Empirical Assessment of the Demand for Residential Solar Distributed Generation and the Impact of Electricity Rate Design Reform

PRESENTED TO

Rutgers University Center for Research in Regulated Industries

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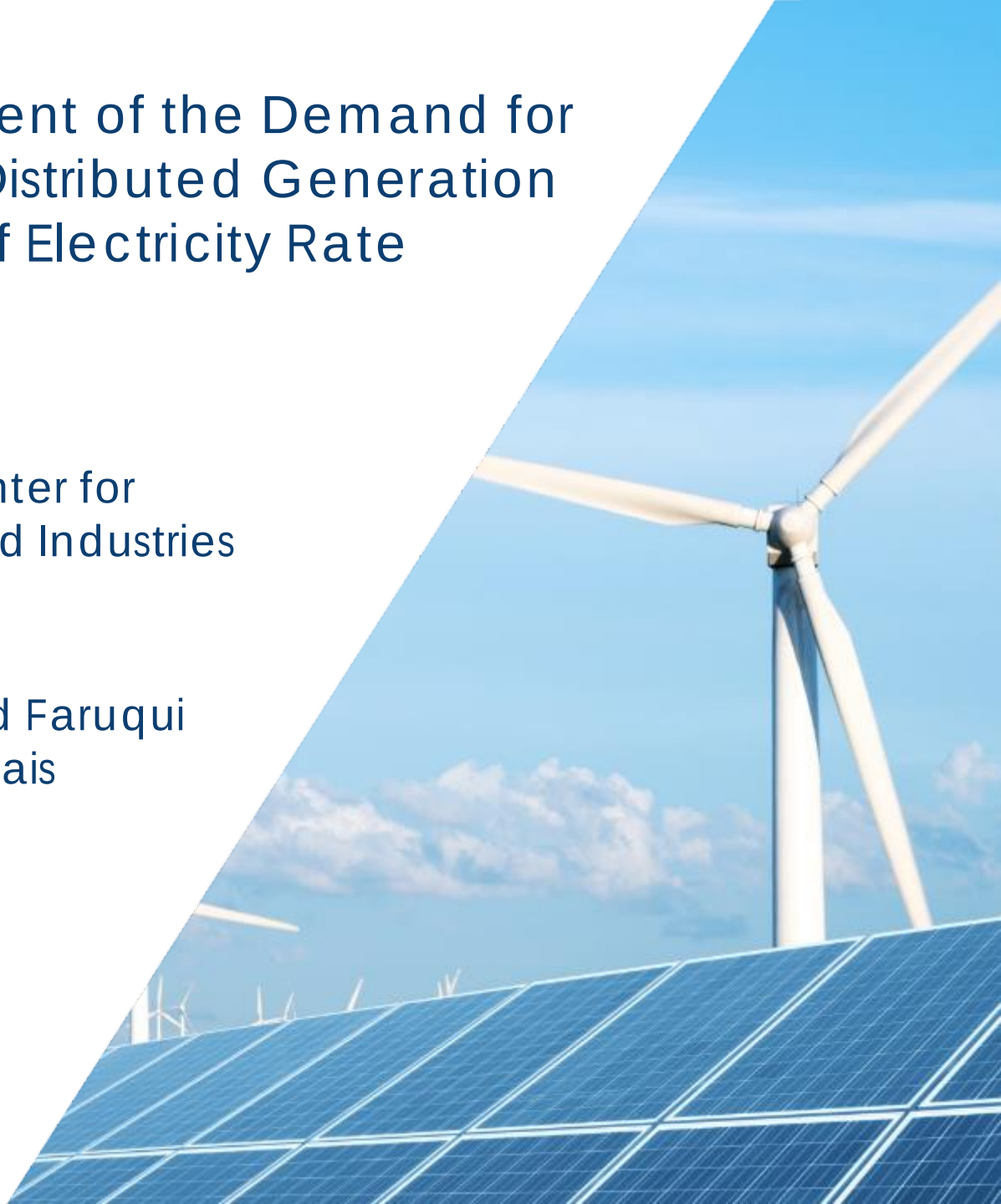
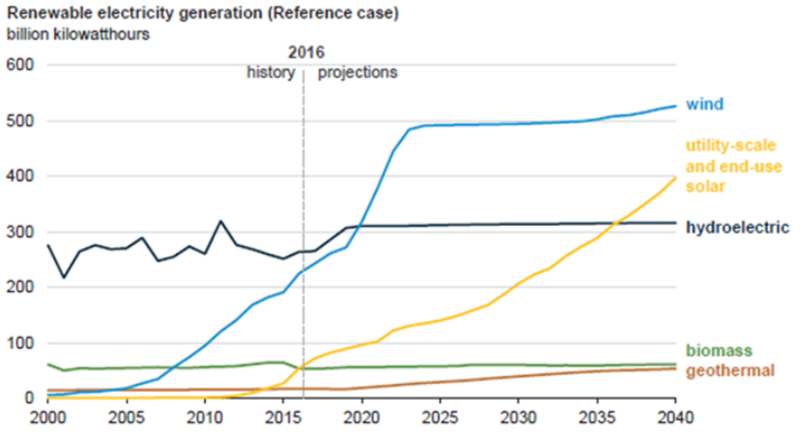
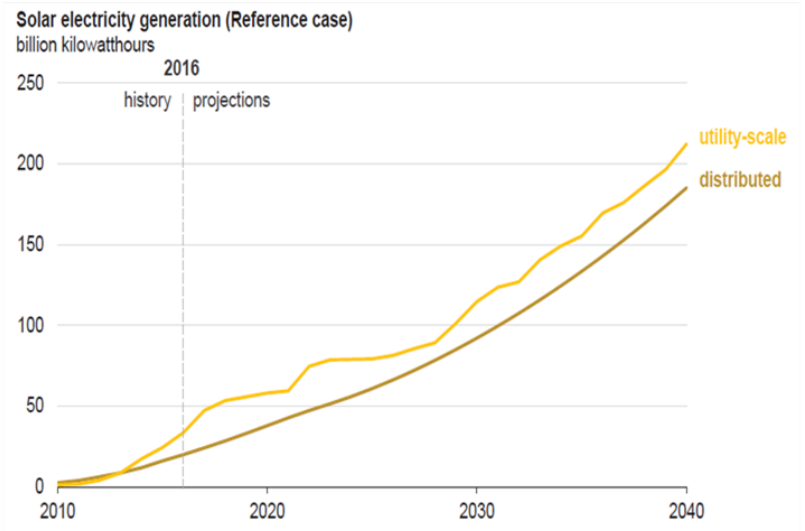
THE Brattle GROUP



DERs and the Growth of Solar PV

Distributed Energy Resources ("DER") are defined as "behind-the-meter" generation resources and demand-side options relied upon to meet all or a portion of customer's electric load





Source: Energy Information Administration (EIA), Annual Energy Outlook, 2017.

Solar PV Demand

Purchase Solar PV if the price of the system is less than the total lifetime expected discounted benefits.

