard, Robison, and Howley

NEW IDP CAPABILITIES

The successful transition to full Integrated Distribution Planning requires the development of five new capabilities, specifically:

1 | Advanced Forecasting and System Modeling

2 | Hosting Capacity Analysis

3 | Disclosure of Grid Needs and Locational Value

4 | New Solution Acquisition

5 | Meaningful Stakeholder Engagement

ADVANCED FORECASTING AND SYSTEM MODELING

An initial step in today's distribution planning process involves the forecasting of load growth and future circuit and substation peak demands over a 5-20 year time horizon. These forecasts are based on circuit and substation loads recorded at the time of previous peaks, adjusted for weather impacts, expected growth rates, and known changes in load such as the addition or loss of major customers.

The resulting forecasts are largely deterministic, meaning they often do not reflect randomness or uncertainty. Utilities apply these static "snapshots" in time and linear extrapolations of historical data to identify where system limits may be exceeded and where upgrades may be required to accommodate load growth. As such, load forecasts are a critical input into a utility's capital expenditure plan and directly impact a utility's revenue requirement. Figure 3 illustrates the deterministic results from a typical utility load forecasting process.

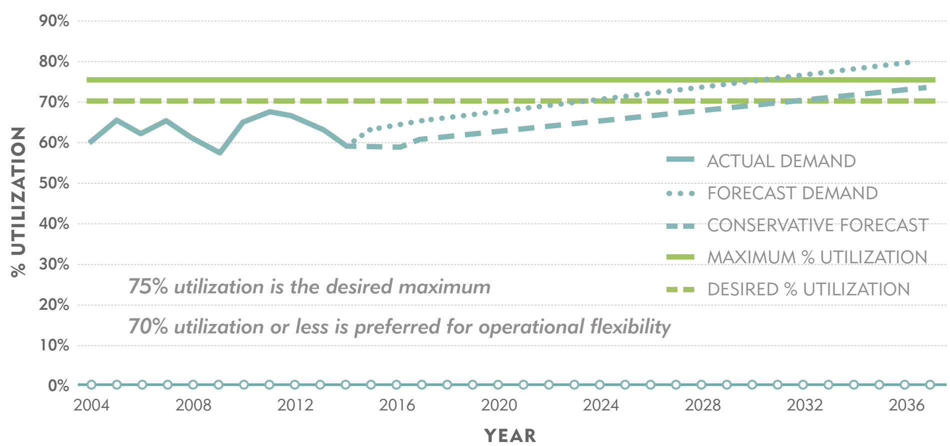


FIGURE 3. Typical Distribution Load Forecasting Results

As DER adoption grows, distribution systems will increasingly experience variability of loading, voltage and other attributes of system performance. New approaches to enhance forecasting in a high-DER future include probabilistic planning and DER adoption scenario analyses. Probabilistic planning, as opposed to the current deterministic approach, accounts for uncertainties introduced by factors such as increasing DER penetration and weather variability. Scenario analyses consider a range of possible futures where varying levels of DER are adopted on the system.[17]

While utilities have well-established methodologies for developing load forecasts, the methodologies for DER forecasting are evolving and the necessary techniques and software tools are still under development. For utilities in the early stages of building this capability, modeling is often based on historical patterns of DER adoption or goals set for utilities.[18] Many leading utilities are using customer-adoption models to forecast expected ***quantities*** of DER, and analysis of individual customers' propensity to adopt based on demographics or load to forecast ***locations*** of DER deployment.[19] Customer-adoption models explicitly use historical DER deployment, location-specific DER technical potential, various DER economic considerations, and end-user behaviors as predictive factors.[20] Table 1 summarizes key steps of an effective DER adoption forecast.

Ultimately, utilities must determine what impacts the adoption of various DER types will have on individual circuit load profiles throughout the year. It is important to know the extent to which DER production is coincident with peak load on each circuit, as well as expected DER output at times of minimum circuit loads.

17 Rhode Island, p. 48
18 Trabish
19 Mills, Barbose, Seel, Dong, Mai, Sigrin, and Zuboy, p. 45
20 *Id.*, p. 7

TABLE 1. Key DER Adoption Forecast Steps[21]

STEP NO.	NAME	DESCRIPTION
1	**Technical Potential**	Estimate the amount of DER capacity that can fit within the physical constraints of each customer site. (For solar PV, the constraint is the amount of unshaded, properly oriented space on the rooftop or the ground available at the site. For other technologies, the constraint may be the electrical panel capacity, natural gas line capacity, customer peak demand, or best available technologies.)
2	**Economic Potential**	Model the economics of DER assets for each customer site to determine the amount of DER capacity that is cost-effective according to a specified financial metric. (Metrics may include levelized cost of energy, payback period, net present value, etc.) This is a subset of the technical potential.
3	**Achievable Potential**	Even if a DER technology is technically feasible and cost-effective, not all customers will adopt it due to other non-technical/non-economic barriers. This step applies an "adoption curve" to estimate what proportion of customers is likely to implement DER technologies (e.g., with a ten-year payback 50 percent of customers will adopt, and with a one-year payback 90 percent of customers will adopt). This is a subset of the economic potential.
4	**Customer-Level Adoption Probability (or "Dispersion Analysis")**	The end result of the DER adoption forecasting process is an adoption probability for each DER technology at each individual customer site, based on the technical/economic/achievable potential calculated in the previous steps. It can also be taken a step further to project how adoption probability will change over time as technical/economic/achievable potential changes (e.g., as technical performance improves or costs decrease). This customer-level adoption probability can be aggregated to calculate the amount of likely DER adoption across an entire distribution circuit, or utility service territory, for distribution planning purposes; or it can be used to select which customers should be targeted for more detailed modeling or for marketing of DER-related programs and services.

DER FORECASTING AT SACRAMENTO MUNICIPAL UTILITY DISTRICT (SMUD)

Like many other utilities, SMUD is seeing increasing adoption of customer-owned and third party-owned DER in its territory. SMUD recognized an opportunity to proactively plan for this DER deployment to minimize extra costs to the grid, maximize grid benefits, and optimize grid investments around the most likely DER deployment scenarios.

SMUD forecasted adoption of various DER technology types through 2030 at the individual customer level and concluded:

- Adoption of DER will be widespread throughout the utility's service territory, mostly resulting in annual net load reductions.
- Adoption will be uneven, with "clustering" of high DER adoption driven by demographics, and technical and economic factors. This unevenness could lead to "hotspots" of distribution grid impacts, the need for mitigation solutions, and opportunities for proactive system planning and customer engagement.

