



# Rooftop PV Financial Performance in Puerto Rico

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# GridMod Technical Assistance Program

- This analysis was conducted at the request of the State Office of Energy Policy (OEPPE) of Puerto Rico.
- This work was supported under the U.S. Department of Energy's (DOE) Grid Modernization Initiative, Future of Electric Utility Regulation project state technical assistance program (project number 1.4.29 in the Grid Modernization Institutional Support category). This work is supported by both the Office of Electricity and the Office of Energy Efficiency and Renewable Energy

# Technical Assistance Request

- The Puerto Rico Electric Power Authority (PREPA) requested approval from the Puerto Rico Energy Commission (PREC) to change its tariff structure
- The State Office of Energy Policy of Puerto Rico (Oficina Estatal de Política Pública Energética, OEPPE) requested NREL to compare the financial performance of rooftop PV systems under:
  - The previous tariff structure
  - The tariff structure proposed by PREPA in 2016
  - And two alternative tariffs from OEPPE
- The request included the analysis for four service classes:
  - General Residential Service (GRS)
  - General Service at Secondary Distribution Voltage (GSS)
  - General Service at Primary Distribution Voltage (GSP)
  - General Service at Transmission Voltage (GST)

# Technical Assistance Scope and Technical Limitations

- NREL used the System Advisor Model (SAM) to model the financial performance of PV systems for each of the aforementioned service classes using tariffs provided by OEPPE.
- The results presented in this document are the modeling results for the various tariff structures and PV system sizes. The results should not be construed as recommendations of any kind.
- In its analysis, NREL did not consider energy policy goals or benefits or externalities not currently monetized by PREPA's tariffs (e.g., social cost of carbon, impacts on the local economy, etc.).
- NREL responded to this technical assistance request in a short timeline with minimal reviews. Analysis findings should be considered illustrative only.

# Caveats, Warnings and Limitations

- All cash flows and present values are presented from the perspective of the PV system owner (i.e., the customer in this case).
- When comparing two systems in the exact same conditions, but different rates, a higher NPV generally means a higher value for the customer.
- Changing the system size for the same load may change the comparative results.

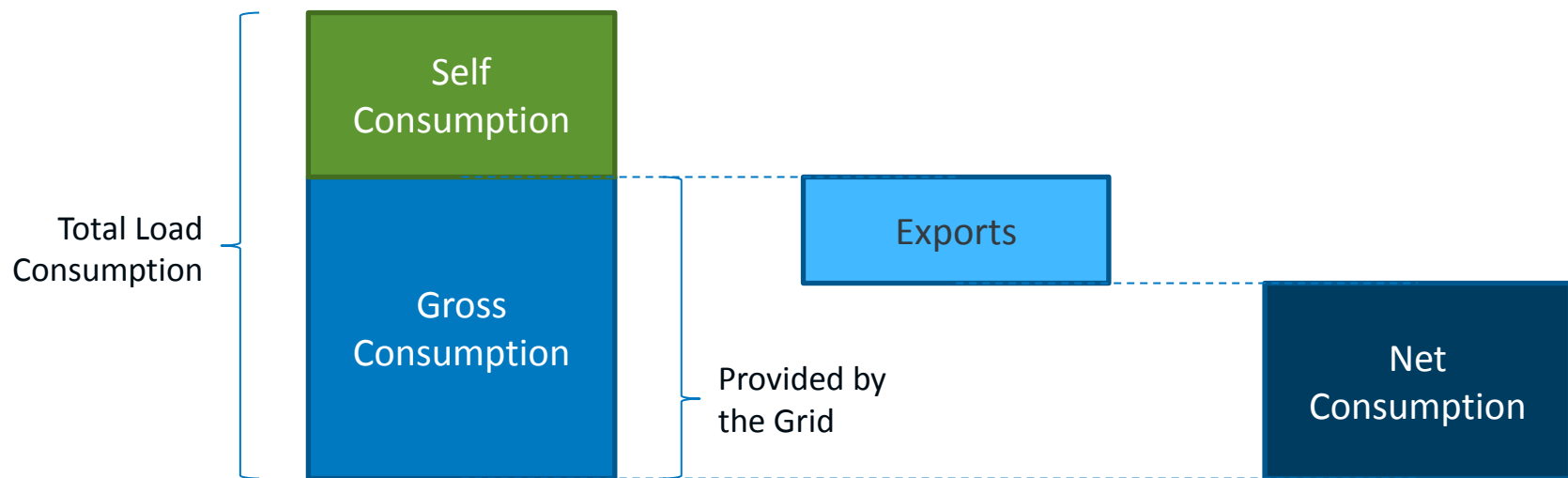
# Modeling Overview and Assumptions

# Rates Analyzed

- **Previous rates** refer to the rates defined in the tariff structure potentially being replaced by new rates.
- **PREPA rates** refer to the rates proposed by PREPA in 2016.
- OEPPE requested NREL to model two types of modifications of the PREPA proposed rates called **OEPPE rates** and **OEPPE-D rates** in this document (see **OEPPE Alternative Tariffs** slide below)