Total expected benefits:

- Reductions in electricity usage from the Local Distribution Company (LDC) and thus lower payments to the LDC
  - ✓ Impact of electricity rate design reform?
- Payments from the utility to the solar PV owner for exporting excess energy back to the distribution grid
  - ✓ Impact of changes to net-metering?
- Intrinsic “value” to the consumer from producing and consuming renewable electricity

Electricity rates are generally "misaligned"

Cost categories	Utility's Costs	Customer's Bill
Variable ($/kWh) - Fuel/gas supply - Operations & maintenance	Variable = $60	Variable = $115
Fixed ($/customer) - Metering & billing - Overhead	Fixed = $10	Fixed = $5
Size-related (demand) ($/kW) - Transmission capacity - Distribution capacity - Generation capacity	Demand = $50	

What impact may reducing volumetric rates have on solar PV demand?

Number of installations in sample by state

State	# Installations	# Years with Data
California	662,886	12
Arizona	111,391	12
Massachusetts	74,113	12
New York	65,909	12
Colorado	40,919	11
Texas	19,125	12
Connecticut	15,882	7
New Mexico	6,265	8
Pennsylvania	5,483	8
New Jersey	3,746	7
Delaware	2,209	12
Florida	2,157	12
Wisconsin	2,066	7
New Hampshire	1,555	10
Minnesota	1,297	10
Oregon	1,124	10
Arkansas	49	2

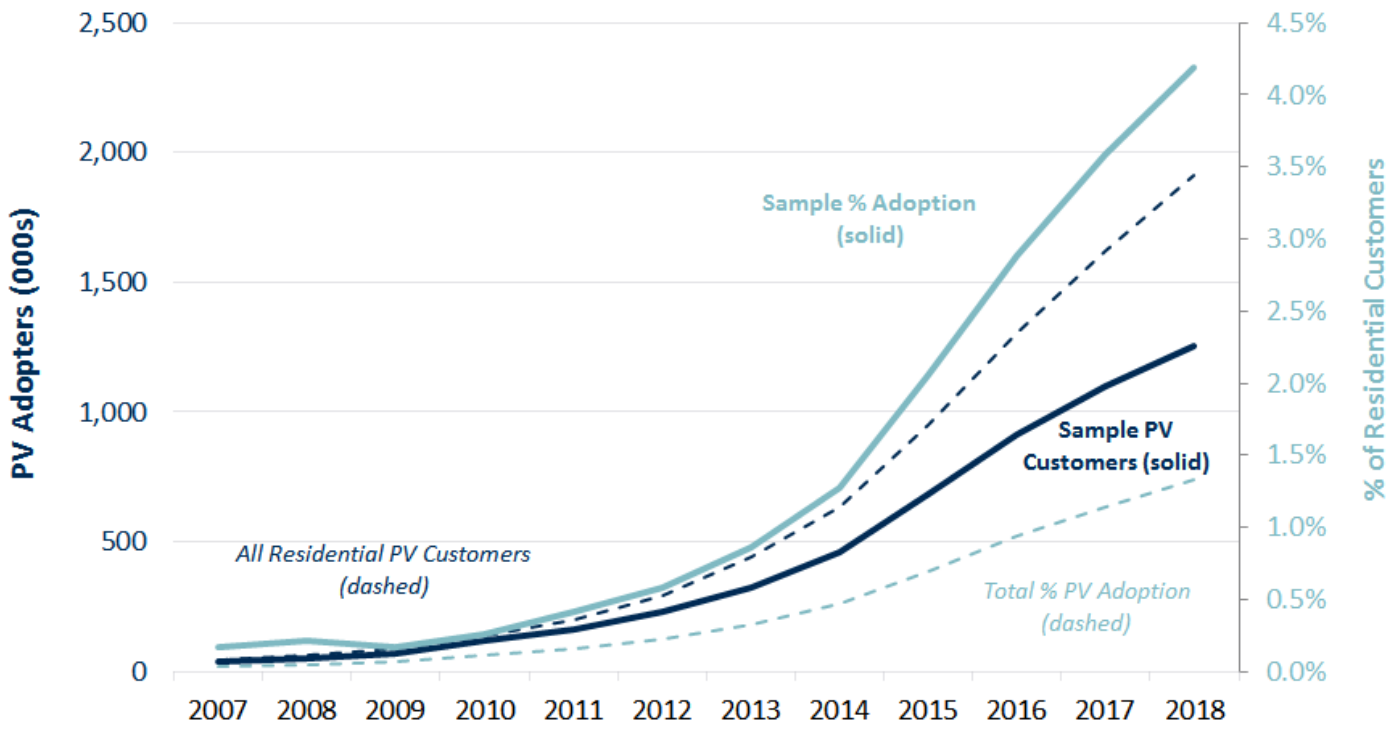
Source: PV system data from Lawrence Berkeley National Laboratory (LBNL), Tracking the Sun database, filtering to systems mapped to a utility service territory.

Top 15 utilities by number of installations in sample

Utility Name	State	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	# Installations
Pacific Gas & Electric	CA	5,487	5,550	7,365	8,530	11,381	13,607	13,254	3,219	31,424	63,272	52,974	56,744	272,807
Southern California Edison	CA	1,838	1,893	3,281	4,863	7,971	13,532	21,489	17,356	32,711	50,104	41,533	42,598	239,169
San Diego Gas & Electric	CA	920	755	2,015	2,575	2,930	3,877	3,501	3,643	19,716	27,948	17,165	22,571	107,616
Arizona Public Service	AZ	217	362	1,580	2,812	3,389	5,952	6,598	1,483	71	11,609	18,008	14,395	66,476
National Grid	MA	78	113	236	178	384	955	1,969	5,031	11,935	12,510	5,601	5,367	44,357
Public Service Co of Colorado	CO	-	1,361	1,975	2,092	1,922	3,633	4,162	6,028	4,904	3,077	5,701	6,064	40,919
LADWP	CA	-	-	7	72	912	2,695	3,900	3,538	4,237	6,773	4,132	3,800	30,066
NSTAR Electric	MA	55	125	310	201	438	1,286	2,154	2,984	6,608	7,334	3,640	3,027	28,162
Long Island Power Authority	NY	278	373	703	1,241	920	786	1,537	3,298	7,091	6,406	1,407	409	24,449
Tucson Electric Power	AZ	-	101	267	664	1,112	993	1,258	2,021	3,137	3,369	3,634	4,423	20,979
Consolidated Edison	NY	-	-	88	73	118	273	459	1,762	2,307	4,343	5,699	5,411	20,533
Salt River Project	AZ	95	100	646	1,336	754	1,751	2,568	3,932	3,305	672	1,334	1,926	18,419
City of San Antonio	TX	-	-	27	126	226	308	544	749	813	3,996	3,353	3,005	13,147
Eversource	CT	-	-	-	-	-	163	578	627	3,863	2,865	1,178	2,993	12,267
SMUD	CA	51	60	225	366	719	663	1,307	1,439	2,963	3,014	22	-	10,829