SMUD intends to use the rich customer database developed through this analysis to improve targeting of future customer-focused DER programs and incentives like community solar. It could also be used to identify optimal locations for new infrastructure, such as DC fast charging stations for EVs.[22]

Planners will require modeling of load and DER performance on an hourly or sub-hourly basis to accurately assess distribution system dynamics. Time Series Power Flow Analysis (TSPFA), which can help to analyze the effects of solar irradiance variations or wind fluctuations on power system controls, such as voltage regulators, load tap changers, and switched capacitors, has increasing importance. Although offered in most distribution planning commercial software tools, TSPFA is not widely adopted and used by utilities due to its nascence, relative complexity, and the lack of suitable

21 Colman, Wilson, and Chung, p. 18
22 Smart Electric Power Alliance, Black & Veatch

data for time-varying inputs.[23]

Traditionally, utilities conduct power system analysis separately for transmission and distribution. Conventional distribution system models aggregate the entire bulk power network into a single connection point, while transmission system analysis models distribution systems as aggregated loads. With the increasing penetration of DER on distribution systems, the net-load characteristics from DER can affect transmission, and the wholesale energy and ancillary services provided by DER can be delivered across the distribution system to the transmission system. Therefore, utilities will require an integrated view of transmission, distribution, and DER to analyze the interaction of the systems.[24]

Upcoming revisions to the industry technical standards for inverters will also require new utility system modeling capabilities. Today's inverters, which provide the interface between many DER and the grid by converting direct current (DC) power to alternating current (AC) power, provide limited functionality beyond disconnecting during system disturbances. A significant 2018 revision to the industry standard for interconnection and interoperability of DER[25] will require many additional functions for all new inverters, including abilities to provide additional grid services.[26] As customers adopt DER with new "smart" inverters, regulators and distribution utilities must modify interconnection requirements and develop the modeling capabilities for these advanced functions to fully utilize these new grid resources.

Each utility will also need to develop new capabilities for operating an increasingly complex distribution system, as well as monitoring, managing, and optimizing DER connected to its circuits. Advanced Distribution Management Systems (ADMS) and DER Management Systems (DERMS), though still in various stages of definition[27] and development, will become standard tools in the toolbox of distribution planners.

23 Tang, Homer, McDermott, Coddington, Sigrin, and Mather, p. iii
24 Tang, pp. 21-22
25 Institute of Electrical and Electronics Engineers (IEEE) Standard 1547. The revised IEEE standard requires Authorities Governing Interconnection Requirements (i.e., public utility commissions) to modify interconnection standards and define required functions and settings for advanced inverters.
26 For example, "smart" or advanced inverters can ride through (not disconnect during) minor voltage and frequency disturbances, enhancing system stability. They can also inject or absorb reactive power to provide voltage regulation services
27 http://www.elp.com/articles/2018/01/sepa-collaborators-tackle-derms-standards-prior-to-distributech.html

HOSTING CAPACITY ANALYSIS

A Hosting Capacity Analysis (HCA) has emerged as a critical capability for proactively managing increased adoption of DER while maintaining grid reliability and safety. The term "hosting capacity" refers to the amount of DER that a circuit can accommodate without adversely impacting power reliability or quality under current configurations, and without requiring mitigation or infrastructure upgrades.[28]

HCA allows utilities, regulators, customers, and DER developers to make more efficient and cost-effective decisions about whether to pursue interconnection of a DER technology at a specific grid location by providing data about the amount of new DER that can be accommodated at a particular node on the grid. Mapping the hosting capacity of the entire distribution grid provides even more powerful benefits: customers can identify optimal locations to install and interconnect DER; regulators and utilities can develop price signals to direct DER to locations on the grid where they can provide the greatest benefit; and utilities can better plan for grid infrastructure improvements that expand hosting capacity at locations with high demand for DER.[29]

A circuit's hosting capacity is not a single number, but rather a range of values depending on the DER type and where the DER is located on the circuit. Hosting capacity for generating DER, such as solar PV, is typically higher closer to the substation than it is at locations further away. A circuit's hosting capacity also varies significantly between DER technologies and is impacted by feeder characteristics such as feeder length, voltage class, conductor size, voltage regulation equipment, system protection settings, and the circuit's load profile.

There are currently four accepted methodologies for conducting an HCA – Stochastic, Streamlined, Iterative, and EPRI's Distribution Resource Integration and Value Estimation (DRIVE) method. Each provides different levels of accuracy and requires different levels of computational intensity. Table 2 summarizes the characteristics of each HCA methodology.

The choice of HCA methodology and the associated data and tool requirements should follow a thoughtful consideration of what value the hosting capacity analysis is intended to provide and what the results will be used for (i.e., its "use cases"). Only by understanding

28 Lew, p. 22
29 Stanfield and Safdi, p. 1

TABLE 2. Hosting Capacity Methodologies[30]

METHOD	APPROACH	ADVANTAGES	DISADVANTAGES	COMPUTATION TIME	RECOMMENDED USE CASE
Stochastic	• Increase DER randomly • Run power flow for each solution	• Similar in concept to traditional interconnection studies • Becoming available in planning tools	• Computationally intensive • Limited scenarios	Hours/feeder	• DER planning
Iterative (Integration Capacity Analysis)	• Increase DER at specific location • Run power flow for each solution	• Similar in concept to traditional interconnection studies • Becoming available in planning tools	• Computationally intensive • Limited scenarios • Vendor-specific implementations can vary • Does not determine small distributed (rooftop PV)	Hours/feeder	• Inform screening process • Inform developers
Streamlined	• Limited number of power flows • Utilizes combination of power flow and algorithms	• Computationally efficient • Not vendor tool specific	• Novel approach to hosting capacity • Not well understood method • Limited scenarios • Not available in current planning tools	Minutes/feeder	• Inform screening process • Inform developers
DRIVE	• Limited number of power flows • Utilizes combination of power flow and algorithms	• Computationally efficient • Many DER scenarios considered • Not vendor tool specific • Broad utility industry adoption and input • Becoming available in planning tools	• Novel approach to hosting capacity • Not well understood method • Lag between modifications/ upgrades and associated documentation	Minutes/feeder	• DER planning • Inform screening process • Inform developers

the intended output and use case(s) of the HCA results can parties identify the right methodology, tools and required data. This should be a shared understanding among utilities, regulators, and other stakeholders, allowing for clear expectations, agreement on necessary investments and appropriate use of the HCA results.[31]

HCA use cases may include:

- Providing customers and DER developers with visibility into circuit locations that can accommodate DER at minimal cost.
- Streamlining DER application and interconnection processes by replacing less accurate rules-of-thumb used in technical screens.
- Identification of opportunities for proactive investment in circuit modifications or upgrades to increase hosting capacity.

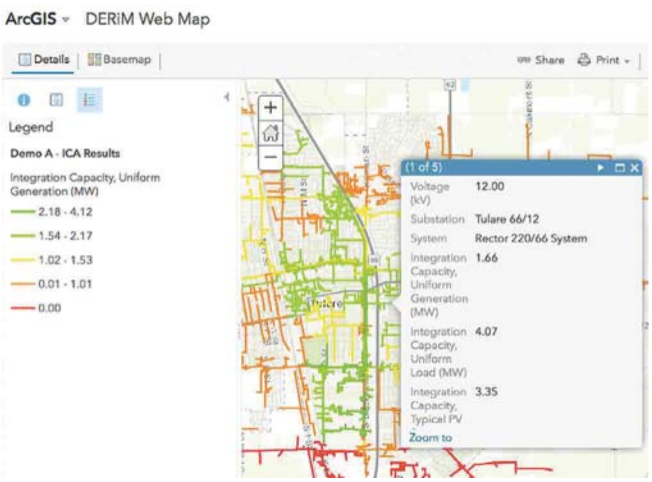
Mapping the hosting capacity of all circuits and making these results publicly available can guide customers and DER developers to locations where they can provide more value to the grid and minimize project costs.[32] User-friendly maps displaying HCA results and downloadable data files also help customers understand what project sizes and technologies can be most easily accommodated in a particular location, which can help them better predict the cost and timeline of the interconnection process. Giving customers the ability

