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IEPEC

LOOKING ON THE BRIGHT SIDE

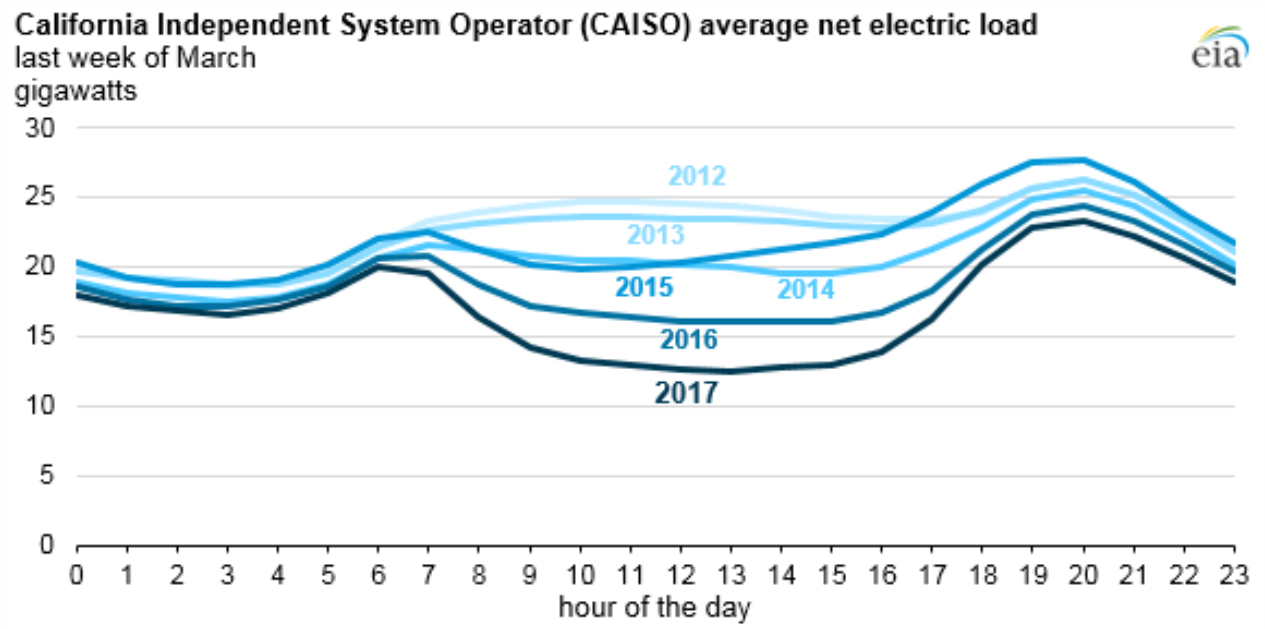
How Actual Solar Production Compares to What is Expected

August 21, 2019

Background

- As the number of solar PV systems increases, so does the impact on the grid and the uncertainty around this impact

California's "Duck Curve"



Source: U.S. Energy Information Administration

Background

- After a decade of actively incentivizing solar PV, there are approximately 40,000 PV systems installed on Long Island
- Utility has little visibility behind the meter
- PSEG Long Island sought a detailed look at the installed base of PV systems and their hourly and annual output