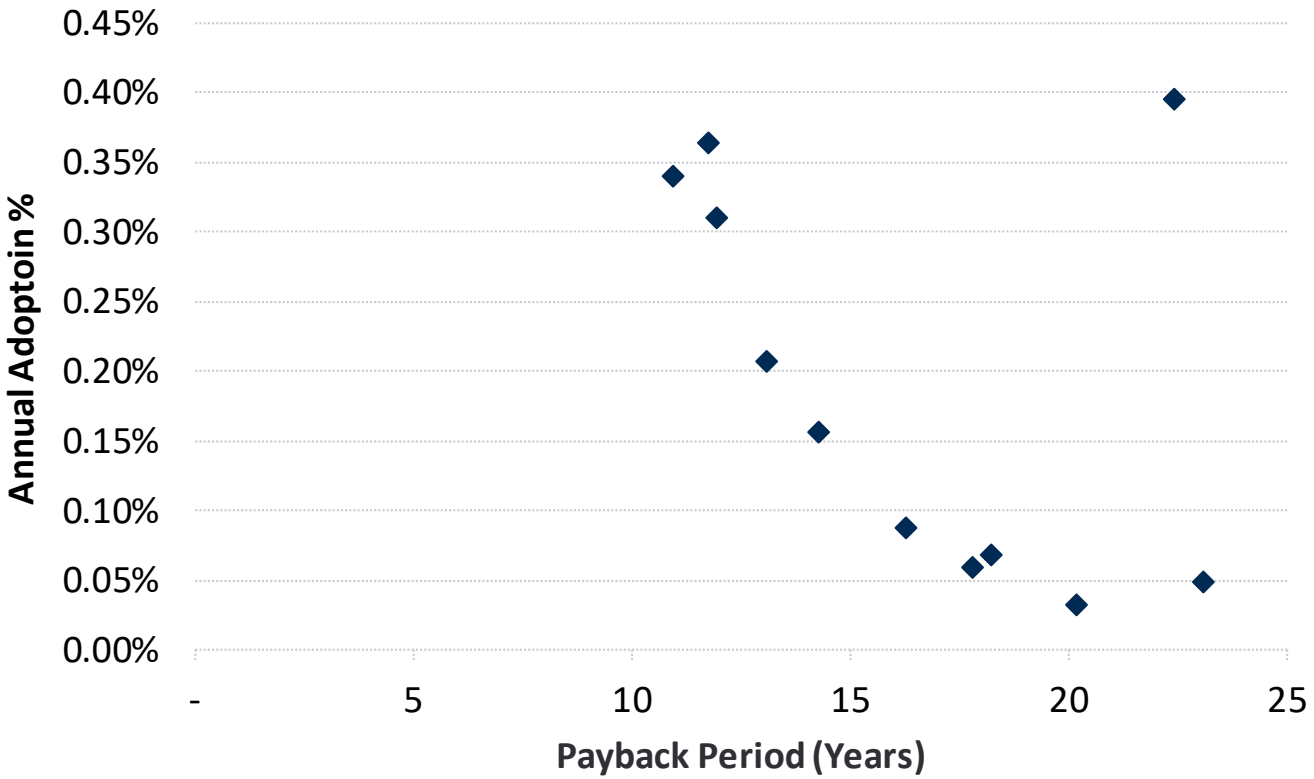
Source: PV system data from LBNL Tracking the Sun database.

% PV Adoption among utilities in sample vs. all utilities



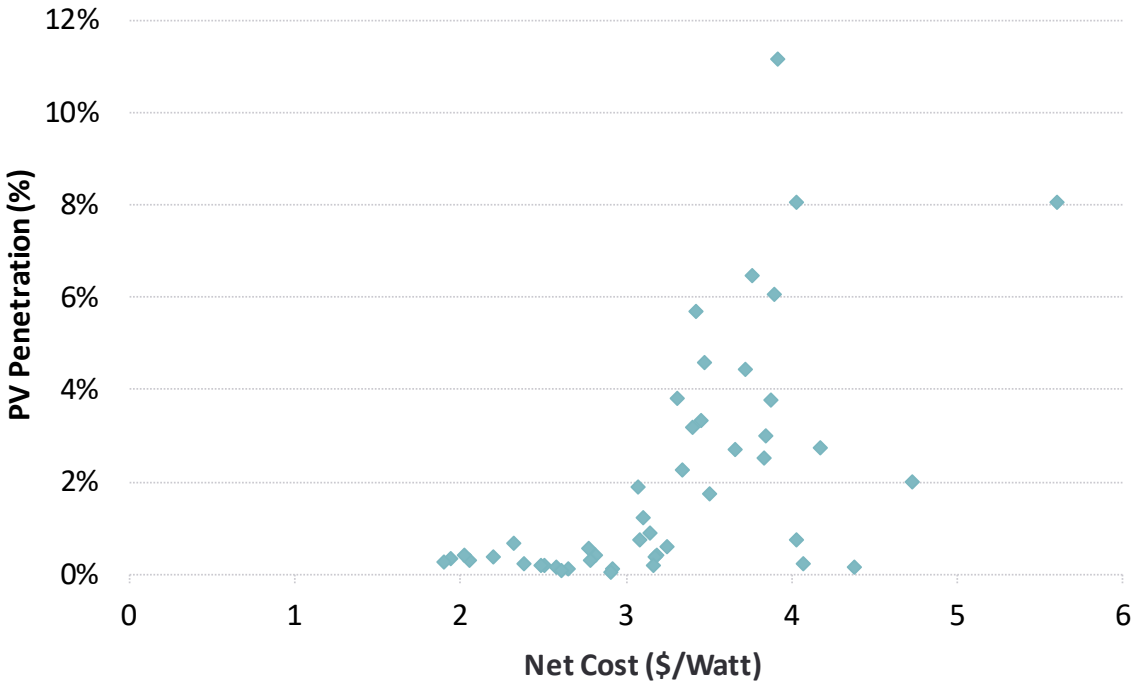
Notes: % PV Adoption calculated from Form EIA-861 data as number of PV customers divided by total residential customers. Sample is defined as utilities for which there is system data in LBNL Tracking the Sun database.