# Puerto Rico Rate Changes – Volumetric Charges

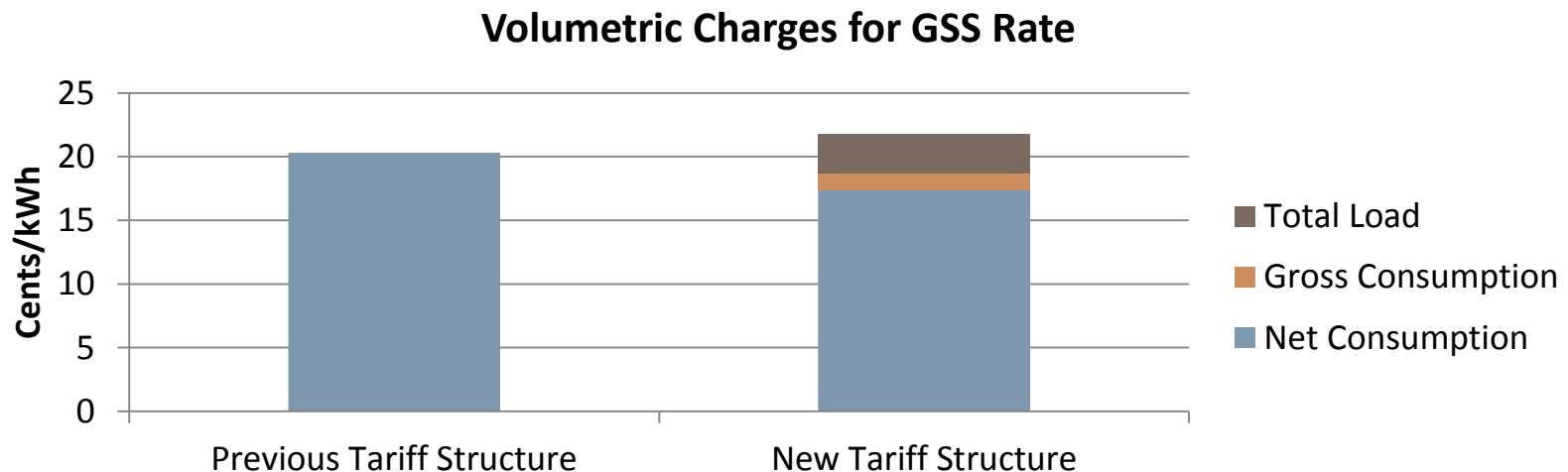
- Volumetric charges are assessed on the amount of energy, in kWh, a customer received from their utility.
- **Total load consumption** equals all the energy the customer received from their utility, plus the energy produced by the customer and consumed on-site
- **Gross consumption** equals all the energy the customer received from their utility after self consumption
- **Net consumption** equals to gross consumption minus the energy in kWh exported by the customer to the grid.





# Puerto Rico Rate Changes – Volumetric Charges

- The volumetric charges in the **previous** rate structure only applied to net consumption.
- The structure proposed by **PREPA** contains volumetric charges that apply to net consumption, charges that apply to gross consumption, and charges that apply to total load.
- Total volumetric rates increased in the PREPA proposed structure for all customer classes analyzed.



# Puerto Rico Rate Changes – Demand Charges

- In the previous and PREPA rate structures, demand charges only apply to the General Service at Primary Distribution Voltage (GSP) and General Service at Transmission Voltage (GST) rates.
- GSP monthly demand charges increased from \$8.10 to \$12 per kW of peak demand.
- GST monthly demand charges increased from \$7.70 to \$9.46 per kW of peak demand.