30 Smith, p. 2
31 Succar, pp. 2-4

32 For example, see the NY joint utilities hosting capacity maps available at http://jointutilitiesofny.org/utility-specific-pages/hosting-capacity/ and the Pepco Holdings' maps available at https://www.pepco.com/MyAccount/MyService/Pages/MD/HostingCapacityMap.aspx

to self-select optimal interconnection sites will in itself speed up the interconnection process by channeling applications to the grid locations where they are most likely to be quickly approved.[33]

FIGURE 4. Hosting Capacity Results[34]



It is important for regulatory commissions to establish common use cases and require consistency in HCA methodologies across its utilities, as it will simplify the implementation and oversight process, while also ensuring a more consistent and efficient utilization of the tool by customers and DER developers. Each utility adopting a different methodology with varying suitability to statewide use cases will likely result in more confusion among those attempting to use the HCA and reduce efficiencies for all, including utilities and regulators. Consistent methodologies among utilities also allows for peer learning and exchange of information, which will help improve the accuracy and functionality of the HCAs over time.[35]

DISCLOSURE OF GRID NEEDS AND LOCATIONAL VALUE

As described previously, today's distribution planning is a closed process with minimal regulator and stakeholder visibility into the rationale for planned projects and the underlying grid needs the projects will address. As customers increasingly adopt distributed energy solutions, many utilities are thinking proactively about how to integrate DER into planning to take advantage of these technologies. For utilities that want to manage DER growth or actually leverage these technologies to reduce costs and improve customer relationships, understanding the value of DER on a locational basis and publishing this understanding is a key capability. Increasing the transparency of grid needs and revealing the potential value of deploying DER at specific locations on the grid allows a utility to collaborate with customers and developers to design more effective tariffs, implement cost effective non-wires alternatives, improve demand-side management programs, and animate the market for DER.[36]

As part of the utility planning process described previously, utilities identify grid needs, conventional solutions to address the needs, and the costs of the conventional solutions. One way to determine locational value of DER is based on the contribution the resources could make to addressing the need and the time value of money of deferring or avoiding the conventional solution. Figure 5 illustrates this concept for the deferral of a capacity-related investment.

The New York Reforming the Energy Vision (REV) process provides guidance on how to estimate the avoided distribution capacity value of DER in its Benefit Cost Analysis Framework. It requires utilities to estimate the value of avoided T&D based on the latest detailed marginal-cost-of-service studies. One of the primary drivers of this cost will be how close the system is to reaching capacity. Reducing the peak load for equipment that is near capacity will provide more deferral value than reducing it for equipment with significant excess capacity.[37]

In addition to identifying locational value, utilities must make this information publicly available in a way that

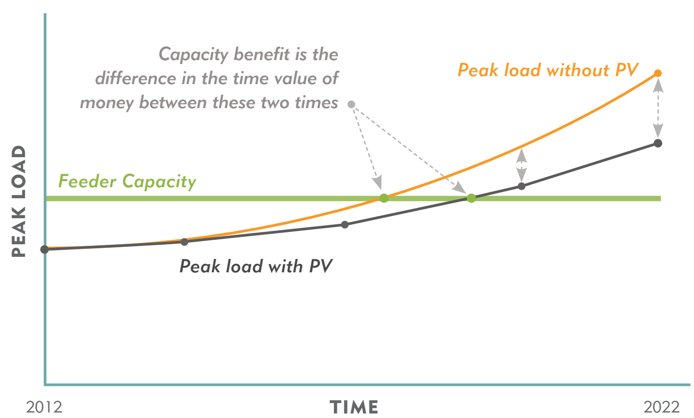


FIGURE 5. Distribution Capacity Deferral Value of DER[38]

33 Stanfield and Safdi, p. 8
34 From Southern California Edison's DER Interconnection Map (DERiM), available at https://drpwg.org/sample-page/drp/
35 Stanfield and Safdi, p. 30

36 Robison, Pickles, Fine, Sakib, and Duffy, p. 1
37 Mills, Barbose, Seel, Dong, Mai, Sigrin, and Zuboy, p. 53
38 Mills, Barbose, Seel, Dong, Mai, Sigrin, and Zuboy, p. 53

motivates DER development at beneficial locations on the grid. For example, each utility in New York now publishes a Distributed System Implementation Plan (DSIP) every two years, which includes identification of specific areas where there are impending or foreseeable infrastructure upgrades needed, such that NWAs could be considered and so that DERs could potentially provide delivery infrastructure avoidance value or other reliability or operational benefits. The utilities have been directed by the NY PSC to list specific infrastructure projects by location and indicate the potential for DERs to address the forecasted system requirements.[39]

The NY utilities also publish heat maps showing where DER can help address system needs, such as load growth or voltage regulation in areas with highly utilized feeders. The heat maps provide a complementary benefit to hosting capacity maps: whereas hosting capacity maps show where DER can avoid creating problems, heat maps reveal where DER can help address problems (e.g., by reducing congestion or peak loads on an overloaded feeder). The heat maps are intended to help direct third-party investment toward areas on the grid where DER can help reduce, defer, or avoid conventional utility infrastructure projects.[45]

California is establishing a Distribution Investment Deferral Framework where its utilities will publish an annual Grid Needs Assessment (GNA), showing grid needs, planned investments, and candidate deferral projects using online maps and downloadable datasets. Importantly, the GNA will describe the performance requirements for any DER solution, including the magnitude, duration and frequency of resources required to address each grid need. The Locational Net Benefits Analysis (LNBA) framework, which includes a broad range of system and societal benefits[46], is the basis for determining the range of value at each location. The utilities and stakeholders are developing prioritization metrics by which to characterize candidate deferral opportunities and identify projects with a high likelihood of successful, cost-effective investment deferrals.[47]

OTHER EXAMPLES OF NON-WIRES ALTERNATIVES (NWA)

- **Tiverton/Little Compton**
  National Grid's deployment of targeted EE and DR to defer a $2.9 million substation upgrade in Rhode Island[40]
- **Boothbay**
  Deployment of 1.6 MW of EE, DR, PV, storage and backup generation to avoid an $18 million transmission upgrade proposed by Central Maine Power[41]
- **Borrego Springs**
  San Diego Gas & Electric's deployment of a solar, storage, and backup generation microgrid for improved reliability at a cost 3-4 times cheaper than the conventional transmission alternative[42]
- **Punkin Center**
  Arizona Public Service's deployment of 1 MW / 4 MWh of battery storage to defer a distribution system upgrade[43]
- **Minster, OH**
  Deployment of 4.2 MW of solar and 7 MW of storage that, among other value streams, avoided the need for $350k of grid upgrades to improve power quality for industrial customers[44]

Utilities have successfully deployed NWA to address capacity, voltage, reliability and power quality grid needs, but not all distribution projects are suitable for deferral or avoidance by DER and candidates for NWA consideration. For example, replacements of distribution system components due to age or poor condition (rather than capacity constraints) typically do not qualify for NWA.