Annual Payback Period (with incentives) across utilities in sample



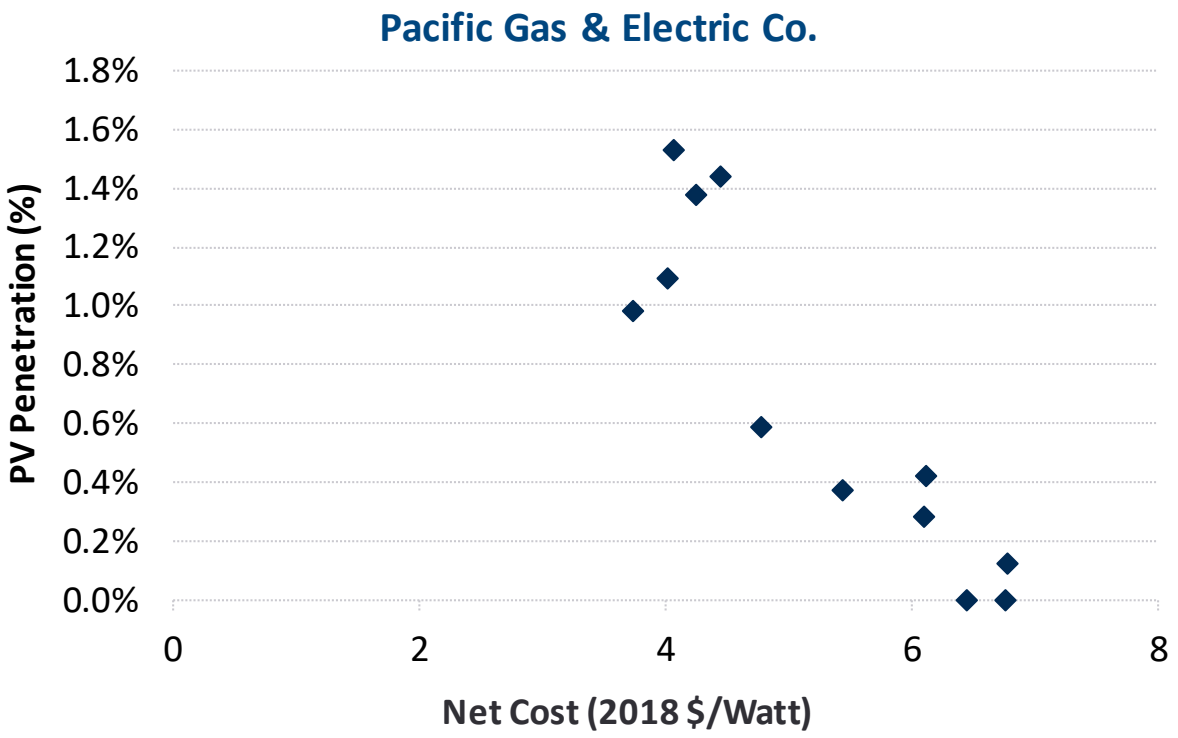
Notes: Calculated as average over individual utility payback periods, weighted by number of installations. Payback period computed as Total Cost (net of 30% ITC and rebates)/Total Savings, using system data for sample from LBNL Tracking the Sun database. Each observation represents one year between 2008-2018.

Solar Penetration vs Net Costs by Utility (2018)



Notes: Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database.

PV Penetration (%) vs. Net Cost (2018 $/Watt)



Notes: Data represents years 2007-2018. PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Net cost per watt computed as (installed cost + sales tax cost – rebate – performance-based incentive)/system size, based on LBNL Tracking the Sun database, which converts all dollars to real 2018 $.

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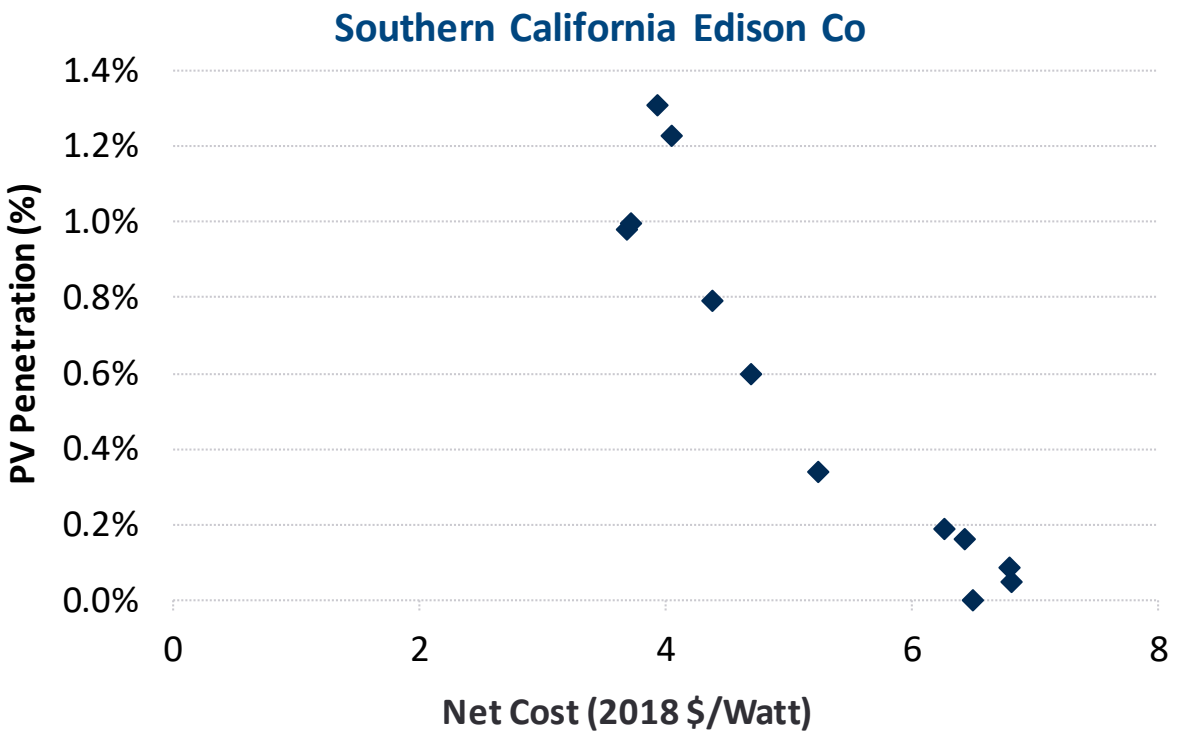

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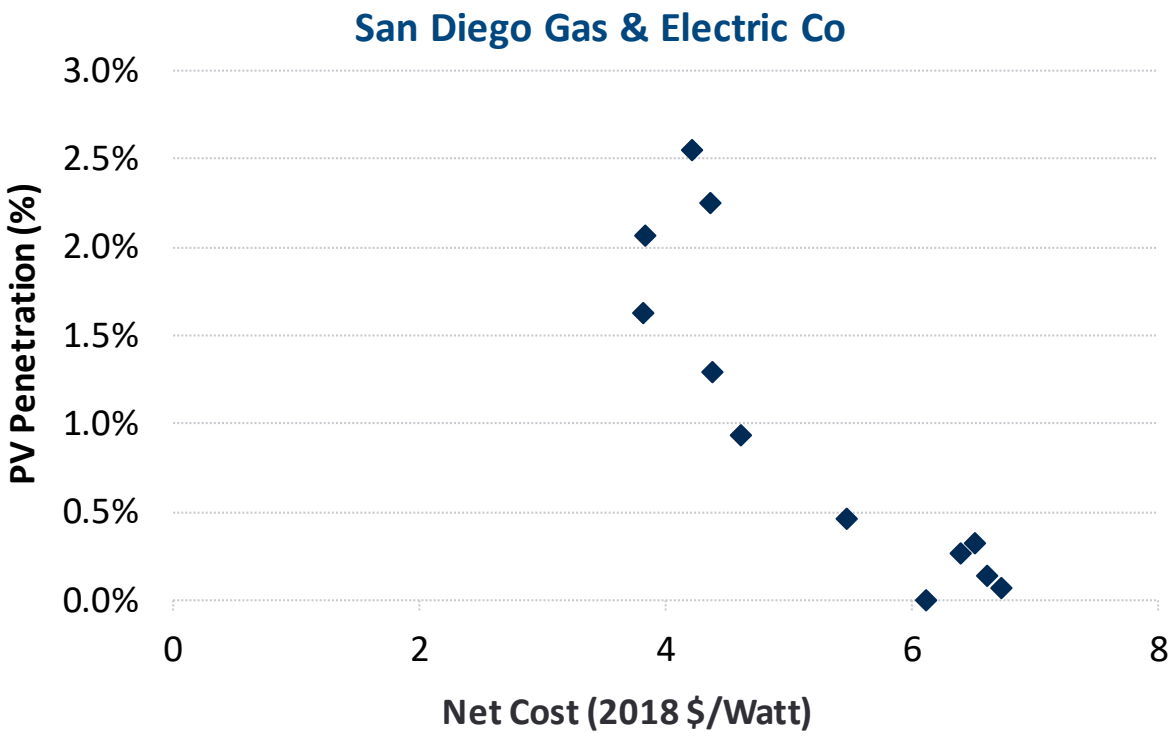