Topics Covered Today

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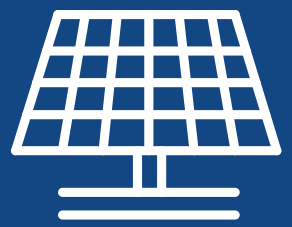
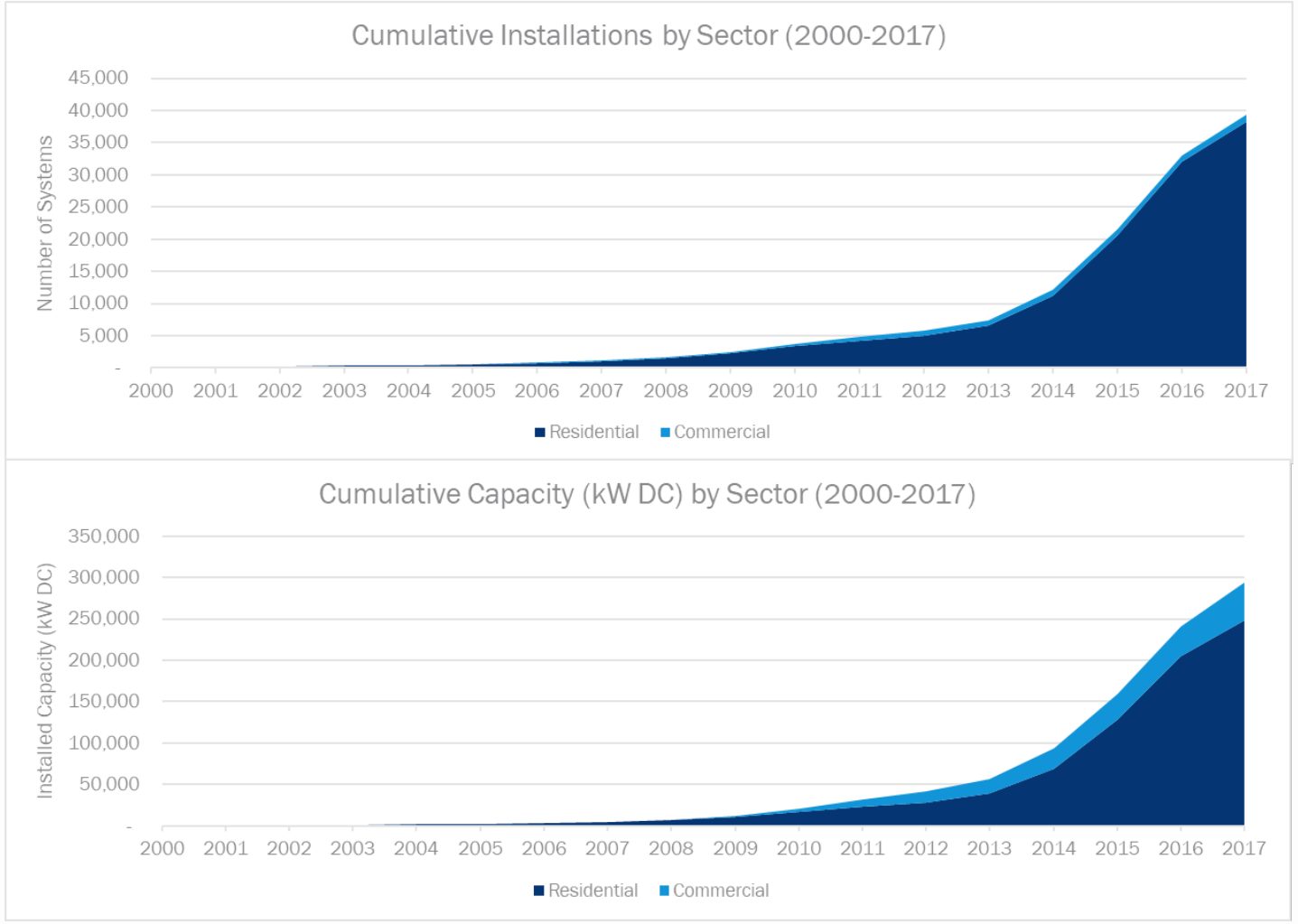


SNAPSHOT OF PV SYSTEMS ON LONG ISLAND

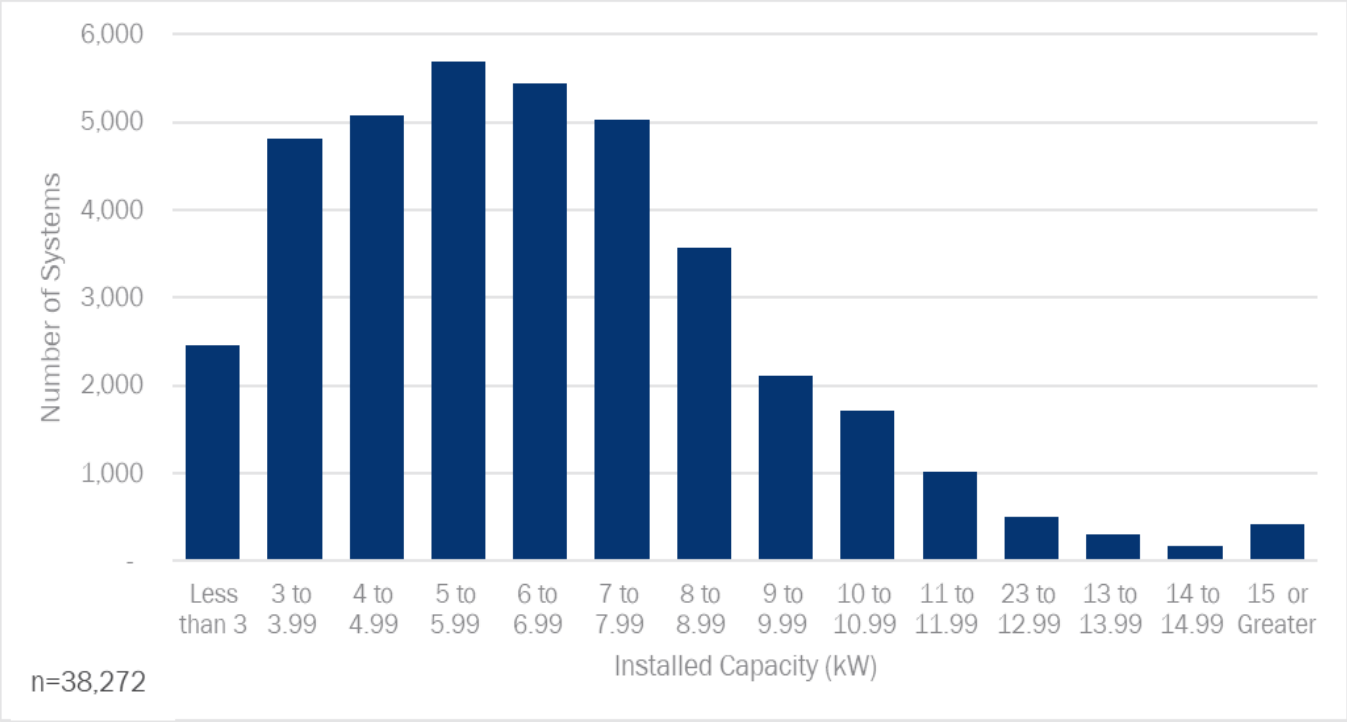
Cumulative PV Installations on Long Island