Leading jurisdictions are establishing criteria for identifying the suitability of projects for NWA. For example, Rhode Island's System Reliability Procurement (SRP) NWA criteria define the type,

39 NY PSC Order Adopting Distributed System Implementation Plan Guidance Order, April 20, 2016.http://www.raabassociates.org/Articles/NY%20PSC%20%282016%29%20DSIP%20Guidance%20Order.pdf

40 http://www.ripuc.org/eventsactions/docket/4581-NGrid-2016-SRP(10-14-15).pdf

41 http://www.neep.org/sites/default/files/resources/FINAL_Boothbay%20Pilot%20Report_20160119.pdf

42 https://www.greentechmedia.com/articles/read/distributech-roundup-microgrids-on-the-march#gs.vaxlsco

43 https://www.greentechmedia.com/articles/read/aes-buys-energy-storage-for-less-than-half-the-cost-of-a-wires-upgrade#gs.ZwQU0v0

44 https://sepapower.org/knowledge/a-small-town-in-ohio-creates-industry-buzz-with-solar-plus-storage/

45 Rhode Island, p. 50

46 Avoided transmission and distribution capital and O&M, voltage and power quality, reliability and resiliency, avoided energy and GHG, avoided losses, other ancillary services and safety/societal benefits

47 See CPUC Docket R.14-08-013 et al., Proposed Decision on Track 3 Policy Issues, Sub-track 1 (Growth Scenarios) and Sub-track 3 (Distribution investment and Deferral Process), 12/8/17

size, and minimum cost of projects that qualify for consideration.[48] In 2017, the most recent triennial update to the SRP Standards included several key revisions including: (1) the use of NWA to address new types of distribution system needs beyond load-growth related issues (e.g., voltage performance, communication systems); (2) the use of NWA to proactively target "highly-utilized" areas of the distribution system with NWA to extend the life of existing equipment; and (3) consideration of "partial NWA" that reduce the scope of infrastructure projects (rather than defer the entire project).[49]

Other regulatory commissions could follow this approach by defining the criteria for types of projects that qualify for NWA, requiring the utilities to identify candidate projects that meet the criteria, and conducting NWA pilots in each utility service territory to validate the effectiveness of the DER solutions. The result would ideally establish a workable process for substituting DER for more expensive grid investments, saving customers money and expanding the DER market.

NEW SOLUTION ACQUISITION

Once utilities have successfully identified and disclosed grid needs, locational value and opportunities for NWA, they must establish the capability to acquire or source the alternative solutions in order for customers and the market to benefit from this new information.
As previously described, the process starts with clearly defined and transparent disclosure of grid needs and performance requirements. Utilities define a set of discrete services and performance levels to meet the operational requirements that, if provided by DER, could effectively substitute for conventional infrastructure projects. These services are typically defined in a neutral manner rather than specifying a pre-determined DER technology.[50]

DER providers then have the opportunity to propose solutions to the utilities that meet the requirements. As the party responsible for the planning process, the utility may assess the alternatives, determine the preferred solution for each need, and then report and explain its recommendations for stakeholder consideration and regulatory approval.[51]

There may be a need to assign an independent, impartial entity to conduct the analysis and develop the recommended portfolio of solutions for regulatory approval if the alternatives have material impacts on a utility's revenue and profitability. A utility could perform this function as long as there is sufficient transparency and regulatory oversight to insure fair consideration of alternative proposals.[52]

In California, review of the Grid Needs Assessments and facilitation of the DER solution solicitation process will be managed by a Distribution Planning Advisory Group, staffed with utility engineers, Commission technical staff, DER market providers, non-market participants, and facilitated by an independent professional engineer.

Potential alternatives to any grid need likely involve a range of solutions that utilities may source through one or more of the following mechanisms:

- **Pricing**
  DER services provided in response to time-varying rates, tariffs and market-based prices. This may involve modifying/targeting existing or designing new dynamic pricing options to deliver locational benefits. For example, Salt River Project (SRP) in Arizona has determined that time-of-use (TOU) price plans are effective at incentivizing electric vehicle drivers to charge later than they normally would, which will help SRP meet customer demand without the need to add infrastructure.[53]

- **Programs**
  DER deployed through programs operated by the utility or third parties with funding by utility customers through retail rates or by the state.[54] This again may involve modifying/targeting existing or designing new programs to deliver locational benefits. For example, Central Hudson Gas & Electric's Peak Perks program targets deployment of Wi-Fi-enabled smart thermostats and pool pump controls on specific circuits to reduce peak loads and postpone or avoid system upgrades.[55]

- **Procurement**
  DER services sourced through competitive solicitations. In addition to the NWA shown on page 14, a commonly cited example of this is the Brooklyn/Queens Demand Management program. ConEd conducted auctions to procure energy efficiency, demand response, storage, and other solutions expected to result in more than 22 MW of

48 http://www.ripuc.org/eventsactions/docket/4684-LCP-Standards_7-27-17.pdf, p. 14
49 http://www.ripuc.org/utilityinfo/electric/DSP_Workstream_proposals_8_15.pdf, p. 7
50 De Martini and Kristov, p. 41
51 *Id.*, pp. 41-42
52 *Id.*, pp. 42-43
53 http://www.elp.com/articles/2018/01/salt-river-project-provides-results-of-electric-vehicles-study.html
54 De Martini and Kristov, p. 42
55 http://hudsonvalleynewsnetwork.com/2016/07/17/reducing-peak-energy-use-targeted-areas/

demand reduction in afternoon and evening hours[56], contributing to the deferral of a new $1.2 billion substation.

Determining an optimal mix from these three categories, plus any grid infrastructure investments, requires both a portfolio development approach and a means to compare each alternative's attributes such as resource dependability, response time and duration, load profile impacts, deployment times, and net benefits (net of the costs to integrate DER into grid operations).[57]

The portfolio assessment to determine the preferred solution for each grid need should use a pre-approved methodology through a transparent regulatory process involving all interested stakeholders. Ideally, approval of a portfolio would be the responsibility of the regulator in the context of its approval of a comprehensive distribution plan.[58]

In addition to transparency and fairness, it is important that the sourcing mechanisms result in DER compensation that is long-term, stable, and financeable. Utilities benefit from a regulatory structure that offers capital returns needed to make long-term investments. This proven mechanism has enabled utilities to confidently finance billions of dollars of assets to meet the needs of customers and society. Financial markets view this favorably, which ultimately results in a lower cost of capital for the incumbent utility and lower costs for its customers. DER providers do not have such regulatory guarantees, but they should be afforded similar long-term assurances for the resources they deploy in lieu of conventional utility infrastructure. Compensation for the locational value of DER should recognize the long-term value of the resources and, assuming the resources reliably and consistently perform as required, be structured to provide a consistent revenue stream over the life of the assets to ensure ease of financing.[59]

MEANINGFUL STAKEHOLDER ENGAGEMENT

A consistent theme throughout this paper – the need to transition from a closed planning process to one that is more open and transparent engaging multiple stakeholders – requires thoughtful design and execution. Unless ordered through contentious rate cases or other regulatory proceedings, it is uncommon for utilities and distribution planners to willingly share system information and accept input on distribution system plans from non-utility stakeholders. It therefore requires new skills, capabilities and a level of trust and collaboration that may be initially uncomfortable for participants. It can also be very time-consuming and requires a high level of commitment from participating stakeholders.