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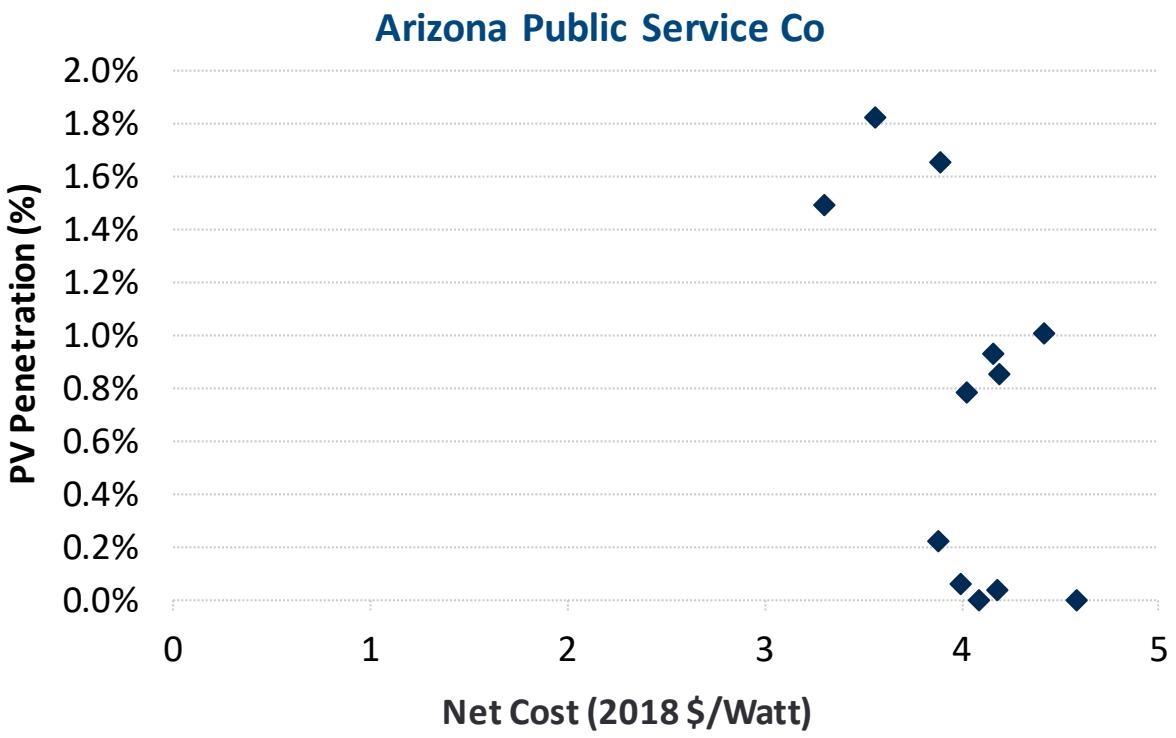

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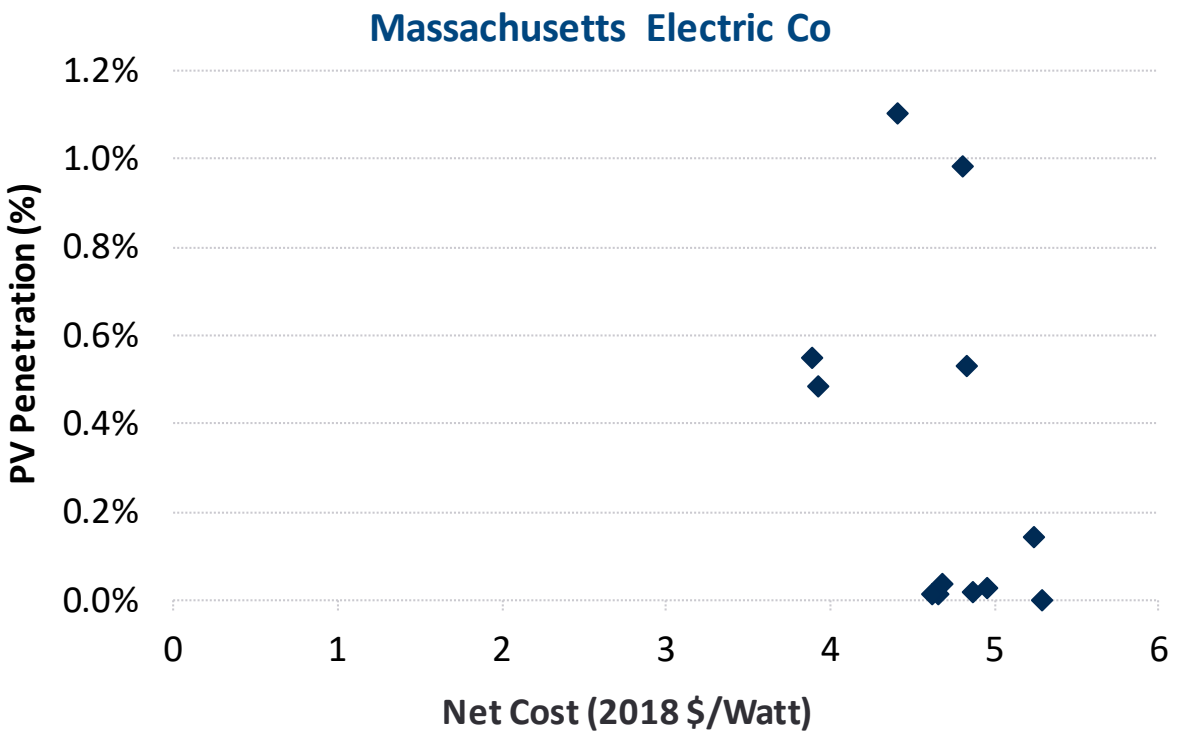