- Total of 39,405 systems interconnected on Long Island from 2000 to 2017
  - 294 MW of rated capacity (DC)
- Commercial sector accounts for only 3% of systems, but 16% of installed capacity
- Approximately two-thirds (63%) of PV systems received an incentive
  - 79% of installed capacity



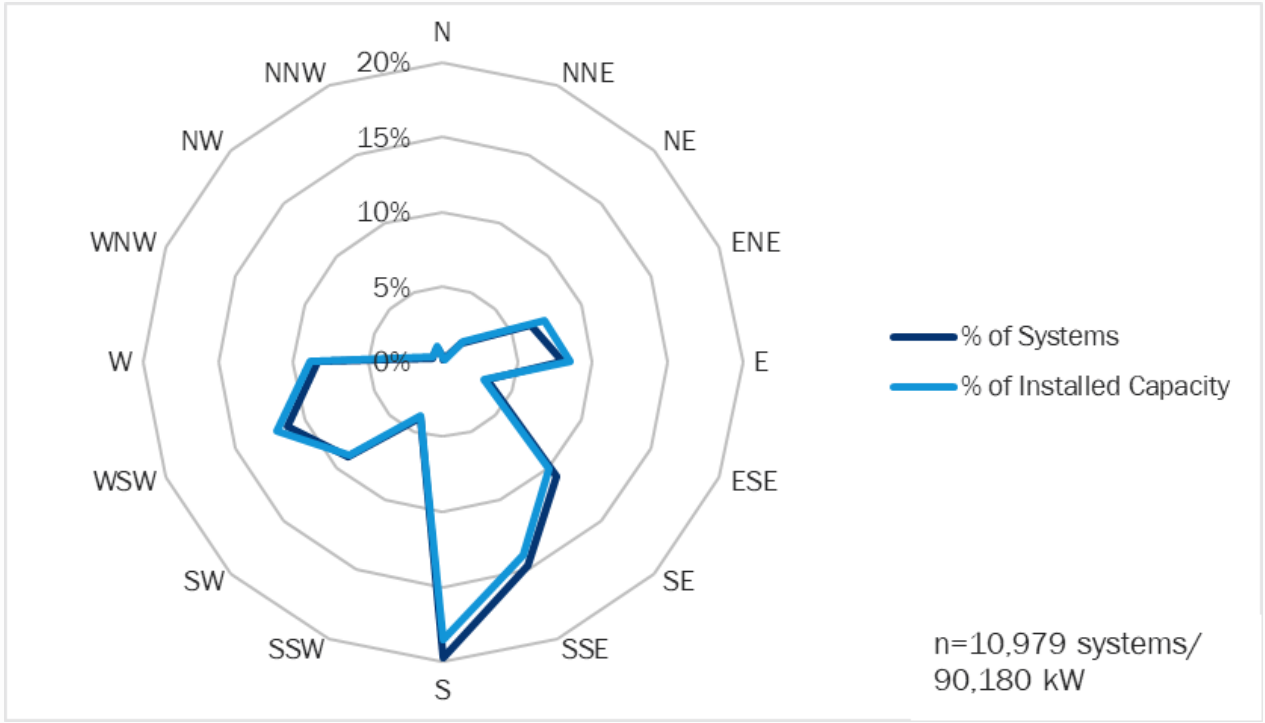
Residential System Characteristics

- Residential PV systems have a mean installed capacity of 6.48 kW
- Average size of systems increased from 2000 to 2010, but has been between 6 and 7 kW since 2011
  - Likely the realistic limit of usable roof area on average homes