However, a well-designed and executed stakeholder engagement process can provide many advantages over the traditional adversarial regulatory proceedings, such as:

- Providing a forum for information sharing and education, leading to a common understanding of issues and a common vocabulary. With a stronger collective understanding, parties are likely to have more meaningful dialogue focused on the issues that matters most. This benefits all parties, but especially regulators who must navigate an increasingly complex web of technical information and stakeholder interests.[60]
- A narrowing of differences and building of support before engaging in the typical back and forth of regulatory proceedings. This back and forth, largely between lawyers and policy advocates, can result in entrenchment of positions and ultimately win/lose outcomes, as opposed to the development of new and potentially innovative alternatives.[61]
- Producing long-term relationship benefits, opening lines of communication and helping to bridge opposing viewpoints. These processes typically are more inclusive and accessible than regulatory proceedings, providing greater opportunity to get to know people, as opposed to positions and posturing.[62]
- Improving the quality and efficiency of regulatory proceedings by narrowing the issues regulators must rule on. Successful stakeholder engagement enables the resolution of some issues and clarifies areas of genuine disagreement, providing regulators with more complete and concise information about where parties stand on key issues.[63]

Proceedings in California and New York offer contrasting examples of meaningful versus less-meaningful stakeholder engagement. In the California Distribution Resources Plan working groups, the utility and non-utility stakeholders have engaged in productive, iterative, and ongoing negotiations, with the utilities fielding stakeholder questions, responding to

56 https://conedbqdmauction.com
57 De Martini and Kristov, p. 42
58 *Id.*
59 Gahl, Lucas, Smithwood, and Umoff, pp.8-9

60 De Martini, Brouillard, Robison, and Howley, p. 2
61 *Id.*
62 *Id.*, p. 3
63 *Id.*

recommendations and concerns, and interacting with stakeholders about possibilities during in-person and web-based working group meetings and through written comments. This interactive process has enabled non-utility stakeholders to play a meaningful role in shaping the assumptions, methodologies and outcomes. It also helps stakeholders understand and often support utility approaches that might otherwise seem objectionable.[64]

In contrast, stakeholders in New York's Reforming the Energy Vision engagement groups reported that utilities had already made critical decisions before talking to stakeholders at engagement group meetings. When stakeholders provided input, the utilities did not consistently report back during the working group process about what input would or would not be taken into account, therefore missing opportunities for the iteration and discussion that could lead to consensus. As a result, the meetings seemed to serve more as an opportunity to inform stakeholders of utilities' plans than a meaningful opportunity for stakeholders to help shape the outcomes of the process.[65]

Best practices and keys for success in meaningfully engaging stakeholders in IDP processes include the following.

- **Clear regulatory relationship.** Whether the process is voluntary or ordered, it is important to have clarity around the role of regulators and if and how the process will intersect with or lead to related regulatory proceedings. Without it, participants may be hesitant and likely will not commit their full attention and resources to the process, which risks rendering the process irrelevant.[66]
- **Clear objectives, guiding principles, process parameters and effective organization structure.** It is important to define the purpose and desired outcomes of a process and reach a common understanding of what a process is and is not intended to achieve. A stakeholder process that has as its goal a set of consensus recommendations will be operated and structured differently than a process designed primarily to educate stakeholders or seek input without reaching consensus. Particularly for the more intensive and interactive stakeholder processes, establishing guiding principles and ground rules for participation help create a level playing field and fosters open dialogue.

  Effective stakeholder engagement also requires the governance and quality assurance of a thoughtfully designed organizational structure. An advisory board may be helpful to provide guidance on the objectives, scope, schedule, and deliverables for working-level stakeholder engagement. Stakeholder working groups provide a forum for subject matter experts to more fully address technical issues. Beyond an advisory board and working groups, open stakeholder sessions to educate a broader audience of people and gain additional input on a refined set of topical aspects may be desirable.[67]
- **Open Membership.** Membership in the stakeholder group should be open to all those who wish to participate to ensure diversity of perspectives and optimal buy-in from interested and affected parties. It may be possible to designate representative members from different groups of stakeholder interests to better manage input, but this needs to be done without unnecessarily constraining party participation. If the process includes written comments, there may need to be active efforts by the Commission to elicit sufficient participation to ensure an adequate range of perspectives are considered.[68]
- **Neutral Facilitation and Reporting.** A knowledgeable, skilled, and objective facilitator is critical. Ideally, the facilitator will be a neutral party, either selected from within the Commission or from a third party, rather than selected and appointed by the utilities. The facilitator should be knowledgeable about the subject matter and also have experience and skills in stakeholder engagement. The facilitator should ensure effective and neutral reporting of stakeholder group outcomes, including producing detailed minutes and reports with stakeholder input. If written comments are used in lieu of a working group, it is important to ensure stakeholder comments are considered by the utilities and that the decision makers are provided with a complete understanding of party perspectives.[69]
- **Active Utility Engagement.** Utilities should be required to actively participate in the stakeholder process. When utilities participate only passively, stakeholders may not be informed of utility concerns and/or may feel that their concerns are not being sufficiently considered by the utilities. There should also be checks in place to ensure that utilities are meaningfully considering stakeholder insights and revising their methods where appropriate based on

64 Stanfield and Safdi, p. 26
65 *Id.*
66 De Martini, Brouillard, Robison, and Howley, p. 4
67 *Id.*, pp. 5-6
68 Stanfield and Safdi, p. 25
69 *Id.*, pp. 25-26

TABLE 3. Data for Designing Non-Wires Alternatives[71]

DATA NEED	DESCRIPTION
Circuit Model	The information required to model the behavior of the grid at the location of grid need.
Circuit Loading	Annual loading and voltage data for feeder and SCADA line equipment (15 min or hourly), as well as forecasted growth.
Circuit DER	Installed DER capacity and forecasted growth by circuit.
Circuit Voltage	SCADA voltage profile data (e.g., representative voltage profiles).
Circuit Reliability	Reliability statistics by circuit (e.g., CAIDI, SAIFI, SAIDI, CEMI).
Circuit Resiliency	Number and configuration of circuit supply feeds (used as a proxy for resiliency).
Equipment Ratings, Settings, and Expected Life	The current and planned equipment ratings, relevant settings (e.g., protection, voltage regulation, etc.), and expected remaining life.
Area Served by Equipment	The geographic area that is served by the equipment in order to identify assets which could be used to address the grid need. This may take the form of a GIS polygon.

those insights.[70]

- **Consensus-Building.** Regulators and facilitators should ensure that the process maximizes opportunities for stakeholders to actively voice their perspectives and concerns. Working group meetings and discussions should promote active dialogue among stakeholders in order to build consensus. Where there are areas of disagreement, there should be opportunities to communicate divergent views to utilities and regulators, including through stakeholder reports.[72]
- **Easy Access.** Access to stakeholder meetings and results should be made as easy as possible. Measures to optimize access include publicizing stakeholder meetings well in advance, holding meetings in a neutral location, establishing a mix of in-person and teleconference meetings, employing technology to maximize meaningful participation, and maintaining detailed minutes. Minutes, reports, and other stakeholder group documents should be posted in an accessible electronic forum to allow interested parties to keep track of proceedings.[73]

Data Sharing

An effective stakeholder engagement process also requires sharing of system data to enable effective collaboration. Utilities are caught between competing demands to increase transparency by sharing more data with interested stakeholders and mandates to ensure high levels of physical and cyber security. Clearly, DER customers and developers can benefit from greater grid data, but utilities can also benefit from data on DER performance and costs, and parties will need to negotiate requirements for data sharing in both directions. This is still an area of very active debate in many states, and each jurisdiction will have to determine what data is appropriate to share and what should be kept confidential. One potential compromise, similar to the CA Distribution Planning Advisory Group described earlier, is allowing greater grid data access to a limited stakeholder group that can review utility plans and provide objective, outside feedback.[74]