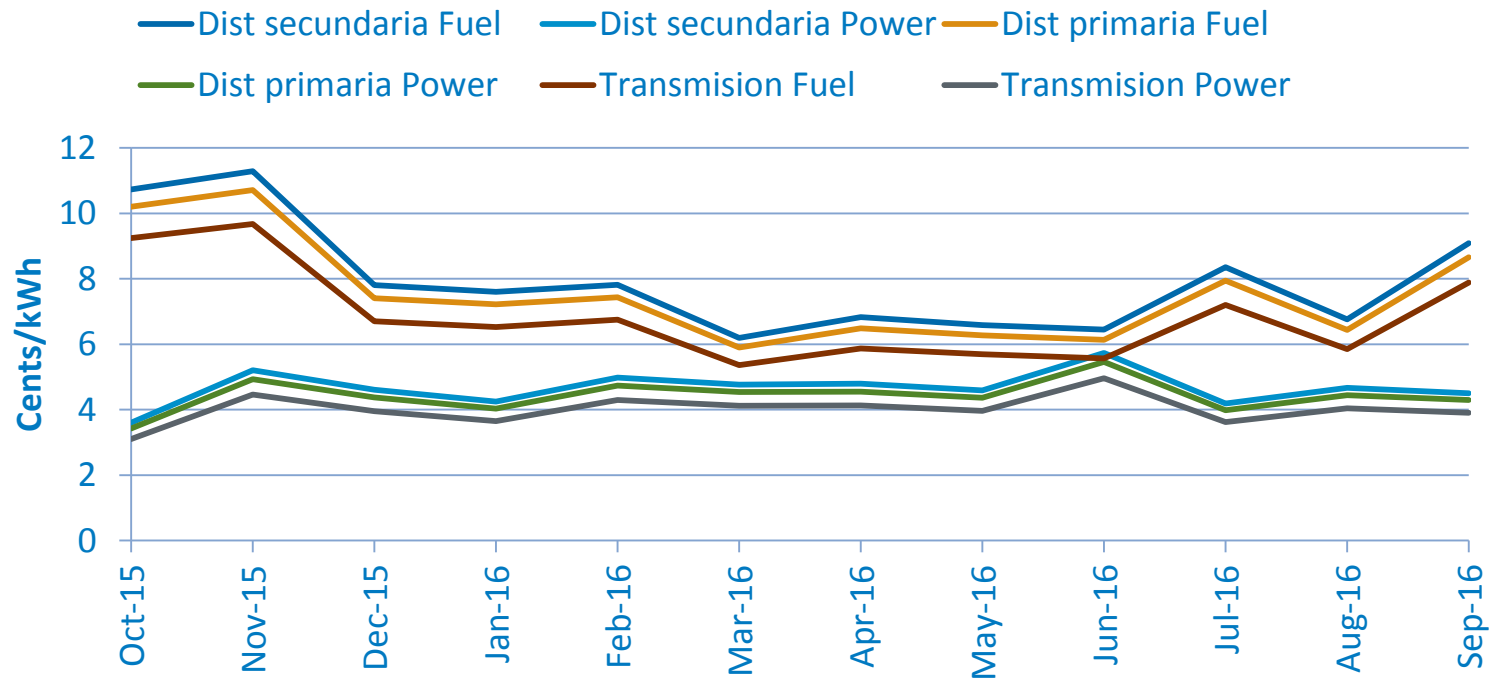
# Previous Rates

	GRS	GSS	GSP	GST
<b>Fixed Charges (\$/month)</b>				
Fixed Charge	\$3.00	\$5.00	\$200.00	\$450.00
<b>Energy Charges (\$/kWh)</b>				
<b>Applicable to net consumption</b>				
First 425 kWh	\$0.04350			
More than 425 kWh / total usage	\$0.04970	\$0.07670		
Fuel Adjustment Factor*	\$0.07960	\$0.07960	\$0.07567	\$0.06862
Purchase Power Factor*	\$0.04659	\$0.04659	\$0.04429	\$0.04017
First 300 kWh per kW of peak demand			\$0.03600	\$0.02800
More than 300 kWh per kW of peak demand			\$0.02800	\$0.02400
<b>Demand Charges (\$/kW)</b>				
Demand Charge			\$8.10	\$7.70
Excess Demand Charge			\$10.00	\$9.60

\* See next slide

# Fuel and Power Purchase Adjustment Factors

- Rate adjustment factors account for the fluctuation in the price PREPA pays for fuel and power purchases
- The adjustment factor used in this analysis was the average of the twelve months from Oct 2015 to Sep 2016.



# PREPA Rates

	GRS	GSS	GSP	GST
<b>Fixed Charges (\$/month)</b>				
Fixed Charge		\$8.00	\$10.00	\$200.00
<b>Securitization Charge (\$/kWh)</b>				
<b>Applicable to total load</b>				
Securitization Charge	\$0.03100	\$0.03100	\$0.03100	\$0.03100
<b>Energy Charges (\$/kWh)</b>				
<b>Applicable to net consumption (grid minus exported)</b>				
Energy Charge - Unbundle Generation/Gross kWh	\$0.08051	\$0.10846	\$0.10999	\$0.09902
Energy Charge - Unbundle Transmission	\$0.00707	\$0.01101		
Energy Charge - Unbundle Distribution	\$0.05254	\$0.05434		
Contributions in Lieu of Taxes (CILT)				
Subsidies, Public Lighting and Other Subventions (SUBA)				
<i>Net consumption charges total</i>	<b>\$0.14012</b>	<b>\$0.17381</b>	<b>\$0.10999</b>	<b>\$0.09902</b>
<b>Applicable to gross consumption (grid)</b>				
Contributions in Lieu of Taxes (CILT)	\$0.00303	\$0.00303	\$0.00303	\$0.00303
Subsidies, Public Lighting and Other Subventions (SUBA)	\$0.01020	\$0.01020	\$0.01020	\$0.01020
<i>Gross consumption charges total</i>	<b>\$0.01323</b>	<b>\$0.01323</b>	<b>\$0.01323</b>	<b>\$0.01323</b>
<b>Demand Charges (\$/kW)</b>				
Production Demand Charge			\$7.81000	\$7.81000
Transmission Demand Charge			\$1.65000	\$1.65000
Distribution Demand Charge			\$2.54000	
<i>Demand charges total</i>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$12.000</b>	<b>\$9.46000</b>