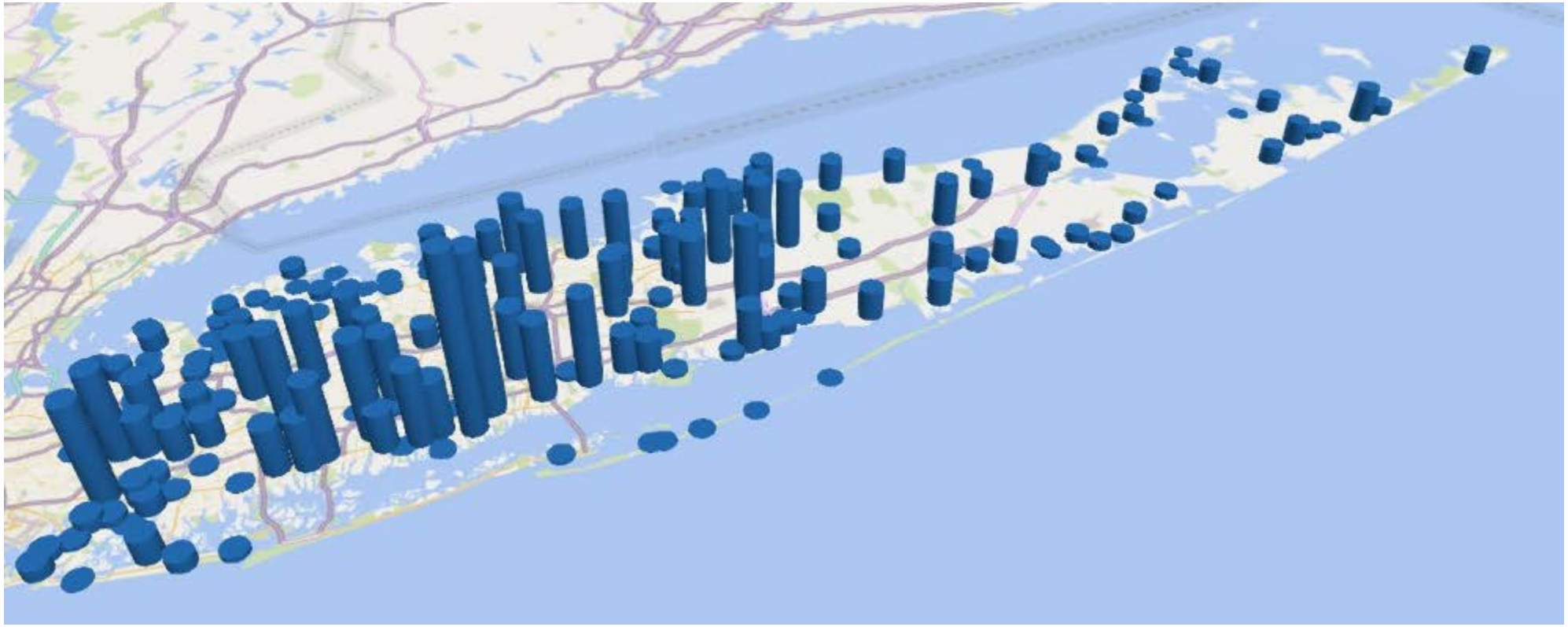


Residential System Characteristics

- To maximize the exposure to sunlight throughout the year, most systems face between 135˚ (SE) and 225˚ (SW)
- Orientation of residential systems is more varied than commercial systems due to sloped roofs and orientation of house



Locations of Residential PV Installations



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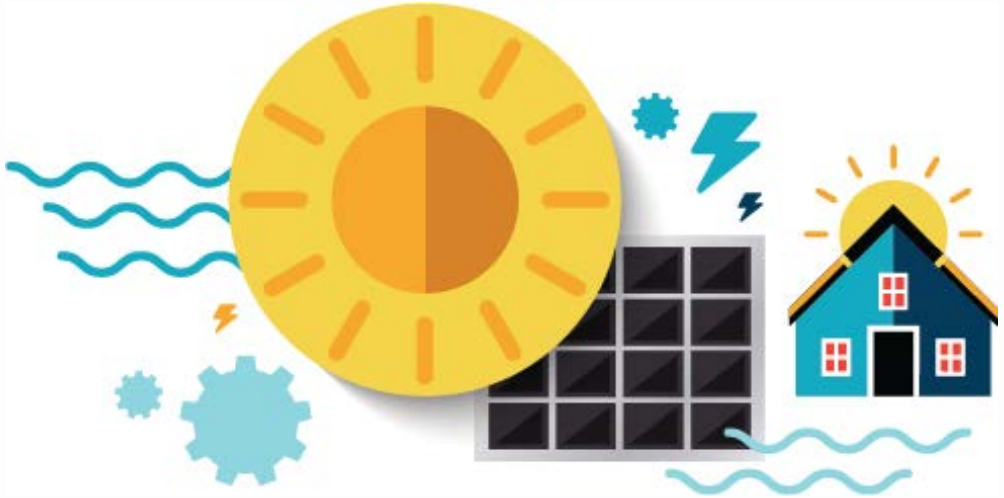
PV OUTPUT ANALYSIS