There are a number of foundational reasons to actively promote grid planning and operational data sharing:

- **Informing optimal locations for investment and economic development.** Should customers and developers pursue projects on a specific feeder, or at a specific feeder location? Do DER providers have enough business opportunities to retain local employees? Should DER providers open a warehouse/office in a specific geographic area?[75]
- **Supporting industry innovation.** Additional industry stakeholder engagement unlocks new and different perspectives on grid design and operations, dramatically increasing the pace of innovation. Third parties can offer expertise to improve grid planning and operations, particularly in areas that are not traditional utility strengths (e.g. data analytics,

70 *Id.*, p. 26
71 SolarCity Grid Engineering, 2016, p. 22
72 *Stanfield and Safdi, p. 27*
73 *Id.*

74 Colman, Wilson, and Chung, p. 23
75 SolarCity Grid Engineering, 2015, p. 11

software development, distributed control).[76]

- **Enabling credible auditing of grid infrastructure investment plans.** Industry stakeholders can suggest alternative means to meet grid investment needs. Underlying data, beyond the publishing of finalized analyses (e.g. deferrable investments) shines a light on the grid investment assumptions, methodology and decision-making criteria. Data transparency is a foundation of ratepayer advocacy and should extend into distribution planning.[77]

Table 3 shows the types of data that are helpful for developers in designing solutions to address grid needs.

Utilities in New York have established data portals for stakeholders to access containing a wide range of planning and system information. For example, National Grid's portal contains information on feeder loading, peak load forecasts, system reliability, hosting capacity, capital investment plans, and potential NWA opportunities.[78] Regulators in Rhode Island are requiring National Grid to publish similar information, stating:

> A new Rhode Island Distribution System Plan (DSP) Data Portal should serve as a clearinghouse for users to access key distribution system and planning data in a central and publicly- accessible online location. Peak load forecasts, capital plans, DSP process descriptions, heat maps, hosting capacity maps, and other key data should be made available through the Portal. Where possible and appropriate, data should be made available in machine-readable format. Annual reporting on Portal performance should occur … and include tracking of key user experience metrics, evaluation of qualitative and/or quantitative costs and benefits, stakeholder feedback, and any proposed improvements. National Grid should develop specific, near-term, new datasets of importance to DSP objectives, (specifically) hosting capacity maps and heat maps.[79]

The utilities in California will create DRP data access portals containing hosting capacity, locational value, grid needs, and NWA deferral opportunities all on the same map and available in downloadable datasets. Users will be able to click between tabs to view various information on the circuit map, and will be able to query and export data in tabular form based on a geographic search or keyword search.[80]

RECOMMENDATIONS AND NEXT STEPS

Although customer adoption of DER in a particular jurisdiction may be lower than the states referenced in this paper, it is not too early for regulatory commissions to take proactive steps toward establishing the new capabilities required for Integrated Distribution Planning. In order for utilities to understand the opportunities and risks in an accelerated DER adoption environment and for their customers to fully realize the benefits, utilities need to be addressing their planning frameworks and performing analyses, at least on a pilot basis, well in advance.[81]

A key decision for each commission is the extent to which it values the importance of opening up the distribution planning process and establishing an open market for distribution grid services. FERC's recent Order 841 takes steps to remove unnecessary barriers to participation for energy storage in wholesale markets to ensure just and reasonable wholesale rates.[82] Each commission must decide if additional customer benefits and cost savings are available by eliminating barriers for third-parties to provide DER grid services at the retail distribution level.

GridLab recommends the following next steps for regulatory commissions in the early stages of transitioning to IDP:

1 | Establish clear objectives and guiding principles for the development of IDP, including the extent to which the commission will establish an open market for distribution grid services. Table 4 provides examples from CA, NY, RI and MN for consideration, but ultimately the objectives and principles must reflect the specific priorities of each commission for its electricity consumers.

76 Technet, SunSpec Alliance, and DBL Partners, pp. 2-3
77 *Id.*, p. 3
78 http://ngrid.maps.arcgis.com/apps/MapSeries/index.html?appid=4c8cfd75800b469abb8febca4d5dab59&folderid=8ffa8a74bf834613a04c19a68eefb43b#map
79 Rhode Island, p. 50
80 CPUC Proposed Decision on Track 3 Policy Issues, Sub-track 1 (Growth Scenarios) and Sub-track 3 (Distribution Investment Deferral Process), 12/8/17, http://docs.cpuc.ca.gov/SearchRes.aspx?docformat=ALL&docid=199995533
81 Fine, De Martini, and Robison, p. 7
82 https://ferc.gov/media/news-releases/2018/2018-1/02-15-18-E-1.asp#.WoslyGbMyqB FERC is expected to rule on market participation for aggregated DER sometime in 2018.

2 | Require each utility to file a report describing its distribution planning process today and any planned improvements or investments in improved capabilities. These reports will reveal similarities and differences in utility approaches and provide a common understanding of the starting points for each utility in building new capabilities for the transition to IDP. After submission, the commission should allow stakeholders to comment on the reports. Each report should, at minimum, address:

a. System characteristics, including total customers served, number of circuits and substations, % of substations with SCADA, AMI coverage (% of customers).

b. Overview of the distribution planning process, including frequency, duration and roles/ responsibilities of organizations involved.

c. Categories of projects that result from the planning process, types of projects in each category, and % of expenditures in each category.

d. Planning assumptions including growth rates and design criteria.

e. Load and DER forecasting methods.

f. Software tools used for planning, including forecasting, system modeling and mapping, power flow analysis, system protection, and hosting capacity analysis.

g. Linkages between distribution, transmission, and any integrated resource planning processes

h. Existing DER (all types) connected to the distribution system.

i. Overview of DG interconnection processes including technical screening rules for fast-tracking applications.

j. Interconnection request volumes, average time to approve applications.

k. Organization structure for planning and interconnection, including number of full-time equivalent employees, and descriptions of roles and responsibilities.

l. Descriptions of existing and planned energy efficiency and demand response programs, and how they are integrated into distribution planning.

m. Proposed use cases, methodology and timeline for Hosting Capacity Analyses.

n. Proposed NWA suitability criteria, identification of candidate capacity, voltage or reliability projects for NWA pilots.

o. Any relevant planned technology investments (e.g., AMI, ADMS) and how they will be used to support or improve distribution planning.

3. Establish an IDP Technical Working Group applying the best practices for stakeholder engagement referenced in this paper and involving the commission staff, all utilities, and all interested stakeholders. The Technical Working Group should develop recommendations to the commission on the following:

a. Future scenarios for customer DER adoption in the state, and how these scenarios should be incorporated into forecasting and transmission, distribution, and integrated resource planning processes.

b. Modifications to interconnection standards defining required functions and settings for advanced inverters.

c. Development of NWA suitability criteria, process and timeline for implementing pilots identified in the utility reports from step 2.

d. Definition of hosting capacity analysis (HCA) use cases; identification of the appropriate HCA methodology and associated tools and data requirements to satisfy the use cases; a timeline for initial HCA analysis and publication of results for each utility. As described earlier, it is highly preferable to simplify and standardize the HCA process by requiring the utilities to use the same methodology and tools.

e. Development of portals for sharing information on circuit load profiles, peak load forecasts, capital investment plans, hosting capacity maps, heat maps reflecting locational value and other key data.