# OEPPPE Alternative Tariffs

- OEPPPE requested that NREL model the following alternative tariff structures:
  - Assess the Contributions in Lieu of Taxes (CILT) and the Subsidies, Public Lighting and Other Subventions (SUBA) charges to net consumption, as opposed to gross consumption.
  - In addition to the changes to net consumption charges described above, reduce demand charges proportionally to the ratio of energy produced over energy consumed by the customer. Under this proposal, a consumer that produced energy equivalent to 10% of the energy they received from the grid would receive a 10% discount on their demand charges.

# OEPE Alternative Tariffs - Energy

	GRS	GSS	GSP	GST	
<b>Fixed Charges (\$/month)</b>					
Fixed Charge		\$8.00	\$10.00	\$200.00	\$450.00
<b>Securitization Charge (\$/kWh)</b>					
<b>Applicable to total load</b>					
Securitization Charge	\$0.03100	\$0.03100	\$0.03100	\$0.03100	
<b>Energy Charges (\$/kWh)</b>					
<b>Applicable to net consumption (grid minus exported)</b>					
Energy Charge - Unbundle Generation/Gross kWh	\$0.08051	\$0.10846	\$0.10999	\$0.09902	
Energy Charge - Unbundle Transmission	\$0.00707	\$0.01101			
Energy Charge - Unbundle Distribution	\$0.05254	\$0.05434			
Contributions in Lieu of Taxes (CILT)	\$0.00303	\$0.00303	\$0.00303	\$0.00303	
Subsidies, Public Lighting and Other Subventions (SUBA)	\$0.01020	\$0.01020	\$0.01020	\$0.01020	
<i>Net consumption charges total</i>	<b>\$0.15335</b>	<b>\$0.18704</b>	<b>\$0.12322</b>	<b>\$0.11225</b>	
<b>Applicable to gross consumption (grid)</b>					
Contributions in Lieu of Taxes (CILT)					
Subsidies, Public Lighting and Other Subventions (SUBA)					
<i>Gross consumption charges total</i>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$0.00000</b>	
<b>Demand Charges (\$/kW)</b>					
Production Demand Charge			\$7.81000	\$7.81000	
Transmission Demand Charge			\$1.65000	\$1.65000	
Distribution Demand Charge			\$2.54000		
<i>Demand charges total</i>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$12.00000</b>	<b>\$9.46000</b>	

# OEPE Alternative Tariffs - Demand

	GRS	GSS	GSP	GST
<b>Fixed Charges (\$/month)</b>				
Fixed Charge		\$8.00	\$10.00	\$200.00
<b>Securitization Charge (\$/kWh)</b>				
<b>Applicable to total load</b>				
Securitization Charge	\$0.03100	\$0.03100	\$0.03100	\$0.03100
<b>Energy Charges (\$/kWh)</b>				
<b>Applicable to net consumption (grid minus exported)</b>				
Energy Charge - Unbundle Generation/Gross kWh	\$0.08051	\$0.10846	\$0.10999	\$0.09902
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<b>Applicable to gross consumption (grid)</b>				
Contributions in Lieu of Taxes (CILT)				
Subsidies, Public Lighting and Other Subventions (SUBA)				
<i>Gross consumption charges total</i>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$0.00000</b>
<b>Demand Charges (\$/kW)</b>				
Production Demand Charge			\$7.81x(1-PCR)	\$7.81x(1-PCR)
Transmission Demand Charge			\$1.65x(1-PCR)	\$1.65x(1-PCR)
Distribution Demand Charge			\$2.54x(1-PCR)	
<i>Demand charges total</i>	<b>\$0.00000</b>	<b>\$0.00000</b>	<b>\$12x(1-PCR)</b>	<b>\$9.46x(1-PCR)</b>

PCR refers to the ratio of energy produced over energy consumed by the customer in the first year of PV operations.