Data Collection

- Opinion Dynamics gathered system-level production data from a variety of sources
  - Total of 295 systems
  - 15-minute, hourly, monthly, and total output to date
- Difficult to obtain data from inverter manufacturers
  - Privacy concerns
  - Lack of data processing resources
- We relied largely on publicly shared production data from customers

Weather Normalization

- All things being equal, PV system output is directly related to the amount of sunlight on its panels
- Important to normalize the output for weather
  - We want to understand performance of system, not the difference in sunny days

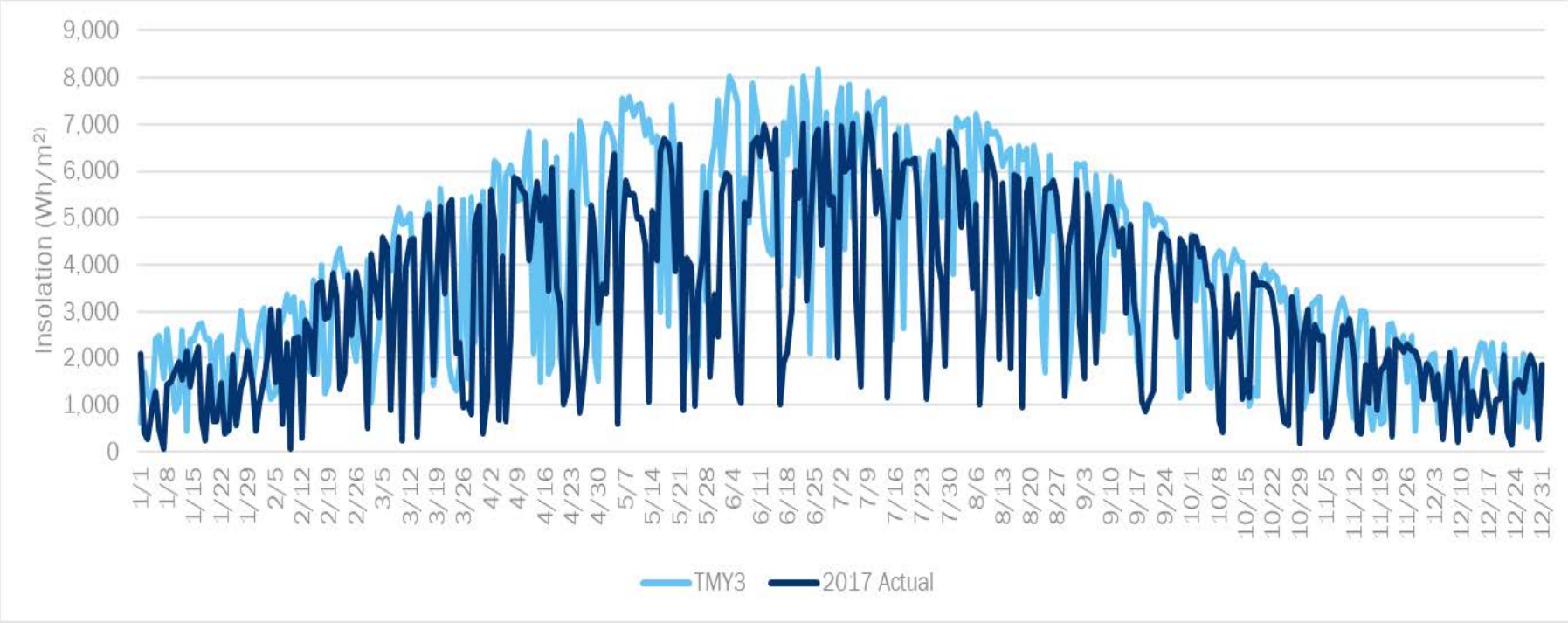


Weather Normalization, continued

- We compared actual insolation on Long Island to a typical meteorological year (TMY) in the National Solar Radiation Database developed by NREL
- Used measured GHI data from a weather station on Long Island and compared this with local TMY3 data
  - Geotagged each system and assigned it to the closest TMY weather station on Long Island

Actual 2017 Insolation Compared to TMY3 Data

- Actual insolation on Long Island in 2017 was 83% of typical value
- Difference varied from day to day



Additional Analysis Steps

- Review of program tracking and interconnection data
- In-depth interviews with stakeholders
  - Determined applicability of extrapolating information about program-participating systems to non-participating systems