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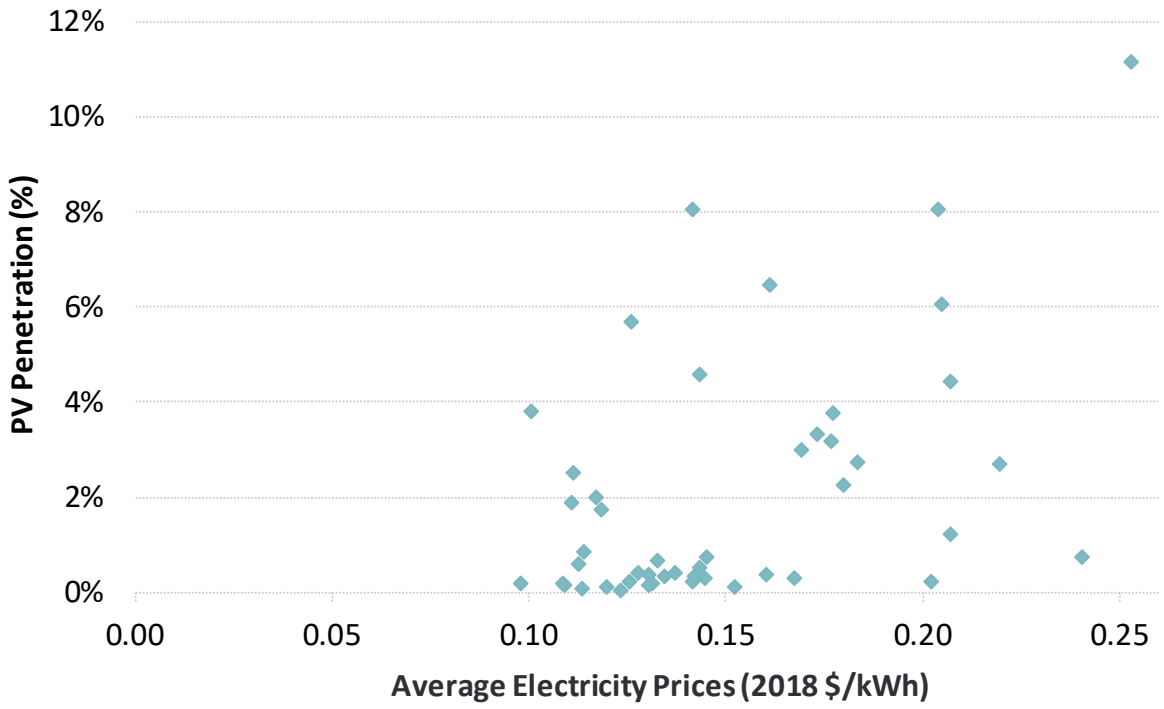
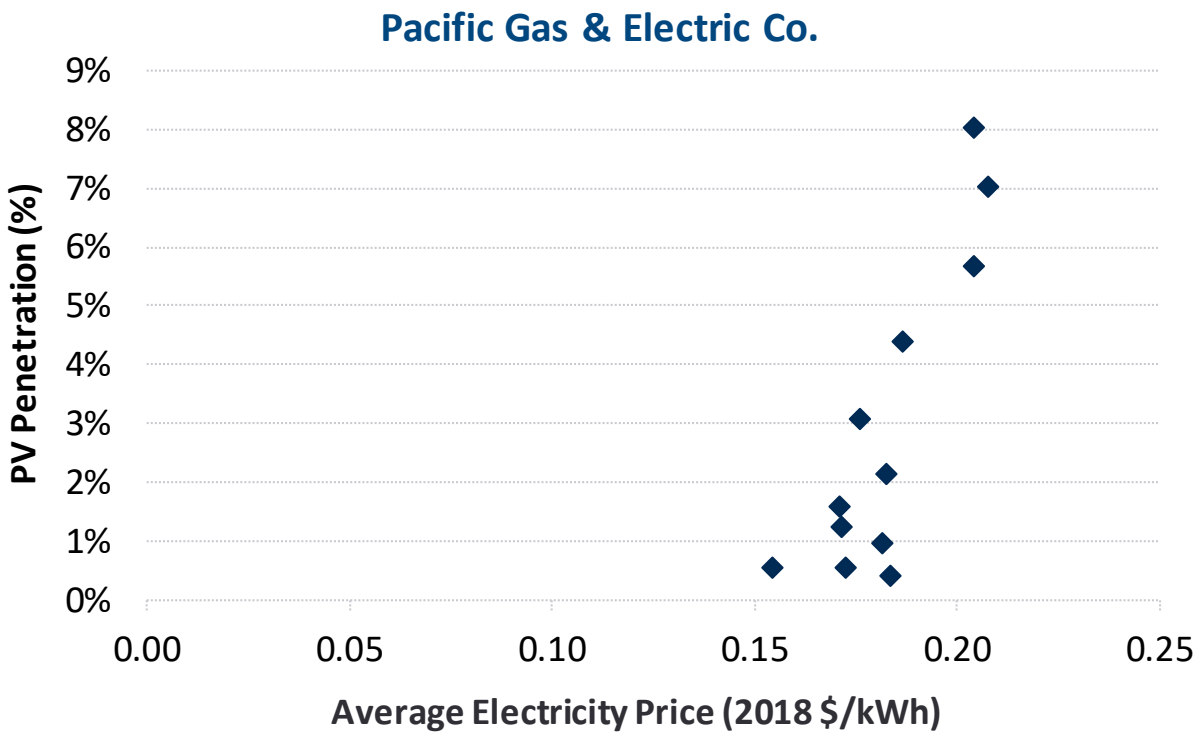
Solar Penetration vs Average Electricity Price by Utility (2018)