# Modeling Parameters

- OEPPE provided NREL with the size of the systems analyzed and the size of the load in kilowatt-hours (kWh) per year for each service class.
- Local system installed costs were provided by OEPPE (not verified by NREL)
  - \$3.00/W for systems under the GRS rate
  - \$2.75/W for systems under the GSS rate
  - \$2.40/W for systems under the GSP rate
  - \$1.80/W for systems under the GST rate
- 25 year economic life period
- 0% property tax
- Annual operations and maintenance (O&M) cost of \$20 per kilowatt (kW) of capacity
- Annual 0.5%/year system degradation
- Weather data from the San Juan International Airport

# Modeling Parameters (cont.)

- Annual insurance fee equivalent to 0.5% of the system cost
- Inflation rate: 2.5% per year; applies to all costs, including O&M and electricity rates
- Nominal discount rate: 7.63%; real discount rate: 5%
  - Assumes a loan at a 5.2% interest rate, 4% state income taxes and 0% federal income taxes.
- The discount rate was held constant throughout the analysis, which allows to objectively compare the financial performance of PV systems under different rate structures
- The actual discount rate depends on the financing options the customer has available and may not correspond with the rate selected in this analysis
- This analysis does not consider the Investment Tax Credit or the Green Energy Fund 30% incentive, at the request of OEPPE.

# Load Profiles

- Load profiles were created using SAM's default load profile, containing 8760 values, one for each hour of the year
- The default values were resized to:
  - Match a specific total annual kWh consumption provided by OEPPE
  - Vary slightly through the year, roughly matching the rather stable weather in San Juan, Puerto Rico, and peaking in the summer
  - Monthly load (as a % of flat monthly load):

<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Jun</b>	<b>Jul</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>
90%	90%	100%	100%	110%	120%	110%	110%	100%	90%	90%	90%

# System Advisor Model Limitations

- NREL's SAM model does not currently have the capability of assessing a charge per kWh on total load consumption. PREPA's proposed securitization charge was modeled using a fixed charge equivalent to the average monthly load in kWh multiplied by \$0.031.
- The discount on demand charges proposed by OEPPE was calculated using Excel. NREL used the present value of demand charges at each P/C ratio and multiplied it by the P/C ratio. This way, a system with a P/C ratio of, say, 10% would only get 10% of the benefits from the discount on demand charges. The result was reduced by 4% to reflect that that expense is no longer available for tax deduction and added to the NPV of each system.

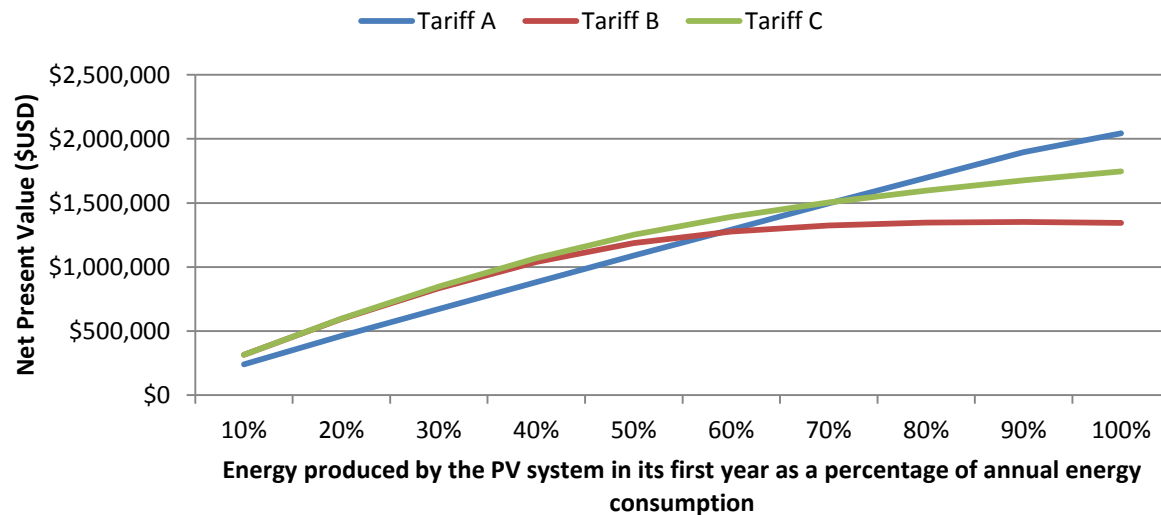
# Results

# Results – System sizes and Performance Metrics

- For each of the four rate classes analyzed (GRS, GSS, GSP and GST), NREL modeled a PV system that in its first year produces approximately 100% of the annual energy consumption of the load OEPPE proposed.
- Additionally, smaller PV system sizes were modeled, each producing a multiple of 10% of annual energy consumption from 10% to 90%.
- That percentage is referred to as the PV production/consumption ratio (**P/C ratio**) in this report.
- The financial performance metric calculated was net present value (NPV). NPV was calculated under the **previous** tariff, the **PREPA** tariffs and **OEPPE's** alternative tariffs.