- Data cleaning
  - Removed outlier production observations
  - Ensured weatherization multiplier was in reasonable range
  - Removed leap years
- Weighting
  - Accounted for under/over-representation of different types of PV systems to reflect population of PV systems
  - Weights based on sector, installation year, inverter type, and capacity

Modeling

- We established expected hourly output of each system for 25 years using NREL's System Advisory Model (SAM)
- Calculated using local TMY3 irradiance data and system characteristics
- Model allows for input of very detailed equipment specifications or can use higher level assumptions if system-specific information is not available
- Through combination of program tracking data, interconnection data, and information from source sites, we entered detailed equipment characteristics for most systems

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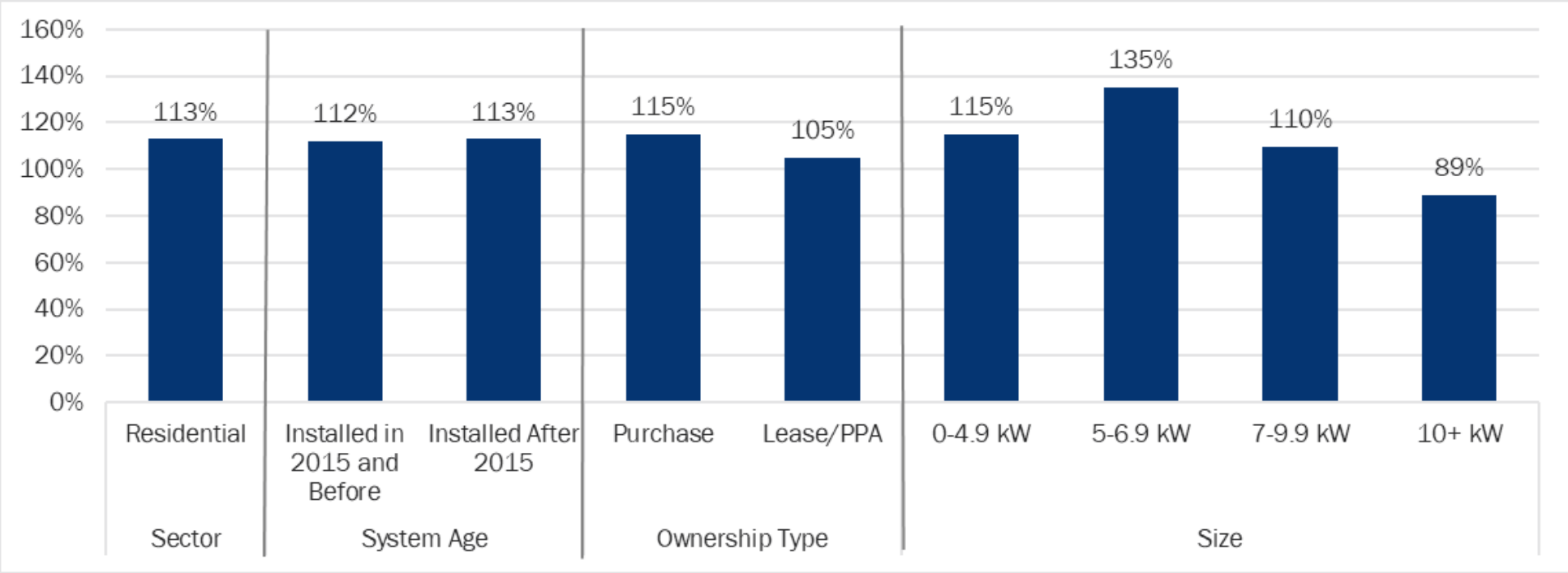
REALIZATION RATES AND OUTPUT CURVES

Production Realization Rates

- Two time periods:
  - Annual period from October 2017 to October 2018
  - Total production to date since installation
- Realization of over 100% for both analyses