In conclusion, many states are on the threshold of experiencing significant growth in a variety of DER over the next several years. It is not too early for regulatory commissions in these states to take proactive steps toward establishing the new capabilities required for Integrated Distribution Planning. Customers and the market can benefit from an IDP process that fully realizes the value of this DER and provides direction for its deployment.

Exhibit LEO-RS-2

TABLE 4. Select Examples of Principles for Grid Modernization and Distribution Planning Reforms

CALIFORNIA PRINCIPLES FOR DISTRIBUTION RESOURCES PLANS[83]	NEW YORK REV PRINCIPLES FOR MARKET DESIGN[84]	RHODE ISLAND GUIDING PRINCIPLES FOR DSP REFORMS[85]	MINNESOTA PRINCIPLES FOR GRID MODERNIZATION[86]
• Distribution planning should start with a comprehensive, scenario driven, multi stakeholder planning process that standardizes data and methodologies to address locational benefits and costs of distributed resources. • CA's distribution system planning, design and investments should move towards an open, flexible, and node-friendly network system that enables seamless DER integration. • CA's electric distribution system operators should have an expanded role in system operations by acting as a technology-neutral marketplace coordinator while avoiding any operational conflicts of interest. • Flexible DER can provide value today to optimize markets and grid operations. CA should expedite DER participation in wholesale markets, unbundle distribution grid operations, create a transparent process to monetize DER services and reduce unnecessary barriers for DER integration.	• Transparency – access to necessary information by market actors, public visibility into market design and performance; • Customer protection – balance market innovation and participation with customer protections; • Customer benefit – reduce volatility and promote bill management and choice; • Maintain and improve service quality and reliability; • Resiliency – enhance ability to withstand unforeseen shocks; • Fair and open competition – design "level playing field" incentives and access policies; • Minimum barriers to entry – reduce data, physical, financial, and regulatory barriers to participation; • Flexibility, diversity of choice, and innovation; • Fair valuation of benefits and costs; • Coordination with wholesale markets; • Promote investments that provide the greatest value to society.	• Distribution System Planning (DSP) reforms should establish specific milestones to achieving the long-term vision, guided by utilities' growing sophistication in DSP data analytics and enabled by increasing system visibility from improvements in grid connectivity and functionality. • Utilities should identify the required resources necessary to achieve material improvements to DSP capabilities and achieve the vision, and include costs of such resources in its rate case filings. • For all DSP reforms, there must be an ongoing process for meaningful review, input, and update of DSP products including: forecasting, data access, DSP data portal, and heat and hosting capacity maps. • As DSP reforms drive increased customer and third-party access to data, utilities and regulators must address all key data privacy and security protections. • Implementation of DSP reforms should achieve consistency across all programs and policies.	• Maintain and enhance the safety, security, reliability, and resilience of the electricity grid, at fair and reasonable costs, consistent with the state's energy policies; • Enable greater customer engagement, empowerment, and options for energy services; • Move toward the creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adoption of new distributed technologies; • Ensure optimized utilization of electricity grid assets and resources to minimize total system costs; • Facilitate comprehensive, coordinated, transparent, integrated distribution system planning.

83 Final Guidance Assigned Commissioner's Ruling on Distribution Resource Plans (DRP), pp. 7-8, http://www.cpuc.ca.gov/General.aspx?id=5071
84 New York Department of Public Service Staff Straw Proposal on Track One Issues, p. 16, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/C12C0A18F55877E785257E6F005D533E?OpenDocument
85 Rhode Island, p. 46
86 Minnesota, p. 13

REFERENCES

Acadia Center. 2017. "UtilityVision 2030 - Grid Modernization Companion Brief." May. http://acadiacenter.org/wp-content/uploads/2017/05/Acadia-Center-EnergyVision-2030-Grid-Modernization.pdf

Acadia Center. 2017. "How Can We Replace Traditional Infrastructure With Clean Energy?" July. http://acadiacenter.org/how-can-we-replace-traditional-infrastructure-with-clean-energy/

Anthony, Abigail. 2016. "Community Energy Proving Successful in Boothbay." Acadia Center, January. http://acadiacenter.org/community-energy-proving-successful-in-boothbay/

Anthony, Abigail, Mark LeBel, Jamie Howland, and Daniel Sosland. 2015. "UtilityVision." Acadia Center. http://acadiacenter.org/wp-content/uploads/2015/02/AcadiaCenter_UtilityVision_WebView_S.pdf

Colman, Andy, Dan Wilson, and Daisy Chung. 2017. "Planning the Distributed Energy Future — Volume 1: Emerging Electric Utility Distribution Planning Practices for Distributed Energy Resources." Black & Veatch and Solar Electric Power Association, May. https://sepapower.org/resource/beyond-the-meter-planning-the-distributed-energy-future-volume-i/

Cooke, Alan, and Juliet Homer. "Distribution System Planning and Operations." Presentation, PowerForward Phase 2: Exploring Technologies from the Ohio Public Utilities Commission, Columbus, OH, July 26, 2017. https://www.puco.ohio.gov/index.cfm?LinkServID=017B9492-5056-B562-E184554FFEC47951

De Martini, Paul. 2014. "More Than Smart – A Framework to Make the Distribution Grid More Open, Efficient and Resilient." Resnick Sustainability Institute, California Institute of Technology. http://morethansmart.org/wp-content/uploads/2015/06/More-Than-Smart-Report-by-GTLG-and-Caltech-08.11.14.pdf

De Martini, Paul, and Lorenzo Kristov. 2015. "Distribution Systems in a High Distributed Energy Resources Future." Future Electric Utility Regulation. Lawrence Berkeley National Laboratory, October. https://emp.lbl.gov/sites/all/files/lbnl-1003797.pdf

De Martini, Paul. 2016. "Integrated Distribution Planning." ICF International, August. https://energy.gov/sites/prod/files/2016/09/f33/DOE%20MPUC%20Integrated%20Distribution%20Planning%208312016.pdf

De Martini, Paul, Carolyn Brouillard, Matt Robison, and Annie Howley. 2016. "The Rising Value of Stakeholder Engagement in Today's High-Stakes Power Landscape." ICF, November. https://www.icf.com/resources/white-papers/2016/the-rising-value-of-stakeholder-engagement

Edge, Ryan, Mike Taylor, and K. Kaufmann. 2014. "Benchmarking Utility Organizational Structures: How Renewable Energy is Reshaping the Utility Hierarchy." Solar Electric Power Association (SEPA), September. https://sepapower.org/resource/how-renewable-energy-is-reshaping-the-utility-hierarchy/

Edge, Ryan, Mike Taylor, Nadav Enbar, and L. Rogers. 2014. "Utility Strategies for Influencing the Locational Deployment of Distributed Solar." Solar Electric Power Association (SEPA) and Electric Power Research Institute (EPRI). https://sepapower.org/resource/utility-strategies-for-influencing-the-locational-deployment-of-distributed-solar/

Electric Power Research Institute. 2014. "The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources." February. https://www.epri.com/#/pages/product/000000003002002733/

Fine, Steve, Paul De Martini, and Matt Robison. 2017. "On the Grid's Bleeding Edge: The California, New York, and Hawaii Power Market Revolution." ICF, November. https://www.icf.com/resources/white-papers/2017/on-the-grids-bleeding-edge