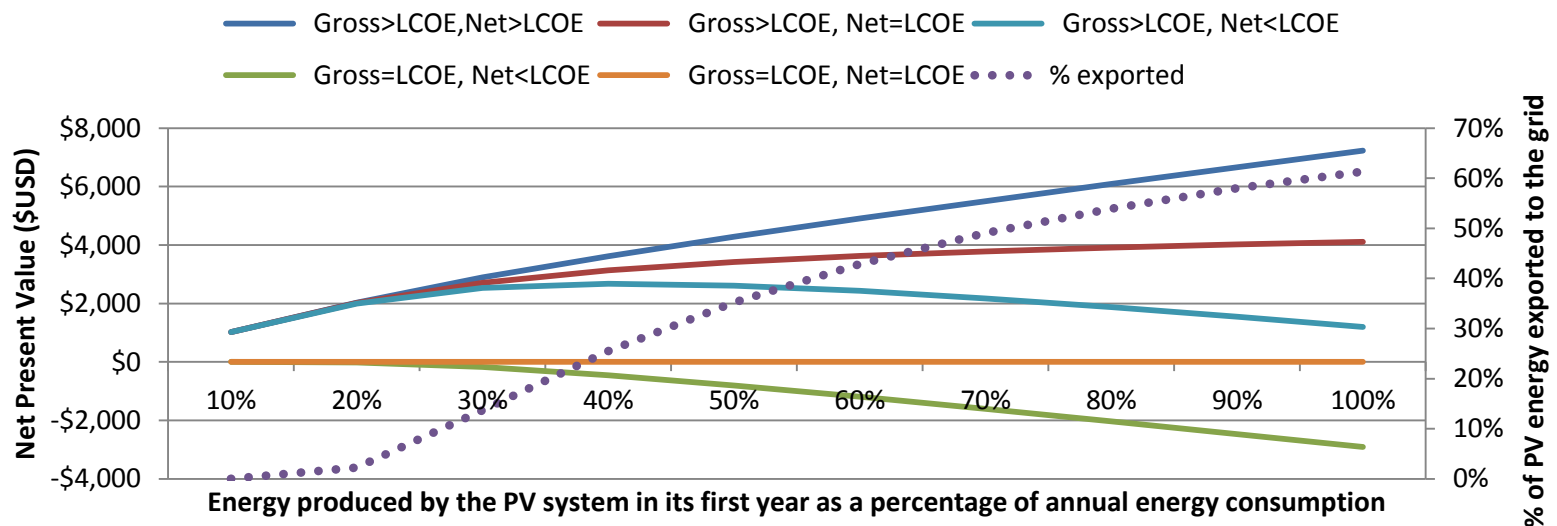
# Results – Comparison Graphs

- For each of the four rate classes analyzed, NREL created a graph that shows the NPV at different P/C ratios. Each line corresponds to a different tariff within the same class. In the example below, the blue line shows the NPV under the hypothetical tariff A.



# Results – Factors that Influence NPV

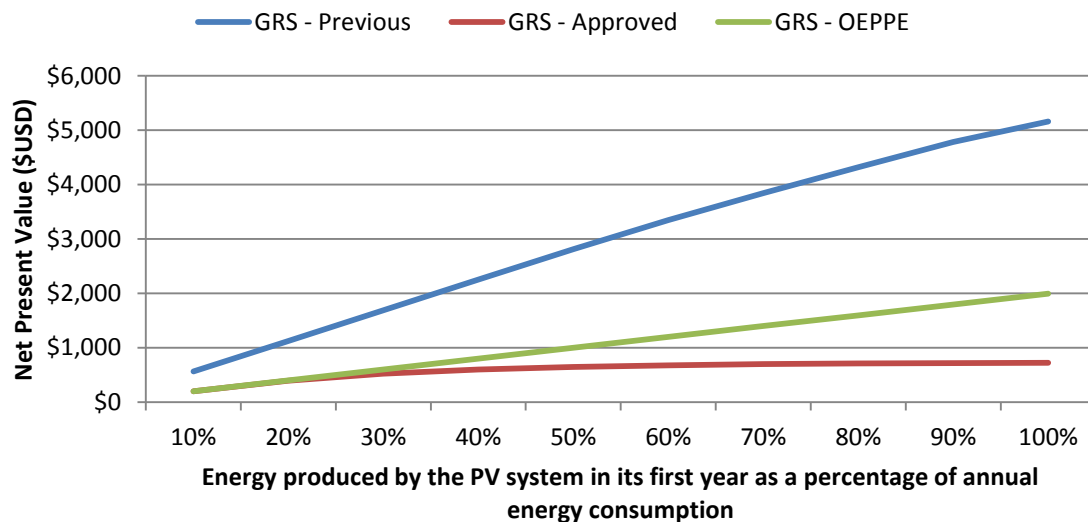
- Energy produced by a rooftop PV system is either consumed on site or exported to the grid. At low P/C ratios, most solar PV energy is consumed on site, thereby offsetting gross consumption (at which point avoided costs per kWh are equivalent to the retail rate). As the percentage of energy exported grows, NPV becomes more sensitive to net consumption charges (avoided costs per kWh exported equal net consumption charges).
- The graph below shows NPVs as a function of the P/C ratio, the gross consumption rate and the net consumption rate for a hypothetical case. The graph shows that consumption rates greater than the PV system's LCOE generally increase NPV, and rates below the system's LCOE decrease NPV. As explained above, NPV is more sensitive to gross consumption rates at lower percentages of exported energy, and more sensitive to net consumption rates at higher percentages. For reference, the LCOE in this example is 15.47 cents/kWh.
- This analysis assumes that electricity rates increase in lockstep with inflation.
- However, other important factors, such as the ITC or a similar grant, can significantly reduce the sensitivity of the PV system's NPV to consumption rates.