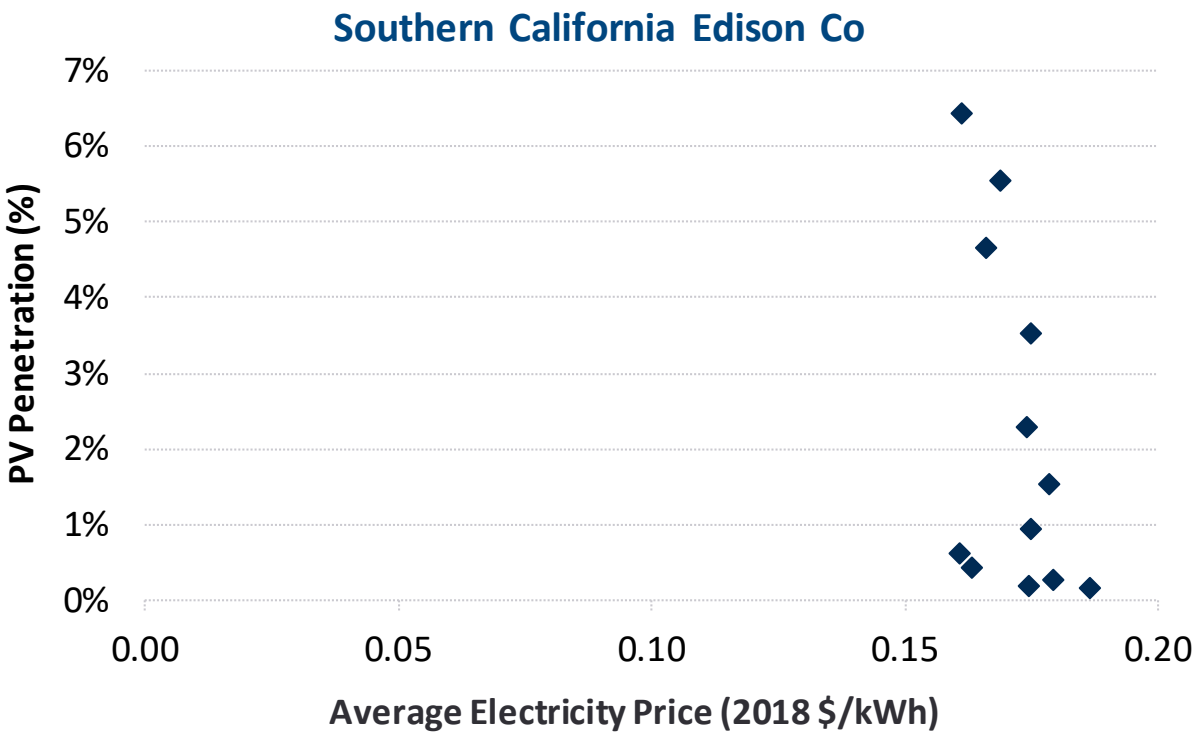
Notes: PV penetration computed from EIA data as number of residential net metering customers over total residential customers. Average electricity prices calculated from Form EIA-861 data as total $ revenues/kWh energy sales.

PV Penetration (%) vs. Average Electricity Price (2018 %/kWh)



Notes: Data represents years 2007-2018. Average electricity prices computed from EIA Form-861 as Total Residential Revenues/Total Residential sales. Nominal prices converted to real 2018 $ using U.S. Bureau of Labor Statistics' "Monthly Consumer Price Index for All Urban Consumers."

PV Penetration (%) vs. Average Electricity Price (2018 %/kWh)



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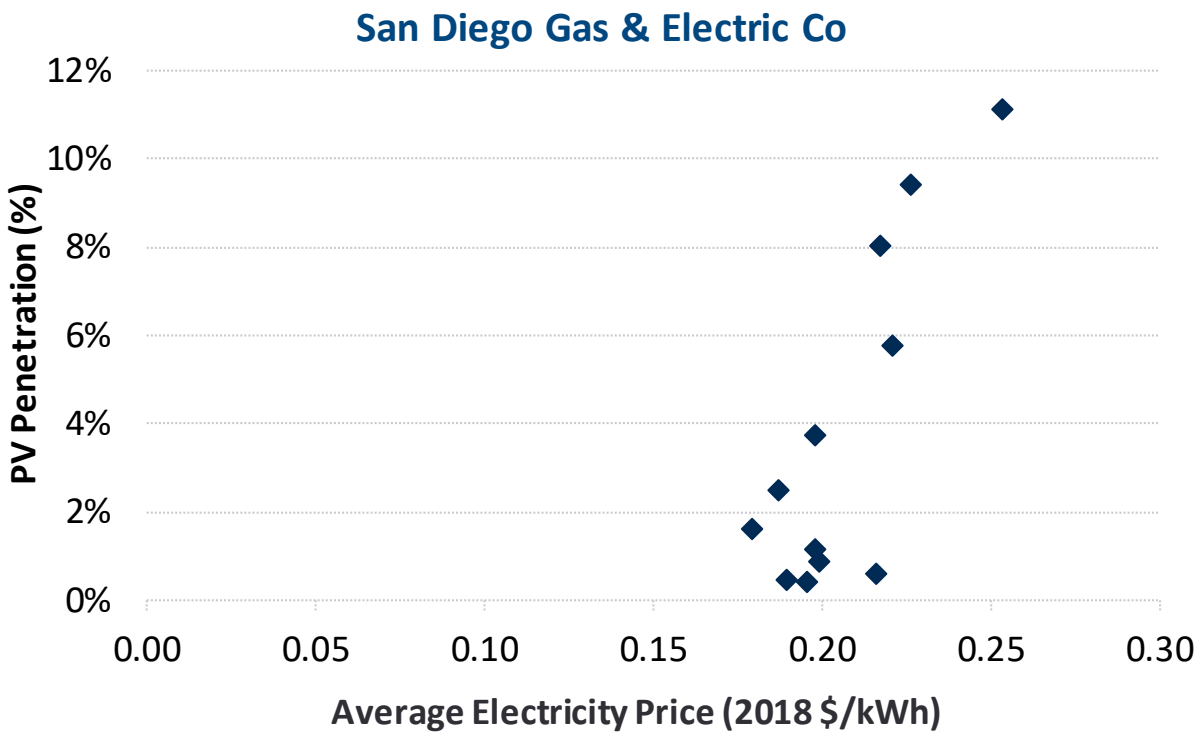

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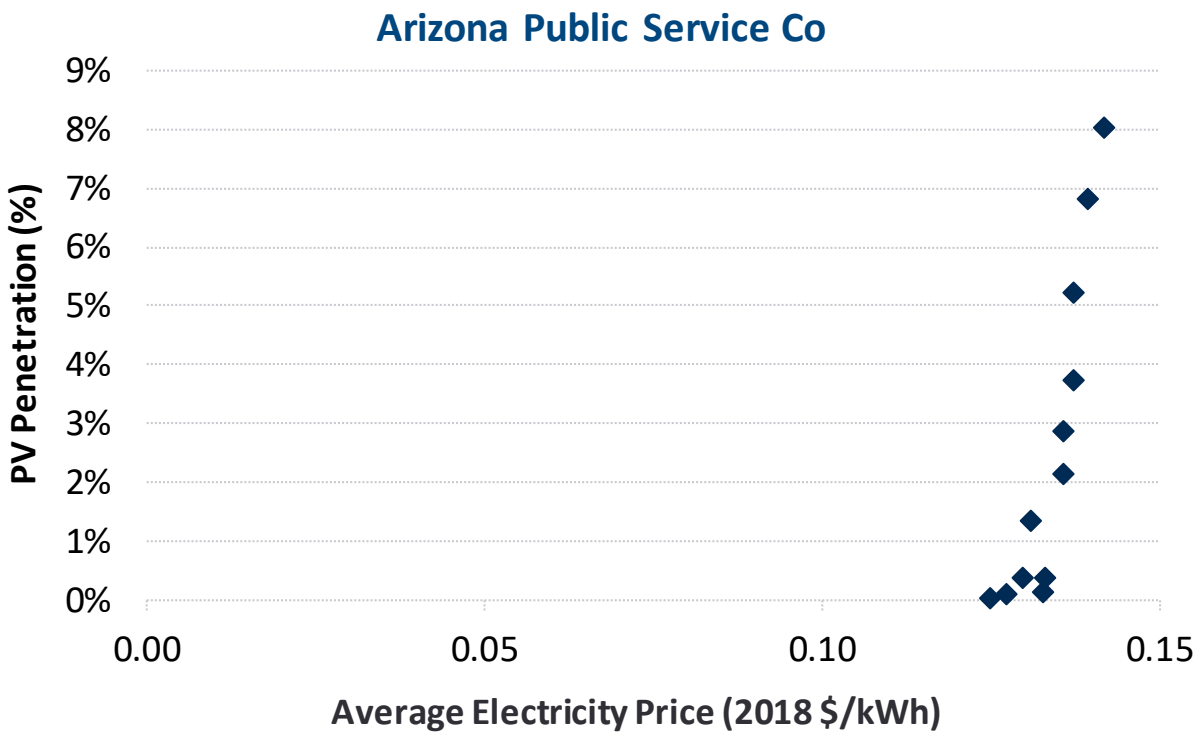