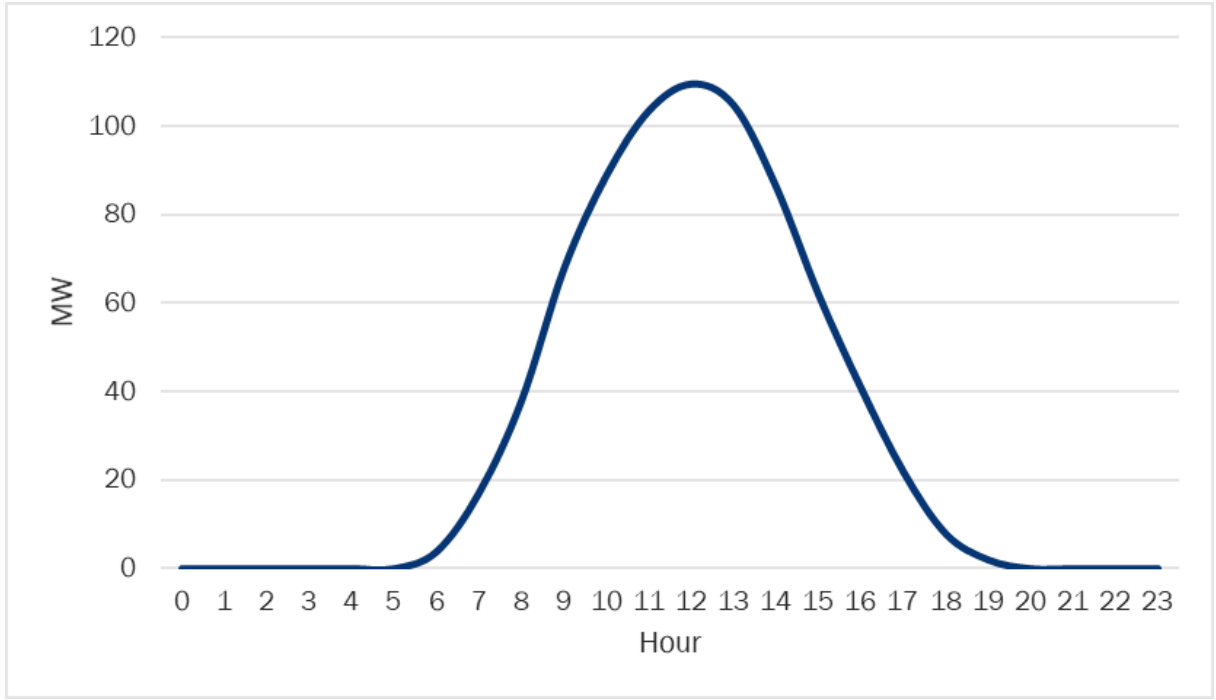
	2017-2018 Production	Total Production
Number of Systems	38,281	
Installed Capacity (kW DC)	248	
Actual MWh	216,047	705,836
Actual MWh (Weather Normalized)	206,650	698,267
Expected MWh (Weather Normalized)	186,178	628,718
Realization Rate (Weather Normalized)	113%	111%

Realization Rates by System Characteristics



Overall Output Curve

- Output curves help to understand the impacts of PV systems at different times of the day
- On an average day, residential PV systems have total peak production of 109 MW at noon