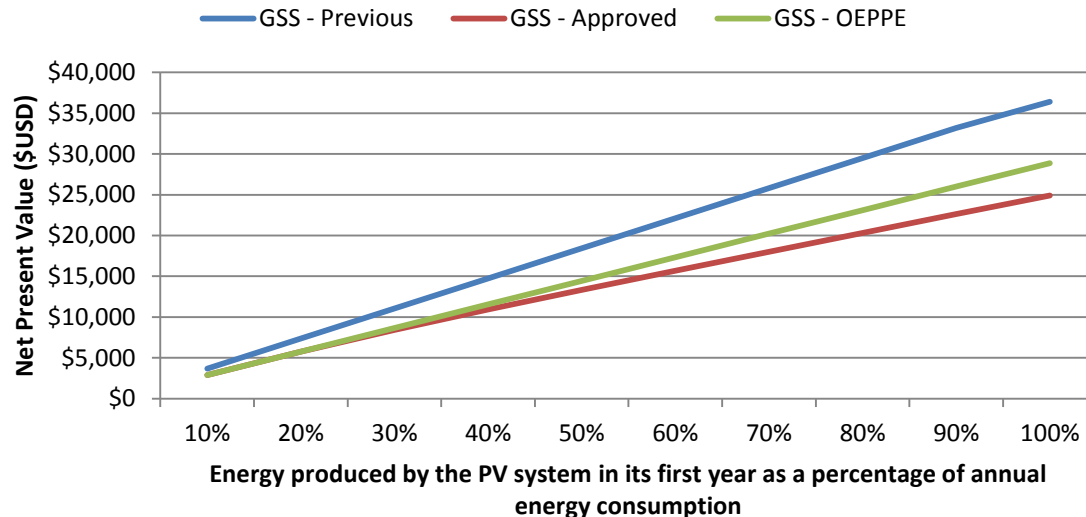
# Results for Residential Customer Class (GRS)

- GRS – General Residential Service
  - PV system size at 100% P/C ratio: 8 kW
  - LCOE: \$0.1410/kWh
  - Calculated annual AC system output at 100% P/C ratio: 12,280 kWh (first year)
  - Electricity load total per year: 12,384 kWh



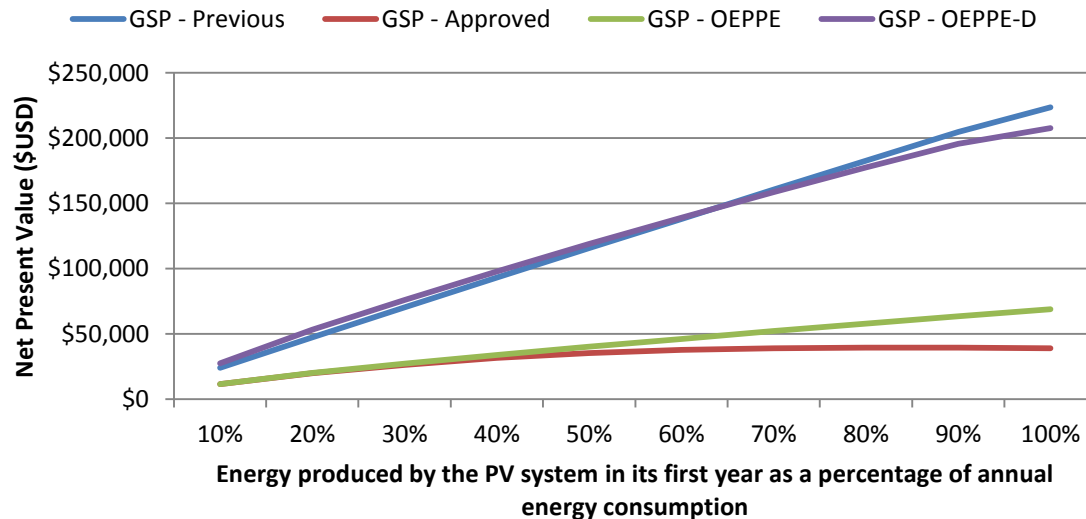
# Results for Small Commercial Class (GSS)