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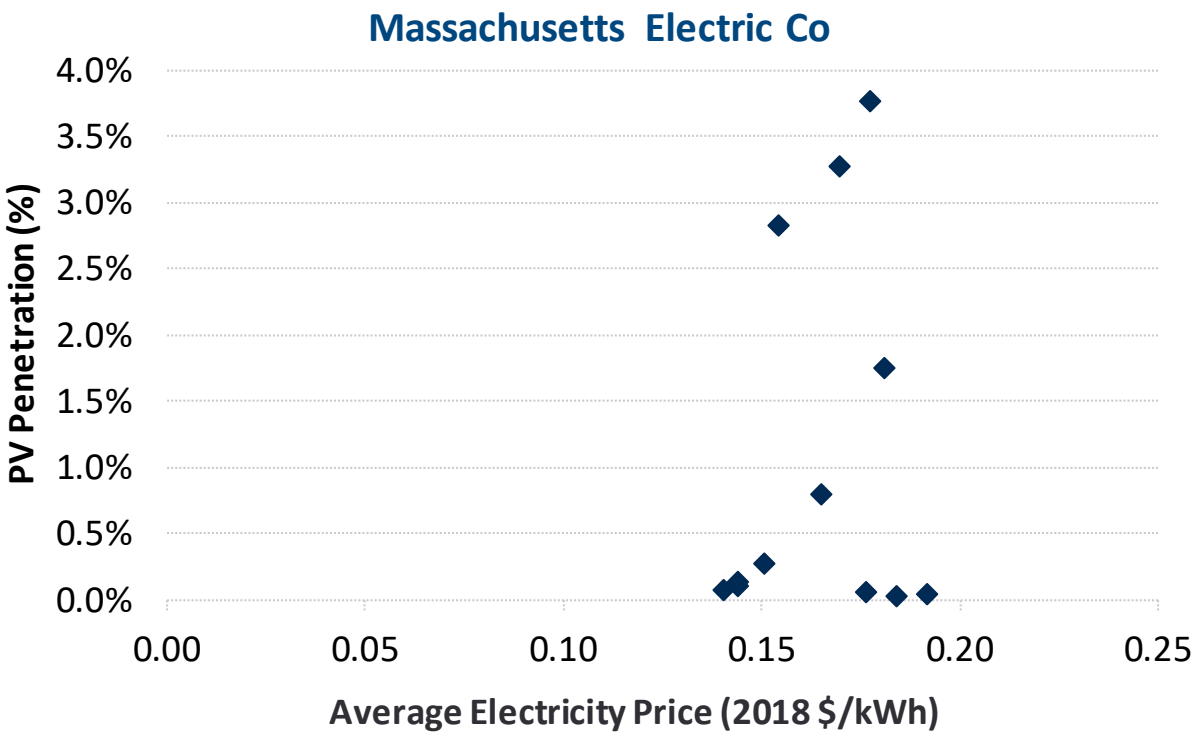

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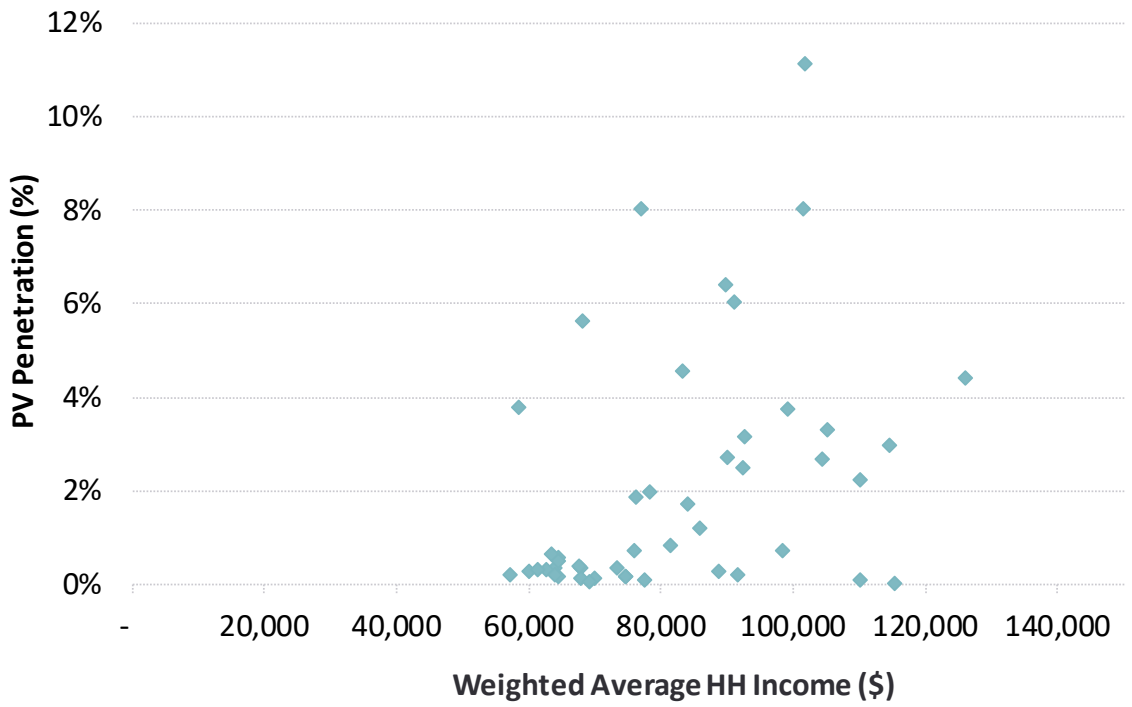
Solar Penetration vs Average HH Income by Utility (2018)



Notes: Includes 47 utilities with installed systems in 2018. PV penetration from Form EIA-861 data on PV customers and total customers. Weighted average household income calculated from 2017 US Census Bureau data as average over zipcodes included in each utility's service territory, weighted by number of households (for entire zipcode). Includes 47 utilities with 2018 PV system data in LBNL Tracking the Sun database.