Gahl, Dave, Kevin Lucas, Brandon Smithwood, and Rick Umoff. 2018. "Getting More Granular: How Value of Location and Time May Change Compensation for Distributed Energy Resources." Improving Opportunities for Solar Through Grid Modernization. Solar Energy Industries Association. January. https://www.seia.org/sites/default/files/2018-01/SEIA-GridMod-Series-4_2018-Jan-Final_0.pdf

Gahl, Dave, Brandon Smithwood, and Rick Umoff. 2017. "Improving Distribution System Planning to Incorporate Distributed Energy Resources." Improving Opportunities for Solar Through Grid Modernization. Solar Energy Industries Association, July. https://www.seia.org/sites/default/files/resources/SEIA-GridMod-Series-2_2017-July-FINAL_0.pdf

Homer, Juliet, Alan Cooke, Lisa Schwartz, Greg Leventis, Francisco Flores-Espino, and Michael Coddington. 2017. "State Engagement in Electric Distribution System Planning." Pacific Northwest National Laboratory , Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, December. https://emp.lbl.gov/sites/default/files/state_engagement_in_dsp_final_rev2.pdf

Lew, Debbie. "Emerging Distribution Planning Analyses." Presentation, Distribution Systems and Planning Training for Midwest Public Utility Commissioners, January 16-17, 2018. https://emp.lbl.gov/sites/default/files/11._lew_emerging_planning_analyses.pdf

Lindl, Tim, Kevin Fox, Abraham Ellis, and Robert Broderick. 2013. "Integrated Distribution Planning Concept Paper — A Proactive Approach for Accommodating High Penetrations of Distributed Generation Resources." Interstate Renewable Energy Council, May. http://www.irecusa.org/publications/integrated-distribution-planning-concept-paper/

Mills, Andrew, Galen Barbose, Joachim Seel, Changgui Dong, Trieu Mai, Ben Sigrin, and Jarett Zuboy. 2016. "Planning for a Distributed Disruption: Innovative Practices for Incorporating Distributed Solar into Utility Planning." Ernest Orlando Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory, August. https://emp.lbl.gov/publications/planning-distributed-disruption

Mills, Andrew. "Forecasting Load on the Distribution and Transmission System with Distributed Energy Resources." Presentation, Distribution Systems and Planning Training for Midwest Public Utility Commissions, January 16-17, 2018. https://emp.lbl.gov/sites/default/files/10._mills_forecasting_load_with_ders.pdf

Minnesota Public Utilities Commission. 2016. "Staff Report on Grid Modernization." March. http://gridworks.org/wp-content/uploads/2015/06/MNPUC_Staff_Report_on_Grid_Modernization_March2016.pdf

Pearlman, Olivia, and Abigail Anthony. 2017. "Distributed System Implementation Plans in New York – Summary and Analysis." Acadia Center, June 21. http://acadiacenter.org/wp-content/uploads/2017/06/DSIP-Summary-and-Analysis_20170621_FINAL.pdf

Rhode Island Division of Public Utilities & Carriers, Office of Energy Resources, and Public Utilities Commission. 2017. "Rhode Island Power Sector Transformation — Phase One Report to Governor Gina M. Raimondo." November. http://www.ripuc.org/utilityinfo/electric/PST%20Report_Nov_8.pdf

Robison, Matt, David Pickles, Steve Fine, MD Sakib, and Kevin Duffy. 2017. "Turning Locational Value into Real Dollars." ICF, May. https://www.icf.com/resources/white-papers/2017/turning-locational-value-into-real-dollars

Schwartz, Lisa, and Juliet Homer. "PUC Distribution Planning Practices." Presentation, Distribution Systems and Planning Training for New England Conference of Public Utility Commissioners, September 27-29, 2017. https://emp.lbl.gov/sites/default/files/4._schwartz-homer_necpuc_training_20170920.pdf

Smart Electric Power Alliance, Black & Veatch. 2017. "Planning the Distributed Energy Future – Volume II: A Case Study of Integrated DER Planning by Sacramento Municipal Utility District." Beyond the Meter. May. https://sepapower.org/resource/beyond-meter-planning-distributed-energy-future-volume-ii/

Smith, Jeff. "Methods and Application Considerations for Hosting Capacity." Presentation, Hawaiian Electric Integrated Grid Planning Symposium, Honolulu, HI, November 15, 2017. https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/igp_symposium/2_4_jeff_smith.pdf

Smith, Jeff, Matthew Rylander, Lindsey Rogers, and Roger Dugan. "It's All in the Plans: Maximizing the Benefits and Minimizing the Impacts of DERs in an Integrated Grid." *IEEE Power and Energy Magazine* Volume 13, Issue 2 (March-April 2015): 20-29. http://ieeexplore.ieee.org/document/7048005/

SolarCity Grid Engineering. 2015. "Integrated Distribution Planning – A holistic approach to meeting grid needs and expanding customer choice by unlocking the benefits of distributed energy resources." September. http://www.solarcity.com/sites/default/files/SolarCity%20White%20Paper%20-%20Integrated%20Distribution%20Planning_final.pdf

SolarCity Grid Engineering. 2016. "A Pathway to the Distributed Grid – Evaluating the economics of distributed energy resources and outlining a pathway to capturing their potential value." February. http://www.solarcity.com/sites/default/files/SolarCity_Distributed_Grid-021016.pdf

Stanfield, Sky, and Stephanie Safdi. 2017. "Optimizing the Grid — A Regulator's Guide to Hosting Capacity Analysis for Distributed Energy Resources." Interstate Renewable Energy Council, December. https://irecusa.org/publications/optimizing-the-grid-regulators-guide-to-hosting-capacity-analyses-for-distributed-energy-resources/

Sterling, John, Ted Davidovich, Karlynn Cory, Alexandra Aznar, and Joyce McLaren. 2015. "The Flexible Solar Utility: Preparing for Solar's Impacts to Utility Planning and Operations." Solar Electric Power Association (SEPA) and National Renewable Energy Laboratory (NREL), September. https://www.nrel.gov/docs/fy15osti/64586.pdf

Succar, Samir. 2017. "Where's the Value In Hosting Capacity Analysis?" ICF, November. https://www.icf.com/resources/white-papers/2017/wheres-the-value-in-hosting-capacity-analysis

Tang, Y, JS Homer, TE McDermott, MH Coddington, B Sigrin, and BA Mather. 2017. "Summary of Electric Distribution System Analyses with a Focus on DERs." Pacific Northwest National Laboratory and National Renewable Energy Laboratory, April. https://epe.pnnl.gov/pdfs/Summary_of_electric_distribution_system_analyses_April_10_FINAL.pdf

Technet, SunSpec Alliance, and DBL Partners. 2016. "Unlocking Grid Data — Enabling Data Access and Transparency to Drive Innovation in the Electric Grid." http://www.dblpartners.vc/wp-content/uploads/2016/12/Grid-Data-Transparency-and-Access-whitepaper.pdf?48d1ff

Tierney, Susan. 2016. "The Value of 'DER' to 'D' - The Role of Distributed Energy Resources in Supporting Local Electric Distribution System Reliability". Analysis Group, March. http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/Thought_Leaders_Events/Tierney%20White%20Paper%20-%20Value%20of%20DER%20to%20D%20-%203-30-2016%20FINAL.pdf

Trabish, Herman K. "How Leading Utilities are Planning for Distributed Energy Resources." *Utility Dive*. Industry Dive, February 6, 2018. Web. Accessed February 9, 2018. https://www.utilitydive.com/news/how-leading-utilities-are-planning-for-distributed-energy-resources/516260/