- GSS – General Service at Secondary Distribution Voltage
  - PV system size at 100% P/C ratio: 25 kW
  - LCOE: \$0.1297/kWh
  - Annual AC system output at 100% P/C ratio: 38,375 kWh (first year)
  - Electricity load total per year: 38,400 kWh



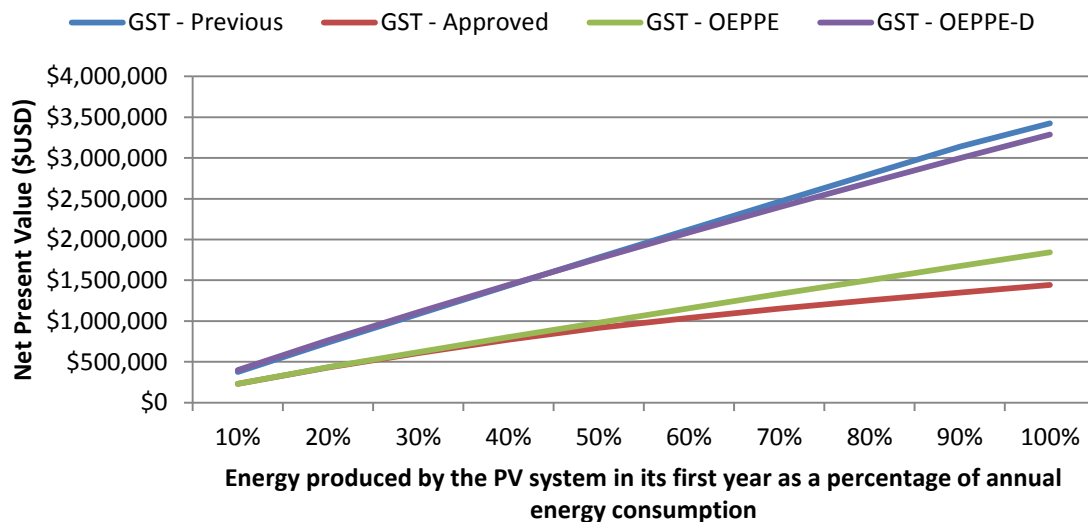
# Results for Large Commercial Class (GSP)

- GSP – General Service at Primary Distribution Voltage
  - PV system size at 100% P/C ratio: 270 kW
  - LCOE: \$0.1112/kWh
  - Annual AC system output at 100% P/C ratio: 414,542 kWh (first year)
  - Electricity load total per year: 417,117 kWh
  - GSP – OEPPE does not include proposal to reduce demand charges, GSP-OEPPE-D does.



# Results for Industrial Class (GST)

- GST – General Service at Transmission Voltage
  - PV system size at 100% P/C ratio: 3,600 kW
  - LCOE: \$0.0867/kWh
  - Annual AC system output at 100% P/C ratio: 5,526,030 kWh (first year)
  - Electricity load total per year: 5,512,350 kWh
  - GST – OEPPE does not include proposal to reduce demand charges, GST-OEPPE-D does.



# Limitations of the Analysis

- Key limitations on this analysis include:
  - This analysis relied on limited information on load profiles in Puerto Rico. More robust data on representative load profiles for each rate class would improve the analysis.
  - Sensitivity analysis on the following variables would improve the analysis, as well:
    - Inflation rate and discount rate
    - PV installed costs
    - Electricity rates escalation (above or below inflation)
    - Investment tax credit (monetized by a 3<sup>rd</sup> party, if necessary) or the Green Energy Fund (GEF) incentive

# References

- H Schedules:
  - <http://www.aeepr.com/Documentos/Ley57/Tarifa/03%20Attachment%20B%20-%20Schedules/H%20Schedules.pdf>
- J Schedules:
  - <http://www.aeepr.com/Documentos/Ley57/Tarifa/03%20Attachment%20B%20-%20Schedules/J%20Schedules.pdf>
- Weather: San Juan Intl Airport, typical meteorological year (TMY3)
- PREPA previous net metering program:
  - <http://www.aeepr.com/DOCS/Folletos/MedicionNeta.pdf>
- Non-bypassability of securitization charge:
  - [http://www.nationalpfg.com/pdf/Presentations/NPFG\\_Demystifying\\_the\\_PREPA.pdf](http://www.nationalpfg.com/pdf/Presentations/NPFG_Demystifying_the_PREPA.pdf)
- Adjustment factors
  - <http://www.aeepr.com/Documentos/Ley57/Tablas%20Factor%20de%20Ajuste.pdf>
- System Advisor Model (SAM)
  - <https://sam.nrel.gov/>
- LCOE calculation
  - Short, Walter, Daniel J. Packey, and Thomas Holt. 1995. "A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies." National Renewable Energy Laboratory. <http://www.nrel.gov/docs/legosti/old/5173.pdf>.

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