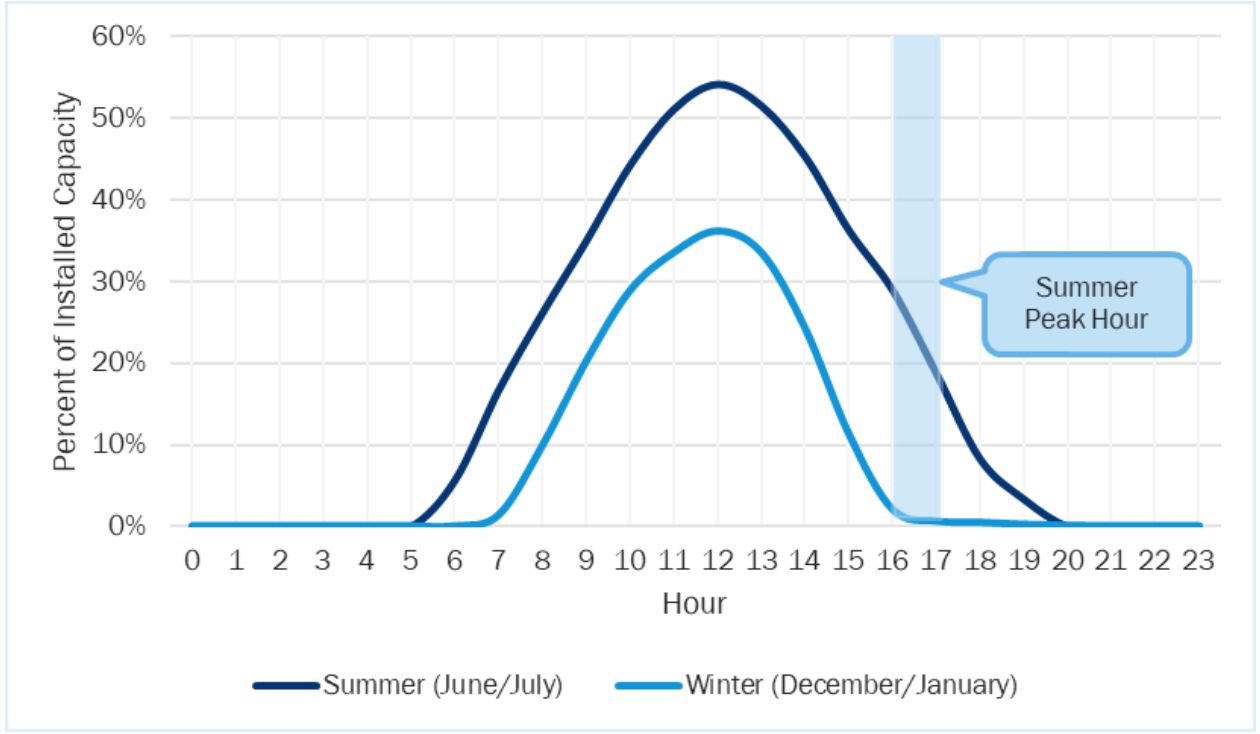


Seasonal Output Curves

- Electricity generated by PV systems varies greatly by season
- Production is at the summer system peak is only about half solar peak production

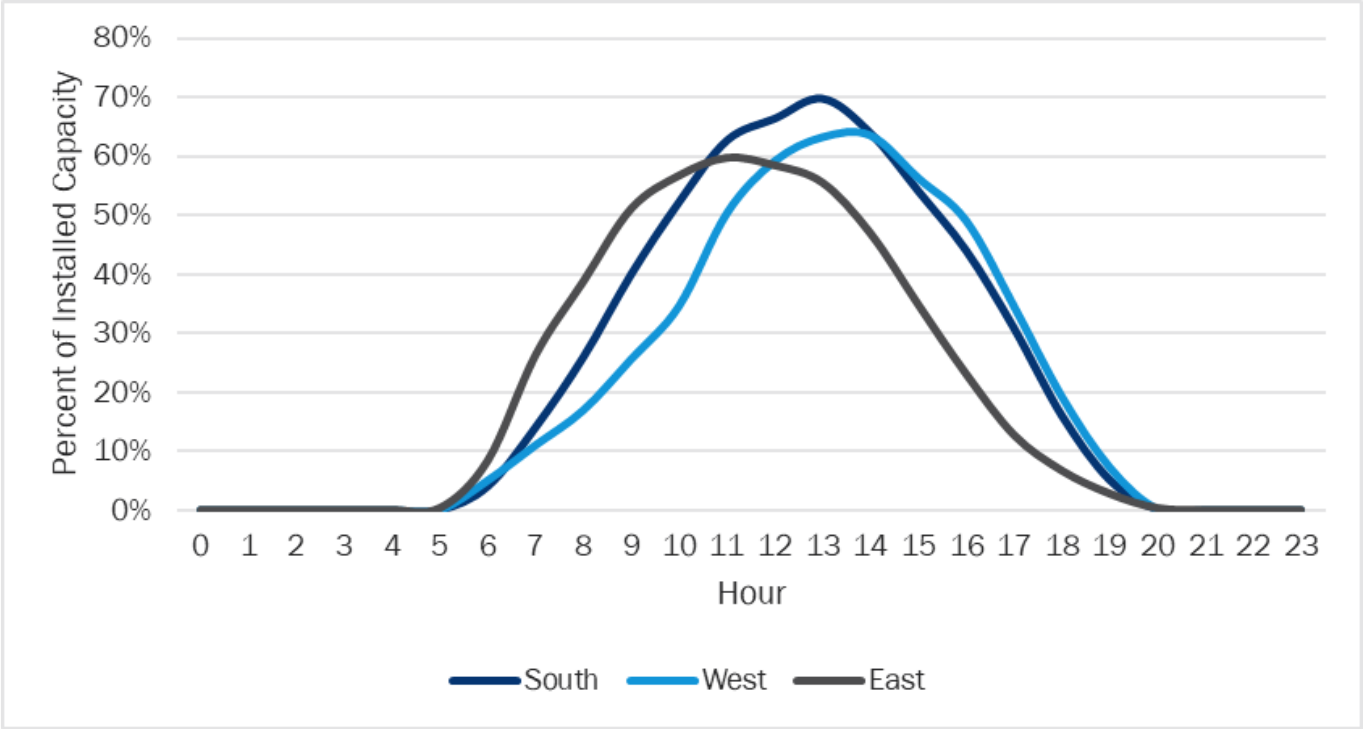
Summer PV Production

	Production (MW DC)	Production/ Capacity
Solar Peak (12:00 pm)	137.0	55%
Summer System Peak (4:00 pm)	73.2	30%



Output Curves by Orientation

- Impact of PV systems can further vary by their orientation
- South-facing systems have greatest total production
- West-facing systems have greatest production during summer system peak



Takeaways

- Weather normalized production exceeded the expected production modeled by NREL's SAM.
- Minimal differences in realization rate among different system types suggests good installation techniques
- The hour of peak solar output does not match the summer system peak
- Understanding how installed production compares to modeled production and the impact at different time periods helps PSEG Long Island better plan for the impact of solar PV

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